FACULTY OF SCIENCES

SYLLABUS FOR THE BATCH FROM THE YEAR 2022 TO YEAR 2024

Programme Code: MPHH

Programme Name: M.Sc. Physics (Under the Honours Scheme)

(Semester I-IV)

Examinations: 2022-24

Department of Physics

Khalsa College, Amritsar

(An Autonomous College)

(b) Subject to change in the syllabi at any time.

(c) Please visit the college website time to time.

S.No.	PROGRAMME OBJECTIVES
1.	To prepare students to take up challenges as globally competitive physicists/ researchers in diverse areas of theoretical and experimental physics.
2.	To impart quality education in physics to students through well designed courses of fundamental interest and of technological importance.
3.	To develop abilities and skills that encourages research and development activities and is useful in everyday life.
4.	To make the students technically and analytically skilled.
5.	To provide opportunity of pursuing high end research as project work.
6.	To prepare them to take up higher studies of interdisciplinary nature.

S.No.	PROGRAMME SPECIFIC OUTCOMES (PSOs)
PSO-1	To train students in such a way that they can objectively carry out investigations, scientific and/or otherwise, without being biased or without having any preconceived notions.
PSO-2	As technology exploits the rules of Physics, students properly trained in Physics can be good researchers in the field of technology too.
PSO-3	To understand the basic concepts of physics particularly concepts in classical mechanics, quantum mechanics, electrodynamics and electronics to appreciate how diverse phenomena observed in nature follow from a small set of fundamental laws.
PSO-4	To apply advanced theoretical and/or experimental methods, including the use of numerical methods and simulations.
PSO-5	To get some research oriented experience by doing theoretical and experimental projects in the last semester under the supervision of faculty.
PSO-6	Students may get opportunities in higher education, research organizations, radiology and radiation oncology. Students can start their career in BARC, DRDO, IPR, ONGC etc.

COURSE SCHEME							
SEMESTER - I							
Course Code	**Course Name**	**Hours/Week**	**Max. Marks**				**Page No.**
			Th	**Pr**	**IA**	**Total**	
MHP-411	Electronics	4	75	-	25	100	4-5
MHP-412	Mathematical Physics	4	75	-	25	100	6-7
MHP-413	Classical Mechanics	4	75	-	25	100	8-9
MHP-414	Computational Techniques	4	75	-	25	100	10-11
MHP-415	Electronics Lab	6	-	75	25	100	12-13
MHP-416	Computer Lab	6	-	75	25	100	14-15
						600	

SEMESTER - II							
Course Code	**Course Name**	**Hours/Week**	**Max. Marks**				**Page No.**
			Th	**Pr**	**IA**	**Total**	
MHP-421	Quantum Mechanics-I	4	75	-	25	100	16-17
MHP-422	Electrodynamics-I	4	75	-	25	100	18-19
MHP-423	Condensed Matter Physics-I	4	75	-	25	100	20-21
MHP-424	Atomic & Molecular Spectroscopy	4	75	-	25	100	22-23
MHP-425	Condensed Matter Lab-I	6	-	75	25	100	24-25
MHP-426	Spectroscopy Lab	6	-	75	25	100	26-27
						600	

SEMESTER - III							
Course Code	**Course Name**	**Hour/ Week**	**Max. Marks**				**Page No.**
			Th	**Pr**	**IA**	**Total**	
MHP-531	Quantum Mechanics-II	4	75	-	25	100	28-29
MHP-532	Electrodynamics-II	4	75	-	25	100	30-31
MHP-533	Condensed Matter Physics-II	4	75	-	25	100	32-33
MHP-534	Nuclear Physics	4	75	-	25	100	34-35
MHP-535	Condensed Matter Lab-II	6	-	75	25	100	36-37
MHP-536	Nuclear Physics Lab	6	-	75	25	100	38-39
						600	

SEMESTER - IV							
Course Code	**Course Name**	**Hours/Week**	**Max. Marks**				**Page No.**
			Th	**Pr**	**IA**	**Total**	
MHP-541	Particle Physics	4	75	-	25	100	40-41
MHP-542	Statistical Physics	4	75	-	25	100	42-43
MHP-543	Dissertation	4	-	37	13	50	44
And any TWO of the following papers (MHP-544 to MHP-549) to the availability of teacher:							
MHP-544	Physics of Material	4	75	-	25	100	45-46
MHP-545	Radiation Physics	4	75	-	25	100	47-48
MHP-546	Reactor Physics	4	75	-	25	100	49-50
MHP-547	Plasma Physics	4	75	-	25	100	51-52
MHP-548	Geophysics	4	75	-	25	100	53-54
MHP-549	Nano Technology	4	75	-	25	100	55-56
MHP-550	Advance Practical	4	-	37	13	50	57
							500
***The student will have to prepare a dissertation and will be evaluated by the external examiners from the University.**							

M.Sc. Physics (Under the Honours Scheme) Semester-I
MHP-411
ELECTRONICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The objective of this course is to impart knowledge about a variety of power and microwave solid state electronic devices, their structure and the underlying physical principles, understand the basics of Digital Electronics and different number systems and conversion between them, design and construction of the basic and universal logic gates, studying the Boolean algebra and simplification of Boolean expression using different methods, study and construction of sequential logic circuits, understanding various design of flip flops and studying the shift registers, counters and various memory devices.

Course Contents:

UNIT-I

Electronic Devices and* Microwave devices*: MESFETs and MOSFETs, Charge Coupled(CCDs) devices, Uni junction transistor (UJT), four layer (PNPN) devices, construction and working of PNPN diode, Semiconductor controlled rectifier (SCR) and Thyristor. Gunn diode, Gunn effect, two valley model, principle and operation of Reflex Klystron and Magnetron.

Hours 15

UNIT-II

Electronic Circuits: Multivibrators (Bistable Monostable and Astable), Differential amplifier, Operational amplifier (OP-AMP) Ideal, Internal circuit &Practical, OP-AMP as inverting and non-inverting, scalar, instrumentation amplifier, summer, integrator, differentiator. Schmitt trigger and logarithmic amplifier, Electronic analog computation circuits.

Hours 15

UNIT-III

Digital Principles: Binary and Hexadecimal number system, Binary arithmetic, Logic gates, Boolean equation of logic circuits, Karnaugh map simplifications for digital circuit analysis, and design, Encoders & Decoders, Multiplexers and Demultiplexers, Parity generators and checkers, Adder-Subractor circuits.

Hours 15

UNIT-IV

Sequential Circuits: Flip Flops, Registers, Up/Down counters, Basics of semiconductor rmemories: ROM, PROM, EPROM, and RAM,D/A conversion using binary weighted resistor network, Ladder, D/A converter, A/D converter using counter, Successive approximation A/D converter.

Hours 15

Books Prescribed:

1. Electronic Devices and Circuits- Millman and Halkias-Tata McGraw Hill, 1983.
2. Solid State Electronic Devices - Ben G Streetman-Prentice Hall, New Delhi, 1995.
3. Digital Principles and Applications- A.P.Malvino and D.P.Leach-Tata McGraw Hill, New Delhi, 1986.
4. Digital Computer Electronics- A P Malvino-Tata McGraw Hill, New Delhi, 1986
5. Microelectronics – Millman-Tata McGraw Hill, London, 1979.
6. Digital Electronics - W.H. Gothmann-Prentice Hall, New Delhi, 1975.
7. Microwave Devices and Circuits-Samuel Y Liao-PHI,1991

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Use techniques for analyzing analogue and digital electronic circuits
CO2	Formulate the concepts of operational amplifier and learn about basic operational amplifier characteristics, OPAMP parameters, applications as inverter, integrator, differentiator etc
CO3	Identify the major properties, types and applications of MOSFET, MESFET, UJT, SCR and Multivibrators.
CO4	Learn digital electronics basics using logic gates and working of major digital devices like flip flops, CMOS, CCD etc
CO5	Learn about Karnaugh maps, Flip Flops and counters in detail.

M.Sc. Physics (Under the Honours Scheme) Semester-I
MHP-412
MATHEMATICAL PHYSICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The objective of this course is to introduce the students to methods of mathematical physics and develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of physics. It includes Fourier Series and transformations, Curvilinear coordinates, Basics of Tensors, Group Theory, Second order differential Equations, Special functions, Function of Complex variable and Calculus of residues etc.

Course Contents:

UNIT-I

Fourier Series: Dirichlet's Conditions, Coefficients of Fourier Series, Even & Odd Function, Half Range Series, Application of Fourier series: Full wave & Half wave rectifier, Square wave, Saw Tooth and Triangle wave. **Fourier transformations:** Fourier Integral Theorem, Fourier Sine & Cosine Integral, Fourier Complex Integral, Fourier Sine & Cosine transform, Convolution theorem, Properties of Fourier's Transform (Linearity theorem, Change of Scale, Shifting, and Modulation Theorem), Parsveal's Identity for Fourier transforms.

Hours 15

UNIT-II

Coordinate Systems and Group Theory: Curvilinear coordinates, differential vector operators in curvilinear coordinates. Spherical and cylindrical coordinate systems. General coordinate transformation, Tensors: covariant, contravariant and mixed, Algebraic operations on tensors, Illustrative applications. Definition of a group, multiplication table, conjugate elements and classes of groups, direct product. Isomorphism, homeomorphism, permutation group. Definitions of the three dimensional rotation group and SU(2).

Hours 15

UNIT-III

Differential Equations and Special functions: Second order differential equations. Frobenius method. Wronskian and second solution, the Sturm Lioville problem. One dimensional Greens function. Gamma function: The exponential integral and related function form of Gamma Function. The exponential integral and related functions. Bessel functions of the first and second kind. Legendre polynomials, associated Legendre polynomials and spherical harmonics. Generating functions for Bessel, Legendre and associated Legendre polynomials.

Hours 15

UNIT-IV

Complex Analysis: The Cauchy-Reimann conditions, Cauchy integral theorem, Cauchy integral formula. Taylor, and Lorent series, singularities and residues. Cauchy residue theorem. Calculation of real integrals.

Hours 15

Books Prescribed:

1. Mathematical Methods for Physicists: George Arfken-New York Academy, 1970.
2. Advanced Mathematical Methods for Engg. and Science Students: George Stephenson and P.M. Radmore-Cambridge Uni Press, 1990.
3. Applied Mathematics for Engineers & Physicists: Pipes and Harvil

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Expand a function in a Fourier series. They will also be aware of the integral transforms and be able to use this to solve mathematical problems relevant to the physical sciences.
CO2	Learn about Gradient, Divergence and Curl in orthogonal.
CO3	Solve ordinary second order differential equations which are important in the physical sciences.
CO4	Have a good grasp of the basic elements of complex analysis, including the important integral theorems. They will be able to determine the residues of a complex function and use the residue theorem to compute certain types of integrals.
CO5	Expand functions in Taylor’s Series & Laurent Series.

M.Sc. Physics (Under the Honours Scheme) Semester-I
MHP-413
CLASSICAL MECHANICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:
1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The main course objective of this subject to understand the basic concepts of constraint and advanced problems involving the dynamic motion, Newton's laws of motion, differential equations have developed in terms of Lagrangian with different examples, central force problems by equations of motion and different Kepler Laws , rigid body by Euler equations of motion and conservation laws on basis of symmetries of classical physics, Canonical transformations, Hamilton equations, Poisson brackets in a comprehensive way.

Course Contents:

UNIT-I

Lagrangian Mechanics: Newton's laws of motion, mechanics of a system of particles, constraints, D' Alembert's principle and Lagrange equations of motion. Velocity dependent potentials and dissipation function. Some applications of Lagrangian formulation, Hamiltons principle, derivation of Lagrange equations from Hamilton's principle. Conservation theorems and symmetry properties.

Hours 15

UNIT-II

Central Force Problem: Two body central force problem, reduction to equivalent one body problem, the equation of motion and first integrals, the equivalent one dimensional problem, and classification of orbits. The differential equation for the orbit and integrable power-law potential. The Kepler problem. Scattering in a central force.

Hours 15

UNIT-III

Rigid Body Dynamics: The independent coordinates of a rigid body, orthogonal transformation, the Euler's angles. Eulers 's theorem on the motion of rigid body, finite and infinitesimal rotations, rate of change of a vector, angular momentum and kinetic energy about a point for a rigid body, the inertia tensor and moment of inertia, the eigen values of the inertia tensor and the principal axis transformation. Euler's equations of motion, torque free motion of a rigid body.

Hours 15

UNIT-IV

Canonical Transformations: Legendre transformation and Hamilton equations of motion, cyclic coordinates and conservation theorems, derivation of Hamiltons equations from a variational principle, the principle of least action. The equations of canonical transformation, examples of canonical transformations, Poisson brackets. Equations of motion, infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation.

Hours 15

Books Prescribed:

1. Classical Mechanics: Herbert Goldstein-Narosa Pub. House, New Delhi, 1970.
2. Mechanics : L.D. Landau-Pergamon Press, Oxford, 1982.
3. Classical Mechanics Rana and Joag-Tata McGraw Hill, New Delhi, 1995.

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Understand the basic concepts of constraint and advanced problems involving the dynamic motion.
CO2	Explain the Newton's laws of motion, differential equations have developed in terms of Lagrangian with different examples.
CO3	Analyse the central force problems by equations of motion and different Kepler Laws.
CO4	Understand the concept of rigid body by Euler equations of motion and conservation laws on basis of symmetries of classical physics.
CO5	Explain the concepts of Canonical transformations, Hamilton equations, Poisson brackets in a comprehensive way.

M.Sc. Physics (Under the Honours Scheme) Semester-I
MHP-414
COMPUTATIONAL TECHNIQUES

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The main objective of the course is to make the student acquainted with major computational techniques like Newton forward and Backward interpolation, Lagrange’s interpolation, Simpson rule, Weddle rule, Trapezoidal rule, Euler method, modified Euler’s method, Runga Kutta method, Bisection method, Regula Falsi method, Newton Raphson’s Methodetc. for solving a broad range of complex problems related to the different fields of Physics. So the purpose of the course is to introduce the students to the main computational tools which permit to simulate and analyse the dynamic behaviour of wide range of physical problems in physics.

Course Contents:

UNIT-I

Programming (Fortran) :

Representation of integers, reals, characters, constants and variables, arithmetic expressions and their evaluation using rules of hierarchy. Assignment statements, Logical constants, variables and expressions, control structures, sequencing alternation, arrays, Manipulating vectors and matrices, Subroutines, I/O Statements

Hours 15

UNIT-II

Interpolation:

Interpolation, Newton's formula for forward and backward interpolation, Divided differences, Symmerty of divided differences, Newton's general interpolation formula, Lagrange’s interpolation formula.

Hours 15

UNIT-III

Numerical Differentiation and Integration, Ordinary Differential Equation:

Numerical integration, A general quadrature formula for equidistant ordinates, Simpson, Weddle
And Trape rules, Monte- Carlo Method, Euler's method, Modified Euler's method, Runge-Kutta Method.

Hours 15

UNIT-IV

Roots of Equation :

Approximate values of roots, Bisection Method, Regula-Falsi Method, Newton-Raphson method, Bairstow method. Simultaneous Linear Algebraic Equations: Solution of Simultaneous Linear equations, Gauss elimination method, Gauss-Jordon method, Matrix inversion.

Hours 15

Books Prescribed:

1. Ram Kumar-Programming with Fortran-77 (Tata McGraw Hill), 1995.
2. R.S. Dhaliwal - Programming with Fortran-77 (Wiley-Eastern Ltd)
3. James Scarborough-Numerical Mathematical Analysis (Oxford and IBH), 1966.
4. S.D. Conte - Elementary Numerical Analysis (McGraw Hill), 1965.
5. John. H. Methews, Numerical Methods for Mathematics, Science and Engineering (Prentice Hall of India).

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Understand the basics of computers, their applications in solving common and scientific problems, scientific word processing and graphical analysis.
CO2	Learn the basic terms like constants, variables, structures, arrays etc. used in Fortran programming language and will learn its application in Numerical analysis.
CO3	Demonstrate the Newton's formula for forward and backward interpolation, divided differences, Newton's general and Lagrange’s interpolation formula through Fortran programming.
CO4	Solve numerical integration and differentiation with the help of different methods like Simpson, Weddle and Trape rules, Monte- Carlo Method, Euler's method, Modified Euler's method, Runge-Kutta Method etc. These concepts are used in solving the problems in various research fields.
CO5	Find roots of equation with the help of Bisection Method, Regula-Falsi Method, Newton-Raphson method, Bairstow method etc.

M.Sc. Physics (Under the Honours Scheme) Semester-I
MHP-415
ELECTRONICS LAB.

Credit Hours (per week): 6
Time: 3 Hrs. **Max. Marks: 100**
(Practical Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:
I. The distribution of marks is as follows: **Max. Marks: 75+25 (Internal Assessment)**
i) One experiment **30 Marks**

ii) Brief Theory **15 Marks**

iii) Viva–Voce **15 Marks**

iv) Record (Practical file) **15 Marks**

II. There will be one sessions of 3 hours duration. The paper will have one session and will consist of 8 experiments out of which an examinee will mark 6 experiments and one of these is to be allotted by the external examiner.

III. Number of candidates in a group for practical examination should not exceed 12.

IV. In a single group no experiment be allotted to more than three examinee in any group.

Course Objectives: The objective of this course is to know the characteristics of diodes and transistors, MOSFET, SCR, UJT, DIAC, TRIAC, Multivibrator, Op Amps. Design simple circuits and mini projects, know the benefits of feedback in amplifier and can use op amps. as scalar, summer, differentiator and integrator. Study, Compare and classify oscillators and multivibrators as free running, monostable and bistable. Logic gates, half adder and full adder. Students can examine the basic structure of logic gates and can use them in half adder and full adder. Arithmatic Logic UnitStudents performs simple addition, subtraction, multiplication, division, and logic operations, such as OR and AND. The memory stores the program's instructions and data. The control unit fetches data and instructions from memory. DA convertor Students learn to convert the digital signal to analog signal using DA convertor.

Course Contents:
List of Experiments:

1. To Study the D C characteristics and applications of DIAC.
2. To study the D C characteristics and applications of SCR.
3. To study the D C characteristics and applications of TRIAC.
4. Investigation of the D C characteristics and applications of UJT.
5. Investigation of the D C characteristics of MOSFET.
6. Study of bi-stable, mono-stable and astable, multivibrators.
7. Study of Op-Amps and their applications such as an amplifier (inverting, non-inverting), scalar, summer, differentiator and integrator.
8. Study of logic gates using discrete elements and universal gates.

9. Study of encoder, decoder circuit.
10. Study of arithmetic logic unit (ALU) circuit.
11. Study of shift registers.
15. Study of half and full adder circuits.
13. Study of A/D and D/A circuits.
14. Study of pulse width and pulse position modulation.

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Know the characteristics of diodes and transistors, design simple circuits and mini projects, know the benefits of feedback in amplifier and can use op amps as scalar, summer, differentiator and integrator. Study, compare and classify oscillators and multivibrators as free running, monostable and bistable.
CO2	Examine the basic structure of logic gates and use them in half adder and full adder.
CO3	Perform simple addition, subtraction, multiplication, division, and logic operations, such as OR and AND. The memory stores the program's instructions and data. The control unit fetches data and instructions from memory
CO4	Learn to convert the digital signal to analog signal using DA convertor.

M.Sc. Physics (Under the Honours Scheme) Semester-I
MHP-416
COMPUTER LAB.

Credit Hours (per week):6
Time: 3 Hrs. **Max. Marks: 100**
(Practical Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:
I. The distribution of marks is as follows: **Max. Marks: 75+25 (Internal Assessment)**
i) One experiment **30 Marks**

ii) Brief Theory **15 Marks**

iii) Viva–Voce **15 Marks**

iv) Record (Practical file) **15 Marks**

II. There will be one sessions of 3 hours duration. The paper will have one session and will consist of 8 experiments out of which an examinee will mark 6 experiments and one of these is to be allotted by the external examiner.

III. Number of candidates in a group for practical examination should not exceed 12.

IV. In a single group no experiment be allotted to more than three examinee in any group.

Course Objectives: The main objective of this course is to make the students aware about the basics of Fortran programming and to develop the required programming skills to solve numerical problems on differentiation and integration using different methods like Simpson, Trapzodial rules, Monte- Carlo Method, Euler's method, Modified Euler's method, Runge-Kutta Method etc. They are also able to find roots of equation with the help of Bisection Method, Regula-Falsi Method, Newton-Raphson method etc.

Course Contents:

List of Experiments:

1. Determination of Roots:
(a) Bisection Method
(b) Newton Raphson Method
(c) Secant Method

2. Matrix Manipulation
(a) Matrix Multiplication
(b) Determinant
(c) Gauss Elimination
(d) Matrix Inversion
(e) Gauss Jordan
3. Integration

(a) Trapezoidal rule
(b) Simpson 1/3 and Simpson 3/8 rules
(c) Gaussian Quardrature

4. Differential Equations
(a) Euler's method
(b) RungeKutta Method

5. Interpolation
(a) Forward interpolation, Backward interpolation
(b) Lagrange's interpolation

6. Applications
(a) Chaotic Dynamics, logistic map
(b) One dimensional Schrondinger Equation
(c) Time period calculation for a potential
(d) Luminous intensity of a perfectly black body vs. temperature

Books Prescribed:
1. Ram Kumar-Programming with Fortran-77 (Tata McGraw Hill), 1995.
2. R.S. Dhaliwal - Programming with Fortran-77 (Wiley-Eastern Ltd)

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Write programs in FORTRAN to solve numerical analysis programme.
CO2	Write the Newton's formula for forward and backward interpolation, divided differences, Newton's general and Lagrange’s interpolation formula through FORTRAN programming.
CO3	Apply Fortran programming to analyze the numerical integration and differentiation with the help of different methods like Simpson, Trap rules, Monte- Carlo Method, Euler's method, Modified Euler's method, Runge-Kutta Method etc. These concepts are used in solving the problems in various research fields.
CO4	Find roots of equation with the help of Bisection Method, Regula-Falsi Method, Newton-Raphson method, Bairstow method etc and develop ability to write programmes in Fortran.

M.Sc. Physics (Under the Honours Scheme) Semester-II
MHP-421
QUANTUM MECHANICS – I

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The main objective of this course is to make students aware about the basic formulations in quantum mechanics. To acquire mathematical skills require to develop theory of quantum mechanics. To develop understanding of postulates of quantum mechanics and to learn to apply them to solve some quantum mechanical systems. To offer systematic methodology for the application of Schrodinger equation to solve quantum mechanical systems. There are many different types of representations of state and operators that are very useful in studying the subject deeply. It teaches about various commutation and uncertainty relations. Students will be given knowledge about unitary transformations, dirac delta function, matrix representation of operators and their applications. Main focus is on angular momentum operator and their representation in spherical coordinates. Addition of angular momenta is also taught.

Course Contents:

UNIT-I

Basic Formulation and quantum Kinematics: Stern Gerlach experiment as a tool to introduce quantum ideas, analogy of two level quantum system with polarisation states of light. Complex linear vector spaces, ket space, bra space and inner product, operators and properties of operators. Eigen kets of an observable, eigen kets as base kets, matrix representations. Measurement of observable, compatible vs. incompatible observable, commutators and uncertainty relations. Change of basis and unitary transformations. Diagonalisation of operators. Position, momentum and translation, momentum as a generator of translations, canonical commutation relations. Wave functions as position representation of ket vectors. Momentum operator in position representation, momentum space wavefunction.

Hours 15

UNIT-II

Quantum Dynamics: Time evolution operator and Schrodinger equation, special role of the Hamiltonian operator, energy eigen kets, time dependence of expectation values, spin precession. Schrodinger vs. Heisenberg picture, unitary operators, state kets and observable in Schrodinger and Heisenberg pictures, Heisenberg equations of motion, Ehrenfest'stheorem.

Hours 15

UNIT-III

One Dimenstional Systems: Potential Step, potential barrier, potential well. Scattering vs. Bounds states. Simple harmonic oscillator, energy eigen states, wave functions and coherent states.

Hours 15

UNIT-IV

Spherical Symmetric Systems and Angular momentum: Schrodinger equation for a spherically symmetric potential. Orbital angular momentum commutation relations. Eigenvalue problem for L_2, spherical harmonics. Three dim harmonic oscillator, three dim. potential well and the hydrogen atom. Angular momentum algebra, commutation relations. Introduction to the concept of representation of the commutation relations in different dimensions. Eigen vectors and eigen functions of J_2 and J_z. Addition of angular momentum and C.G. coefficients. **Hours 15**

Books Prescribed:

1. Modern Quantum Mechnics: J.J. Sakurai-Pearson Educaton Pvt. Ltd., New Delhi, 2502.
2. Quantum Mechanics :L I Schiff-Tokyo McGraw Hill, 1968.
3. Feynmann Hours in Physics Vol. III-Addison Wesly, 1975.
4. Quantum Mechanics :Powel and Craseman-Narosa Pub. New Delhi, 1961.
5. Quantum Mechanics :Merzbacher-John Wiley & Sons, New York, 1970.

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Explain the basic formulation of Quantum mechanics developed by Dirac.
CO2	Understand quantum dynamics of states using time evolution operator.
CO3	Understand the detailed quantum mechanical analysis of few one dimensional potential systems.
CO4	Understand the quantum mechanical analysis of few three dimensional potential systems.
CO5	Understand and use the concept of addition of angular momenta and evaluation of Clebsch Gordan coefficients.

M.Sc. Physics (Under the Honours Scheme) Semester-II
MHP-422
ELECTRODYNAMICS-I

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The main objective of this course to introduce about the basic mathematical concepts related to electromagnetic vector fields. To impart knowledge on the concepts of electrostatics, electric potential, energy density and their applications. To impart knowledge on the concepts of magnetostatics, magnetic flux density, scalar and vector potential and its applications. To impart knowledge on the concepts of Faraday‘s law, induced emf and Maxwell‘s equations. To impart knowledge on the concepts of Concepts of electromagnetic waves etc.

Course Contents:

UNIT-I

Electrostatics: Coulomb's law, Guass's law, Poisson's equation, Laplace equation. Solution of boundary value problem: Green's function, method of images and calculation of Green'sunction for the image charge problem in the case of a sphere, Laplace equation, uniqueness theorem. Electrostatics of dielectric media, multipole expansion. Boundary value problems in dielectrics; molecular polarisability, electrostatic energy in dielectric media.

Hours 15

UNIT-II

Magnetostatics: Biot and Savart's law. The differential equation of Magnetostatics and Ampere's law, vector potential and magnetic fields of a localised current distribution. Magnetic moment, force and torque on a magnetic dipole in an external field. Magnetic materials, Magnetisation and microscopic equations.

Hours 15

UNIT-III

Time-varying fields: Time varying fields, Maxwell's equations, conservation laws: Faraday's law of induction, Energy in a magnetic field. Maxwell's displacement current, vector and scalar potential, Gauge transformations; Lorentz gauge and Coulomb gauge. Poynting theorem, conservation laws for a system of charged particles and electromagnetic field, continuity equation.

Hours 15

UNIT-IV

Electromagnetic Waves: Plane wave like solutions of the Maxwell equations. Polarisation, linear and circular polarisation. Superposition of waves in one dimension. Group velocity. Illustration of propagation of a pulse in dispersive medium. Reflection and refraction of electromagnetic waves at a plane surface between dielectrics. Polarisation by reflection and total internal reflection. Waves in conductive medium, Simple model for conductivity.

Hours 15

Books Prescribed:

1. Classical Electrodynamics - J.D. Jackson-John & Wiley Sons Pvt. Ltd. New York, 2504.
2. Introduction to Electrodynamics - D.J. Griffiths-Pearson Education Ltd., New Delhi, 1991.
3. Classical Electromagnetic Radiation - J.B. Marion-Academic Press, New Delhi, 1995.

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Understand basics of Electrostatic and Magnetostatics.
CO2	Apply the principles of electrostatics to the solutions of problems relating to electric field and electric potential, boundary conditions and electric energy density.
CO3	Understand conservation laws for a system of charged particles and electromagnetic field.
CO4	Describe Maxwell equations and its physical consequences.
CO5	Describe the nature of electromagnetic wave and its propagation through different media and interfaces.

M.Sc. Physics (Under the Honours Scheme) Semester-II
MHP-423
CONDENSED MATTER PHYSICS-I

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The main objective of this course to introduce about the basics of magnetic materials and their properties. Acquire knowledge of the behavior of Lattice Vibrations and phonons theory in crystals. To become familiar with the Superconductivity and Properties of superconductors using different theories. Familiar with defects in crystal etc.
Course Contents:

UNIT-I

Dia-Para and Ferromagnetism:
Classification of magnetic materials, the origin of permanent magnetic dipoles, diamagnetic susceptibility, classical theory of para magnetism, Quantum theory of paramagnetism, Quenching of orbital angular momentum, cooling by adiabatic demagnetization. Paramagnetic susceptibility of conduction electrons. Ferromagnetism, the Weiss molecular field, the interpretation of the Weiss field. Ferromagnetic domains, Spin waves, quantization of spinwaves, Thermal excitations of magnons.

Hours 15

UNIT-II

Antiferro-Ferrimagnetism and Superconductivity:
The two sub lattice model, super exchange interaction, the structure of ferrites, saturation magnetisation, Neel's theory of ferrimagnetism, Curie temperature and susceptibility of ferrimagnets. Superconductivity, zero resistivity, critical temperature, Meissner effect, Type Iand Type II superconductors, specific heat and thermal conductivity, BCS theory, Ginzsburg-Landou theory, Josephson effect: dc Josephson effect, ac Josephson effect, high temperature superconductivity (elementary).

Hours 15

UNIT-III

Defects and Diffusion in Solids:
Point defects: Impurities, Vacancies- Schottky and Frankel vacancies, Color centers and coloration of crystals, F-centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, Planar (stacking) Faults, Grain boundaries, Low angle grain boundaries, the Hydration energy of ions, Activation

energy for formation of defects in ionic crystals, Ionic conductivity inpure alkali halides.

Hours 15

UNIT-IV

Lattice Vibrations and Phonons:

Vibrations of one dimensional linear monoatomic lattice, Normal modes of vibrations in a finite length of the lattice, The linear diatomic lattice, Excitation of optical branch in ionic crystals –the infra-red absorption, Quantization of lattice vibrations – concept of phonons, Phonon momentum, Inelastic scattering of photons by phonons, Inelastic scattering of neutrons by phonons.

Hours 15

Books Prescribed:

1. An Introduction to Solid State Physics: C. Kittel-Wiely Estem Ltd., New Delhi, 1979.
2. Solid State Physics-A.J. Dekkar-Maemillan India Ltd., New Delhi, 2504.
3. Principles of Solid State Physics-R.A. Levy-New York Academy, 1968.
4. Introduction to Solids-Azaroff-Tata McGraw Hill, New Delhi, 1992.
5. Elementary Solid State Physics-Omar, Addison Wesly, 1975.
6. Solid State Physics-Aschroft and Mermin-New York Holt, 1976

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Understand the basics of Magnetic properties of solids and able to explain diamagnetism, paramagnetic susceptibility and ferromagnetism on the basis of classical & quantum theory.
CO2	Learn about the Superconductivity, properties of superconductors, Meissner effect, BCS Theory etc.
CO3	Understand about the different types of defects in solids.
CO4	Understand about the Lattice Vibrations and Phonons theory in crystals

M.Sc. Physics (Under the Honours Scheme) Semester-II
MHP-424
ATOMIC AND MOLECULAR SPECTROSCOPY

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The purpose of the course is to introduce students to methods of Atomic and Molecular Spectroscopy and to develop required skills to solve problems of atomic spectra of one and two valance electrons, spectroscopy terminology, Molecular spectroscopy, structural determination of molecules, Fourier Series and transformations in quantum mechanics, and other fields of physics. It includes interaction energies involving L-S and J-J interactions and selection rules governing transitions, effect of magnetic field on spectral lines and broadening of lines. molecular spectra pertaining to rotational and vibrational motion, Raman and electronic spectroscopy and Frank-Condon principle etc.

Course Contents:

UNIT-I

Spectra of one and two valance electron systems:
Magnetic dipole moments; Larmor's theorem; Space quantization of orbital, spin and total angular momenta; Vector model for one and two valance electron atoms; Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectroscopic terminology; Spectroscopic notations for L-S and J-J couplings; Spectra of alkali and alkaline earth metals; Interaction energy in L-Sand J-J coupling for two electron systems; Selection and Intensity rules for doublets and triplets

Hours 15

UNIT-II

Breadth of spectral line and effects of external fields:
The Doppler effect; Natural breadth from classical theory; natural breadth and quantum mechanics; External effects like collision damping, asymmetry and pressure shift and stark broadening; The Zeeman Effect for two electron systems; Intensity rules for the Zeeman effect; The calculations of Zeeman patterns; Paschen-Back effect; LS coupling and Paschen –Backeffect; Lande's factor in LS coupling; Stark effect.
Hours 15

UNIT-III

Microwave and Infra-Red Spectroscopy:

Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator, Intensity of rotational lines, Effect of isotopic substitution, Microwave spectrum of poly atomic molecules, Microwave oven, The vibrating diatomic molecule as a simple harmonic and anharmonic oscillator, Diatomic vibrating rotator, The vibration-rotation spectrum of carbon monoxide, The interaction of rotation and vibrations, Outline of technique and instrumentation, Fourier transform spectroscopy.

Hours 15

UNIT-IV

Raman and Electronic Spectroscopy:

Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrarional Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, Born Oppenheimer approximation- The Franck-Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, example of spectrum of molecular hydrogen.

Hours 15

Books Prescribed:

1. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1934
2. Fundamentals of Molecular spectroscopy: C.B. Banwell-Tata McGraw Hill, 1986.
3. Spectroscopy Vol. I, II & III: Walker &Straughen
4. Introduction to Molecular Spectroscopy: G.M.Barrow-Tokyo McGraw Hill, 1962.
5. Spectra of Diatomic Molecules: Herzberg-New York, 1944.
6. Molecular Spectroscopy: Jeanne L McHale-NewJersy Prentice Hall, 1999.
7. Molecular Spectroscopy: J.M. Brown-Oxford University Press, 1998.
8. Spectra of Atoms and Molecules: P.F. Bermath-New York, Oxford University Press, 1995.
9. Modern Spectroscopy: J.M. Holias

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Understand the basic information about atomic spectra of one and two valance electrons, interaction energies involving L-S and J-J interactions and selection rules governing transitions.
CO2	Understand the effect of magnetic field on spectral lines and broadening of lines.
CO3	Explain the applications of molecular spectra pertaining to rotational and vibrational motion of different types of molecules
CO4	Understand the Raman and electronic spectroscopy of diatomic molecules.
CO5	Understand about intensity of spectral lines and the Frank-Condon principle.

M.Sc. Physics (Under the Honours Scheme) Semester-II
MHP-425
CONDENSED MATTER LAB-I

Credit Hours (per week): 6
Time: 3 Hrs. **Max.Marks: 100**
(Practical Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:
I. The distribution of marks is as follows: **Max. Marks: 75+25 (Internal Assessment)**
i) One experiment **30 Marks**

ii) Brief Theory **15 Marks**

iii) Viva–Voce **15 Marks**

iv) Record (Practical file) **15 Marks**

II. There will be one sessions of 3 hours duration. The paper will have one session and will consist of 8 experiments out of which an examinee will mark 6 experiments and one of these is to be allotted by the external examiner.

III. Number of candidates in a group for practical examination should not exceed 12.

IV. In a single group no experiment be allotted to more than three examinee in any group.

Course Objectives: The objective of this course is to experimentally study some of the fundamental concepts in condensed matter physics like free electron theory of metals, semiconductor transport, crystal structure determination, magnetism and electron spin resonance. The students are expected to study lab manuals in advance and perform the experiments on their own with minimal help from instructors.

Course Contents:
List of Experiments:
1. To determine Hall coefficient by Hall Effect.
2. To determine the band gap of a semiconductor using p-n junction diode.
3. To determine the magnetic susceptibility of a material using Quink's method.
4. To determine the g-factor using ESR spectrometer.
5. To determine the energy gap and resistivity of the semiconductor using four probe method.
6. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.
7. To determine dielectric constant.
8. To study the series and parallel characteristics of a photovoltaic cell.
9. To study the spectral characteristics of a photovoltaic cell.

Books Prescribed:
1. An Introduction to Solid State Physics: C. Kittel-Wiely Estem Ltd., New Delhi, 1979.
2. Solid State Physics-A.J. Dekkar-Maemillan India Ltd., New Delhi, 2504.
3. Principles of Solid State Physics-R.A. Levy-New York Academy, 1968.
4. Advanced Practical Physics by S.P.Singh, Pragati Prakashan, Meerut – 250001 (India).

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Determine Hall coefficient by Hall Effect.
CO2	Understand the dielectric constant of liquids.
CO3	Study the spectral characteristics of a photovoltaic cell.
CO4	Calculate the band gap of a semiconductor using p-n junction diode.
CO5	Find out the magnetic susceptibility of a material using Quink's method.

M.Sc. Physics (Under the Honours Scheme) Semester-II
MHP-426
SPECTROSCOPY LAB

Credit Hours (per week): 6
Time: 3 Hrs. **Max. Marks: 100**
(Practical Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:
I. The distribution of marks is as follows: **Max. Marks: 75+25 (Internal Assessment)**
i) One experiment **30 Marks**

ii) Brief Theory **15 Marks**

iii) Viva–Voce **15 Marks**

iv) Record (Practical file) **15 Marks**

II. There will be one sessions of 3 hours duration. The paper will have one session and will consist of 8 experiments out of which an examinee will mark 6 experiments and one of these is to be allotted by the external examiner.

III. Number of candidates in a group for practical examination should not exceed 12.

IV. In a single group no experiment be allotted to more than three examinee in any group.

Course Objectives: The purpose of the course is to introduce students to methods of Spectroscopy analysis and to develop required skills to study spectra of Atoms and Molecules. Lab work will help the students to work with Michelson and Febry-Perot interferometer to determine Wavelength of source. It includes how a deviation spectrometer helps to find unknown wavelengths of light, wavelength determination of the source with the help of diffraction experiment using laser, experimental confirmation of Bohr energy levels and how Zeeman pattern appear when source is placed in external magnetic field.

Course Contents:

List of Experiments:

1. To find the wavelength of monochromatic light using Febry Perot interferometer.
2. To find the wavelength of sodium light using Michelson interferometer.
3. To calibrate the constant deviation spectrometer with white light and to find the wavelength of unknown monochromatic light.
4. To find the grating element of the given grating using He-Ne laser light.
5. To find the wavelength of He-Ne laser using Vernier calipers.
6. To verify the existence of Bohr's energy levels with Frank-Hertz experiment.
7. To determine the charge to mass ratio (e/m) of an electron with normal Zeeman Effect.
8. To determine the velocity of ultrasonic waves in a liquid using ultrasonic interferometer.

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Get basic information about confirmation of existence of Bohr energy levels atom by Frank Hertz Experiment
CO2	Understand how a deviation spectrometer helps to find unknown wavelengths of light using Constant deviation spectrometer
CO3	Explain the wavelength determination with the help of Michelson and Febry-Perot interferometer.
CO4	Understand how Zeeman pattern appear when source is placed in external magnetic field.
CO5	Get an idea about wavelength determination of the source with the help of diffraction experiment.

M.Sc. Physics (Under the Honours Scheme) Semester-III
MHP-531
QUANTUM MECHANICS-II

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III &IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: Objectives of this course are to understand the concepts of advance quantum mechanics like perturbation theory, scattering theory, relativistic quantum mechanics, quantum theory of identical particles etc. To realize various phenomenon in terms of quantum mechanics and to apply different quantum formulations and concept to understand various phenomenon in nature. To understand the use of scattering theory for various kind of problems. To understand the importance of relativistic quantum mechanics. To develop numerical ability for quantum theory.

Course Contents:

UNIT-I

Perturbation Theory: Time independent perturbation theory for non-degenerate systems; Perturbed harmonic oscillator; Normal helium atom; Stark effect of the plane rotator; first order time independent perturbation theory for degenerate systems; first order stark effect in hydrogen; Time dependent perturbation theory; **Transition to the continuum (Fermi Golden rule); Harmonic perturbation**; Variation (**Rayleigh-Ritz**) method and **its applications to calculate the ground state energy of the hydrogen atom and normal state of the helium atom**.

Hours 15

UNIT-II

Scattering Theory: Scattering cross section; Quantum mechanical description; Scattering by spherically symmetric potentials: partial wave analysis; Optical theorem; Scattering by a perfectly rigid sphere; **Scattering by an attractive square potential well, Ramsauer effect, application to neutron proton scattering**; Born approximation, **Condition for the validity of Born approximation**; Scattering by a square well potential, validity of Born's approximation for a square well potential; **Scattering by a screened coulomb potential**.

Hours 15

UNIT-III

Relativistic Quantum Mechanics: Schrodinger relativistic equation-Klein Gordon equation for a free particle; **Probability and current densities**; **Klein Gordon equation in presence of electromagnetic field**; Dirac relativistic equation for a free electron; **alpha, beta** & gamma matrices and their properties; **free particle solution of Dirac's equation; Probability and current densities in Dirac's formulation**; **Dirac's equation in a central field (electron spin)**; spin orbit energy; Covariance of Dirac's equation. **Hours 15**

UNIT-IV

Identical particles in quantum mechanics; **Distinguishability and distinguishability of identical particles; Exchange symmetry of wave function: symmetric & anti-symmetric wave functions and their construction**; Statistics of identical particles; Pauli exchange principal; **Pauli spin operators; Further Pauli operators; Commutation relations**; Systems of two-electrons.

Hours 15

Books Prescribed:

1. Modern Quantum Mechnics: J.J. Sakurai-Pearson Educaton Pvt. Ltd., New Delhi, 2502.
2. Quantum Mechanics: L I Schiff-Tokyo McGraw Hill, 1968.
3. Feynmann Hours in Physics Vol. III-Addison Wesly, 1975.
4. Quantum Mechanics: Powel and Craseman-Narosa Pub. New Delhi, 1961.
5. Quantum Mechanics: Merzbacher-John Wiley & Sons, New York, 1970.
6. Quantum Mechanics : Gupta Kumar Sharma- Jai Prakash Nath Publications Meerut

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	understand the concepts of advance quantum mechanics like perturbation theory, scattering theory, relativistic quantum mechanics, quantum theory of identical particles etc.
CO2	Realize various phenomenon in terms of quantum mechanics and develop ability to apply different quantum formulations and concept to understand various phenomenon in nature.
CO3	Understand WKB method, bound states of potential wells and useof scattering theory for various kind of problems.
CO4	Understand the importance of relativistic quantum mechanics.
CO5	Develop numerical ability for quantum theory.

M.Sc. Physics (Under the Honours Scheme) Semester-III
MHP-532
ELECTRODYNAMICS – II

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: One of the objectives of this course is to introduce students with the formulation of four vectors. They are to be introduced by the Lorentz transformations and the invariance of various quantities in four dimensions. Main aim is to feed student's mind by fields and radiations from various types of dipoles and localized sources. They will be taught to calculate power radiated in each case. The students will be able to calculate the velocity dependent potentials, their fields and power radiated by a charged particle moving with arbitrary velocity. Students will be introduced by the characteristics of waveguides and resonant cavities and how waves propagate through it. The objective is to introduce them about wave guides and their applications.

Course Contents:

UNIT-I

Wave guides, field equations in rectangular waveguides, TM and TE modes, propagartion characteristics of TM and TE modes in rectangular wave guides, dominant modes, TEM modes, wave impedance in rectangular wave guides, Attenuation and quality factor in rectangular waveguides, cavity resonator, field equations for rectangular cavity resonator, TM and TE modes in rectangular cavity, attenuation and quality factor in rectangular cavity. **Circuit representation of parallel plane transmission lines, velocity of wave propagation, parallel plane transmission line with losses, transmission line equations, RH and UHF transmission lines, Standing wave ratio.**

Hours 15

UNIT-II

Relativistic formulation of electrodynamics: Special theory of relativity, simultaneity, Lorenz's transformations in tensor notation. Structure of space-time, four scalars, four vectors and tensors, four velocity, four acceleration, four acceleration, Relativistic equation of motion:Minkowiski force, relativistic electrodynamics, four current density, four potential, electromagnetic field tensor and field transformations, field invariants, Recasting Maxwell equations in the language of special relativity, covariance, Lagrangian formulation for the covariant Maxwell equations.

Hours 15

UNIT-III

Radiation Systems: Fields of radiation of localized oscillating sources, electric dipole fields and radiation, and electric quadrupole fields, central fed antenna, brief introduction to radiation damping and radiation reaction, **Line Breadth and level shift of an oscillator. Scattering from a free electron: Thomson scattering, Scattering from a bound electron: Rayleigh scattering**

Hours 15

UNIT-IV

Fields of moving charges: Lienard Wiechert potential, field of a moving charge. Radiated power from an accelerated charge at low velocities: Larmour's power formula and its relativistic generalization, **radiations from an ultra relativistic particle**, Angular distribution of radiation emitted by an accelerated charge.

Hours 15

Books Prescribed:

1. Classical Electrodynamics: J.D. Jackson-Wiley, 1967
2. Electricity and Magnetics: D.J. Griffiths-Prentice hall, 1996
3. Classical Electromagnetic Radiation: J.B. Marian-Academic Press, 1965
4. Fundamentals of electromagnetics M.A. Wazid Miah Tata Mc Graw Hill 1986

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Derive expression of various fields, energy flow and attenuation in wave guides and resonant cavities.
CO2	Understand formulation of electrodynamics using four tensors.
CO3	Derive various electric and magnetic fields from localized oscillating sources.
CO4	Derive velocity dependant potentials and the power loss using Larmor power formula.
CO5	Understand terms related to radiation reaction, radiation daming and angular distribution of radiation.

M.Sc. Physics (Under the Honours Scheme) Semester-III
MHP-533
CONDENSED MATTER PHYSICS-II

Credit Hours (per week): 6
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: This course enables the students to understand about the basics of semiconductors, conductivity of metals, luminescence materials and dielectrics materials.

Course Contents:

UNIT-I

Bonding in Solids and Elastic Constants:
Types of Bonding, Ionic or Electrovalent Bonding, Covalent Bonding, Metallic Bonding, Vander Waal's bonding, Hydrogen Bonding, Cohesive energy, Madelung Constant. Elastic strain and stress components, **Analysis of elastic stress and strain**, Elastic compliance and stiffness constants, **Elastic energy density**, Elastic constants of cubic crystals, Elastic waves in cubic crystals.

Hours 15

UNIT-II

Physics of Semiconductors:
Semiconductors, Chemical bonds in semiconductors, Mechanism of current flow, Forbidden, valence and conduction bands, Band structure of silicon and germanium, Mobility, drift velocity and conductivity of intrinsic semiconductors, Carrier concentration in intrinsic semiconductors, Impurity semiconductors, **Carrier concentration in p and n type semiconductors, Conductivity in p and n type semiconductors** Thermal ionization of impurities, Impurity states, energy band diagram and Fermi level, **Hall Effect, Measurement of Hall Effect, Applications of Hall Effect.**

Hours 15

UNIT-III

The conductivity of Metals and Luminescence:
Electrical conductivity of metals, Drift velocity and relaxation time, The Boltzmann transport equation, The Sommerfield theory of conductivity, Mean free path in metals, Qualitative discussion of the features of the resistivity, Mathiesson's rule. Luminescence, excitation

and emission, Decay mechanisms, Thallium activated alkali halides.

UNIT-IV

Dielectrics and Ferro Electrics:

Macroscopic field, The local field, Lorentz field. The Claussius-Mossotti relations, Different contribution to polarization: dipolar, electronic and ionic polarizabilities, General properties of ferroelectric materials, The dipole theory of ferroelectricity, objection against dipole theory, Thermodynamics of ferroelectric transitions.

Hours 15

Books Prescribed:

1. An Introduction to Solid State Physics: C. Kittle-Wiley, 1958
2. Condensed Matter Physics, Vol I and II, T.S. Bhatia, Rajesh Khatri, Vishal Publishing House, Jallandhar, 2018.
3. Solid State Physics: A.J. Dekker-Prentice Hall, 1965.
4. Principles of Solid State Physics: R.A. Levey-Academic Press, 1968
5. Introduction of Solid State Physics: Ashcroft-Cengage Learning, 1999.

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Explain the concepts of lattice specific heat and elastic constants of solids.
CO2	Understand about the Physics of Semiconductors materials & theirs different properties.
CO3	Learn about the conductivity of Metals and Luminescence of materials.
CO4	Understand the Dielectrics and Ferro Electrics

M.Sc. Physics (Under the Honours Scheme) Semester-III
MHP-534
NUCLEAR PHYSICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The purpose of the course is to introduce students to the concept of nuclear properties and to develop required knowledge to solve problems in quantum mechanics, spectroscopy, electrodynamics and other fields of physics. It includes nuclear two body problem, details of nuclear models, nuclear reactions calculations of cross sections , basics of nuclear decay theory, Fermi theory of beta decay, multipole radiations and gamma decay etc.

Course Contents:

UNIT-I

Nuclear Interactions

Nuclear Forces: Two nucleon interaction potential, Ground state of deuteron, excited state of deuteron, **magnetic dipole and electric dipole moment of deuteron and tensor forces**. Neutron proton scattering at low energy, Scattering length**,** spin dependence**, coherent and incoherent scattering ,**Proton proton scattering at low energy, **Comparison of n-p and p-p scattering** ,meson theory of nuclear forces, Exchanges forces e.g. Bartlett, Heisenberg, Majorans forces and potentials, , Effective range theory in n-p scattering.

Hours 15

UNIT-II

Nuclear Models

Liquid drop model**, Semi empirical mass formula**, Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Applications of Shell model like Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition rates magnetic moments and Schmidt lines, Collective model, Nuclear vibrations spectra and rotational spectra, applications, Nilsson model.

Hours 15

UNIT-III

Nuclear Decay

Kinematics of alpha decay (HYDE). Beta decay, Fermi theory of beta decay, shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions selection rules, parity violation, , Detection and properties of neutrino, Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism. **Directional correlation in gamma emission**

Hours 15

UNIT-IV

Nuclear Reactions

Types of nuclear reactions, Nuclear reaction kinematics and Q value. Direct and compound nuclear reaction mechanisms, **Resonance reactions, Heavy ion reactions**, Cross sections in terms of partial wave amplitudes, Compound nucleus, scattering matrix, Reciprocity theorem, Breit Winger one level formula, Resonance scattering.

Hours 15

Books Prescribed:

1. A. Bohr and B.R. Mottelson: Nuclear Structure, Vol.1(1969) and Vol.2 Benjamin, Reading, A.1975.
2. Kenneth S. Krane: Introductory Nuclear Physics, Wiley, New York, 1988
3. G.N. Ghoshal: Atomic and Nuclear Physics Vol.2, S. Chand and Co., 1997
4. P. H. Perkins, introduction to High Energy Physics, Addison-Wiley, London, 1982.
5. Introduction to Elementary particle physics by D. Grifiths.

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Understand the concept of Nuclear two body problem by considering a deuteron, basic concepts underlying nuclear forces and exchange nature of nuclear forces.
CO2	Easily understand the concept underlying liquid drop model, shell model, collective model , Nillson model and Bohr- Wheelar theory of nuclear fission.
CO3	Study nuclear decays and detailed understanding of Fermi theory of beta decay, gamma decay , multipole radiations and selection rules.
CO4	Let the student know about Nuclear reaction cross section , types of reactions, Q value and conservation laws governing nuclear reactions.
CO5	Easily understand direct and compound nuclear reactions, partial wave analysis of nuclear reaction cross section and Breit- wigner one level dispersion.

M.Sc. Physics (Under the Honours Scheme) Semester-III
MHP-535
CONDENSED MATTER PHYSICS LAB-II

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Practical Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:
I. The distribution of marks is as follows: **Max. Marks: 75+25 (Internal Assessment)**
i) One experiment **30 Marks**

ii) Brief Theory **15 Marks**

iii) Viva–Voce **15 Marks**

iv) Record (Practical file) **15 Marks**

II. There will be one sessions of 3 hours duration. The paper will have one session and will consist of 8 experiments out of which an examinee will mark 6 experiments and one of these is to be allotted by the external examiner.

III. Number of candidates in a group for practical examination should not exceed 12.

IV. In a single group no experiment be allotted to more than three examinee in any group.

Course Objectives: The objective of this course is to experimentally study some of the fundamental concepts in condensed matter physics like Stefan and Boltzmann laws, curie temperature, BH Curve, nanotechnology and magnetism. The students are expected to study lab manuals in advance and perform the experiments on their own with minimal help from instructors.

Course Contents:
List of Experiments:

1. To determine the energy loss in transformer and ferrite cores using B-H curve.
2. To determine Stefan's constant using Boltzmann's Law.
3. To determine temperature coefficient of junction voltage and energy band gap in a p-n junction diode.
4. **To measure magnetoresistance of a semiconducting specimen.**
5. To study the depletion capacitance and its variation with reverse bias in a p-n junction.
6. **To determine the g-factor using ESR spectrometer.**
7. **To determine dielectric constant.**
8. Experiments with Microwaves set up. Experiments on Nanotechnology.
9. Study of Thermoluminescence of f-centres in Alkali Halide Crystals.
10. Study of optical Band gap using UV-Visible spectrophotometer.

11. Study of optical Band gap using UV-Visible spectrophotometer.

Books Prescribed:

1. An Introduction to Solid State Physics: C. Kittel-Wiely Estem Ltd., New Delhi, 1979.
2. Solid State Physics-A.J. Dekkar-Maemillan India Ltd., New Delhi, 2504.
3. Principles of Solid State Physics-R.A. Levy-New York Academy, 1968.
4. Practical Physics, Vol III, T.S. Bhatia, G.Kaur and I. Singh, Vishal Publishing House, Jalandhar
5. Advanced Practical Physics by S.P.Singh, Pragati Prakashan, Meerut – 250001 (India).

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Learn and determine Stefan's constant using Boltzmann's Law.
CO2	Determine the energy loss in transformer and ferrite cores using B-H curve.
CO3	Study the Curie temperature of ferrites.
CO4	Determine the energy loss in transformer and ferrite cores using B-H curve.
CO5	Study the depletion capacitance and its variation with reverse bias in a p-n junction

M.Sc. Physics (Under the Honours Scheme) Semester-III
MHP-536
NUCLEAR PHYSICS LAB

Credit Hours (per week): 6
Time: 3 Hrs. **Max. Marks: 100**
(Practical Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:
I. The distribution of marks is as follows: **Max. Marks: 75+25 (Internal Assessment)**
i) One experiment **30 Marks**

ii) Brief Theory **15 Marks**

iii) Viva–Voce **15 Marks**

iv) Record (Practical file) **15 Marks**

II. There will be one sessions of 3 hours duration. The paper will have one session and will consist of 8 experiments out of which an examinee will mark 6 experiments and one of these is to be allotted by the external examiner.

III. Number of candidates in a group for practical examination should not exceed 12.

IV. In a single group no experiment be allotted to more than three examinee in any group.

Course Objectives: The purpose of the course is to introduce students to the radiation detectors and to develop required skills use Geiger Muller counter to study different parameters including operating voltage of GM tube, dead time, absorption of radiations in matter, source strength, statistics of radioactive measurements, Poisson and Gaussian distribution. Lab work will help the students to work with scintillation counter calibrate it, draw cesium spectrum to find energy of unknown source.

Course Contents:
List of Experiments:
1. Pulse-Height Analysis of Gamma Ray Spectra.
2. Calibration of Scintillation Spectrometer.
3. Least square fitting of a straight line.
4. **Verification of inverse square law**
5. **Determination of beta decay energy**.
6. To study the characteristics of a G.M. Counter.
7. To determine the Dead time of a G.M. Counter.
8. Absorptions of Beta Particles in Matter.
9. Source strength of a Beta Source.
10. Window thickness of a G.M. Tube.
11. To investigate the statistics of radioactive measurements.

12. Study of Poisson Distribution.
13. Study of Gaussian Distribution.
14. Range of beta particles

Books Prescribed:

1. Experiments in Nuclear Physics (Lab Manual): Kulwant Singh Thind, Leif Gerward, H.S Sahota, Publication Bureau, Guru Nanak Dev University Amritsar, 2012

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Learn how a Geiger Muller counter works and how to find its operating voltage.
CO2	Learn about experimental confirmation of statistical fluctuation of radioactive decay while doing experiment with Geiger Muller counter.
CO3	Understand the concept of dead time, source strength and window thickness determination with the help of Geiger Muller counter.
CO4	Understand the concept of Scintillation counter and how does it works to find energy of unknown source.
CO5	Understand the concept of absorption of radiation in matter with the help of Geiger Muller counter.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-541
PARTICLE PHYSICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The main course objective of this subject to understand the fundamental particles of nature and their different inherent properties related to physics, conservation laws of quantum physics and different discrete and continuous symmetries, special theories of Weak interactions and CPT theorem, four fundamental forces of nature and their unification have understandable by latest development of grand unification theory, current development of particle physics including Goldstone theorem and Higgs mechanism including all the mediators.

UNIT-I

Elementary Particles and Their Properties: **Interactions and fields in particles physics**, Historical survey of elementary particles and their classification, determination of mass, life time, decay mode, spin and parity of **pions**, muons, kaons and hyperons. Experimental evidence for two types of neutrinos, production and detection of some important resonances and antiparticles, **Daltiz plot for spin-parity of ω^0 resonance particle** **Hours 15**

UNIT-II

Symmetries and Conservation Laws: Conserved quantities and symmetries, the electric charge, baryon number, leptons and muon number, particles and antiparticles, hypercharge(strangeness), the nucleon isospin, isospin invariance, isospin of particles, parity operation, charge conservation, time reversal invariance, CP violation and CPT theorem, the K^O – antiparticle of K^O doublet unitary symmetry SU(2), SU (3) and **meson nonet and baryon decuplet**, quark model.and **their quantum numbers, contents of mesons and baryons**.

Hours 15

UNIT-III

Week Interaction: Classification of weak interactions, Fermi theory of beta decay, matrix element, classical experimental tests of Fermi theory, **Inverse beta decay**, Parity non conservation in beta decay, lepton polarization in beta decay, the V-A interaction, Weak decays of strange-particles and Cabibbo's theory**.** **Hours 15**

UNIT-IV

Gauge theory and GUT: Gauge symmetry, field equations for scalar (spin 0), spinor (spin ½), vector (spin-1) and fields, global gauge invariance, local gauge invariance, **basics of Feynmann rules**, introduction of neutral currents. Spontaneously broken symmetries in the field theory, standard model, **particle masses and Higgs field**

Hours 15

Books Prescribed:

1 Subatomic Physics: H. Fraunfelder and E.M. Henley- N.J. Prentice Hall
2 Introduction to Elementary Particles: D. Griffiths-Wiley-VCH-2508
3 Introduction to High Energy Physics: D.H Perkins-Cambridge University Press, 2500.

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Understand the fundamental particles of nature and their different inherent properties related to physics.
CO2	Explain the concept of conservation laws of quantum physics and different discrete and continuous symmetries.
CO3	Explain the special theories of Weak interactions and CPT theorem
CO4	Explain the four fundamental forces of nature and their unification have understandable by latest development of grand unification theory.
CO5	Know about an overview of current development of particle physics including Goldstone theorem and Higgs mechanism including all the mediators.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-542
STATISTICAL PHYSICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: Its main purpose is to clarify the properties of matter in aggregate, in terms of physical laws governing atomic motion. Statistical physics develops the phenomenological results of thermodynamics from the probabilistic examination of the underlying microscopic systems.

Course Contents:

UNIT-I

Classical Stat. Mech. I: Foundation of statistical mechanics; specification of states in a system, contact between statistics and thermodynamics, the classical ideal state, the entropy of mixing and Gibbs paradox, **the correct enumeration of the microstate, concept of ensemble,** The phase space of classical systems, Liouville's theorem and its consequences.

Hours 15

UNIT-II

Classical Stat. Mech. II: The microcanonical ensemble, **classical ideal gas, one dimensional simple harmonic oscillator**, the canonical ensemble, **equilibrium between a system and a heat reservoir, A system in a canonical ensemble by methods of most probable values,** the canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations in the canonical ensemble & **correspondence with the microcanonical ensemble, equipartition theorem,** A system of harmonic oscillators, the statistics of paramagnetism, the grand canonical ensemble, **equilibrium between system and a particle energy reservoir, a system in a grand canonical ensemble,** the physical significance of the statistical quantities, c**lassical ideal gas for non localized and localized particles, solid – vapor equilibrium**, fluctuation of energy and density, cluster expansion of classical gas, the virial equation of state.

Hours 15

UNIT-III

Quantum Stat. Mech.I : Quantum states and phase space, the density matrix, **Liouville's theorem in quantum statistical mechanics, condition for statistical equilibrium,** statistics of various ensembles. Example of electrons in a magnetic field, a free particle in a box and a linear harmonic oscillator. **System composed of indistinguishable particles**

Hours 15

UNIT-IV

Quantum Stat. Mech. II : An ideal gas in quantum mechanical microcanonical ensemble. Statistics of occupation numbers, concepts and thermodynamical behaviour of an ideal gas, Bose Einstein condensation, Discussion of a gas of photons and phonons, Thermodynamical behaviour of an ideal fermi gas, electron gas in metals, Pauli paramagnetism, statistical equilibrium of white dwarf stars.

Hours 15

Books Prescribed:

1. Statistical Mechanics: R.K. Patharia-ButtenWorth Heinemann, 1996
2. Statistical and Termal Physics: F. Reif-Mc-Graw Hill, 1965
3. Statistical Mechanics: Kerson Huang-Wiley, 1963.

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Define and discuss the concepts of statistical physics, microstate and macro state of a system, apply the principles of statistical mechanics to classical ideal gas and phase space.
CO2	Define and discuss the concepts and roles of entropy and free energy from the view point of statistical mechanics.
CO3	Understand the concept of ensemble and statistics of various ensembles. Will also study different examples in a micro canonical, canonical and grand canonical ensemble.
CO4	Understand the fundamental difference between classical and quantum statistical mechanics. They can also very easily understand the significance of Boltzmann formula in classical and quantum statistical mechanics.
CO5	Understand the concepts and thermodynamics of ideal fermi gas, Bose Einstein condensation, photon, phonon, electron gas in metals, Pauli's paramagnetism and statistical equilibrium of white dwarf.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-543
Dissertation

Course Hrs: 60 **Credit Hours (per week): 4**
Time: 3 Hrs. **Max. Marks: 50**
(Project Marks: 37+ Internal Assessment: 13)

Course Objectives	The main objective of this course is to understand the research methodology and help the students in their future research career, to provide sufficient hands-on learning experience related to the area of specialization with a focus on research orientation.
Sr. No.	**On completing the course, the students will be able to:**
CO1	Complete a Guided Research Project.
CO2	Learn Conceptual understanding and scientific reasoning skills like applying scientific reasoning skills.
CO3	Develop rigorous quantitative understanding of core physical theories.
CO4	Give formal and informal scientific presentations to various audiences, including peers.
CO5	Complete a Guided Research Project.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-544
PHYSICS OF MATERIALS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The objective of this course is to impart knowledge about physics of materials including vacuum technology, thin films deposition techniques, polymers, ceramics, liquid crystals, nanophase materials and their characterization techniques.

Course Contents:

UNIT I

Vacuum Technology:
Basic ideas about vacuum, Throughput, Conductance, Vacuum pumps: rotary pump, diffusion pump, ion pump, molecular pump, cryo pump, Vacuum gauges: pirani gauge, penning gauge, ionization gauge (hot cathode ionization gauge, cold cathode ionization gauge).

15 Hours

UNIT II

Thin Film
Thin Film and growth process, Influence of nature of substrate and growth parameters (substrate temperature, thickness, deposition rate). Thin film deposition, techniques: thermal evaporation, chemical vapor deposition, spray pyrolysis, sputtering. Epitaxial growth, Thin film thickness measurement techniques: film resistance method, optical method, microbalance method.

15 Hours

UNIT III

Polymers, Ceramics, Liquid Crystals and Nanophase Materials: Characteristics, Application and Processing of polymers : Polymerization, Polymer types, Stress-Strain behaviour, melting and glass transition, thermo sets and thermo plasts. Characteristics, Application and Processing of Ceramics, glasses and refractories, Liquid Crystals: classification and applications, Nano phase materials: synthesis and applications. **15 Hours**

UNIT IV

Characterization of Materials
Powder and single crystal X-ray diffraction, Transmission electron microscopy, Scanning electron microscopy, Low Energy Electron Diffraction (LEED), Auger electron microscopy, Atomic force microscopy. **15 Hours**

Books Prescribed:

1. Vacuum Technology: A. Roth-North Holland Pub. Co., 1976
2. Thin Film Phenomenon: K.L. Chopra-R E Kriegn Pub. Co., 1979.
3. High Temperature Superconductors: E.S.R. Gopal& SV. Subhramanyam-Wiley, 1989
4. Material ScienceandEngg: W.D. Callister-.Wiley, 1994
5. Nanostructured Materials: J.C. Ying-Wiley-. Academic Press, 2501
6. Methods of Surface Analysis: J.M. Walls- CUP Archive, 1990.
7. Introduction to Nanotechnology - Charles P.Pooler, Frank J. Owens- IEEE, 2503

Course Outcomes:

Sr. No.	On completing the course, the students will be able to:
CO1	Students will be able to have knowledge about the vacuum techniques, vacuum pumps and pressure gauges.
CO2	Students will be able to learn the thin film deposition techniques and their thickness measurement methods.
CO3	Identify the characteristics of polymers, melting and glass transitions.
CO4	Learn the chararcteristics and applications of ceramics liquid crystals etc.
CO5	Learn about synthesis of nanopahse materials and various characterization tools.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-545
RADIATION PHYSICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. Max. Marks: 100
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: Objectives of this course are to understand radioactive decays, production and types of ionizing radiation and the interactions of ionizing radiation with matter. To understand the use of devices and protocols for the accurate measurement of ionizing radiation and calibration of clinical equipment. To understand the role of the physicis in radiation medicine and radiation protection. To understand the concept of dosimetry and various types of dosimeters. To understand the need of shielding and important shielding materials.

Course Contents:

UNIT-I

Radiations; Ionizing Radiations; Types and sources of ionizing radiation; **Directly and indirectly ionizing radiations**; **Stochastic & Non-Stochastic Quantities**; Fluence; Energy fluence; Kerma; **Relation between kerma and energy fluence of photons & fluence of neutrons**; Absorbed dose; Exposure, Exposure rate, Exposure unit; **Roentgen**; Exposure measurement - The free air chamber and air wall; Bragg Gray Principle; some Radiation units like rem, rad, Gray and Sievert; **Dose equivalent commitment; committed dose equivalent**; Qquality factor and dose equivalent.

Hours 15

UNIT-II

Dosimeters: Passive and Active dosimeters; Pocket dosimeter; **Indirectly and directly reading type pocket dosimeters**; Film badge dosimeters; Thermoluminescent dosimeters; SSNTDs, **Semiconductor dosimeters; MOSFET dosimeters**; Chemical detectors; **Neutron detection**; **Commonly used nuclear reactions for neutron detection**; Neutron detectors.

Hours 15

UNIT-III

Radiation Effects and Protection: Biological effects of radiation at molecular level; Dose response characteristics; **Directly and indirectly action of ionizing radiations; acute and delayed effects of radiations**; Relative Biological Effectiveness (RBE); Linear energy transformation (LET); MIRD concept; **Philosophy of radiation protection**; ALARA and ALI concept; **Basis of radiation safety regulations**; maximum permissible concentration for non-occupational exposure; Maximum permissible concentration in air and water; Safe handling of radioactive materials; **Mechanism of radiation effects**-single hit target theory, single hit Multi target theory, Multi hit single target theory, multi hit multi target theory; Radioactive waste and its disposal, simple numerical problems.

Hours 15

UNIT-IV

Radiation Shielding: Thermal and biological shielding; shielding materials **in details**; radiation attenuation calculations-The point kernal technique, radiation attenuation from a uniform plane source; The exponential point Kernal; Radiation attenuation from a line and plane source; Practical applications of some simple numerical problems.

Hours 15

Books Prescribed:

1. S. Glasstone and A. Sesonke: Nuclear Reactor Engineering-Van Nostrand Reinhold,1981

2. Alison. P. Casart: Radiation Theory

3. A. Edward Profio: Radiation Biology-Radiation Bio/Prentice Hall, 1968

4. F.H. Attix: Introduction to Radiological Physics and Radiation Dosimetry-Wiley-VCH,

1986.

Course Outcomes:

Sr. No.	On completing the course, the student will be able to:
CO1	Understand radioactive decay, production and types of ionizing radiation and the interactions of ionizing radiation with matter.
CO2	Understand the use of devices and protocols for the accurate measurement of ionizing radiation and calibration of clinical equipment.
CO3	Understand the role of the physicist in radiation medicine and protection.
CO4	Understand dosimetry and various types of dosimeters.
CO5	Understand the need of shielding and important shielding materials.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-546
REACTOR PHYSICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: Main aim of this course is to have the knowledge of basic reactor science, critically examine reactor types to identify their advantages and disadvantages, technical status of various reactors with special reference of Indian reactors, to critically review the issues affecting the economy of nuclear power, evaluate reactor safety measurements.

Course Contents:

UNIT-I

Interaction of Neutrons with Matter in Bulk:
Thermal neutron diffusion, Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length-the albedo concept.

Hours 15

UNIT-II

Moderation of Neutron:
Mechanics of elastic scattering, energy distribution of thermal neutrons, average logarithmic energy decrement, slowing down power and moderating ration of a medium. Slowing down density, slowing down time, Fast neutron diffusion and Fermi age theory, solution of agee quation for a point source of fast neutrons in an infinite medium, slowing down length and Fermi age.

Hours 15

UNIT-III

Theory of Homogeneous Bare Thermal and Heterogeneous Natural Uranium Reactors
Neutron cycle and multiplication factor, four factor formula, neutron leakage, typical calculations of critical size and composition in simple cases, The critical equation, material and geometrical bucklings, effect of reflector, Advantages and disadvantages of heterogeneous assemblies, various types of reactors with special reference to Indian reactors and a brief discussion of their design

feature. **Classification of reactors: Research reactors, Production reactors, Power reactors (Basic Features)**.

Hours 15

UNIT-IV

Power Reactors Problems of Reactor Control

Breeding ratio, breading gain, doubling time, Fast breeder reactors, dual purpose reactors, concept of fusion reactors, Role of delayed neutrons and reactor period, Inhour formula, excess reactivity, temperature effects, fission product poisoning, use of coolants and control rods.

Hours 15

Books Prescribed:

1. The elements of Nuclear reactor Theory: Glasstone & Edlund-Vam Nostrand, 1952.
2. Introductions of Nuclear Engineering: Murray-Prentice Hall, 1961.

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Explain basic reactor science, critically examine reactor types to identify their advantages and disadvantages.
CO2	Understand the technical status of various reactors with special reference of Indian reactors.
CO3	Critically review the issues affecting the economy of nuclear power.
CO4	Evaluate reactor safety measurements.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-547
PLASMA PHYSICS

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The objective of this course is to provide the students a basic to detailed knowledge of Plasma Physics and different types of theories, mechanisms and dynamics involved in the study of plasma which will help the students to understand the advanced Plasma Physics in a better way.

Course Contents:

UNIT-I

Basics of Plasmas: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding and plasma parameter. Single particle motion in uniform E and B, non uniform magnetic field, grid B and curvature drifts, invariance of magnetic moment and magnetic mirror. Simple application of plasmas.

Hours 15

UNIT-II

Plasma Waves: Plasma oscillations electron plasma waves, ion waves, electrostatic electron and ion oscillations perpendicular to magnetic field upper hybrid waves, lower hybrid waves, ion cyclotron waves. Light waves in plasma.

Hours 15

UNIT-III

Boltzmann and Vlasov Equations: The fokker plank equation, integral expression for collision lernzeroth and first order moments, the single equation relaxation model for collision lern. Application kinetic theory to electron plasma waves, the physics of landau damping, elementary magnetic and inertial fusion concepts.

Hours 15

UNIT-IV

Non-linear Plasma Theories: Non-linear Electrostatic Waves, KdV Equations, Non-linear Schrodinger Equation, Solitons, Shocks, Non-linear Landou Damping.

Hours 15

Books Prescribed:

1. Introduction to Plasma Physics and Controlled Fusion: F. F. Chen-Springer, 1984
2. Plasma Physics: R. O. Dendy-Cfambridge University Press, 1995.
3. Ideal Magnetohydro dynamics: J. P. Friedberg-Springer edition, 1987
4. Fundamental of Plasma Physics: S. R. Seshadri-American Elsevier Pub. Co., 1973.

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Learn about basics of Plasmas: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding and plasma parameter.
CO2	Have knowledge about single particle motion in uniform E and B, non uniform magnetic field, grid B and curvature drifts, invariance of magnetic moment and magnetic mirror. Simple application of plasmas.
CO3	Learn about Plasma Waves in which they study Plasma oscillations electron plasma waves, ion waves, electrostatic electron and ion oscillations perpendicular to magnetic field upper hybrid waves, lower hybrid waves, ion cyclotron waves.
CO4	Learn about different equations like Fokker Plank equation, integral expression for collision zeroth and first order moments, the single equation relaxation model for collision. They also understand the application of kinetic theory to electron plasma waves, the physics of landau damping, elementary magnetic and inertial fusion concepts and solve the related problems.
CO5	Learn about Non-linear Plasma theories in which they study Non-linear Electrostatic Waves, KdV Equations, Non-linear Schrodinger Equation, Solitons, Shocks, Non-linear Landou Damping, Microscopic instabilities, Inverse Landau damping, ion acoustic wave instability, Absolute and convective instabilities and solve the related problems.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-548
GEOPHYSICS

Credit Hours (per week): 4
Total Hours: 60

Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The objective of this course is to impart knowledge about interior, seismology, geochemistry, geochronology, geodynamics, radioactivity of different rocks and other related effects, different nuclear techniques to study of earth.

Course Contents:

UNIT-I

Seismology and Interior of the Earth:
Origin of earth, shape, size, mass and density of the earth. Theory of seismic waves. The variation of P and S wave velocity, temperature, density, pressure and elastic parameters with depth. Mineralogical and chemical composition of crust, mental and core. Formation of core. Earthquake; effects, types, mechanism, source parameter, and hazard assessment.

Hours 15

UNIT-II

Geochronology and Geodynamics:
Geological Time Scale. Radioactive dating methods; U-Pb, Th-Pb, Pb-Pb, Rb-Sr, K-Ar, and C-14. Fission Track dating. Interpretation and discordant ages, age of earth. Heat flow: thermal and mechanical structure of the continental and oceanic lithosphere. Plate tectonics theory: kinematics, dynamics and evolution of plates; types of boundaries, processes. Geodynamics of Indian plate, formation of Himalaya.

Hours 15

UNIT-III

Radioactivity of Rocks: Magnetic differentiation, Browns reaction series. Radioactivity of rocks, soil, water and air. Uranium mineralization and its occurrences in India. Radiometric survey of rocks: ground and air borne surveys. Radiometer and emanometer. Role of radiometry in geophysical prospecting, gamma logging and gamma testing.

Hours 15

UNIT-IV

Nuclear Techniques: Gamma-transmission method for determination of rock densities in Laboratory and in-situ. Gamma spectrometric analysis for U, Th and K in rock/soil. Neutron activation analysis: Equation for buildup of induced activity.

Hours 15

Books Prescribed:

1. The Solid Earth – C.M.R. Fowler
2. Interior of the earth – M.H.P. Bott
3. The Earth's age and Geochronology- D.York and R.M. Fraquhar
4. Physics of the Earth – F.D. Stacey.
5. Principles and Methods of Nuclear Geophysics- V. L. S. Bhimasankaran and N. Venkat Rao.

Course Outcomes:

Sr. No.	On completion of the course, the students will be able to
CO1	Get knowledge about the origin of earth, shape, mass and density of earth.
CO2	Study seismic waves, their types, pressure and elastic parameters with depth.
CO3	Differentiate between geochronological and geodynamics effects of earth.
CO4	Learn about the Brown reaction series, Uranium occurrence in India specially with the help of radiometers and emanometers.
CO5	Learn about the gamma spectrometric analysis of decay of radioactive rocks and other induced activities.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-549
NANO TECHNOLOGY

Credit Hours (per week): 4
Total Hours: 60
Time: 3 Hrs. **Max. Marks: 100**
(Theory Marks: 75+ Internal Assessment: 25)

Instructions for paper setter and students:

1. **There will be five sections.**
2. **Section A carries 15 marks and is compulsory consisting of eight short answer type questions of 2.5 marks each covering the whole syllabus. The candidate will have to attempt six questions in section A.**
3. **Sections B, C, D and E will be set from units I, II, III & IV respectively and will consist of two questions of 15 marks each from the respective unit. The candidates are required to attempt one question from each of these sections.**
4. **Scientific calculator is allowed.**

Course Objectives: The objective of this course is to impart knowledge about physics of materials including vacuum technology, thin films deposition techniques, polymers, ceramics, liquid crystals, nanophase materials and their characterization techniques.

Course Contents:

UNIT-I

Introduction and Synthesis of Nano Materials:
Introduction, Basic idea of nanotechnology, nano particles, metal Nano clusters, Semiconductor nano particles, Physical Techniques of Fabrication, inert gas condensation, Arc Discharge, RFplasma, Ball milling, Molecular Beam Epitaxy, Chemical Vapour deposition, Electrodeposition, Chemical Methods-Metal nanocrystals by reduction, Photochemical synthesis, Electrochemical synthesis, Sol-gel, micelles and micro emulsions, Cluster compounds. Lithographic Techniques-AFM based nanolithography and nano manipulation, E-beam lithography and SEM based nanolithography, X ray based lithography.

Hours 15

UNIT-II

Characterization Techniques:
X-ray diffraction, data manipulation of diffracted X-rays for structure determination, Scanning Probe microscopy, Scanning Electron microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Optical microscopy, FTIR Spectroscopy, Raman Spectroscopy, DTA,TGA and DSC measurements

Hours 15

UNIT-III

Carbon Nanotubes and other Carbon based materials:
Preparation of Carbon nano tubes, CVD and other methods pf preparation of CNT, Properties of CNT; Electrical, Optical, Mechanical, Vibrational properties etc. Application of CNT; Fieldemission, Fuel Cells, Display devices. Other important Carbon based materials; Preparation

and Characterization of Fullerene and other associated carbon clusters/molecules, Graphene preparation, characterization and properties, DLC and nano diamonds.

Hours 15

UNIT-IV

Nano semiconductors and Nano sensors:
Semiconductor nanoparticles-applications; optical luminescence and fluorescence from directband gap semiconductor nanoparticles, carrier injection, polymers-nanoparticles, LED and solarcells, electroluminescence. Micro and nano sensors; fundamentals of sensors, biosensor, microfluids, MEMS and NEMS, packaging and characterization of sensors.

Hours 15

Books Prescribed:

1. Solid State Physics: J.P. Srivastva-Prentice Hall, 2507.
2. Introduction to nanoscience and Nanotechnology: K.K. Chattopadhyay and A.N.Banerjee- PHI Learning Pvt. Ltd. 2509
3. Nanotechnology Fundamentals and Applications: ManasiKarkare, I.K.- InternationalPublishing House, 2508.
4. Nanomaterials: B. Viswanathan- Narosa, 2509.
5. Encyclopedia of Nanotechnology: H.S. Nalwa-American Scientific Publishers, 2504.
6. Introduction to Nanotechnology: Charles P. Poole Jr. and Franks J. Qwens,-John Wiley & Sons, 2503.
7. Nanostructures and Nanomaterials, Synthesis, Properties and Applications: Guoahong Cao- Imperial College Press, 2504.
8. Springer Handbook of Nanotechnology: Bharat Bhushan-Springer, 2504.
9. Science of Engineering Materials: C.M. Srivastva and C. Srinivasan-New AgeInternational, 2505.
10. The Principles and Practice of electron Microcopy: Ian. M. Watt-Cambridge University Press, 1997.
11. Ultrasonic Testing of Materials: J.K. Krammer and H.K. Krammer-Springer Verlag,1996.
15. Physical Properties of Carbon Nanotube: R. Satio, G. Dresselhaus and M. S. Dresselhaus- Imperial College Press, 1998.
13. Sensors Vol. 8, Micro and Nanosensor Technology: H. Meixner and R. Jones (Editor)-John Wiley and Sons, 2500.

Course Outcomes:

Sr. No.	**On completing the course, the students will be able to:**
CO1	Study different methods for synthesis of nano materials which include Top down and Bottom up approaches .
CO2	Learn the characterization of nano structures. Methodologies such as Electron Microscopy, Scanning Probe Microscopy, Photo luminescence spectroscopy, IR and Raman spectroscopy, X – Ray diffraction methods etc are studied.
CO3	Study carbon nanotubes and other carbon based materials, their method of fabrication and applications
CO4	Understand Semiconductor nanoparticles based applications in sensors memes, LED's etc.
CO5	Pursue higher education or apply the acquired knowledge in solving industrial problems.

M.Sc. Physics (Under the Honours Scheme) Semester-IV
MHP-550
ADVANCE PRACTICAL

Course Hrs: 60 **Credit Hours (per week): 4**
Time: 3 Hrs. **Max. Marks: 50**
(Max. Marks: 37+ Internal Assessment: 13)

Course Objectives	Acquire the appropriate data accurately from experiments of two probe conductivity of highly resistive sample, heat capacity, thermo emf of copper constantan and chromelalumal thermocouples, dielectric constant measurements, capacitance measurements, Boltzmann constant measurement etc. and keep systematic record of laboratory activities. Interpret findings using the correct physical scientific framework and tools. Prepare professional quality textual and graphical presentations of laboratory data and spectral results. Evaluate possible causes of discrepancy in practical experimental observations, results in comparison to theory.
Course Outcomes:	
Sr. No.	**On completing the course, the students will be able to:**
CO1	Determine the resistivity of highly resistive sample using two probe.
CO2	Calculate the Fermi energy of copper.
CO3	Determine the Thomson, Pelter and Seebeck coefficient using thermocouple.
CO4	Determine the permittivity of free space using parallel plate capacitor.
CO5	Study the variation of dielectric constant of a given sample.