JAYOTI VIDYAPEETH WOMEN'S UNIVERSITY, JAIPUR

Faculty of Education & Methodology

SYLLABUS

M.SC.(PHYSICS

SESSION – 2022-23

DURATION – 2 YEARS/4 SEMESTER

SYLLABUS FOR:
I YEARS

FACULTY OF EDUCATION

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PROGRAM DETAIL

Name of Program	-	M.Sc.Physics
Program Code	-	M.Sc.
Mode of Program	-	Yearly /Semester
Duration of Program	-	2 yrs/ 4 Semester
Total Credits of Program	-	
Curriculum Type and Medium Choice	-	English

Program objectives of M.Sc.(Physics)

1. To impart high quality education in Physical Sciences.
2. To prepare students to take up challenges as globally competitive physicists/researchers in diverse areas of theoretical and experimental physics.
3. To make the students technically and analytically skilled.
4. To provide opportunity of pursuing high end research as project work.
5. To give exposure to a vibrant academic ambience.
6. To create a sense of academic and social ethics among the students.
7. To prepare them to take up higher studies of interdisciplinary nature.

Program Outcomes of M.Sc.(Physics)

1. The students will obtain good knowledge in Physical Sciences. They will be trained tocompete national level tests like UGC-CSIR NET, JEST, GATE, etc., successfully.
2. They will be prepared to take up challenges as globally competitive physicists/researchersin diverse areas of theoretical and experimental physics.
3. They will be technically and analytically skilled enough to pursue their further studies.
4. They will have a sense of academic and social ethics.
5. They will be capable of taking up higher studies of interdisciplinary nature.
6. They will be able to recognize the need for continuous learning and develop throughout forthe professional career.

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SEMESTER-I

Nature of Course	Name of subjects	C	T	D	P	P.S.
Physics -I	Mathematical Physics	8	7	0.5	0	0.5
Physics -II	Classical Mechanics	8	7	0.5	0	0.5
Physics -III	Quantum Mechanics	8	7	0.5	0	0.5
Physics -IV	Electrodynamics	8	7	0.5	0	0.5
Physics Lab-I	Electronics Lab	2	0	0	2	0
Total Credits		34	28	2	2	2

SEMESTER-II

Nature of Course	Name of subjects	C	T	D	P	P.S.
Physics -V	Statistical Physics	8	7	0.5	0	0.5
Physics -VI	Atomic and Molecular Physics	8	7	0.5	0	0.5
Physics -VII	Electronics Devices & Circuits	8	7	0.5	0	0.5
Physics -VIII	Condensed Matter Physics	8	7	0.5	0	0.5
PhysicsLab-II	Condensed Matter Physics Lab	2	0	0	2	0
Total Credits		34	28	2	2	2

SEMESTER-III

Nature of Course	Name of subjects	C	T	D	P	P.S.
Physics -IX	Nuclear and Particle Physics	8	7	0.5	0	0.5
Physics -X	Advanced Quantum Mechanics	8	7	0.5	0	0.5
Physics -XI	Laser Physics and Applications	8	7	0.5	0	0.5
Physics -XII	Computational Physics	8	7	0.5	0	0.5
Physics Lab-III	Laser Physics Lab	2	0	0	2	0
Total Credits		34	28	2	2	2

SEMESTER-IV

Nature of Course	Name of subjects	C	T	D	P	P.S.
Physics -XIII	Electronic Instrumentation	8	7	0.5	0	0.5
Physics -XIV	Physics of Nanomaterials	8	7	0.5	0	0.5
MAJOR PROJECT	Project and Dissertation	18	0	0	0	0
Total Credits		34	28	2	2	2

Note:

- **C represents number of credit per course**
- **T represents number of theory credit per course**
- **P represents number of practical and per course**
- **D represents Demonstration/Tutorial in the lecture hall**
- **PS represents practice session in the lecture hall**

SEMESTER-I

Physics -I

MATHEMATICAL PHYSICS

Course objectives
To provide students the ability to hone the mathematical skills necessary to approach problems in advanced physics courses.

Course content

1. **Complex Variables**: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation. (Lectures 7)

2. **Delta and Gamma Functions:** Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function. (Lectures 7)

3. **Differential Equations:** Partial differential equations of theoretical physics, boundary value, problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution. (Lectures 7)

4. **Special Functions:** Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions: Hermite functions, Laguerre functions. (Lectures 7)

5. **Elementary Statistics:** Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution. (Lectures 7)

Text Books:
1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2011.

Reference Books:
1. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
2. Mathematical Physics: A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi),1986.
3. Mathematical Methods in the Physical Sciences – M.L. Boas (Wiley, New York) 3rd edition, 2007.
4. Special Functions: E.D. Rainville (MacMillan, New York), 1960.
5. Mathematical Methods for Physics and Engineering: K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.

Course outcomes
1. The students will be able to understand and apply the mathematical skills to solve quantitative problems in the study of physics.
2. Will enable students to apply integral transform to solve mathematical problems of interest in physics.
3. The students will be able to use Fourier transforms as an aid for analyzing experimental data.
4. The students should be able to formulate and express a physical law in terms of coordinate transforms.

SEMESTER-I

Physics -II

CLASSICAL PHYSICS

Course objectives

The course aims to develop an understanding of Lagrangian and Hamiltonian formulation which allow for simplified treatments of many complex problems in classical mechanics and provides the foundation for the modern understanding of dynamics.

Course content

1. **Lagrangian Formulation:** Mechanics of a system of particles; constraints of motion, generalized coordinates, d'Alembert Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation. (Lectures 7)

2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems. (Lectures 7)

3. **Hamilton's Equations:** Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action. (Lectures 7)

4. **Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton- Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom. (Lectures 7)

5. **Rigid Body Motion:** Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion. (Lectures 7)

Text Books:

1. Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi), 3rd ed 2001.
2. Mechanics by L.D. Landau & E.M. Lifschz (Pergamon), 1976.

Reference Books:

3. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi), 1988.
4. Classical Mechanics- J. W. Muller- Kirsten (World Scientific) 2008.
5. Advanced Classical & Quantum Dynamics by W. Dittrich, W. And M Reuter, M. (Springer) 1991.
6. Classical mechanics by T.W.B. Kibble and Frank H. Berkshire (Imperial College Press) 2004.
7. Mathematical Methods of Classical Mechanics by V. I. Arnold, (Springer) 1978.

Course outcomes

1. The students will be able to apply the Variational principles to real physical problems.
2. The students will be able to model mechanical systems, both in inertial and rotating frames, using Lagrange and Hamilton equations.

SEMESTER-I

Physics -III

QUANTUM PHYSICS

Course objectives
1. To provide an understanding of the formalism and language of non-relativistic quantum mechanics.
2. To understand the concepts of time-independent perturbation theory and their applications to physical situations.

Course content

1. **Linear Vector Space and Matrix Mechanics:** Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation, Harmonic oscillator in matrix mechanics. (Lectures 8)

2. **Angular Momentum:** Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of L2 and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of J2 and Jz. Representation of general angular momentum operator. (Lectures 7)

3. **Stationary State Approximate Methods:** Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems. (Lectures 8)

4. **Time Dependent Perturbation:** General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light. (Lectures 7)

Text Books:
1. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004.
2. Quantum Mechanics: V.K. Thankappan (New Age, New Delhi), 2004.

Reference Books:
1. Quantum Mechanics: M.P. Khanna (Har Anand, New Delhi), 2006.
2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
3. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
4. Quantum Physics: S. Gasiorowicz (Wiley, New York), 3rd ed. 2002.
5. Quantum Physics: Concepts and Applications: Nouredine Zettili (Wiley, New York), 2nd ed. 2009.

Course outcomes
1. The students will be able to formulate and solve problems in quantum mechanics using Dirac representation.
2. The students will be able t0 grasp the concepts of spin and angular momentum, as well as their quantization and addition rules.
3. The students will be familiar with various approximation methods applied to atomic, nuclear and solid-state physics.

SEMESTER-I

Physics -IV

ELECTRODYNAMICS

Course objectives
1. To evaluate fields and forces in Electrodynamics and Magneto dynamics using basic scientific method.
2. To provide concepts of relativistic electrodynamics and its applications in branches of Physical Sciences.

Course content

1. **Electrostatics:** Electrostatic potential and potential of a charge distribution, dipole moment, Electric Quadrupole and multipoles, Multipole expansion of the scalar potential, Dielectric polarization and its types, Polarization vector, Relation between electric displacement, electric field and Polarisation, Electrostatic energy and energy density in free space and dielectric, Boundary conditions at the interface of two dielectrics. (Lectures 8)

2. **Magnetostatics:** Current density, magnetic induction, Force on a current element: Ampere's Force law, Divergence of magnetic induction, Magnetic scalar and vector potential, Boundary conditions on magnetic fields. (Lectures 6)

3. **Boundary value problems:** Uniqueness theorem, Green's theorem, Green's reciprocation theorem, Solution of electrostatic boundary value problem with Green function, Method of images with examples; Point charge near an infinite grounded conducting plane; Dielectric slab of infinite face in front of a point charge, Laplace and Poisson's equations in different coordinates, Solution of Laplace equation. (Lectures 7)

4. **Maxwell equations and Electromagnetic Waves:** Maxwell equations, Concept of displacement current, Maxwell's equations for free space, static fields and in Phasor notation, Wave equations in free space, non-conducting and conduction medium (Phasor form), Propagation characteristics of EM waves in free space, non-conducting and conducting media, conductors and dielectrics, depth of penetration, Poynting vector, Poynting theorem, (Lectures 8)

Text Books:
1. Classical Electrodynamics: S.P. Puri (Narosa Publishing House) 2011.
2. Classical Electrodynamics: J.D. Jackson, (New Age, New Delhi) 2009.
3. Introduction to Electrodynamics: D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2011.

Reference Books:
1. Classical Electromagnetic Radiation: J.B. Marion and M.A. Heald(Saunders College Publishing House) 2nd edition, 1995.

Course outcomes
1. To explain and solve advanced problems based on classical electrodynamics using Maxwell's equation.
2. The students will be able to analyze s radiation systems in which the electric dipole, magnetic dipole or electric quadruple dominate.
3. The students will have an understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration.

SEMESTER-I

Physics Lab-I

Electronics Lab

Course objectives: The aim and objective of the laboratory on **Electronics Lab** is to expose the students of M.Sc. class to experimental techniques in electronics so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

Note: Students are expected to perform atleast 10 experiments out of following list.

1. Study the forward and reverse characteristics of a Semiconctor/Zener diode.
2. Construction of adder, subtracter, differentiator and integrator circuits using the given OP-Amp.
3. Study the static and drain characteristics of a JFET.
4. Construction of an Astable multivibrator circuit using transistor.
5. Construction of a single FET amplifier with common source configuration.
6. To study the operation of Analog to Digital convertor.
7. To study the operation of Digital to Analog convertor.
8. Construction of a low-pass filter circuit and study its output performance.
9. Construction of a high-pass filter circuit and study its output performance.
10. To verify the Dmorgan's law using Logic Gates circuit.
11. To study the Characteristics of Tunnel Diode.
12. To study Amplitude Modulation.
13. To study Frequency Modulation.
14. To study the Characteristics of SCR.
15. To study the Characteristics of MOSFET.
16. To study the Characteristics of UJT.
17. To study the Characteristics of TRIAC.
18. To verify the different Logic and Arithmetic operations on ALU system.
19. To study the operation of Encoders and Decoders.
20. To study the operation of Left and right shift registers.
21. To study the operation of Counters, Ring counters.
22. To determine the thermal coefficient of a thermistor.
23. To study the operation of an Integrated Circuit Timer.

Text Books:

1. Text Book of Electronics: S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
2. Digital Principles and Applications: A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.

Reference Books:

1. Electronics Principles and Applications: A.B. Bhattacharya, New Central Book Agency P.Ltd., Kolkata, 2007.
2. Integrated Electronics Analog and Digital Circuits and Systems: J. Millman, C.C Halkins and C. Parikh, 2nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

SEMESTER-II

Physics -V

STATISTICAL PHYSICS

Course objectives

1. To have an appreciation for the modern aspects of equilibrium and non-equilibrium statistical physics
2. To describe the features and examples of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics

Course content

1. **The Statistical Basis of Thermodynamics:** The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution. (Lectures 7)

2. **Ensemble Theory:** Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble. (Lectures 8)

3. **Quantum Statistics of Ideal Systems:** Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems. (Lectures 8)

4. **Elements of Phase Transitions:** Introduction, a dynamical model of phase transitions, Ising model in zeroth approximation. (Lectures 8)

Text Books:

1. Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 3rd edition, 2011.

Reference Books:

1. Statistical Mechanics: K. Huang (Wiley Eastern, New Delhi), 1987.
2. Statistical Mechanics: B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) 2nd edition, 2011.
3. Elementary Statistical Physics: C. Kittel (Wiley, New York), 2004.
4. Statistical Mechanics: S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.

Course outcomes

The students will be able to work out equations of state and thermodynamic potentials for elementary systems of particles; and use and develop mean field theory for first and second order phase transitions.

SEMESTER-II

Physics -VI

ATOMIC AND MOLECULAR PHYSICS

Course objectives
1. To provide an understanding of the fundamental aspects of atomic and molecular physics
2. To study spectroscopy of the multi-electron atoms and diatomic molecules

Course content

1. **Electronic Spectroscopy of Atoms:** Bohr-Sommerfeld model of atomic structure, Electronic wave function and atomic quantum numbers – hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum (Lectures 7)

2. **Electronic Spectroscopy of Molecules:** Diatomic molecular spectra: Born-Oppenheimer approximation – vibrational spectra and their progressions – Franck-Condon principle – dissociation energy and their products –rotational fine structure of electronic-vibration transition (Lectures 7)

3. **Microwave and Raman Spectroscopy:** Rotation of molecules and their spectra – diatomic molecules – intensity of line spectra – the effect of isotropic substitution – non-rigid rotator and their spectra – polyatomic molecules (linear and symmetric top molecules) – Classical theory of Raman effect - pure rotational Raman spectra (linear and symmetric top molecules). (Lectures 8)

4. **Infra-red and Raman Spectroscopy:** The energy of diatomic molecules – Simple Harmonic Oscillator - the Anharmonic oscillator– the diatomic vibrating rotator – vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation (Lectures 7)

5. **Spin Resonance Spectroscopy** Spin and magnetic field interaction – Larmor precession – relaxation time – spin-spin relaxation - spin–lattice relaxation - NMR chemical shift - coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR. (Lectures 8)

Text Books:
1. Fundamentals of Molecular Spectroscopy: Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
2. Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.

Reference Books:
1. Physical method for Chemists (Second Edition):Russell S. Drago (Saunders College Publishing).
2. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1924.
3. Spectroscopy Vol. I, II & III: Walker & Straughen
4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1961.
5. Spectra of diatomic molecules: Herzberg-New York, 1944.

Course outcomes
The students will have an understanding of quantum behavior of atoms in external electric and magnetic fields; and become familiar with the working principle of various instruments.

SEMESTER-II

Physics –VII

ELECTRONICS DEVICES AND CIRCUITS

Course objectives
1.To impart knowledge about a To impart knowledge about a variety of special, power and microwave solid state electronic devices, their structure and the underlying physical principles.
2.To expose the students to the integrated circuit chip development technologies and associated processes.

Course content

1. **Electronic Devices:** Varactor diode, photo-diode, Schottky diode, solar cell, Principle of Operation and I-V Characteristics of JFET, MOSFET. Thyristors (SCR, LASCR, Triac and Diac) Microwave semiconductor devices: Tunnel diode, IMPATT, Gunn effect and Gunn diode. (Lectures 7)

2. **Integrated circuits:** Monolithic lC's, Hybrid lC's. Materials for IC fabrication (Si and GaAs), Crystal growth and wafer preparation, processes Epitaxy, Vapour phase epitaxy (VPE), Molecular beam epitaxy (BME), MOCVD Oxidation, Ion implantation, Optical lithography, electron beam lithography, Etching processes. (Lectures 7)

3. **Amplifiers using discrete devices:** Amplifiers using BJTs, FETs, MOSFETs and their analysis. Feedback in amplifiers, **c**haracteristics of negative feedback amplifiers, input resistance, output resistance, method of analysis of a feedback amplifier, feedback types and their analyses, Bode plots, two-pole and three–pole transfer function with Feedback, approximate analysis of a multipole feedback amplifier, stability, gain and phase margins, compensation, dominant-pole compensation, polezero compensation. (Lectures 8)

4. **Operational amplifiers:** Differential Amplifier, emitter-coupled differential amplifier, transfer characteristics of a differential amplifier, current mirror and active load, Measurement of op-amps parameters, frequency response of op-amps. (Lectures 7)

Text Books:
1.Physics of Semiconductor Devices- S. M. Sze
2.Solid State Electronic Devices- B. G. Streetman, PHI

Reference Books:
1.VLSI Technology, S. M. Sze Mc Graw Hill
2.Integrated Electronics, Jacob Millman and Christos Halkias, -Tata McGraw Hill Publication
3.Thomas L. Floyd. ELECTRONIC. DEVICES. 9th Edition. Prentice Hall.

Course outcomes
1.Understanding the physics of the devices their characteristics and applications, to be able to use them in electronic circuits.
2.Students would develop an insight into the technologies that go into an IC chip that they would be extensively using during and after the course.
3.In depth understanding would enable the students to appreciate the beauty of the subject and design amplifiers that are technically sound.

SEMESTER-II

Physics –VIII

CONDENSED MATTER PHYSICS

Course objectives
1. To provide extended knowledge of principles and techniques of solid state physics
2. To provide an understanding of structure, thermal and electrical properties of matter

Course content

1. **Crystal binding and Elastic constants:** Binding in solids; Cohesive energy, Crystals of Inert gases, ionic crystal, Covalent Crystals, Analysis of elastic strains: dilation, stress components; Elastic Compliance and Stiffness: elastic constants, elastic waves in cubic crystals. (Lectures 6)

2. **Lattice Dynamics and Thermal Properties:** Vibrations of crystal with monatomic and two atom per primitive Basis; Quantization of Elastic waves, Phonon momentum; Inelastic scattering by phonons, Phonon Heat Capacity, Planck Distribution, normal modes; Density of states. (Lectures 7)

3. **Energy Band Theory:** Electrons in a periodic potential: Bloch theorem, Nearly free electron model; Kronig Penney Model; Electron in a periodic potential; tight binding method; Wigner-Seitz Method Semiconductor Crystals, Band theory of pure and doped semiconductors; effective mass elementary idea of semiconductor superlattices. (Lectures 7)

4. **Transport Theory:** Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance. (Lectures 7)

5. **Dielectrics and Ferro Electrics:** Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity; Dipole theory of ferroelectricity; thermodynamics of ferroelectric transition. (Lectures 7)

Text Books:
1. Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.
2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

Reference Books:
1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1971
2. Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
3. Liquid Crystals: S. Chandrasekhar (Cambridge University), 2nd ed. 1991.

Course outcomes
The students will be able to formulate basic models for electrons and lattice vibrations for describing the physics of crystalline materials; and develop an understanding of relation between band structure and the electrical/optical properties of a material.

SEMESTER-II

Physics Lab-II

Condensed Matter Physics Lab

Course objectives: The aim and objective of the courses on **Condensed Matter Physics Lab** is to train the students of M.Sc. class to advanced experimental techniques in condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.

Note: Students are expected to perform at least ten experiments out of following list.
1. To study temperature dependence of conductivity of a given semiconductor crystal using four probe method.
2. Verification of curie-weiss law for the electrical susceptibility of a ferroelectric material.
3. To determine charge carrier density and Hall coefficient by Hall effect.
4. To determine magnetic susceptibility of material using Quink 's tube method.
5. To determine energy gap and resistivity of the semiconductor using four probe method.
6. To study the B-H loop characteristics.
7. To determine dielectric constant of a material with Microwave set up.
8. To measure the Curie temperature of a given PZT sample.
9. To measure the velocity of ultrasonic wave in liquids.
10. To study dispersion relation for Mono-atomic and Diatomic lattices using Lattice dynamic kit.
11. To study the properties of crystals using X-Ray Apparatus.

Text Books:
1. Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.
2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

Reference Books:
1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1971
2. Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
3. Liquid Crystals: S. Chandrasekhar (Cambridge University), 2nd ed. 1991.

SEMESTER-III

Physics –IX

NUCLEAR AND PARTICLE PHYSICS

Course objectives
1. To provide an understanding of static properties of nuclei, nuclear decay modes, nuclear force and nuclear models
2. To provide broad understanding of basic experimental nuclear-detection techniques

Course content

1. **Detection of radiations:** Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter (Qualitative description only) . General properties of Radiation detectors, energy resolution, detection efficiency and dead time, Error propagation in experimental data. (Lectures 7)

2. **Detectors:** Introduction to Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber. Organic and inorganic scintillators and their characteristics, (Lectures 8)

3. **Applications of Detectors:** Description of electron and gamma ray spectrum from detector, semiconductor detectors in X- and gamma-ray spectroscopy, Semiconductor detectors for charged particle spectroscopy and particle identification. (Lectures 7)

4. **Experimental methods:** Large gamma and charge particle detector arrays, heavy-ion reaction analysers, production of radioactive ion beams. Detector systems for high energy experiments: Collider physics (brief account), Particle Accelerators (brief account), Modern Hybrid experiments- CMS. (Lectures 7)

Text Books:
1. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

Reference Books:
1. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
2. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
3. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

Course outcomes
The students will have an understanding of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of nuclear radiation with matter; and develop an insight into the building block of matter along with the fundamental interactions of nature.

SEMESTER-III

Physics –X

Advanced Quantum Mechanics

Course objectives
1. To understand the concepts of the time-dependent perturbation theory and their applications to physical situations.
2. To understand the basics of scattering theory.

Course content

1. **Relativistic Quantum Mechanics-I:** Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, the non-relativistic limit of Dirac equation. (Lectures 9)

2. **Relativistic Quantum Mechanics-II:** Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift. (Lectures 9)

3. **Quantum Field Theory:** Resume of Lagrangian and Hamiltonian formalism of a classical field, Noether theorem, Quantization of real scalar field, complex scalar field, Dirac field and electromagnetic field, Covariant perturbation theory, Wick's theorem, Scattering matrix. (Lectures 8)

4. **Feynman diagrams**: Feynman rules, Feynman diagrams and their applications, Yukawa field theory, calculations of scattering cross-sections, decay rates with examples, Quantum Electrodynamics, calculations of matrix elements - for first order and second order. (Lectures 8)

Text Books:
1. Relativistic quantum Mechanics, J D Bjorken and S D Drell, (Tata McGraw Hill, New Delhi) 2012.
2. A first book of Quantum Field Theory, A. Lahiri & P. Pal, (Narosa Publishers, New Delhi), 1st ed. 2005.
3. Introduction to Quantum Field Theory, M. Peskin & D.V. Schroeder. (Levant Books) 2015.

Reference Books:
1. Quantum Field Theory in a Nutshell: A Zee (University Press), 2012.
2. Lecture on Quantum Field Theory, A. Das (World Scientific), 2008.
3. Text Book of Quantum Mechanics-P.M. Mathews & K. Venkatesan (Tata McGraw Hill, New Delhi), 2004.
4. Quantum Field Theory: H. Mandl and G. Shaw (Wiley, New York), 2010.
5. Advance Quantum Mechanics: J.J. Sakurai (Addison- Wesley, Reading), 2004.

Course outcomes
1. The students will be able t0 grasp the concepts of spin arising naturally from the Dirac equation.
2. The students will be familiar with various approximation methods applied to atomic, nuclear and solid-state physics.

SEMESTER-III

Physics –XI

Laser Physics and Applications

Course objectives
1. To identify conditions for lasing phenomenon and properties of the laser.
2. To classify different types of lasers with respect to design and working principles.

Course content

1. **Optical fibre and its properties:** Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. (Lectures 7)

2. **Fiber fabrication and cable design:** Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing. (Lectures 5)

3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S. (Lectures 7)

4. **Electro-optic and acousto-optic effects and modulation of light beams**: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator. (Lectures 9)

Text Books:
1. The Elements of Fibre Optics: S.L.Wymer and Meardon (Regents/Prentice Hall), 1992.

Reference Books:
1. Lasers and Electro-Optics: C.C. Davis (Cambridge University Press), 1996.
2. Optical Electronics: Gathak & Thyagarajan (Cambridge Univ. Press), 1989.
3. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press), 1991.

Course outcomes
1. The students will be able to evaluate conditions for lasing phenomenon and properties of the laser.
2. The students will be familiar with applications of a laser for measurement of distance, holography and medical surgeries etc.

SEMESTER-III

Physics –XII

Computational Physics

Course objectives: The aim and objective of the course on **Computational Physics** is to familiarize the students of M.Sc. students with the numerical methods used in computation and programming using any high level language such as Fortran, C++, etc., so that they can use these in solving simple physics problems.

Course content

1. **Introduction to Computational Physics:** Need and advantages of high level language in physics, programming in a suitable high level language, input/output, interactive input, loading and saving data, loops branches and control flow, Matrices and Vectors, Matrix and array operations, need for Graphic tools. (Lectures 10)

2. **Programming with C++:** Introduction to the Concept of Object Oriented Programming; Advantages of C++ over conventional programming languages; Introduction to Classes, Objects; C++ programming syntax for Input/Output, Operators, Loops, Decisions, simple and inline functions, arrays, strings, pointers; some basic ideas about memory management in C+. (Lectures 10)

3. **Numerical methods:** Computer algorithms, interpolations-cubic spline fitting, Numerical differentiation – Lagrange interpolation, Numerical integration by Simpson and Weddle's rules, Random number generators, Numerical solution of differential equations by Euler, predictor- corrector and Runge-Kutta methods, eigenvalue problems, Monte Carlo simulations. (Lectures 10)

Text Books:
1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.

Reference Books:
1. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
3. Object Oriented Programming with C++: Balagurusamy, (Tata McGraw Hill) 4th edition 2008.

Course outcomes
At the end of the course, the student will be able to-
1. Apply basics knowledge of computational physics in solving the physics problems.
2. Programme with the C++ or any other high level language.
3. Use various numerical methods in solving physics problems.

SEMESTER-III

Physics Lab-III

Laser Physics Lab

Course objectives: The aim and objective of the course on **Fibre Optics and Nonlinear Optics** is to expose the M.Sc. students to the basics of the challenging research field of optical fibres and their use in nonlinear optics.

Note: Students are expected to perform at least eight experiments out of following list.

1. To determine the wavelength of sodium light using Michelson Interferometer
2. Demonstrate interference fringe pattern using Mach Zhender interferometer.
3. Study of mercury spectrum using grating and spectrometer.
4. Determine the coherence length of a diode laser using a Michelson Interferometer.
5. Perform Faraday Effect experiment and find verdet constant of flint glass.
6. To study the birefringence with respect to applied voltage in an electro optic crystal.
7. To determine the Kerr constant of the liquid (Nitro Benzene)
8. Study of hydrogen spectrum using grating and spectrometer.
9. To find the velocity of ultrasonic wave in a liquid using ultrasonic diffraction apparatus.

Text Books:

1. The Elements of Fibre Optics: S.L.Wymer and Meardon (Regents/Prentice Hall), 1992.

Reference Books:

1. Lasers and Electro-Optics: C.C. Davis (Cambridge University Press), 1996.
2. Optical Electronics: Gathak & Thyagarajan (Cambridge Univ. Press), 1989.
3. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press), 1991.

SEMESTER-IV

Physics –XIII

Electronic Instrumentation

Course objectives: Course on Instrumentation and control intends to impart knowledge of measurement, data acquisition and control for experiments.

Course content

1. **Measurement basics:** Range, resolution, linearity, hysteresis, reproducibility and drift, calibration, accuracy and precision. (Lecture 05)

2. **Sensors:** Sensor Systems, characteristics, Instrument Selection, Measurement Issues and Criteria, Acceleration, Shock and Vibration Sensors, Interfacing and Designs, Capacitive and Inductive Displacement Sensors, Magnetic Field Sensors, Flow and Level Sensors, Load Sensors, Strain gauges, Humidity Sensors, Accelerometers, Photosensors, Thermal Infrared Detectors, Contact and Non-contact Position sensors, Motion Sensors, Piezoresistive and Piezoelectric Pressure Sensors, Sensors for Mechanical Shock, Temperature Sensors (contact and non-contact) (Lecture 08)

3. **Actuators :** Correction and regulating elements used in control systems, pneumatic, hydraulic and electric correction elements. (Lecture 05)

4. **Control System** Open loop and closed loop (feedback) systems and stability analysis of these systems, Signal flow graphs and their use in determining transfer functions of systems; transient and steady state analysis of linear time invariant (LTI) control systems and frequency response. (Lecture 07)

Text Books:
1.Electronic Instrumentation -H. S. Kalsi, Tata McGraw-Hill Education, 2010
2.Electronic Instrumentation -W. Bolton

Reference Books:
1.Instrumentation: Electrical and Electronic Measurements and Instrumentation -A. K. Sawhney.
2.Modern Electronic Instrumentation & Measurement Techniques -Helfrick & Cooper.

Course outcomes
1.Learners would develop understanding of various experimental parameters of measurements like range, resolution, reproducibility and precision.
2.Through this course, students would develop an insight into fundamentals of sensors / transducers, data acquisition and processing, noise minimization and control systems for automation.

SEMESTER-IV

Physics –XIV

Physics of Nanomaterials

Course objectives: The aim and objective of the course on **Physics of Nano-materials** is to familiarize the students of M.Sc. to the various aspects related to preparation, characterization and study of different properties of nanomaterials so that they can pursue this emerging research field as career.

Course content

1. **Introductory Aspects:** Free electron theory and its features, Idea of band structure - metals, insulators and semiconductors. Density of state in one, two, and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials. (Lectures 7)

2. **Synthesis of Nanomaterials:** Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling. (Lectures 7)

3. **General Characterization Techniques:** Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy. (Lectures 7)

4. **Quantum Dots:** Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots. (Lectures 7)

5. **Carbon based Nanomaterials:** Synthesis, structural, and electronics properties of fullerenes, carbon nanotubes, and graphene, Functionalisation of carbon Nanomaterials, Applications of carbon based Nanomaterials. (Lectures 7)

Text Books:

1. Nanotechnology-Molecularly Designed Materials: G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.
2. Nanotechnology Molecular Speculations on Global Abundance: B.C. Crandall (MIT Press), 1996.

Reference Books:

1. Quantum Dot Heterostructures: D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley),1998.
2. Introduction to Nanotechnology, Charles P. Poole Jr., Frank J. Owens, Wiley Student edition, John Wiley & Sons Inc. Publishes (2003).
3. Nanotechnology: A gentle introduction to the next Big Idea, Mark Ratner & Daniel Ratner, LPE, Pearson Education (2002).

Course outcomes

1. Acquire knowledge of basic approaches to synthesize the inorganic nanoparticles
2. Understand the physical and chemical properties of carbon nanotubes and nanostructured mesoporous materials.
3. Determine the structure-property relationships in nanomaterials as well as the concepts, not applicable at larger length scales.