POSTGRADUATE COURSES

VISION, MISSION, PROGRAM SPECIFIC OUTCOMES, CURRICULUM, COURSE OBJECTIVES, COURSE OUTCOMES AND SYLLABI

DEPARTMENT OF PHYSICS
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)
DEPARTMENT OF PHYSICS
Aligarh Muslim University

VISION
The department aims to excel and achieve a prominent status in Physics teaching and research.

MISSION
- To build a creative and stimulating environment conducive for teaching and research.
- To impart high quality Physics education and equip students for global Physics competence.
- To promote research and creative activities among faculty and students.
- To develop state of art facilities for teaching and research.
- To sensitise students to contribute for the welfare of society through competence in Physics.
M.Sc. Physics- PROGRAM SPECIFIC OUTCOMES (PSOs)

Upon completion of the Master’s degree program in physics at the Department of Physics, students will be able to:

- **Demonstrate competence in advanced knowledge of Physics in the core areas of Classical Physics, Mathematical Physics, statistical physics, and Quantum mechanics.**
- **Demonstrate proficiency in multiple allied areas of physics such as Astrophysics, Condensed Matter Physics, Particle physics, Nuclear Physics, High Energy Physics, Spectroscopy and Electronics.**
- **Demonstrate advanced ability in techniques of scientific computing to solve problems.**
- **Demonstrate their ability to present information clearly, logically, truthfully and critically, both in verbal and written communication.**
- **Demonstrate both an understanding and the practical application of ethical standards implicit in science as well as scientific temperament in public and private life,**
- **Demonstrate their competence for Doctoral study in physics and/or careers in scientifically oriented jobs in the public or private sector.**
# CURRICULUM
## M.Sc. (Physics)
### Department of Physics
#### Aligarh Muslim University, Aligarh

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<th>Semester-I</th>
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<td><strong>Course Code</strong></td>
<td><strong>Course Title</strong></td>
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<tr>
<td>PHM-1001</td>
<td>Mathematical Physics</td>
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<tr>
<td>PHM-1002</td>
<td>Classical Mechanics</td>
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<tr>
<td>PHM-1003</td>
<td>Quantum Mechanics-I</td>
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<td>PHM-1004</td>
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<td>PHM-1005</td>
<td>Experimental Techniques</td>
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<tr>
<td>PHM-1071</td>
<td>General Lab – I</td>
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<tr>
<td><strong>Total</strong></td>
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<tr>
<th>Semester-II</th>
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<tr>
<td><strong>Course Code</strong></td>
<td><strong>Course Title</strong></td>
</tr>
<tr>
<td>PHM-2001</td>
<td>Classical electrodynamics</td>
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<tr>
<td>PHM-2002</td>
<td>Atomic, Molecular and Laser Physics</td>
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<td>PHM-2003</td>
<td>Nuclear and Particle Physics</td>
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<td>PHM-2004</td>
<td>Condensed Matter Physics</td>
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<tr>
<td>PHM-2005</td>
<td>Astrophysics</td>
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<td>PHM-2071</td>
<td>General Lab – II</td>
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<tr>
<td>PHM-2072</td>
<td>Computational Lab – III</td>
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<th>Semester-III</th>
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<td><strong>Core Papers</strong></td>
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<tr>
<td>PHM-3001</td>
<td>Quantum Mechanics – II</td>
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<td>PHM-3002</td>
<td>Statistical Mechanics</td>
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<tr>
<td>PHM-3071</td>
<td>General Lab – III</td>
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<tr>
<td><strong>Elective Papers (Students have to choose any two of the following)</strong></td>
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<tr>
<td>PHM-3012</td>
<td>Atomic and Laser Spectroscopy</td>
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<tr>
<td>PHM-3013</td>
<td>Condensed Matter Physics-A</td>
</tr>
<tr>
<td>PHM-3017</td>
<td>Nonlinear Dynamics</td>
</tr>
<tr>
<td>PHM-3021</td>
<td>High Energy Physics -A</td>
</tr>
<tr>
<td>PHM-3022</td>
<td>Nuclear Physics-A</td>
</tr>
<tr>
<td>PHM-3023</td>
<td>Physics of Nano Materials</td>
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<tr>
<td>PHM-3024</td>
<td>String Theory</td>
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<tr>
<td>PHM-3034</td>
<td>Quantum Field Theory</td>
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<tr>
<td><strong>Ability Enhancement Elective Papers (Students have to choose any one of the following)</strong></td>
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<tr>
<td>PHM-3031</td>
<td>Programming and Computational Physics -A</td>
</tr>
<tr>
<td>PHM-3032</td>
<td>Instrumentation and Analytical Methods-A</td>
</tr>
<tr>
<td>PHM-3033</td>
<td>Atmospheric Physics</td>
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<tr>
<td>PHM------</td>
<td>Optical Electronics And</td>
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<tr>
<td>Applications</td>
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<tr>
<td><strong>Elective Lab-I (Students have to choose any one of the following)</strong></td>
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<tr>
<td>PHM-3072 Atomic, Molecular and Optical Physics Lab-A</td>
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<tr>
<td>PHM-3073 Nuclear Physics Lab-A</td>
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<tr>
<td>PHM-3075 Condensed Matter Physics Lab-A</td>
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<tr>
<td>PHM-3076 Advance Computational Lab-A</td>
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**Semester-IV**

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<tr>
<th>Core Papers</th>
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<tr>
<td>PHM-4071 General Lab – IV</td>
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<tr>
<td>PHM-4077 Project</td>
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<td><strong>Elective Papers (Students have to choose any two of the following)</strong></td>
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<tr>
<td>PHM-4012 Molecular Physics</td>
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<tr>
<td>PHM-4013 Condensed Matter Physics-B</td>
<td>4</td>
</tr>
<tr>
<td>PHM-4015 High Energy Physics -B</td>
<td>4</td>
</tr>
<tr>
<td>PHM-4016 Nuclear Physics-B</td>
<td>4</td>
</tr>
<tr>
<td>PHM-4017 Physics Of Laser and Laser Applications</td>
<td>4</td>
</tr>
<tr>
<td>PHM-4022 Quantum Electrodynamics</td>
<td>4</td>
</tr>
<tr>
<td>PHM-4036 Standard Model of Particle Interactions</td>
<td>4</td>
</tr>
<tr>
<td>PHM-4037 Soft Matter Physics</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>24</strong></td>
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<tr>
<th>Ability Enhancement Elective Papers (Students have to choose any one of the following)</th>
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<tbody>
<tr>
<td>PHM-4033 Digital Signal Process</td>
<td>2</td>
</tr>
<tr>
<td>PHM-4035 Instrumentation and Analytical Methods-B</td>
<td>2</td>
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<tr>
<td><strong>Total</strong></td>
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</table>

| Elective Lab-II (Students have to choose any one of the following)                         |       |
| PHM-4072 Atomic, Molecular and Optical Physics Lab-B                                      | 2     |
| PHM-4073 Nuclear Physics Lab-B                                                             | 2     |
| PHM-4075 Condensed Matter Physics Lab-B                                                    | 2     |
| PHM-4076 Advance Computational Lab-B                                                       | 2     |
| **Total**                                                                                | **24**|

| Open Elective Paper (Students have to choose a paper from any one of the Chemistry, Mathematics, Statistics, Geology, Geography, Computer Science, Remote Sensing departments while as Physics Department runs the following paper for other departments’ students) |       |
| PHM-4091 Elements of Modern Physics                                                        | 4     |
| **Total**                                                                                | **24**|
| **Grand Total**                                                                          | **96**|
Course Title: **MATHEMATICAL PHYSICS**  
Course Number: **PHM-1001**  
Credits: 04  
Type of course: Core (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%  

**Course Objectives**  
To introduce students to methods of mathematical physics and to develop required mathematical skills in the area of Tensors, Green’s Function and Group Theory to solve problems in theoretical physics.

**Course Outcomes**  
On completion of the course, students will be able to:  
1. work with Tensors.  
2. solve linear differential equations with inhomogeneous term by the method of Green’s function.  
3. apply the concept of Discrete and Continuous groups to physics problems, which is a pre-requisite for deeper understanding of crystallography, particle physics, quantum mechanics and energy bands in solids.  
4. Understand the significance of Lie Algebra and solve problems on them.  
5. apply Young’s diagram technique to unitary groups.
Syllabus for M.Sc. (Physics) I Semester
MATHEMATICAL PHYSICS
Paper Code: PHM-1001

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

UNIT-I: Review of Tensors Analysis and General Relativity
Tensor Algebra: Linear combinations, direct product, contraction, tensor densities, transformation of affine connection, covariant differentiation, gradient, curl and divergence.

UNIT-II: Green’s Functions
Introduction to Green’s function method, Green’s function as a solution to Poisson’s equation with a point source, symmetry of Green’s function, forms of Green’s functions, spherical polar coordinate expansion, quantum mechanical scattering-Neuman series as well as Green’s function solutions, eigen function expansion, one dimensional case, integral-differential equation, linear Harmonic oscillator, Green’s function and Dirac delta function.

Unit-III: Group Theory I
Symmetries in classical and Quantum mechanics, Definition and examples of groups, Cyclic groups, Subgroups, Conjugacy classes, Invariant subgroups, Cosets and Factor groups, Homomorphism, Isomorphism, group representation, Schur’s Lemma, Orthogonality of characters, Permutation group \( S_n \), Partition and Young Diagram. Point groups in the context of crystals and molecules.

Unit-IV: Group Theory II
Continuous groups, Definition and example of Lie groups and Lie Algebras, Rotation groups \( SO(2) \), \( SO(3) \) and their irreducible representations, Angular momentum algebra, Rotation group \( SO(n) \). Connection between \( SU(2) \) and \( SO(3) \). Spin and Iso-spin groups, Group \( SU(3) \), Unitary group \( SU(n) \), Many-particle Irreducible representation, Young diagrams for Unitary groups and their simple application for \( SU(2) \) and \( SU(3) \).

Reference Books:
- Steven Weinberg : Gravitation and Cosmology (John Wiley)
- Joshi A. W. : Elements of Group theory for physicist (New Age)
- Tung W. K. : Group theory in Physics (World Scientific)
Course Title: **CLASSICAL MECHANICS**  
Course Number: **PHM-1002**  
Credits: 04  
Type of course: Core (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

**Course Objectives**  
Aim of this advanced level course on classical mechanics is to polish the learner’s understanding of the subject, to learn how complex classical systems could be formulated and solved using the Hamiltonian and Lagrangian by observing symmetries of the system and/or through advanced co-ordinate transformation techniques such as canonical transformations of various kinds and action-angle variable technique. In addition to it the students also learn how to solve problems having large degrees of freedom such as rigid-bodies, complex and chaotic systems and small oscillations.

**Course Outcomes**  
On completion of the course, students will be able to:  
1. Write and solve Lagrangian and Hamiltonian of the system, look for the symmetries associated with the system and employ the corresponding the law of conservations.  
2. Understand, transform and solve the problems using various canonical transformations, Poisson bracket and action-angle variable techniques and classical perturbation-theory  
3. Learn to perceive the symmetries and associated conservation laws and their applications to solve a classical system.  
4. Understand how systems with large degrees of freedom such as rigid-bodies could be solved and be able to extract the interesting dynamics which is displayed by rigid-bodies while in motion via Euler-angles technique.  
5. Derive the dynamics of complex systems and be able to develop an elementary understanding of chaos and fractals.
Syllabus for M.Sc. (Physics) I Semester
CLASSICAL MECHANICS
Paper Code: PHM-1002

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I: Lagrangian & Hamiltonian Dynamics

Unit-II: Hamilton-Jacobi Theory and Rigid Body Motion-I
Hamilton-Jacobi equation for Hamilton’s principal and characteristic functions, harmonic oscillator, Noether’s theorem, action angle variables, frequency of harmonic oscillator, Kepler’s problem in action-angle variables.
Rigid Body Motion: Degrees of freedom, orthogonal transformations, statements of Euler’s and Chasle’s theorems, infinitesimal rotations, rotating coordinate systems, centrifugal and Coriolis force. Angular momentum and kinetic energy of a rigid body.

Unit-III: Rigid Body Motion-II and Small Oscillations
Inertia tensor, principal axes transformation Euler’s equation of motion for a rigid body, torque free motion of symmetric top, precession of Earth’s axis of rotation and a charged particle in magnetic field. Small Oscillations: General formalism, eigenvalue equation, normal coordinates and normal modes.

Unit-IV: Continuous Media, Perturbation Theory and Chaos
Continuous Media: Coupled pendula, triatomic molecule, Linear chain of interacting particles, elastic rod problem, Lagrangian formalism, stress energy tensor.
Classical Perturbation Theory: Time dependent perturbation theory, harmonic oscillator.
Qualitative discussion of Classical Chaos, Phase space dynamics and stability analysis.

Reference Books:
• Goldstein, H, Poole, C. and Safko, J. Classical Mechanics, 3rd Edition (Pearson)
• Rana, N.C. and Joag, P.S. Classical Mechanics (Tata McGraw-Hill)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) I Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: QUANTUM MECHANICS-I
Course Number: PHM-1003
Credits: 04
Type of course: Core (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
To acquire working knowledge of the Non-relativistic Quantum Mechanics and apply mathematical formulation developed for the quantum mechanical systems on the physical systems.

Course Outcomes
1. The students feel well equipped to understand physics of microscopic systems like the topics in spectroscopy, condensed matter physics, nuclear physics, high energy physics, statistical physics, etc.
2. The students observe that learning these topics are stepping stone to understand quantum field theory, the theory where the microscopic objects move with a speed close to the speed of light.
3. The topics covered in the syllabus show an understanding of quantization of angular momentum.
4. Taking up this course students are able to apply techniques such as ladder operators, scattering theory, etc. for selected problems in quantum mechanics.
Syllabus for M.Sc. (Physics) I Semester
QUANTUM MECHANICS-I
Paper Code: PHM-1003

(Credit: 04)
Theory: 48 Lectures, Tutorials: 08

UNIT-I: Matrix Formulation of Quantum Mechanics
Linear vector spaces, elements of Hilbert space, Dirac’s bra-ket notation, triangle inequality, Schwartz inequality and Gram-Schmidt theorem, linear operators, projection operator, Hermitian and unitary operators, matrix representation of operators, elements of transformation theory, linear harmonic oscillator by operator method.
Time development of a quantum mechanical system: Schrödinger, Heisenberg and interaction pictures, Heisenberg’s equation of motion.
Problems based on the above topics (Shankar)

UNIT-II: Approximation Methods
Time-independent perturbation theory
Nondegenerate perturbation theory: General formulation, First order theory, Second-order energies.
Degenerate perturbation theory: Two-fold degeneracy, Higher-order degeneracy.
The variational principle: Theory and its application to find out the ground state energies of harmonic oscillator and helium atom.
Time Dependent perturbation theory: General formulation, sinusoidal perturbations, Emission and absorption of radiation, Fermi’s golden rule.

UNIT-III: Collision Theory
Definition of S- and T- matrices, the Lippmann-Schwinger equation, Derivation for the scattering amplitude, Optical theorem (first and higher order), Born approximation, Scattering from Yukawa and screened coulomb potentials, Low-energy soft-sphere scattering, Eikonal approximation, Method of partial waves, unitarity and phase shifts, determination of phase shifts, hard sphere scattering, scattering from square well potential, Low-energy scattering and bound states, Resonance scattering, Breit-Wigner formula.

UNIT-IV: Symmetries in Quantum Mechanics
Space and time displacements, displacement operators, symmetry and degeneracy, rotation operator, orbital angular momentum operators and their commutation relations, eigen values and eigen functions of L^2 and Lz operators, spin angular momentum operators and their algebra; Eigen states of spin 1/2, 1, 3/2 particles, total angular momentum \( \vec{J} \), coupling of two angular momenta, Clebsch-GordanCoefficients and their properties, Wigner-Eckart theorem (statement and Explanation).

Reference Books:
- L. I. Schiff. : Quantum Mechanics, 3rd Ed. (McGraw Hill)
- R. Shankar : Principles of Quantum Mechanics (Plenum)
- J. J. Sakurai: Modern Quantum Mechanics (Rev. Ed., Addison-Wesley)
- David J. Griffiths: Introduction to Quantum Mechanics (2nd Ed., Pearson)
Course Title: **ELECTRONICS**  
Course Number: **PHM-1004**  
Credits: 04  
Type of course: Core (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%  

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**Course Objectives**  
To understand the basic concepts of Analog and Digital Electronics and apply it in experimental Physics and also for various Engineering Applications.  

**Course Outcomes**  
On completion of the course, students will be able to:  
1. Analyse and Design Combinational Logic Circuit.  
2. Design different types of memories (ROM, RAM, EPROM etc).  
3. Understand different ADCs & DACs and use them in practical applications.  
4. Understand the basic concepts of OP-AMP, its various parameters and Oscillators.  
5. Understand Schmitt trigger and use it in square wave, triangular wave generators and voltage controlled oscillators.  
Syllabus for M.Sc. (Physics) I Semester
ELECTRONICS
Paper Code: PHM-1004

(Credit: 04)
Theory: 48 Lectures, Tutorials: 08

UNIT-I: Codes, Basic and Combinational Logic Circuits
BCD, ASCII and Gray Codes. Basics logic gates, logic systems, laws and theorems of
Boolean algebra. Different ways of implementing exclusive-OR gate, TTL and CMOS logic
family characteristics. Open collector TTL gates, tri-state gates. Sum of product and product
of sum representation. Algebraic and Karnaugh map simplifications. binary adders, digital
(magnitude) comparators, parity checker/generator. Decoders/demultiplexers, data
selectors/multiplexers. Encoders Read only memory (ROM), ROM organization and
applications, PROMS, EPROMS, PAL and PLA.

UNIT-II : Sequential Logic Circuits and Very Large Scale Integrated System
Clocked S-R flip-flops, J-K and D-type flip-flops, edge triggering, preset and clear inputs.
Ripple counters, synchronous binary counters, decade counters, shift registers, shift and ring
counters, up/down counters. Static and dynamic random access memory (RAM),
Microprocessors and Microcontroller basics.

UNIT-III : Operational Amplifier Applications and Regulators
OP Amp, ideal characteristics, op amp as inverting amplifier, effect of finite open loop gain,
generalized basic equation of op amp with impedances, integrator and differentiator,
inverting and non-inverting summer, voltage follower. Op Amp parameters, offset voltage
and current, slew rate, full wave BW, CMRR. OP AMP as voltage regulator, fixed and
variable 3 pin regulator, switching regulator.

UNIT-IV : Waveform Generators, Waveshaping and Data Conversion
Barkhausen criterion of oscillation. Wein’s bridge and LC oscillators (op amp). Comparators,
regenerative comparator (Schmitt trigger), square and triangular wave generator, voltage
controlled generators. Multivibrators: astable/monostable and 555 timer. D-A converters:
weighted resistor, ladder and multiplying types. A-D converters: parallel, counter type,
successive approximation and dual slope integration types.

Reference Books:
- Millman, J. and Grabel, A.:Microelectronics; Digital Analog Circuits and Systems (Tata
  McGraw Hill)
- Leach, D.P. and Malvino, A.P.:Digital Principles and Applications (Tata McGraw Hill)
- Tocci, R.J. and Widmer, N.S.:Digital Systems, Principles and Applications (Prentice Hall)
- Moris Mano, M. Digital Design (Pearson)
Course Title: EXPERIMENTAL TECHNIQUES  
Course Number: PHM-1005  
Credits: 02  
Type of course: Core (Theory)  
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%  

Course Objectives  
To develop experimental skill in Spectroscopy and Nuclear Techniques.  

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

1. understand the principle and experimentation of UV-VIS-NIR, EPR and NMR spectroscopy.  
2. apply nuclear techniques in time of flight and coincidence measurements.  
3. apply vacuum techniques in spectroscopy and nuclear physics experiments.  
4. apply statistical interpretation and analysis in experimental data.  
5. apply statistical interpretation and analysis in experimental data.
Syllabus for M.Sc. (Physics) I Semester
EXPERIMENTAL TECHNIQUES
Paper Code: PHM-1005

(Credits:02)
Theory: 24 Lectures, Tutorials: 04

UNIT-I: Spectroscopic Techniques.
Light sources, Prism and grating spectrographs, Grating mountings: Czerny-Turner and Ebert
mountings, Monochromators. Resolution and dispersion of prism and grating spectrographs.
Light detectors: Photomultiplier, charged coupled device (CCD).

UNIT-II: Continuum sources for absorption studies: uv, visible and infrared sources, Single-
beam and double-beam infrared instruments, infrared detectors. Basic of Electron spin
resonance (ESR) and Nuclear magnetic resonance (NMR), Chemical shift.

UNIT-III: Nuclear Instrumentations
Detectors: Ionization chamber, proportional counter, GM counter, scintillation detectors,
solid state detectors, surface barrier and HPGe detectors. Time of flight technique. Idea of
coincidence measurements. Determination of lifetime of nuclear levels.

UNIT-IV: Data Analysis and Vacuum Techniques
Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors,
least squares fitting, linear and nonlinear curve fitting, chi-square test;
Vacuum Techniques: Basis idea of conductance, pumping speed, mechanical pump, diffusion
pump.
Gauges: Penning and Pirani.

Reference Books:
- Thorne, A., Litzen, U, Johansson, S : Spectrophysics (Springer)
- Sawyer, R.A. : Experimental Spectroscopy (Dover)
- Aruldhas, G. : Molecular Structure and Spectroscopy (Printice Hall of India)
- Leo, W.R. : Techniques for Nuclear and Particle Physics Experiments
  (Narosa)
- Kapoor, S.S. & Ramamurthy, V.S. : Nuclear Radiation Detectors (New Age)
- Singru, R.M. : Introduction to Experimental Nuclear Physics (Wiley Eastern Pvt.)
Course Title: **CLASSICAL ELECTRODYNAMICS**  
Course Number: **PHM-2001**  
Credits: 04  
Type of course: Core (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%  

**Course Objectives**  
To gain an understanding of Maxwell’s equations and the ability to apply them to explain the behaviour of electromagnetic wave propagation in different media, phenomenon of refraction, reflection, scattering, interference, diffraction and polarization.

**Course Outcomes**  
On completion of the course, students will be able to:  
1. Achieve an understanding of Maxwell’s equation, gauge transformation and boundary conditions between different media.  
2. Manipulate and apply Maxwell’s equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.  
3. Analyse the phenomena of wave propagation in unbounded, bounded, vacuum, dielectric and guided and unguided media.  
4. Calculate the reflection and transmission coefficients at plane interface in bounded media.  
5. Know the features of planar, optical and rectangular wave guides and obtain the field components, Eigen value equation and energy flow, phase and group velocities in the dielectric media.  
6. Familiarize about Lienard-Wiecherts potentials and fields, Larmor’s and Thomson’s classical radiation and scattering concepts.  
7. Understand various theories and mathematical concepts of interference and diffraction of electromagnetic waves.
Syllabus for M.Sc. (Physics) II Semester
CLASSICAL ELECTRODYNAMICS
Paper Code: PHM-2001
(Credits: 04)
(Theory: 48 Lectures, Tutorials: 08)

Unit-I : Electromagnetic Waves-I
Review of Maxwell’s equation. The Maxwell stress tensor, Radiation pressure, Propagation of e.m. waves in non-conducting medium. Propagation of e.m. waves in a conducting medium. Skin depth. Linear, circular and elliptical polarization. Oblique incidence – The Fresnel Equations, Total internal reflection, Brewster’s angle.

Unit-II : Electromagnetic Waves-II

Unit-III : Electromagnetic Radiation

Unit-IV : Interference and Diffraction of e.m. Waves

Reference Books:
- Jackson, J.D. : Classical Electrodynamics (John Wiley)
- Laud, B.B. : Electromagnetics (Wiley Eastern)
Course Title: ATOMIC, MOLECULAR AND LASER PHYSICS
Course Number: PHM-2002
Credits: 04
Type of course: Core (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)

Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
To develop basic theoretical knowledge in Atomic, Molecular and Laser Physics.

Course Outcomes
On completion of the course, students will be able to:
1. know the theoretical background of atomic spectra of one electron systems as well as spectra of di-atomic molecule.
2. analyze and explain the atomic spectra (e.g. Hydrogen, Helium and Alkali type).
3. explain the various types of spectra of di-atomic molecules as well as Infrared/ Raman spectra of linear molecules.
4. understand various types of Lasers, their working and applications.
5. understand the Physics of Lasers.
6. understand the Laser beam properties.
Syllabus for M.Sc. (Physics) II Semester

ATOMIC, MOLECULAR AND LASER PHYSICS

Paper Code: PHM-2002

(Credits: 04)

Theory: 48 Lectures, Tutorials: 08

Unit I: Atomic Spectroscopy

Unit II: Molecular Spectroscopy

Unit III: Laser Physics

Unit IV: Laser Systems

Reference Books:
- White, H.E. : Introduction to Atomic Spectra (McGraw Hill)
- Bransden B.H. and Joachain C J : Physics of Atoms and Molecules (Pearson)
- King, G.W. : Spectroscopy and Molecular Structure (Rinehart and Winston)
- Herzberg, G. : Spectra of Diatomic Molecules (D. Van Nostrand)
- Laud, B.B. : Laser and Non-linear Optics (Wetey-Eastern)
Syllabus with Course Objectives and Course Outcomes

M.Sc. (Physics) II Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **NUCLEAR AND PARTICLE PHYSICS**
Course Number: **PHM-2003**
Credits: 04
Type of course: Core (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

**Course Objectives**
1. To develop the understanding of nuclear decay, nuclear reaction and application of liquid drop model.
2. To acquire basic understanding of particle nature and the interaction.

**Course Outcomes**
On completion of the course, students will be able to:
1. understand the microscopic theory of alpha, beta and gamma decay and will be able to use the various selection rules to find the allowed and forbidden transitions.
2. identify the different types of nuclear reactions and able to apply the liquid drop model to describe some basic features of nucleus.
3. get familiar with the various particle detectors.
4. determine the nature of particle and the role of symmetries in their interactions
5. know the idea of resonance (spin 3/2) and the quark model and be able to calculate the magnetic moment and mass splitting of particles.
6. solve the particle flavor oscillation based on semi-quantum mechanical approach for neutrino and K-mesons.
Syllabus for M.Sc. (Physics) II Semester
NUCLEAR AND PARTICLE PHYSICS
Paper Code: PHM-2003

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit I - Nuclear Decay
Alpha decay; energetics of $\alpha$-decay, Geizer-Nuttal law, Gamow theory of $\alpha$-decay. Beta decay: Neutrino hypothesis, energetics of $\beta$-decay, Fermi theory of $\beta$-decay, Fermi-Kurie plot, comparative half life. Selection rules: allowed and forbidden transitions, Idea of electron capture, Gamma decay: energetic of $\gamma$-decay, Multipole radiations, Selection rules, Idea of Internal Conversion of $\gamma$-rays and Coulomb excitation.

Unit II – Nuclear Reactions
Liquid drop model: Weizsacker’s semi-empirical mass formula and some of its applications.

Unit-III
Neutral units, Review of Particle Accelerations and Detectors, Linacs, Synchrotrons and colliding-beam accelerators, principle of Cerenkov counters and calorimeters.
The fundamental fermions and interactions. Classification of particles into – fermions and bosons, leptons and hadrons, particles and resonant states.
Space reflection and parity, parity of charged pion, parity non-conservation in $\beta$-decay, charge conjugation, time reversal, CPT theorem, symmetry and conservation rules.
Neutrino flavours, mass limits, neutrino detection helicity of neutrino, energy of neutrino for pion decay in flight and decay at rest, difference between $\nu_e$ and $\nu_\mu$ and neutrino flavour oscillations.

Unit-IV
Introduction to Spin $\frac{1}{2}$ and Spin 3/2 Resonances, Quark model of hadrons, quark flavours, confinement and QCD potential. Isospin and Gell-Mann-Nishijima relation. Baryon decuplet and octet. Colour degree of freedom. Magnetic moments of baryons, Mass relations and splittings. Mesons built of light and heavy quarks.
Weak, electromagnetic and strong decays of particles, calculation of branching ratios, weak decays of strange particles and Cabbibo theory. Decay rates for $\pi^\pm \rightarrow \mu^\pm \nu_\mu (\bar{\nu}_\mu)$ and $\pi^\pm \rightarrow e^\pm \nu_e (\bar{\nu}_e)$ processes.
Regeneration phenomenon, strangeness oscillations, $K_L$—$K_S$ mass difference and CP non-conservation in $K^0$–decays.

Reference Books:
- Enge, H.A. : Introduction to Nuclear Physics (Addison Wesley)
- Preston, M.A. & Bhaduri, R. : Nuclear Physics (Addison Wesley)
- Roy, R.R. & Nigam, B.P. : Nuclear Physics (John Wiley)
- Evans, R.D. : Atomic Nucleus (McGraw Hill)
- Halliday, D. : Introductory Nuclear Physics (John Wiley)
• Ghosal, S.N. : Atomic and Nuclear Physics (S. Chand & Company Ltd.)
• Segre, E. : Nuclei and Particles (2nd Ed.) (Benjamin/Cummings)
• Hughes, I.S. : Elementary Particles (Cambridge)
• Povh, Rith. Scholz Zetche : Particles and Nuclei (Springer)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) II Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: CONDENSED MATTER PHYSICS
Course Number: PHM-2004
Credits: 02
Type of course: Core (Theory)
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
To make aware students about the useful concepts of condensed matter physics at post
graduate level. These include symmetry operations, crystal defects, reciprocal lattice,
semiconductors, magnetism and superconductivity.

Course Outcomes
On completion of the course, students will be able to:
1. Understand the basic symmetry operations performed in crystals and various types of
defects that exist in crystals.
2. Construct the reciprocal lattice of any given direct lattice.
3. To perform the structure factor calculations.
4. Appreciate the need of band theory and figure out different types of band structures.
5. Explain the quantum theory of magnetism.
6. Grasp the concepts and basic ideas related to superconductivity.
Syllabus for M.Sc. (Physics) II Semester
CONDENSED MATTER PHYSICS
Paper Code: PHM-2004

(Credits: 02)
Theory: 24 Lectures, Tutorials: 04

UNIT –I
Symmetry Elements: Symmetry operations, proper rotation axis, improper rotation axis, rotoreflection, rotoinversion, glide planes, screw axes.
Symmetry Groups: Point groups, space groups: Quasi crystals.
Imperfections: Types of imperfections: Point defects (Schottky and Frenkel), Dislocations, Illustration of types of dislocation, Burger’s vector, Low angle grain boundaries.

UNIT –II
Reciprocal Lattice: Concept of Brillouin zone; reciprocal lattice, its significance, relationships between direct and reciprocal primitive translation vectors. Construction of reciprocal lattices; determination of reciprocal lattice of SC, BCC, FCC.
Diffraction from Crystals and Crystal Structure Study:

UNIT-III
Free Electron Fermi Gas: Review of Sommerfeld model of free election gas; Boltzmann transport equation, derivation of the expression for d.c. conductivity.
Energy Bands: Electron wave equation in periodic crystal potential, solution for energy at zone boundary, comparative picture of the band structures of metals, semi-metals and insulators.
Semiconductors: Band gap, concept of hole; equations of motion of charge carriers in electric and magnetic fields, effective mass, intrinsic and extrinsic conductivity, law of mass action.

UNIT –IV

Reference Books:
- Srivastava, J.P. : Elements of Solid State Physics (Prentice-Hall of India)
Course Title: **ASTROPHYSICS**  
Course Number: **PHM-2005**  
Credits: 02  
Type of course: Core (Theory)  
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

**Course Objectives**
To develop an elementary understanding of universe and applications of physical processes including elementary relativistic physics.

**Course Outcomes**
On completion of the course, students will be able to:
1. Explain radiation mechanism and radiative transport of energy under various conditions.
2. Describe physical states of the matter and application of Saha & Boltzmann formula in stellar classification.
3. Differentiate between the roles of sources of energy (thermal, gravitational and nuclear) and its role in star and galactic formulation.
4. Explain structures of our sun and physical process involved in the interior and exterior of the sun.
5. Explain the various era of the evolution of universe.
Syllabus for M.Sc. (Physics) II Semester
ASTROPHYSICS
Paper Code: PHM-2005

(Credits: 02)
Theory: 24 Lectures, Tutorials: 04

Unit-I

Unit-II

Unit-III
Stellar Energy Sources and Nucleosynthesis [Basic Conditions, Thermonuclear Reaction Rates and Nuclear Burning (P-P, CNO, Triple Alpha, Carbon & Other Heavy Elements)], Internal Structure of the Sun and Solar Neutrino Problem.

Unit-IV

Reference Books:
- The New Cosmos: Albrecht Unsold and Bodo Baschek (Springer-Verlag)
- Stellar Structure and Evolution: R. Kippenhahn and A. Weigert (Springer-Verlag)
Course Title: **QUANTUM MECHANICS-II**  
Course Number: **PHM-3001**  
Credits: 04  
Type of course: Core (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%  

**Course Objectives**  
To impart knowledge to make the students able to pursue research in theoretical physics in general and to the fields of nuclear physics, particle physics and astrophysics in particular.

**Course Outcomes**  
After completion of the course, students have knowledge and ability to apply Quantum mechanics and Quantum Field Theory to particles and fields. Attached syllabus is self explanatory.
UNIT-I: Relativistic Wave Equation
Relativity and problems will Schrodinger equation, Free particle Klein-Fock-Gordon equation and physical problems associated with it, continuity equation, minimal electromagnetic coupling, non-relativistic reduction.
Dirac equation, Covariant and adjoint Dirac equations, continuity equation, free-particle solution, Dirac and Feynman interpretations of negative energy states, Dirac equation in electromagnetic field, non-relativistic reduction.

UNIT-II:
Dirac Equation in a Central Field, spin-orbit energy, spin angular momentum, constants of motion for central field and their simultaneous eigen-functions, energy levels of relativistic hydrogen atom, anomalous magnetic moment.

Unit-III: Quantization of Klein-Gordon and Dirac field
Lagrangian field theory. Statement of Noether’s theorem and conserved energy momentum tensor.
Quantization of Klein-Gordon field (number representation), Hermitian and non-Hermitian fields energy, momentum and charged operators for scalar fields. Covariant commutation rules and meson propagator.
Quantization of Dirac field (number representation), Covariant commutation rules and the fermion propagator.

Unit-IV: Quantization of e.m. field
Covariant quantization of e.m. field. Four polarization vector. Covariant commutation rules and the photon propagator.

Reference Books:
- Biswas, S.N. : Quantum Mechanics; Chapters 8 & 9 (Books and Allied )
- Schiff, L.I. : Quantum Mechanics, Chapters 13,14 (McGraw Hill; 3rd Edition)
- Bjorken, J.D. and Drell, S.D. : Relativistic Quantum Mechanics; Chapters 1 and 3 (McGraw Hill)
- Mandl, F. and Shaw, G. : Quantum Field Theory (John-Wiley)
- Sakurai, J.J. : Advanced Quantum Mechanics (Benjamin/Cummings)
Course Title: **STATISTICAL PHYSICS**
Course Number: **PHM-3002**
Credits: 04
Type of course: Core (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)

Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

**Course Objectives**
Aim of this course is to develop an understanding of how the physics laws of statistical systems are formulated from scratch at the classical as well as quantum level with the aid of statistical distributions, and thereby partition function and entropy of the system. In addition the learners also get acquainted with some exotic phenomenon of the nature which are based upon the phase-transitions of various types, random walk, Heisenberg and Ising model for Magnetic materials.

**Course Outcomes**
On completion of the course, students will be able to:

1. Understand, derive and apply the classical and quantum statistical distribution function from scratch for different statistical systems.
2. Formulate statistical models and derive the associated thermo-dynamical properties such as entropy, temperature, pressure and chemical potentials.
3. Differentiate between Bosonic and Fermionic systems and understand the allied phenomenon such as black-body radiation, Bose-Einstein condensations.
4. Learn and apply the ideas of phase-transitions of first and second order, ferromagnetism using Ising and Heisenberg models.
5. Formulate random walk problem and should be able to apply it to realistic systems in nature.
Syllabus for M.Sc. (Physics) I Semester
STATISTICAL PHYSICS
Paper Code: PHM-3002

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I:
Introduction to statistical physics, phase space and phase space trajectory, concept of statistical ensemble, distribution function, mean value of a physical quantity, statistical equilibrium, statistical independence and quasi-closed systems. Fluctuations and its dependence on number of particles.
Liouville’s theorem and its significance, microcanonical distribution in classical statistics, statistical matrix, statistical distribution in quantum statistics.
Entropy. Law of increase of entropy. Thermodynamic quantities: temperature, pressure, free energy and thermodynamic potential. Theorem of small increments (no derivation), Concept of chemical potential, dependence of thermodynamic quantities on number of particles. An ideal gas in microcanonical ensemble.

Unit-II:
Gibbs canonical distribution. The Maxwellian distribution. Free energy and partition function.
Grand canonical distribution and partition function. Ideal gas in canonical and grand canonical ensemble.
Energy fluctuations in canonical and concentration fluctuations in grand canonical ensemble.

Unit-III:
F-D and B-E distributions. Equation of state of ideal F-D and B-E gases of elementary particles.
Degenerate electron gas, equation of state, degeneracy temperature, specific heat. The electron gas in metals, Richardson effect.
Degenerate Bose gas – Bose-Einstein condensation, condensation temperature, specific heat, entropy and pressure.
Black-body radiation: Planck’s formula and Boltzmann’s law.
Magnetism of an electron gas – Pauli paramagnetism, Landau diamagnetism, de-Hass Van Alphen effect.

Unit-IV:
Ferromagnetism – First and second order phase transition, the Bragg-Williams approximation, Heisenberg and Ising model in one dimension; an idea in two dimensions.
Reference Books:

- Pathria, R.K. Statistical Mechanics (Butterworth-Heinemann)
- W. Greiner, Ludwig Neise & Horst Stoecker: Thermodynamics and Statistical Mechanics (Springer)
- Yu. B. Rumer & M. Sh. Rajvkin: Thermodynamics, Statistical Physics, and Kinematics (Mir Publisher, Moscow)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) III Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: ATOMIC AND LASER SPECTROSCOPY
Course Number: PHM-3012
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)

Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
To develop theoretical and experimental knowledge in Atomic, Molecular and Laser Spectroscopy

Course Outcomes
On completion of the course, students will be able to:
1. Apply the experimental techniques like optogalvanic, ionization, optoacoustic, laser induced fluorescence, optical double resonance and nonlinear techniques (saturation, polarization, two-photon spectroscopy, to atoms and molecules.
2. Analyze and explain the complex spectra of atoms/molecules.
3. Apply these techniques for advance studies at research levels.
4. Apply the atomic and laser spectroscopy to environmental and astrophysical studies.
5. Apply the nonlinear laser spectroscopy to test the fundamentals of physics in general.
Syllabus for M.Sc. (Physics) III Semester
ATOMIC AND LASER SPECTROSCOPY
Paper Code: PHM-3012

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I: Atomic Structure

Unit-II: The Analysis of Atomic Spectra

Unit-III: Laser Spectroscopy

Unit-IV: Non-Linear and Molecular Beam Laser Spectroscopy

Reference Books:
- White, HE : Introduction to Atomic Spectra (McGraw-Hill)
- Kuhn, HC : Atomic Spectra (Longman)
- Demtroder, W : Laser Spectroscopy (Springer Verlag)
- Hollas, JM : High Resolution Spectroscopy (John Wiley)
Course Title: **CONDENSED MATTER PHYSICS-A**  
Course Number: **PHM-3013**  
Credits: 04  
Type of course: Core (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

### Course Objectives
To familiarize the students about the advanced concepts of condensed matter physics at post graduate level. These include lattice vibrations, plasma oscillations, thermal properties of solids, band structure calculations, Fermi surfaces, magneto-conductivity and magnetic materials.

### Course Outcomes
On completion of the course, students will be able to:
1. Understand the general theory of harmonic approximations in ideal and real crystals and theory of neutron-phonon scattering.
2. Grasp the knowledge of plasma oscillations and thermal properties of solids including quantum theory of lattice heat capacity, thermal expansion, phonon collision processes, occurrence of thermal resistance and phonon thermal conductivity.
3. Calculate the band structures using tight binding approximation and Wigner-Seitz cellular method.
4. Construct the Fermi surfaces and study these surfaces using Cyclotron resonance, de Haas van Alphen effect.
5. Distinguish between various types of paramagnetic materials and explain the origin of the domains.
Syllabus for M.Sc. (Physics) III Semester
CONDENSED MATTER PHYSICS –A
Paper Code: PHM-3013

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I:
Review of the concept of reciprocal lattice, Properties of reciprocal lattice, reciprocal lattice of a hexagonal space lattice, calculation of structure factor for FCC and hexagonal crystals.

Unit-II:
Plasmons, Polaritons: Plasma oscillations, plasmons. Transverse optical modes in plasma, application to optical phonon modes in ionic crystals, interaction of e.m. waves with optical modes (polaritons). LST relation.

Unit-III:
Fermi Surface: Construction of Fermi surface. Electrons in a uniform magnetic field, Onsager quantization condition. Experimental methods of studying Fermi surface (Cyclotron resonance, de Haas van Alphen effect), closed and open orbits.

Unit-IV:
Magnetotransport: Classical theory of magnetoconductivity, a.c. conductivity of metals. Boltzmann equation in the magnetic field, Hall effect, magnetoresistance in two-band model.

Reference Books:
- Srivastava, J.P.: Elements of Solid State Physics (Prentice-Hall)
Syllabus with Course Objectives and Course Outcomes  
M.Sc. (Physics) III Semester  
Department of Physics  
Aligarh Muslim University, Aligarh

Course Title: **NONLINEAR DYNAMICS**  
Course Number: **PHM-3017**  
Credits: 04  
Type of course: Elective (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

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**Course Objectives**  
To develop basic understanding of the fundamentals of Nonlinear Dynamics namely the qualitative behaviour of the solution of dynamical systems and synchronization in coupled chaotic maps and flows.

**Course Outcomes**  
On completion of the course, students will be able to:  
1. Find equilibria in 1, 2 and 3 dimensional systems and determine their local stability using linear analysis or graphical means.  
2. Identify various types of bifurcations that leads to chaos in maps and flows.  
3. Understand sensitivity to initial conditions and use Lyapunov exponents to characterise chaos.  
4. Explain synchronization of chaotic systems and other natural systems.  
5. Describe dynamics in case of conservative and stochastic systems.
Syllabus for M.Sc. (Physics) I Semester
NONLINEAR DYNAMICS
Paper Code: PHM-3017

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I
Physics of nonlinear systems, conservative versus dissipative systems, dynamical equations and constants of motion, phase space, fixed points, periodic orbits, limit cycles. Linearization and stability analysis.

Unit-II
Bifurcations: Saddle-Node, transcritical, pitchfork, Hopf, period doubling and universality. Poincare section and iterative maps. Chaos, features of chaos; continuous and discrete dynamical systems.

Unit-III
Sensitive dependence on initial condition, Lyapunov exponents, Logistic map, Henon map, Lorenz system. Attractors and dimensions- Cantor set, Coupled systems, quasiperiodicity, ergodicity.

Unit-IV
Stochastic systems, Oscillation and chaos in chemistry, biology and social sciences: some examples, Control of chaos, synchronization- complete, phase, lag, generalized; multistability.

Reference Books:
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) III Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **HIGH ENERGY PHYSICS –A**
Course Number: **PHM-3021**
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

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**Course Objectives**
To study the physics of elementary particles through the collisions of particles and nuclei at relativistic energies. Production and detection of particles and concept of origin of the Universe.

**Course Outcomes**
On completion of the course, students will be able to:
1. Apply concept of relativistic kinematics in solving related problems.
2. Explain the mechanism and features of particle production in hadronic and ion collisions.
3. Describe validity and failure of models of particle production.
4. Discuss the design of detectors in Mega Experiments like CMS, ALICE, PHENIX, CBM, etc.
Unit-I: Relativistic Kinematics
Review of Lorentz transformations for energy and momentum, four-vectors and invariants, Laboratory and Centre-of-momentum systems, calculation of energy, momentum and angle of particles produced in nuclear reactions in Lab. and centre-of-momentum frames and their transformations and calculation of threshold energies for particle production.
Mandelstam variables, Fermi Golden Rule, differential and total scattering cross sections, Lorentz invariant phase space, calculation of decay rates and phase space for two- and three-body decays, Dalitz plots and their applications to three-body decays.

Unit-II: High Energy Hadron-Nucleon and Hadron-Nucleus Interactions
High energy hadron-nucleon collisions: Features of relativistic hadron-nucleon collisions upto very high energy, behaviour of elastic, inelastic and total cross-sections as a function of incident energy, multiplicity distribution, Negative Binomial Distribution, KNO scaling and Feynman scaling.
Relativistic hadron-nucleus and ion-ion collisions: Rapidity and pseudorapidity variables, Lab. and CM-rapidity, Maximum and minimum rapidities, Pseudorapidity distribution in projectile, target and central fragmentation regions.
Fluctuations and correlations: Two-particle correlations, short- and long-range multiplicity correlations, particle correlation and clusterization, Multiplicity fluctuations, Entropy and its generalization; Shanon and Renyi entropies.
Features of non-statistical fluctuations: Intermittency and beyond;-; erraticity, Multifractality and multifractal specific heat.

Ultra-relativistic nucleus-nucleus collisions: Glauber model of nucleus-nucleus collision, participant-spectator model, Bjorken estimate of the initial energy density, hadron structure and quark confinement, hydrodynamics of Quark-Gluon Plasma and phase diagram, deconfinement phase transition, global observables at RHIC and LHC energies, possible signatures of Quark-Gluon Plasma formation, dilepton production, Drell-Yan Process in nucleus-nucleus collision, direct photon production, Debye screening in the QGP, J/ψ suppression in the QGP, strangeness enhancement, correlation and event-by-event fluctuations, Handbury-Brown-Twiss effect, transverse mass, transverse energy, an isotropic flow and jet quenching.

Unit-IV: Detectors in High Energy Physics Experiments
General characteristics of detectors: Sensitivity, energy resolution and fano factor, detector efficiency and dead time.
Multiwire and Drift Chambers: Ionization, drift and diffusion of charges in gases, pulse formation and its shape in proportional counters, Multiwire proportional counter:-basic principle of working, construction and readout method, The drift chamber:-principle of working, drift gases and
spatial resolution, Di-Muon Spectrometer of ALICE and MuCh of CBM, Cerenkov counter and its applications.

**Calorimetry in High-Energy Physics:**
Idea of radiation length and critical energy, electromagnetic shower and hadronic shower detectors.

**Review of some Major High Energy Physics Experiments:**
Neutrino Flavour Oscillation experiments and Physics Scenarios at RHIC and LHC energies.

**Reference Books:**
- Pilkuhn, H.: The Interactions of Hadrons
- Martin, L.P.: High Energy Hadron Physics (John Willey)
- Collins, P.D.B. & Martin, A.D.: Hadron Interactions (Adam Hingler)
- Hagedorn, R.: Relativistics Kinematics (Benjamin)
- Ferbel, T.: Experimental Techniques in High Energy Physics (Addison Wesley)
- Leo, W.R.: Techniques for Nuclear and Particle Physics Experiments (Narosa)
- Kleinknecht, W.: Detectors for Particle Radiation (Cambridge)
Syllabus with Course Objectives and Course Outcomes

M.Sc. (Physics) III Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **NUCLEAR PHYSICS-A**
Course Number: **PHM-3022**
Credits: 04
Type of course: Core (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)

Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

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**Course Objectives**
To impart knowledge to make the students able to pursue research in experimental and theoretical nuclear physics.

**Course Outcomes**
Students are able to apply realistic NN potential to nuclei in the framework of many-body theories. The shell model and deformed shell model and their applications to nuclear systems and various processes are taught in detail. Besides, the semi classical treatment of heavy-ion reactions is also taught to them that includes scatterings, diffraction theories, exotic and super heavy nuclei, complete and incomplete fusion. These are important for reactor physics too.
Syllabus for M.Sc. (Physics) III Semester
NUCLEAR PHYSICS-A
Paper Code: PHM-3022

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I: The Two-Nucleon Problem
The nucleon-nucleon potential:
Conservation laws and invariance principles, general form of the nucleon-nucleon potential.,
the tensor potential, the V14 potential, nucleon-nucleon states.
The ground state of the deuteron:
Ground state of the deuteron and D-state admixture, Magnetic and electric quadrupole
moments.
Electromagnetic properties of nuclei:
Transition probabilities, electric and magnetic multipole moments.

Unit-II: The Shell Model
General considerations, evidence of shell effects, average potential of the nucleus, spin-orbit
coupling. Symmetry properties, isotopic spin.
The extreme single particle model, the single particle model, seniority, reduced isotopic spin.
Nordheim’s rule and ground state spins of odd-odd nuclei, configuration mixing. The
independent particle model, LS and JJ coupling schemes, experimental evidence of the single
particle states.

Unit-III: The Deformed Shell Model and The Collective Model
The Deformed shell model:
Experimental evidence (Rotational bands, Very large quadrupole moments, Fission isomers,
Single particle structure, Strongly enhanced quadrupole transition probabilities, hexadecupole
shapes, etc.), General deformed potential, Nuclear rotational motion, rotational energy
spectra and the nuclear wave functions for even-even and odd-A nuclei, nuclear moments.
The Collective model (Bulk properties):
Deformation parameters, Nuclear shapes with quadrupole, octupole and hexadecupole
deformations, Collective oscillations and the liquid drop model, Kinetic energy and potential
energy for quadrupole deformations. The Nilsson model, coupling between modes of
collective excitation: rotation-vibration interaction, Rotation-particle coupling, core
excitation.

Unit-IV: The Heavy-Ion Physics
Physical description of heavy ion interaction, elementary idea of classical and approximate
quantum mechanical theories, classical and semi-classical analysis of heavy ion reaction data,
nuclear rainbow scattering, exotic and super heavy nuclei, complete and incomplete fusion,
idea of sub-barrier fusion, high-spin states.

Reference Books:
  Structure, (JohnWiley)
- Roy, R.R. and Nigam, B.P. : Nuclear Physics, Theory and Experiment (John-Wiley
  and Sons, INC.)
- P Ring and P. Schuk (Springer) : The Nuclear many-body Problem.
- P. E. Hodgson (Oxford) : The Heavy Ion Reactions.
- Greiner (Springer) : The nuclear Models.
Course Title: **PHYSICS OF NANOMATERIALS**  
Course Number: **PHM-3023**  
Credits: 04  
Type of course: Elective (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%  

**Course Objectives**  
To comprehend the fundamental theory and influence of dimensionality on the properties of nanomaterials with their prospects in advanced devices. This course will also familiarize the student not only with existing techniques and underlying principles/concepts involved in the fabrication of nanomaterials but also to make them well versed in various characterization techniques.

**Course Outcomes**  
On completion of the course, students will be able to:  
1. familiarize about the principles and background to nanotechnology.  
2. optimize suitable process to synthesize nanostructures of desired size, shape and surface properties.  
3. Perceive the basic theories, properties, characterization techniques and applications of nanomaterials.  
4. familiarize with the structure, synthesis and properties of different fullerenes and identify their potential applications.  
5. Comprehend the meaning and significance of the phenomenon of single electron transistors and their novel applications in industry.
Syllabus for M.Sc. (Physics) III Semester
PHYSICS OF NANO MATERIALS
Paper Code: PHM-3023

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I: Introduction to Nanomaterials and properties
Brief history and overview of nanomaterials; Synthesis techniques: Top down and Bottom up approaches (High energy ball milling, Sol-gel process, Chemical bath deposition, Plasma Arc discharge, Chemical vapor deposition, Sputtering, Pulsed Laser deposition, Molecular beam epitaxy). Mechanical, Thermal, Electrical, Magnetic and Optical properties.

Unit-II: Characterization tools of Nanomaterials

Unit-III: Carbon based Nanomaterials
Nature of carbon bond, Carbon structures, Small carbon clusters; Fullerenes: Synthesis and Properties, various forms of fullerene materials; Graphene: Synthesis and Applications; Carbon nanotubes: classification, synthesis, properties (Electrical, Vibrational & Mechanical) and applications, Nanodimond.

Unit-IV: Quantum Nanostructures and Nanostructured Ferromagnetism
Quantum wells, wires and dots, Fabrication of Quantum Nanostructures, Size effect, Conduction electron and dimensionality, Fermi gas and density of states. Partial confinement, Single electron transistor (SET), Single electron capacitor, Quantum effects on SET, Fabrication of SET, Bulk Nanostructuring and Magnetic properties, Dynamics of Nanomagnets, Nanopore containment of magnetic particles.

Reference Books:
- Poole Jr., C.P. & Owens, F.J. Introduction to Nanotechnology (Wiley
- Fujita, F.E. Physics of New Materials, Second Edn. (Springer-Verlag
- Zhen Guo, Li Tan Fundamentals and Applications of nanomaterials
- Gaber L. H. Harry F. Tibbals, Joydeep Dutta and John J. Moore Introduction to Nanoscience and Nanotechnology (CRC Press)
- Michael F. Ashby, Paulo J. Ferreira & Daniel L. Schodek
Course Title: **STRING THEORY**
Course Number: **PHM-3024**
Credits: 04
Type of course: Core (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

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**Course Objectives**
To develop a thorough background of the classical and quantum theory of strings.

**Course Outcomes**
On completion of the course, students will be able to:

1. Describe the technical route we have to take to reach string theory starting with the standard model of particle physics.
2. Solve mathematical problems using higher mathematics needed in string theory.
3. Explain classical theory of strings.
4. Describe stringy concepts like compactification and dualities.
5. Describe very sophisticated theoretical technology called the AdS/CFT correspondence.
Syllabus for M.Sc. (Physics) III Semester  
STRING THEORY  
Paper Code: PHM-3024  

(Credits: 04)  
Theory: 48 Lectures, Tutorials: 08

Unit-I: Before String Theory  
Achievements and problems with the standard model (SM) of particle interactions. Grand unified theories, supersymmetry and supergravity. Spheres in various dimensions, Planck length in higher dimensions.

Unit-II: String Theory Primer  
Point particle, relativistic strings, closed strings, world sheet and background aspects, bosonic string theory, Gupta Bleuler, light cone and BRST quantizations, superstrings of type I, IIA, IIB and heterotic strings.

Unit-III: Physical Aspects of String Theory  
Compactification and supersymmetry breaking. Calabi-Yau manifolds and their mathematical properties, examples of Calabi-Yau manifolds, T-Duality in presence of background fields, Low energy effective actions, S-duality, M-Theory.

Unit-IV: AdS/CFT  
Branes, D-brances & hints for gauge gravity duality in branes and scalar absorption. Maldacena conjecture. $\text{AdS}_5$ and $\text{AdS}_3$ case. Applications.

Reference Books:  
- Kiritsis, E. : String Theory in a Nut-shell (Princeton)  
- Becker, K., Becker, M., Schwarz, J.H. : String Theory and M-Theory (Cambridge)  
- Zwiebach, B. : A First Course in String Theory (Cambridge)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) III Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: PROGRAMMING AND COMPUTATIONAL PHYSICS-A
Course Number: PHM-3031
Credits: 02
Type of course: Ability Enhancement Elective (Theory)
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
Objective of the course is to develop basic understanding and skills to C++ language and its application in solving problems.

Course Outcomes
On completion of the course, students will be able to:
1. Write and execute C++ codes that solve problems especially physics problems numerically.
2. Use both in-build and customise functions, read and write to and from a file.
3. Use advanced arrays and pointers e.g. dynamical memory allocation techniques to optimise the basic C++ codes.
4. Convert a code written in some other language e.g. in Fortran to a C++ code
Syllabus for M.Sc. (Physics) III Semester
PROGRAMMING AND COMPUTATIONAL PHYSICS-A
Paper Code: PHM-3031

(Credits:02)
Theory: 24 Lectures, Tutorials: 04

Unit I
Basic concepts of Object Oriented Programming (OOP); benefits and application of OOP; Introduction to C++ language and its application; C/C++ statements, Structure of C++ program, creating source file, compiling and linking. Identifiers and Keywords. Constants: String, Numeric, Character constants; Variables: integer, float and character variables, local and global variables
Operators: Arithmetic, logical operators
Type conversion; declaration of constants and variables
Exercises

Unit II
Input / output: scanf(), printf(), cin, cout statements, Unformatted/ Formatted I/O operations Control and iterative statements: simple if, if-else, nested if, switch-case statements, while and do-while loop, for loop, Break, continue statements, goto statement and the conditional expression (? : operator); Simple programs based on these statements

Unit III
Header files: standard and user defined
Functions: Introduction, types of functions, in-built functions, defining functions, arguments, function prototype, parameters, calling functions, return statement, recursion. Void function and function returning results
File handling: file concepts, file creation, I/O operations on files and file functions, stream state member function. Opening, closing and rewinding a file, reading data from a file, writing output to a file.

Unit IV
Arrays: notations, declaration and initialization, multidimensional arrays
Structure: declaration and initialization. Functions and structures.
Unions: The union tag, processing with unions, Initialization of unions.
Exercises

References Books:
- Object-oriented Programming with C++, E. Balagurusamy
- Programming with C++, John Hubbard and Atul Kahate
- Practical C++ Programming, Stew Oualline
- Thinking in C Including Object Oriented Programming with C++, P.B. Mahapatra
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) III Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **INSTRUMENTATION AND ANALYTICAL METHODS-A**
Course Number: **PHM-3032**
Credits: 02
Type of course: Ability Enhancement Elective (Theory)
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

**Course Objectives**
To develop theoretical and experimental knowledge in advance experimental and analytical methods of electronics and spectroscopy.

**Course Outcomes**
On completion of the course, students will be able to:
1. Use electronic circuits for the study of different type transducers/detectors.
2. Make the electric circuits which will be suitable to give input and output of transducers.
3. Apply phase sensitive detection system for accurate measurement of signal.
5. Apply FTIR and Raman microscopy to study of condensed and biological materials in research labs. And industries.
6. Apply atomic absorption and x-ray fluorescence spectroscopy for elemental analysis of sample in research labs. And industries.
Syllabus for M.Sc. (Physics) III Semester

INSTRUMENTATION AND ANALYTICAL METHODS-A

Paper Code: PHM-3032

(Credits:02)

Theory: 24 Lectures, Tutorials: 04

UNIT-I: Transducers
Transducers: Temperature, magnetic field and vibration, linear position transducer: Piezoelectric. Optical detectors.

UNIT-II: Signal Measurement
Signal conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding; lock-in detector, box-car integrator, modulation techniques.

UNIT-III: Spectroscopy Techniques-I
Fourier transforms infrared spectroscopy (FTIR), FTIR Microscopy and ATR-FTIR. Raman spectroscopy: Dispersive, FT- Raman and micro Raman spectroscopy. Raman Imaging.

UNIT-IV: Spectroscopy Techniques-II

Reference Books:

- Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.
- Lakowicz, J.R. : Principles of Fluorescence Spectroscopy
- Demtroder, W : Laser Spectroscopy (Springer Verlag)
- D. Patranabis: Principles of Electronic Instrumentation, PHI Learning Pvt. Ltd.
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) III Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: ATMOSPHERIC PHYSICS
Course Number: PHM-3033
Credits: 02
Type of course: Ability Enhancement Elective (Theory)
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
To develop understanding of elements of atmosphere and concepts of physical and dynamical meteorology.

Course Outcomes
On completion of the course, students will be able to:
1. Explain the basic elements of atmosphere.
2. Describe the physical and dynamical meteorological concepts and apply them to study various aspects of atmospheric physics.
3. Learn numerical methods in atmospheric physics such as finite difference method, the finite difference equation for sound, gravity and Rossby waves, filtering of gravity and Rossby waves, the equivalent-Barotropic model, essentials of numerical weather analysis and forecasting.
4. Describe the working principle of conventional and modern observational techniques such as LIDARS, SODARS, RADARS to measure pressure, temperature, humidity, wind, precipitation, visibility etc.
ATMOSPHERIC PHYSICS
Paper Code: PHM-3033

(Credits:02)
Theory: 24 Lectures, Tutorials: 04

Unit – I: Elements of Atmosphere and Physical Meteorology

Unit – II: Dynamical Meteorology
The fundamental forces, hydrostatic equation, Lapse rate, Enthalpy equation, Entropy of dry air and entropy change, The circulation theorem, vorticity, potential vorticity and potential vorticity equations.

Unit – III: Numerical Methods in Atmospheric Physics
The finite difference method, the finite difference equation for sound, gravity and Rossby waves, filtering of gravity and Rossby waves, The equivalent-Barotropic model, essentials of numerical weather analysis and forecasting.

Unit – IV: Observational Techniques in Atmospheric Physics
Conventional observational techniques, conventional measurement of pressure, temperature, humidity, wind, precipitation, visibility.
Modern Observational Techniques: LIDARS, SODARS, RADARS.

Reference Books:
- Iribarne, J.V. and Godson, W.L. : Atmospheric Thermodynamics (D. Reidel)
- Thomson, P.D. : Numerical Weather Analysis and Prediction (Macmillan)
Course Title: **QUANTUM FIELD THEORY**  
Course Number: **PHM-3034**  
Credits: 04  
Type of course: Core (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

**Course Objectives**  
Quantum Field Theory (QFT) is a theoretical framework that combines classical field theory, special relativity, and quantum mechanics. Objective of the course is to develop basic understanding and skills of the subject of quantum mechanics and quantum field theory in path integral formalism.

**Course Outcomes**  
On completion of the course, students will be able to:  
1. Demonstrate the path integral formalism of quantum mechanics and able to solve harmonic oscillator problem in path integral formalism.  
2. Develop the path integral formalism of scaler field theory and calculate n-point functions.  
3. Solve problems involving Grassmann algebra and develop the path integral quantisation of Dirac field theory.  
4. Fix the gauge in electromagnetic theory by Faddeev-Popov procedure.
Syllabus for M.Sc. (Physics) III Semester
QUANTUM FIELD THEORY
Paper Code: PHM-3034

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit I: Path integral in quantum mechanics

Unit II: Path integral quantization
Path integral for scalar fields, generating functional, 2-point function, n-point functions and Wicks contraction, interacting theory, Feynman diagrams in configuration space, connected diagrams, Feynman diagram in momentum space, Greens functions, 1-loop diagrams, path integral for Dirac field.

Unit III: Path integral quantization of electromagnetic field
Path integral for electromagnetic field, gauge fixing, Faddeev-Popov procedure, symmetries and Ward identities, LSZ reduction for the gauge field and scattering amplitudes.

Unit IV: Renormalization in QED
Renormalization of photon propagator, electron propagator and QED vertex function, QED beta function at one loop, renormalization group evolution and running coupling.

Reference Books:
- F. Mandl and G. Shaw, Quantum Field Theory, 2nd edition, Wiley publication.
- L. H. Ryder, Quantum Field Theory, 2nd edition, Cambridge University Press.
- Mark Srednicki, Quantum Field Theory, 1st edition, Cambridge University Press.
Course Title: **OPTICAL ELECTRONICS AND APPLICATIONS**  
Course Number: **PHM-**  
Credits: 02  
Type of course: Ability Enhancement Elective (Theory)  
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

**Course Objectives**

1. To introduce the basic effects such as the electro optic, acousto optic and magneto optic used in modulation and switching of optical signals and to apply them in device design and materials properties.
2. To provide a platform both for the selection of suitable devices for various applications in light detection and optoelectronics and an idea for the development of next generation devices.

**Course Outcomes**

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

1. Explain the concept of electro optic, acousto optic and magneto optic effects and their applications in device design and properties.
2. Describe the basic principle of detection of optical radiations.
3. Explain the concepts of light absorbing, display and other devices.
4. Get an idea for the development of next generation devices and life-skills in hands-on mode so as to increase their employability.
Syllabus for M.Sc. (Physics) III Semester
OPTICAL ELECTRONICS AND APPLICATIONS
Paper Code: PHM-

(Credits:02)
Theory: 24 Lectures, Tutorials: 04

Unit I: Introduction
Light sources, Colour temperature, Radio metric and photometric units, PN junction, Carrier recombination and diffusion, Injection efficiency, Heterojunction, Internal quantum efficiency, External quantum efficiency, Light propagation through anisotropic media, Electro optic (EO), Acousto optic (AO) and magneto optic (MO) effects.

Unit II: Light detection
Basic principle of detection of optical radiations, Thermal detectors, Photo detectors, Photo multipliers, Photoconductive detectors, Photodiodes, Avalanche photodiodes, PIN diode, Charge coupled devices, Image intensifiers, Arrays, Noise considerations.

Unit III: Optoelectronic modulators and light emitting devices
Basic principle of modulators, Birefringence, EO, MO, and AO modulators, EO switches, Spatial light modulators, Transmitters, Optical transmitter circuits, LED and laser drive circuits, LED-Power and efficiency, LED structures, LED characteristics.

Unit IV: Light absorbing, display and other devices
Camera chips and solar cells, Display devices, EL display, LED display, Plasma panel display, Liquid crystals: Properties, LCD displays, Acousto optic tunable filter, Acousto optic deflector, Scanner and spectrum analyser, Nanophotonic devices.

Reference Books:
- Wilson, J. and Jis Hawkers, J. F. B. : Opto electronics - An introduction (PHI, 1996)
- Bhattacharya, P. :Semiconductor optoelectronic devices (Prentice Hall of India, 1995)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) IV Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **MOLECULAR PHYSICS**
Course Number: **PHM-4012**
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

**Course Objectives**
To develop theoretical and experimental knowledge in Advance Molecular Physics and Spectroscopy.

**Course Outcomes**
On completion of the course, students will be able to:

1. Apply the molecular symmetry Group Theory to find the point group normal modes and their activity in infrared and Raman spectroscopy of molecules.
2. Understand and analyse the electronic rotational, vibrational spectra of molecules.
3. Understand the quantum mechanics of simple molecules.
4. Apply the experimental techniques in molecular spectroscopy like FTIR, Raman matrix isolation and microwave spectroscopy.
5. Apply the knowledge of spectroscopy for characterization of material in research laboratories and industry.
Syllabus for M.Sc. (Physics) IV Semester
MOLECULAR PHYSICS
Paper Code: PHM-4012

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I: Molecular Symmetry and Vibrations Spectra

Unit-II: Rotational and Vibration-rotation Spectra of Polyatomic Molecules

Unit-III: Molecular Orbital Theory and Electronic Spectra

Unit-IV: Experimental Techniques in Spectroscopy
Microwave spectroscopy, Fourier transform spectroscopy, Matrix isolation spectroscopy. Linear Raman spectroscopy, Non-linear Raman spectroscopy: Stimulated Raman spectroscopy, coherent anti-stokes Raman scattering, resonance Raman spectroscopy, hyper Raman effect. Surface-Enhanced Raman Scattering.

Reference Books:
- Townes, C.: Microwave Spectroscopy (Dover)
- Lakowicz, J.R.: Principles of Fluorescence Spectroscopy
- Demtroder, W.: Laser Spectroscopy (Springer Verlag)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) IV Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: CONDENSED MATTER PHYSICS-B
Course Number: PHM-4013
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
This Condensed Matter Physics-B covers the remaining topics of the Condensed Matter Physics-A paper taught in M.Sc I Semester to give a complete understating of Solid State Physics at the Post Graduate level. The objective of the course is to develop understanding of the crystalline structure, physical properties and underlying principles of the solid state.

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

2. Differentiate between defects, Diffusion, Excitons (Frenkel, Mott-Wannier), Polarons, alkali halide and molecular crystals Colour centres, and describe their production and properties.
4. Describe the phenomenon of superconductivity, key properties, BCS theory, Ginzburg-Landau theory, London equation., flux quantization, coherence length, Giaever tunnelling, Josephson tunnelling, super current quantum interference and salient features of High Tc Superconductors.
UNIT-I

UNIT-II

UNIT-III

UNIT-IV
High temperature superconductors, salient features. Qualitative discussion on applications of superconductors.

Reference Books:
- C. Kittel : Introduction to Solid State Physics 8th Ed. (John-Wiley)
- Srivastava, J.P. : Elements of Solid State Physics (Prentice-Hall)
- Ashcroft, N.W. and Mermin, N.D. : Solid State Physics, (Saunders College)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) IV Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **HIGH ENERGY PHYSICS B**
Course Number: **PHM-4015**
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)

Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

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**Course Objectives**
To impart the knowledge of fundamental particles and interactions, exact and approximate conservation laws, symmetry principles, form factors, Feynman techniques to calculate decay rates and cross sections.

**Course Outcomes**
1. Describe weak interactions phenomenology and its limitations.
2. Use the quark model for understanding the properties of hadrons
3. Calculate decay rates (for pions, neutron) and cross sections for scattering between point particles as well as scattering of point particle with a hadron.
Unit-I: Discrete Symmetries and Weak Interactions
Elementary particles and their interactions, Quark and leptons. Discrete symmetries, C, P, T
symmetries and CPT theorem (without proof) and its consequences. Parity of leptons and
anti-leptons, Parity of quarks and hadrons, Parity of charged and neutral pions, Parity of
Photon, C-Parity of neutral pion and eta. Parity violation in $\pi$-decay, Measurement of
Parity of Helicity of Neutrino, Bilinear covariants, V-A theory of weak interactions and current
Lagrangian. Properties of weak currents, Neutrino-electron scattering, CVC and PCAC. $\pi \rightarrow \mu \nu$ decay.

Unit-II: Nucleon Structure and Quark Model
Nucleon as a composite particle. Nucleon resonances and baryon spectroscopy. Isospin:
SU(2), SU(3) symmetry and classification of particles and resonances. Quark model of
hadrons, spin and flavour SU(6) wave functions of mesons and baryons. Mass formula for
baryons and mesons. Calculation of magnetic moments.

Unit-III: High Energy Lepton-Nucleon Scattering
e$^-\mu^-$ scattering.
Elastic-electron-nucleon scattering: Matrix element, Rosenbluth cross section formula,
nucleon form factors and their q-dependence. Electric and Magnetic Sachs form factors,
Comparison with experimental results.
Deep inelastic electron-nucleon scattering: Kinematics and cross section formula.
Experimental results. Bjorken scaling. Nucleon structure functions and partons. Electron-
quark scattering.

Unit-IV: Physics of heavy flavor particles
Phenomenology of strange particles and their semileptonic and nonleptonic decays. Cabibbo
theory. Neutral kaon decays and CP violation. Flavor oscillation, Discovery of quarks,
Charm, bottom and top quarks. Quarkonium and their spectra. Predicted c-char and b-bbar
states with principal quantum numbers n= 1 & 2 with their properties. The quark-antiquark
potential, Lepton-Quark symmetry, Quark mixing, CKM matrix (idea).

Reference Books:
- Halzen, F and Martin, A.D. : Quarks and Leptons (John-Wiley)
- Martin, B R and Shaw, G. : Particle Physics (John-Wiley)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) IV Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **NUCLEAR PHYSICS B**  
Course Number: **PHM-4016**  
Credits: 04  
Type of course: Elective (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

**Course Objectives**  
To impart knowledge to make the students able to pursue research in experimental and theoretical nuclear physics.

**Course Outcomes**  
Scattering theories are studied in detail along with compound nucleus theory and optical model. Glauber multiple scattering theory is developed from scratch. Students are trained to apply it to intermediate energy nuclear scatterings. Fermi Theory and V-A theory of Beta decay is also included in a unit.
Unit-I: Nuclear Reactions
Types of nuclear reactions.

The Collision matrix:

The Optical model:
The nuclear optical potential, Optical model at low energies, formal derivation of the optical model potential.

Unit-II: The Direct Reactions
Compound nucleus theory and its limitations, Ghoshal’s experiments, Kinematics and theory of stripping and pick-up reactions, Statistical theory of reactions.

The high energy approximation and the Glauber theory:
The Eikonal approximation, the high energy potential scattering, Glauber model for nucleon-nucleus and nucleus-nucleus scattering.

Unit-III: Many-Body Theories

Non relativistic theories:
Nuclear matter, the Goldstone expansion, reaction matrix, Bruckner-Bethe-Goldstone integral equation, coordinate space correlation wave function, properties of reaction matrix.

Relativistic Mean Field Theory (RMF):
Mean Field Theory, Lagrangian density, Dirac equation and Field expansion, Hamiltonian density, nuclear matter, Neutron Matter (Equation of state).

Unit-IV: Electromagnetic and Weak Interactions in Nuclei

The Electromagnetic Interaction:
Electromagnetic current and its interaction with nucleons and nuclei. Electron scattering from nucleons and nuclei. Four-momentum transfer and the Mott scattering, the nucleon and nuclear form factors and their experimental determination, Electric and Magnetic Sachs form factors.

The Weak Interaction:
The β-decay and weak currents, Fermi theory., The V-A theory of weak interactions, inelastic nutrinoproton scattering. The weak form factors, Deep inelastic scattering, Scale invariance and Partons.

Reference Books:
- Wong, S.M. : Introductory Nuclear Physics, (Prentice Hall)
- Preston, M.A. : Physics of the Nucleus, (John Wiley)
- Preston, M.A. & Bhaduri, R.K. : Structure of the Nucleus, (Addison Wesley)
• Ed. Y. K. Ghambir : Mean Field Theory of Nuclei.
• J. D. Walecka (Oxford Press) : Theoretical nuclear and subnuclear Physics.
Syllabus with Course Objectives and Course Outcomes  
M.Sc. (Physics) IV Semester  
Department of Physics  
Aligarh Muslim University, Aligarh

Course Title: PHYSICS OF LASER AND LASER APPLICATIONS  
Course Number: PHM-4017  
Credits: 04  
Type of course: Elective (Theory)  
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)  
Course Assessment:  
Internal assessment (1 Hour): 30%  
End Semester Examination (2.5 Hours): 70%

Course Objectives  
To develop the basic understanding and theoretical concept of laser and its application in Spectroscopy

Course Outcomes  
On completion of the course, students will be able to:  
1. Explain the characteristics of laser beams and uses of various types of resonators for the laser cavity  
2. Explain the working principle of different kinds of laser used in spectroscopy as well as in various field of science and communication  
3. Use the nonlinear laser spectroscopy to produce sum and difference of frequency which is helpful in advance study of interaction of laser with atoms and molecules.  
4. Apply these lasers to atmospheric measurements with LIDAR as well as spectroscopic analysis of chemical components in a unknown sample.  
5. Describe the case of lasers in optical communication and holography which is the most recent branch of science.
Unit-I: Laser Characteristics

Unit-II: Laser Systems

Unit-III: Nonlinear Optical Mixing Technique

Unit-IV: Applications of Lasers

Reference Books:
- Demtroder, W.: Laser Spectroscopy (SpringerVerlag)
- Laud, B.B.: Lasers and Nonlinear Optics (Willey Eastern)
- LASERS: Theory & Application: Thyagarayan, K. and Ghatak, A.K.
Course Title: QUANTUM ELECTRODYNAMICS
Course Number: PHM-4022
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)

Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
Quantum Electrodynamics (QED) is the quantum field theory of electrodynamics. In essence, it describes how light and matter interact and is the first theory where full agreement between quantum mechanics and special relativity is achieved. QED represents the quantum counterpart of classical electromagnetism giving a complete account of matter and light interaction. Objective of the course is to develop basic understanding and skills of the subject of quantum electrodynamics.

Course Outcomes
On completion of the course, students will be able to:
1. Demonstrate the problem of quantising the classical electrodynamics and able to fix the gauge to calculate observables in the framework of QED.
2. Calculate tree level cross-sections of electron-electron scattering, Bhabha scattering and photon bremsstrahlung.
3. Apply dimensional regularisation techniques to calculate electron self energy, vacuum polarisation and electron-photon vertex function at one loop.
4. Calculate QED beta function and demonstrate how electron charge changes with change in scale.
Syllabus for M.Sc. (Physics) I Semester
QUANTUM ELECTRODYNAMICS
Paper Code: PHM-4022

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit I : Quantization of electromagnetic field
Brief review of classical theory and canonical quantization of the electromagnetic field, gauge invariance, problem with quantization, gauge fixing, QED propagator, quantization in Coulomb gauge and Lorentz gauge, symmetry properties, unitarity and expansion of S-matrix.

Unit II : QED at tree level
Feynman rules for QED, Lagrangian for a basic vertex, lowest order processes of QED, electron-electron scattering, Bhabha scattering, photon bremsstrahlung. (Tutorial problems based on trace algebra, spin and polarization sums, invariant matrix elements and cross-section formula for all three processes).

Unit III : QED at one loop
Ultraviolet and infrared divergences, dimensional regularization technique, electron self energy - mass renormalization, vacuum polarization - field renormalization, vertex function - charge renormalization.

Unit IV : Applications of QED
Anomalous magnetic moment of the electron, correction to Lande g-factor, modification to Coulomb interaction, Lamb shift, running of QED coupling, Landau pole.

References Books:
- F. Mandl and G. Shaw, Quantum Field Theory, 2nd edition, Wiley publication.
- L. H. Ryder, Quantum Field Theory, 2nd edition, Cambridge University Press.
Course Title: **PROGRAMMING AND COMPUTATIONAL PHYSICS – B**
Course Number: **PHM-4031**
Credits: 02
Type of course: Ability Enhancement Elective (Theory)
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

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**Course Objectives**
Aim of this course is to prepare students with advanced computational skills to develop C++ codes through object oriented approach, learn interfacing computer programs written in different languages, and get equipped with numerical tools to solve realistic physics problems.

**Course Outcomes**
On completion of the course, students will be able to:
1. apply object-oriented C++ techniques to write simple codes for solving a scientific problem.
2. learn advanced level numerical analysis techniques of the calculus, linear algebra and statistics.
3. write interfaces to work with various computational languages
4. understand and work with statistical techniques such as random number generation and its applications such as Monte-Carlo simulation.
5. work with already existing codes written by others in C++ and perform numerical computation for a realistic physics problem.
Syllabus for M.Sc. (Physics) IV Semester
PROGRAMMING AND COMPUTATIONAL PHYSICS-B
Paper Code: PHM-4031

(Credits:02)
Theory: 24 Lectures, Tutorials: 04

Unit I
Review C++ and Object Oriented Programming,
**Classes and Objects:** classes, class definition, Declaration of class, member functions, defining the object of a class, accessing a member of class, base classes and derived classes
**Constructors and destructors:** copy constructor, default constructor
Debugging a C++ program

Exercises

Unit II
**Problem Solving:** Evaluation of mean, variance, standard deviation; straight line fitting.
Monte Carlo Method: natural and pseudo random numbers, generation of random numbers: Mid square and multiplicative congruential methods. Quality test of random numbers: uniform distribution and autocorrelation tests, Gaussian and exponential distribution.

Unit III
Determination of pi, Simulation of random physics phenomena, Brownian Motion, Radioactive decay law
Evaluation of functions using power series: sin, cos, log, exponential functions etc.
Numerical Integration: Trapezoidal and Simpson rules

Unit IV
Matrix operation, solving linear equations system, root finding: quadratic equation etc.
Odd calculations in sports, constructing prime number generator, dice construction.
Interfacing a C++ program with program in other computational languages e.g. FORTRAN, Python.

References Books:
- Programming with C++, John Hubbard and Atul Kahate
- Practical C++ Programming, Stew Oualline
- A First Course in Computational Physics, Paul Devries, Javier E. Hasbun
- Computer Simulation in Physics, R.C. Verma
Course Title: **DIGITAL SIGNAL PROCESS**
Course Number: **PHM-4033**
Credits: 02
Type of course: Ability Enhancement Elective (Theory)
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

### Course Objectives
To develop mathematical and theoretical knowledge in advance digital filter and to know how to transformation time domain signal to frequency domain signal in detail.

### Course Outcomes
On completion of the course, students will be able to:
1. Explain the different type of digital signals and know the transformation from time domain to frequency domain.
2. Describe the design of different types of digital filter in detail.
3. Explain the design of IIR and FIR filters using windows and bilinear transformations in the analog and digital domain.
4. Explain the multi rate signal using sampling, down sampling and up sampling applications.
5. Understand about wavelets and have skill to apply uncertainty of time and frequency.
Syllabus for M.Sc. (Physics) IV Semester
DIGITAL SIGNAL PROCESSING
Paper Code: PHM-4033

(Credits:02)
Theory: 24 Lectures, Tutorials: 04

Unit-I: Discrete-Time Signals, Systems and The Z-Transform
Discrete-time signals: elementary, classifications, simple manipulations; discrete-time systems: input-output description, block diagram representations, classifications, interconnections; analysis of discrete-time linear time-invariant systems: techniques, resolution into impulses, the convolution sum, properties of convolution and the interconnection of LTI systems, causality and stability of LTI systems. Cross correlation and auto correlation sequences, correlation of periodic sequences; The Z-transform: evaluation and properties, inverse Z-transform.

Unit-II: Frequency-Domain Analysis of LTI Systems and The Discrete Fourier Transform (Properties and Applications)
Design of low pass and high pass filters, digital resonators, digital sinusoidal oscillators, notch filters, all pass filters, the discrete Fourier transform (DFT), inverse DFT, relation of DFT to other transforms. Use of the DFT in linear filtering. Frequency analysis of signals using the DFT.

Unit-III: Design of Digital Filters

Unit-IV: Power Spectrum Estimation, Linear Prediction, Wavelet Analysis and Multi-rate Digital Signal Processing
Rational power spectra, linear prediction (forward and backward); Estimation of spectra from finite duration observation of signals, computation of the energy density spectrum; Introduction to multi-rate signal processing: introduction, sampling, downsampling, upsampling applications; Wavelet analysis: introduction, use and applications.

Reference Books:
Course Title: **INSTRUMENTATION AND ANALYTICAL METHODS-B**
Course Number: **PHM-4035**
Credits: 02
Type of course: Ability Enhancement Elective (Theory)
Contact Hours: 2 Lectures per week (Total: 24 Lectures and 04 Tutorials)

**Course Assessment:**
- Internal assessment (1 Hour): 30%
- End Semester Examination (2.5 Hours): 70%

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**Course Objectives**
To equip the students with the basic knowledge of advanced materials characterization techniques and to understand fundamentals of qualitative and quantitative analysis concept.

**Course Outcomes**
On completion of the course, students will be able to:
1. Determine the crystal structure and other structural parameters by analysis of XRD/SAXS data.
2. Explain the basics of low temperature production and measurements.
3. Discuss the theory and measurements of electrical resistivity and dielectric properties.
4. Describe the principle, construction and working of sophisticated instruments used in research and industry.
5. Explain the principle, instrumentation and applications of various characterization techniques for surface and elemental analyses.
Syllabus for M.Sc. (Physics) IV Semester
INSTRUMENTATION AND ANALYTICAL METHODS-B
Paper Code: PHM-4035

(Credits:02)
Theory: 24 Lectures, Tutorials: 04

Unit-I
X-ray diffraction (XRD): Powder diffraction, Phase identification, Grain size and strain determination, Small angle x-ray scattering and its applications, Low temperature generation and measurement.

Unit-II
Two and four probe resistivity measurement methods; Dielectric properties and measuring technique; X-ray photo electron spectroscopy (XPS) and Auger Electron Spectroscopy (AES): Instrumentation and applications.

Unit-III
Scanning Tunneling Microscope (STM), Atomic Force Microscopy (AFM): Different operational mode and typical applications.

Unit-IV
Thermal analysis techniques: DTA, DSC, TGA and STA; Magnetic measurement systems: Vibrating Sample Magnetometer (VSM), Superconducting Quantum Interference Device (SQUID), Electron Spin Resonance (ESR).

References Books:
- S. Zhang Liu Li & Ashok Kumar Materials Characterization Techniques (CRC Press 2009)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) IV Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: STANDARD MODEL OF PARTICLE INTERACTIONS
Course Number: PHM-4036
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
To develop a thorough background of the classical and quantum quantum field theory for the standard model of particle interactions.

Course Outcomes
1. Students would be able to apply Noether's theorem to very non-trivial settings of field theory.
2. Students will be able to describe quantum electrodynamics as a gauge theory.
3. Students will be able to explain non-Abelian gauge theories.
4. Students will be able to describe spontaneous breaking of symmetry in very non-trivial case of quantum field theory.
5. Students will be able to describe the Salam-Weinberg's unified model of electro-weak interactions.
6. Students would be able to describe the very complex idea called the renormalization in quantum field theory.
Syllabus for M.Sc. (Physics) IV Semester
STANDARD MODEL OF PARTICLE INTERACTIONS
Paper Code: PHM-4036

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit I: Symmetries and Quantum Electrodynamics
Lagrangian dynamics, symmetries and conservation laws. QED: Global and local gauge invariances in quantum mechanics and field theory, minimal e.m. substitution, gauge field, covariant derivative, QED as a gauge theory, Applications of QED.

Unit II: Yang-Mills Theories

Unit III: Salam-Weinberg Model
Hidden symmetry, spontaneously broken discrete and continuous symmetries, Goldstone theorem, Goldstone model, Higgs Mechanism, Glashow-Salam-Weinberg model for leptons, various pieces of the Lagrangian, mass generation of gauge bosons and fermions, extension to hadrons and GIM mechanism.

Unit IV: Renormalization and Anomalies
Renormalization of QED, Faddeev-Popov ghosts, regularization schemes, renormalization of spontaneously broken gauge theories, Wilson’s approach, anomalies, grand unified theories and beyond.

Reference Books:
- Sterman, G. : Quantum Field Theory (Cambridge)
- Quigg, C. : Gauge Theoreis of the Strong, Weak and Electromagnetic Interactions (Benjamin-Cummings)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) IV Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: **SOFT MATTER PHYSICS**
Course Number: **PHM-4037**
Credits: 04
Type of course: Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)

Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

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**COURSE OBJECTIVES**

1. To understand fundamental physics behind different soft materials, such as liquid crystals, macromolecules, colloids, DNA, biological membrane etc., commonly seen in everyday life and industry and find a link between microscopic structure and bulk properties in a variety of soft condensed matter systems.

2. To find use of soft condensed materials in a variety of applications and modern technologies.

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**COURSE OUTCOMES**

On completion of the course, students will be able to;

1. Understand the physical aspects of different soft materials such as liquid crystals, macromolecules, colloids, DNA, biological membrane etc. and predict material properties on the basis of microscopic structure and application of physical principles.

2. Learn the importance of different soft materials in a variety of applications and explain how different technological devices function.

3. Get an idea for the development of next generation devices and life-skills in hands-on mode so as to increase their employability.

4. Read and understand research papers and produce their own term project on a relevant topic.
Syllabus for M.Sc. (Physics) IV Semester

SOFT MATTER PHYSICS

Paper Code: PHM-4037

(Credits: 04)

Theory: 48 Lectures, Tutorials: 08

Unit I: Introduction to Soft Matter Systems
What is soft matter? Classification in terms of their thermal, mechanical and unusual physical properties, Liquid crystals, Colloidal systems, Biological membranes, Macromolecules, Numerical methods for studying soft matter: Lattice model and Gaussian overlap model.

Unit II: Liquid Crystals
Structure and classification of mesophases, Statistical theories of the nematic order, Symmetry and order parameter, Phase identification with differential scanning calorimetry, Kinds of liquid crystalline order: Structural and chemical standpoint, Generalization of Landau’s theory to liquid crystals, Polymer liquid crystals, Dielectric and electro-optical properties, Ferroelectric liquid crystals (introduction only), Liquid crystal display (LCD).

Unit III: Colloidal Systems and Biological Membranes

Unit IV: Macromolecules
Polymer: Terminology and nomenclature, Molar masses and distributions, Chain-dimensions and structures, Random walk polymer, Self-avoiding random walk polymers, Polymer solutions.
DNAs: Flory’s model of DNA condensation, Polymorphism of liquid crystal states by low molecular mass double stranded DNA complexes, DNA condensation in water-polymeric solution, Biological activity. Gel electrophoresis, Gene therapy.

Reference Books:
- de Gennes, P.G. : Physics of Liquid Crystal (Clarendon Press (Oxford University Press))
- Singh, S. : Liquid Crystals Fundamentals (World Scientific)
- Collings, P. J. and Hard, M. : Introduction to Liquid Crystals (Taylor and Francis)
- Hamley, I. W. : Introduction to Soft Matter (John Wiley and Sons Ltd.)
- Gelbart, Roux and Ben-Shaul : Micelles, Membranes, Micremulsions and Monolayers (Springer)
Syllabus with Course Objectives and Course Outcomes
M.Sc. (Physics) IV Semester
Department of Physics
Aligarh Muslim University, Aligarh

Course Title: ELEMENTS OF MODERN PHYSICS
Course Number: PHM-4091
Credits: 04
Type of course: Open Elective (Theory)
Contact Hours: 4 Lectures per week (Total: 48 Lectures and 08 Tutorials)
Course Assessment:
Internal assessment (1 Hour): 30%
End Semester Examination (2.5 Hours): 70%

Course Objectives
This course is introduced for those students who are doing post graduation in any other subject except physics to familiarize them with useful concepts of modern physics. The course topics include properties of waves and particles, quantum mechanics, atoms and molecules and basic ideas of solid state physics.

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

1. Explain the particle properties of wave like Photoelectric effect, Compton effect, pair production and wave properties of particle like De Broglie wavelength, wave function, probability density, De Broglie phase velocity.
2. Describe the basic concepts of quantum mechanics including Wavefunction, Probability Schrödinger’s equation, Operators, Eigenvalues and eigenfunctions, Finite potential well, Harmonic oscillator, Electron spin, Exclusion principle.
4. Describe the mechanism involved in different types of bonding in solids, theory of x-ray diffraction and functioning of various electronic devices like Junction diode, Photodiodes, Tunnel diode, Zener diode, Junction transistor, Field-effect transistor.
Syllabus for M.Sc. (Physics) IV Semester
ELEMENTS OF MODERN PHYSICS
Paper Code: PHM-4091

(Credits: 04)
Theory: 48 Lectures, Tutorials: 08

Unit-I: Properties of Particle and Waves

Particle Properties of Waves: Blackbody radiation, Ultraviolet Catastrophe, Planck Radiation Formula, Photoelectric effect, Compton effect, pair production, pair annihilation, Photon Absorption, linear attenuation coefficient, photons and gravity: Photon “mass, Photon energy after falling through height H. Gravitational red shift. black hole Schwarzschild Radius, Black Holes.

Wave Properties of Particles: De Broglie waves: De Broglie wavelength, wave function, probability density, De Broglie phase velocity, phase velocity and group velocity, particle diffraction, Davisson-Germer experiment, particle in a box, uncertainty principle.

Unit-II: Quantum Mechanics


Unit-III: Atoms and Molecules


Unit- IV: Solids


Reference Books:

- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.