छत्रपति शाहू जी महाराज विश्वविद्यालय, कानपुर

CHHATRAPATI SHAHU JI MAHRAJ UNIVERSITY, KANPUR

(पूर्ववर्ती कानपुर विश्वविद्यालय कानपुर)

Formerly Kanpur University, Kanpur – 208024

A Documentary Support

For

Metric No. – 1.1.1

Programme Outcomes & Course Outcomes

Under the

Criteria - I

(Curriculum Design and Development)

Key Indicator - 1.1

In

Metric No. – 1.1.1

M.Sc. Physics

Co-ordinator
Internal Quality Assurance Cell
CSJM University, Kanpur

(Registrar)
C.S.J.M.University
Kanpur

REGISTRAR
C.S.J.M. UNIVERSITY
KANPUR

Department of Physics,
School of Basic Sciences, CSJM University Campus Kanpur.

Vision:

- To excel in quality teaching and research by attracting the best of minds and keep pace with contemporary research in terms of infrastructure and facilities.

Mission:

- The mission of this department is to teach and learn physics in a collaborative, performance- based pathway. We look to encourage the students towards observation and analysis of the natural phenomena of the world and to provide the tools and skills to the students to be the torch bearers of Physics by contributory effectively to the existing laws of nature.

M.Sc. in Physics (2 year duration)
Department of Physics, School of sciences
CSJM University, Kanpur

Program Outcomes of M.Sc. (Physics), School of Basic Sciences:

1. The M.Sc. in Physics program provides the students with knowledge, general competence and analytical skills on an advanced level needed in educational institutes, industry, consultancy, research or public administration.
2. The dissertation work in M.Sc. program gives special expertise with in one of the research areas offered at that department of physics such as High Energy Particle of Physics, Solid State Physics, Fiber Optics and Photonics, Material Characterization Techniques and Laser & Laser applications Physics.
3. This M.Sc. in physics has offered 20 courses during four semesters. The course is so design that after completion of post-graduation program, the students will be able to Create, apply and disseminate knowledge leading to innovation at both local and national level.

4. Think critically through acquired knowledge in various major branches of Physics, explore possibilities and exploit opportunities positively.
5. Sustain intellectual curiosity and know how to continue to learn not only areas that are relevant to physics, but also that are important to society.
6. Successfully carry out advanced tasks and projects, both independently and in collaboration with other discipline.
7. Enhanced regional, national and international competency lead a sustainable life and become socially and environmentally citizens.
8. Lead a sustainable life and become socially and environmentally citizens

Program Specific Outcomes:

1. The Master of Science in Physics programme provides the candidate the required knowledge, general competence, and analytical skills on an advanced level, needed in industry, consultancy, education, research, or in public administration.
2. The students would gain substantial knowledge in various branches of physics: Electronics, Quantum, classical, statistical mechanics, condensed matter physics, astrophysics, particle, nuclear and high energy Physics.
3. Would learn use of mathematical tools in solving complex physical problems and have the solid background and experience required to model, analyze, and solve advanced problems in physics globally.
4. Would able to apply advanced theoretical and/or experimental methods, including the use of numerical methods and simulations.
5. This course would empower the student to acquire scientific and engineering skills and the required practical knowledge by performing experiments in general physics and electronics.
6. Would also get some research oriented experience by doing theoretical and experimental projects in the last semester under the supervision of faculty.
7. The course as a whole opens up several career doors for the students interested in various areas of science and technology in private, public and government sectors.

8. Students may get job opportunities in higher education, research organizations, physics consultancy, radiology, radiation oncology and many others. Some of the institutions where physics students can start their carrier are: BARC, DRDO, NPTC, IISc, ISRO, ONGC, BHEL, PRL, NPL, SINP, VECC, IITs, NITs, IIPR etc.

Program Educational Objectives:

1. The two year M.Sc. in Physics program offered by the department of physics, school of sciences has been designed to impart high quality education in physical sciences.
2. The objectives of the curriculum to prepare students to take up challenges as a researchers/ competitive physicist in diverse areas of theoretical and experimental physics.
3. The program also aims to make the students technically and analytically skilled. In third and fourth semesters the students are offered various elective papers in the following advanced areas: Theoretical high energy physics, fiber optics and photonics, material characterization technique and Laser physics and its applications along with several core subjects of physics. Moreover, the students are trained to carry out laboratory experiments in certain advanced areas of physics such as nuclear physics, electronics and lasers.
4. A research oriented dissertation in 4th semester will enable the students to develop analytical and integrative problem-solving skills.
5. After completing this 2 year M.Sc. (Physics) program the students can pursue higher education in physics by clearing NET, SLET, GATE, UGC-CSIR tests. The course as a whole opens up several career doors for the students interested in various areas of science and technology in private, public and government sectors at national level. Students may get job opportunities in higher education, research organization, physics consultancy, radiology and many others.
6. There are some institutions like BARC, DRDO, NTPC, ISRO, SINP, VECC, IITs, NIT, etc where physics students can start their career after completing the master degree in physics.

□ Local □ Regional □ National □ Global

Semester-wise Course Structure

First Year				Second Year			
I[st] Semester		**2[nd] Semester**		**3[rd] Semester**		**4[th] Semester**	
Paper/Type	Credit	Paper/Type	Credit	Paper/Type	Credit	Paper/Type	Credit
Mathematical Physics Core	4	Numerical Analysis & Computer Programming Core	4	Atomic and Molecular Physics Core	4	Nuclear and Particle Physics Core	5
Classical Mechanics Core	4	Statistical Physics Core	4	Fiber optics and Photonics Core	4	Electronics-2 Core	5
Quantum Mechanics- I Core	4	Electronics-1 Core	4	Quantum Mechanics- II Core	4	Condensed Matter Physics-2 Core	5
Condensed Matter Physics-1 Core	4	Elective-1 **High energy particle Physics** **Or** **Electrodynamics**	4	Elective-2 **Material Characterization Techniques** **Or** **Physics of Nano Materials**	4	Elective-3 **Physics of Lasers and Applications** **Or** **Plasma Physics**	5
Laboratory-I	4	Laboratory-II	4	Laboratory-III	4		-
Research Project	-	Research Project	8	Research Project	-	Research Project	8
Total credits	20		28		20		28
Minor elective from other department faculty to be taken in I[st] year only(I[st] or II[nd] semester)							
Minimum credits annually	**52**			**48**			

Semester-I, Total Marks: 500, Credit:24

Sl.No.	Course Code	Name of Paper	Maximum mark	Credit
1.	MPC-101	Mathematical Physics	100	4
2.	MPC-102	Classical Mechanics	100	4
3.	MPC-103	Quantum Mechanics- I	100	4
4.	MPC-104	Condensed Matter Physics-1	100	4
5.	MPL-105	Laboratory-I	100	4
6	MPR-110	Research Project	-	-

Semester-II, Total Marks:700, Credit:28

Sl. No.	Course Code	Name of Paper	Maximum mark	Credit
7.	MPC-201	**Numerical Analysis & Computer Programming**	100	4
8.	MPC-202	Statistical Physics	100	4
9.	MPC-203	Electronics-1	100	4
10.	MPE-204/ MPE-205	Elective-1	100	4
11.	MPL-206	Laboratory-II	100	4
12.	MPC-207	Minor (from other faculty)	100	4
	MPR-210	Research Project	100	8

Semester-III, Total Marks: 500, Credit:24

Sl. No.	Course Code	Name of Paper	Maximum mark	Credit
13.	MPC-301	Atomic and Molecular Physics	100	4
14.	MPC-302	Fiber optics and Photonics	100	4
15.	MPC-303	Quantum Mechanics- II	100	4
16.	MPE-304/ MPE-305	Elective-2	100	4
17.	MPL-306	Laboratory-III	100	4
18.	MPR-310	Research Project	-	-

Semester-IV, Total Marks: 500, Credit: 24

Sl. No.	Course Code	Name of Paper	Maximum mark	Credit
19.	MPC-401	Nuclear and Particle Physics	100	5
20.	MPC-402	Electronics-2:	100	5
21.	MPC-403	Condensed Matter Physics-2	100	5
22.	MPE-404/MPE-405	Elective-3	100	5
23.	MPR-410	Research Project	100	8

Students may select one of the following elective papers:

Semester-II- Elective I

- MPE-204: High energy particle Physics
- MPE-205: Electrodynamics

Semester-III- Elective II

- MPE-304: Material Characterization Techniques
- MPE-305: Physics of Nano Materials

Semester-IV- Elective III

- MPE-404: Physics of Lasers and Applications
- MPE-405: Plasma Physics

Detailed Syllabus

SEMESTER-I

Course Code: MPC-101 **Full Marks: 100, Credit: 4**
Course Name : Mathematical Physics

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Gain knowledge about special type of matrices that are relevant in physics and then learn about tensors which can be applicable globally.
CO2	Get introduced to special functions like Gamma function, Beta function Delta function, Dirac Delta function, Bessel functions and their recurrence relations.
CO3	Learn different ways of solving second order differential equations and familiarized with singular points and Frobenius method.
CO4	Learn the fundamentals and applications of Fourier series, Fourier and Laplace transforms, their inverse transforms etc. These mathematical concepts are widely used in various physics derivations.
CO5	Knowledge about special type of matrices that are relevant in physics and then learn about tensors.

Course Details:

Unit I- Elementary ideas about tensors:
Covariant and contravariant tensor, Addition and multiplication of tensors, Tensor contraction, Kronecker delta and Levi-Civita symbols, Definition of stress and strain tensor, moment of inertia tensor, dielectric tensor.

Unit II- Elements of complex analysis:
Analyticity, Cauchy-Riemann condition, Singularities, Cauchy's theorem and integral formula, calculus of residues, Evaluating integrals.

Unit III- Second order linear differential equation:
Series solution of Bessel, Legendre, laguerre and Hermits equations, Generating functions, Recurrence relations and Ortho-normal properties, Green function.

Unit IV- Fourier series and Integral transforms:
Fourier Series of even and odd function, fourier sine and cosine integrals, Laplace transform, Inverse Laplace transform, its properties and applications, Laplace transform of Dirac delta function, Fourier transform and inverse Fourier transform, their properties and applications.

Text and Reference Books:

1. Mathematical Methods for Physicists by G.Arfken and H.Weber, 6E, Elsevier Academic Press 2005.
2. Advanced Engineering Mathematics by E. Kreyszig, 10E, John Wiley & Sons Inc. 2011.
3. Mathematical Physics by H. K. Dass, 1E, S Chand & Company 1997.

SEMESTER-I

Course Code: MPC-102 **Full Marks: 100, Credit: 4**

Course Name: Classical Mechanics

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	This paper enables the students to understand the Lagrangian and Hamiltonian approaches in classical Mechanics.
CO2	The classical background of Quantum mechanics and get familiarized with poisson brackets and Hamilton- Jacobi equation
CO3	Kinematics and dynamics of rigid body in detail and ideas regarding Euler's equation of motion
CO4	Theory of small oscillations in detail along with basis of free vibrations.
CO5	This paper enables the students to understand the Lagrangian and Hamiltonian approaches in classical Mechanics.

Course Details:

Unit I- Review of Newtonian mechanics: Constraints, D' Alemnbert's principle, Generalized coordinates, Lagrange's equation, Gyroscopic forces, Dissipative systems, gauge invariance, Generalized momenta, Symmetries of space and time with conservation laws, invariance under Galilean transformations.

Unit II- Central forces: definition and characteristics, Two body problems, General analysis oforbits, Keplar's laws and equation, closure and stability of circular orbits, Rutherford scattering.

Unit III- Hamiltonian equations: Principal of least action, derivation of equation of motion,Variation and end points, Hamilton principle and characteristic functions.

Unit IV- Canonical transformations: generating functions, Properties, infinitesimal generators, Poisson Brackets, Poisson theorems, Angular momentum Poisson brackets.

Unit V- Hamilton — Jacobi theory: Harmonic oscillator and Kepler's problem by Hamilton-Jacobi method, Action angle variables.

Unit VI- Problem of Small oscillations: Examples of two coupled oscillators, General theory of normal coordinates and normal modes of vibration.

Text and Reference Book:

1. Classical Mechanics by H.Goldstein, 2E, Narosa Publishing House, Delhi 2018.
2. Classical Mechanics by N.C. Rana and P.S. Joag, Tata McGraw-Hill , New Delhi, 2001.
3. Classical Mechanics by J.C. Upadhyaya, 3E, Himalaya Publishing House, Mumbai, 2022
4. Classical Mechanics of Particles and Rigid Bodies by K.C. Gupta, 3E, New Age International Ltd, New Delhi, 2018.

SEMESTER-I

Course Code: MPC-103 **Full Marks: 100, Credit: 4**

Course Name: Quantum Mechanics

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Linear vector spaces, Hilbert space, concepts of basis and operators and bra and ket notation.
CO2	Both Schrodinger and Heisenberg formulations of time development and their applications.
CO3	Theory of angular momentum and spin matrices, orbital angular momentum and Clebsh Gordan Coefficient, space time matrices and conservation laws, Theory of identical particles.
CO4	Theory of scattering and calculations of scattering cross section, optical theorem, partial wave analysis.
CO5	Linear vector spaces, Hilbert space, concepts of basis and operators and bra and ket notation.

Course Details:

Unit I- Dimension and basis of vector space: Hilbert space, Dirac bra-ket notation, equation, equations of motion, observables and operator, Eigen values and Eigen vectors of an operator.

Unit II- Matrix representation of operators: solution of one-dimensional harmonic oscillator by operator method, unitary transformations, Dirac delta function Postulate of QM values expectation values and their time evolution Poisson bracket and commutator.

Unit III- Angular Momentum: Matrix representation, Eigen function and Eigen value 0f L_x and $L^{2'}$ operators, solution. of Schrodinger equation. for spherically symmetric potentials, Hydrogen atom, spin angular momentum, spin 1/2 and Pauli matrices, total angular momentum, addition of two angular moments, Clebsch -Gordan coefficients.

Unit IV- Identical Particles: Symmetric and anti-Symmetric wave functions, Pauli exclusion principle, collision of identical particles.

Text and Reference Book:

1. Quantum Mechanics Theory and Applications by A. Ghatak and S. Lokanathan, 5E, Macmillan, 2004.
2. A Textbook of Quantum Mechanics by P.M. Mathews and K. Venkatesan, 2E, McGraw-Hill Education (India) Pvt Limited, 2010.
3. Quantum Mechanics Concepts & Applications by N. Zettili, 2E, John Wiley & Sons Inc. 2009.
4. Quantum Mechanics by L.I. Schiff, 4E McGraw-Hill Education (India) Pvt Limited, 2017.
5. Introduction to Quantum Mechanics by D.J.Griffiths, 3E, Cambridge University Press 2018.
6. Quantum Mechanics by J.L.Powell and B.Crasemann, Addison-Wesley, 1961.
7. Quantum Mechanics by E.Merzbacher, 3E, John Wiley & Sons Inc. 2011.

SEMESTER-I

Course Code: MPC-104 **Full Marks: 100, Credit: 4**
Course Name: Condensed Matter Physics-I
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Identify the Crystal structure
CO2	Learn about X-ray electron and neutron Scattering
CO3	Learn about Bloch theorem
CO4	Identify defects in crystal structure which has significant role while preparing material for both local and national level applications

Course Details:

Unit I- Crystallography: Fundamentals of crystallography, symmetry operations, crystal systems, Bravais lattices, unit cells, primitive cells, crystallographic planes and directions, symmetry elements in crystals, proper rotation axis, plane of symmetry, inversion centre, screw axis, glide plane, Type of Bravais lattices, closed packed structures, diamond structure, Zinc blend structure, Weigner-Seitz cell, Miller indices, Liquid crystals.

Unit II- X-rays Diffraction and Reciprocal Lattice: Choice of x-ray, electron and neutron for crystal structure determination, Bragg's diffraction, Reciprocal lattice, The Braggs condition and Ewald construction, Brillouin zones of SC, BC and FCC lattices, Atomic scattering factor, Geometrical structure factor, Laue method, Rotating crystal method, Powder method, Debye Scherer technique, Analysis of powder photograph, Crystal structure determination.

Unit III- Electron in a periodic lattice: Bloch **theorem,** Band theory, Effective mass, Nearly free electron approximation, tight binding approximation, Fermi surfaces, Cyclotron resonance, The De Hass-Van Alfen effect, Magneto resistance, quantum Hall effect. Weiss theory of ferromagnetism, Heisenberg model, Mean field theory, Exchange intraction, Spin waves and magnons, Curie-Weiss law for susceptibility, Domain theory and hysteresis loop, Bloch wall, Anti-ferromagnetism, Ferrimagnetic materials.

Unit IV- Imperfections in Crystal: Point imperfections, Vacancies, Interstitial, Schottky and Frenkel defect. Colour centres, Dislocation of elastic and plastic deformation of solids, Slip planes, Critical resolved shear stress, Elastic energy, Frank and Reid source, Stacking faults, Grain boundaries, Tilt boundaries, and Twin boundaries, Whiskers, Observations of dislocation and other defects.

Text and Reference books:

1. X-Ray diffraction by B.D.Cullity, 3E, Pearson 2001.
2. Interpretation of X-ray Diffraction Photographs by Henry, Lipson and Booster, Macmillian Ltd, London 1961.
3. Crystal Structure Analysis by M. J. Burger, John Wiley, 1960.
4. Elementary Solid State Physics by M.Ali Omar, 1E, Pearson India, 2002.
5. Solid State Physics by Charles Kittel, 8E, John Wiley & Sons Inc. 2012.
6. Principles of Condensed Matter Physics by P.MChaikin and T.C. Lubensky, Cambridge University Press, 1995.
7. Solid state physic by N.W. Aschroft and N.D. Mermin, 2E, CENGAGE Learning Asia, 2016.
8. Introduction to Solids by L. Azaroff, McGraw Hill Education, 2017.

SEMESTER-I

Course Code: MPL-105 **Full Marks: 100, Credit: 4**
Course Name: Laboratory -I

Course outcomes (CO): At the end of the lab course, the student will be able to:

CO1	Perform basic experiments related to Optics
CO2	Be familiar with various measuring instruments and also would learn the importance of accuracy of measurements.

Name of Experiments:-

- Measurement of wavelength of He-Ne laser using a steel scale.
- Passive Filter
- Resolving power of prism
- Young's Modulus and Poisson’s ratio of glass by Cornu's fringes
- Verification of Fresnel's formula
- Thermal and electrical conductivity of copper and thermal conductivity of a poor conductor
- Verification of Curie and Weiss law for a ceramic capacitor
- Calibration of a silicon diode and copper constantan thermocouple against Pt Resistance thermometer

SEMESTER-II

Course Code: MPC-201 **Full Marks: 100, Credit: 4**
Course Name: Numerical Analysis & Computer Programming
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understanding of methods of determination of zeroes of linear and nonlinear algebraic and transcendental equations,convergence of solutions.
CO2	Know about Solution of simultaneous linear equation
CO3	Knowledge of numerical differentiation and integration
CO4	To learn numerical solution of ordinary differential equations

Course Details:

Unit I- Computational Methods:
Methods of determination of zeroes of linear and nonlinear algebraic and transcendental equations, convergence of solutions.

Unit II- Numerical Solution of linear equation and Ordinary Differential Equation:
Gaussian elimination, Iterative method, Matrix inversion, Eigen values and Eigen vectors of matrices, Power and Jacobi method, Euler's and Runge-Kutta method, Predictor-Corrector methods, Elementary ideas of solution of partial differential equations. **Finite differences:** Interpolation with equally spaced and unevenly spaced points curve fitting, polynomial least squares and cubic spline fitting.

Unit III- Numerical differentiation and integration:
Trapezoidal, Simpson and Gaussian integration Methods, Newton-Cotes formula, Cubic spline method. Monte- Carlo evaluation of integrals, Methods of importance sampling.

Unit IV: Introduction to computers and Computer Programming in FORTRAN
Basic Structure and functioning of computers Memory, I/O devices. Secondary storage Computer languages, Introduction to UNIX and WINDOWS Data Processing, principle of programming, Algorithms and flow-charts. Elements of the computer language, Constants and variables, Expressions, Arithmatic assignment statement, Input and Output, Format statement, Termination statements, branching statements

Unit V: Idea of Simulation

Generation of uniformly distributed random integers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Metropolis algorithm, Random walk problems and their Monte-Carlo simulation.

Text and Reference Books:

1. Introductory methods of Numerical Analysis by S. S. Sastry, 5E, Prentice Hall India, 2012.
2. Matrices and tensors for physicist by A. W. Joshi, 3E, New Age International, 1995.
3. Numerical analysis by V. Rajaraman, 3E, Prentice Hall of India, 1993.
4. Computer Programming in FORTRAN 77 by V. Rajaraman, 4E, Prentice-Hall of India, 2009.
5. A Guide to Monte Carlo Simulations in Statistical Physics by D.P.Landau and K.Binder, 3E, Cambridge University Press, 2009.

SEMESTER-II

Course Code: MPC-202 **Full Marks: 100, Credit: 4**
Course Name: Statistical Physics
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Explain statistical physics and thermodynamics as logical consequences of the postulates of Statistical mechanics, Apply the principles of statistical mechanics to selected problems.
CO2	Grasp the basis of ensemble approach in statistical mechanics to a range of situation.
CO3	To learn the fundamental differences between classical and quantum statistics.

Course Details:

Unit I- Foundation of Statistical Physics: Review of probability concepts; Random talk problem in one dimension-binomial distribution, Specification of state of system, Macrostates and microstates, Concept of statistical equilibrium, Fundamenta1 postulates of equal a priory probability.
Unit II Ensembles: Micro-canonical, Canonical and grand canonical ensembles and their comparative study, Partition function, Calculation of statistical quantities in terms of partition function (connection to thermodynamics), Entropy of mixing of gases (using partition function), Gibbs paradox and its resolution; Derivation of equation of state of classical ideal gas using partition function
Unit III Statistical Mechanics: Ideal quantum gases, Indistinguishability, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics and its applications, Photon statistics, Ideal Bose gas, Bose-Einstein condensation, Ideal Fermi gas, Correlation function. Planck's Radiation formula, Concept of Fermi Energy, Fermi temperature and Fermi velocity. Low Specific heat of metals.
Unit IV Interacting systems: Virial expansion of equation of state, Second Virial coefficient, Ising model, Weiss molecular mean field theory of ferromagnetism.

Text and Reference Book :

1. Fundamental of statistical and Thermal Physics by F.Reif, 2E, Tata-McGraw Hill, 2010.
2. Statistical Physics by L.D. Landau and E.M. Lifshitz, course on Theoretical Physics, Vol.5, Pergamon Press, 1970.
3. Statistical Mechanics by K.Huang, 2E, John Wiley &Sons, 2008.
4. Statistical Physics by R.K.Patharia, 4E, Academic Press Inc.2021.

SEMESTER-II

Course Code: MPC-203 **Full Marks: 100, Credit: 4**
Course Name: Electronics I
Course outcomes (CO): At the end of the course, the student will be able to learn :

CO1	Power bipolar junction transistor, Power MOSFET, Junction Transistor, Silicon controlled rectifier applications
CO2	Schottky Barrier FET (MES FET) avalanche and transit time Tunnel diode.
CO3	Electron – Hole pair generation, Light emitting diode, Photoconductivity Cell, Photodiode applications
CO4	Complementary metal oxide semiconductor, Static random access memory

Course Details:

Unit I-Basics of Operational Amplifier: Differential Amplifier, circuit configurations, dual input balanced output differential amplifier. DC analysis, AC analysis, inverting and non-inverting inputs, CMRR, constant current bias, level translator. Block diagram of a typical Op-Amp analysis. Schematic Symbols, Integrated circuits and pin identification, Open Loop Operational Amplifier Configurations (Differential, Inverting and Non-inverting) Op-Amp with negative feedback, voltage series and shunt feedback, Inverting and non-inverting amplifiers, effect of feedback on closed loop gain, input resistance, output resistance, bandwidth and output offset voltage, voltage follower. Practical Op-Amp input offset voltage, input bias current, input offset current, total output offset voltage, CMRR frequency response.

Unit II - OpAmp Applications: Addition, Subtraction, Summing, scaling and averaging amplifier, Integrator and differentiator, Logarithmic and anti logarithmic amplifier, Oscillators principles, oscillator types, frequency Stability, response, Phase shift, Wein bridge, LC tunable oscillators, Square wave and Triangular wave generators, VCO, Comparators, Schmitt trigger, V/F and F/V converter, A/D and *D/A* converters, Sample and hold circuit, multivibrators.
Unit III- Memory and other devices: Complementary metal oxide scmiconductor (CMOS), MOSFET transistors as n-channel (NMOS), Static random acces s memory (SRAM) and dynamic random access memory (DRAM), Read only memory (ROM), electrically programmable ROM (EPROM) and electrically erasable programmable ROM

(EEPROM), volatile and non volatile memory, Magnetic, optical and ferroelectric memories and devices, Charge coupled device (CCD). Piezoelectric, electrostrictive and magnetostrictive effect related materials and their application in devices.

Unit IV -High frequency devices: Frequency dependence of gain, transit time effect in bipolar and in field effect transistors, Schottky Barrier FET (MES FET), modulation doped transistor (MODFET or HEMT) , Ballistic transistors- Metal base transistors, ballistic GaAs Transistors Two terminal devices- Gunn diode, Impact avalanche and transit time (IMPATT) diode Tunnel diode.

Text and Reference books:

1. Optical Electronics by A.Ghatak and K.Thygrajan, 1E, Cambridge University Press, 2012.
2. Introduction to semiconductor materials and devices by M.S.Tyagi, 2E, John Wiley & Sons 2008.
3. Physics and Technology of Semiconductor Devices by S.M.Sze, 3E, John Wiley &Sons, 2008.

SEMESTER-II

Course Code: MPE-204 Elective Paper **Full Marks: 100, Credit: 4**
Course Name: High Energy Particle Physics
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understanding about basic concepts of high energy particles
CO2	Their decay and lifetime. Students will also gain knowledge about the unification of the fundamental forces like strong weak and electromagnetic forces through the gauge group $SU(3)_c \times SU(2)_L \times U(I)_Y$.

Course Details:

Unit I- Symmetries and Conservation Laws

Conservation laws, parity transformations, charge conjugation, time reversal, CPT theorem, G-parity, Gell-Mann-Nishijima relation, Isotopic Spin, Lie algebras and fundamental representations of SU(2) and SU(3).

Unit II- Quark Model of Hadrons

Historical development of the quark model, Quark flavors and colours, quark-antiquark and three quark bound states of Mesons and Baryons, colour factors, Application of quark model to Hadron masses, Quark Parton model.

Unit III- Weak Interactions

Intermediate vector bosons, four-fermi interactions, parity violation and V-A theory of weak current, CP violation in Kaon decays.

Unit IV- Gauge Invariances

Global and local gauge symmetries, Noether's theorem and conservation laws, Abelian and Non-Abelian gauge invariance.

Unit V- Standard Model and Beyond Spontaneous breaking of gauge symmetry, Higggs mechanism, Glashow-Salam-Weinberg theory of electroweak interactions, fermion masses, Phenomenlogy of extra dimensions.

Text and Reference books:

1. Quarks and Leptons: Quarks and Leptons by F. Halzen and A.D. Martin, Wiley India, 2008.
2. Introduction to Particle Physics by M. P. Khanna, PHI Learning, 1998.
3. Gauge Theories in Particle Physics by I.J.R. Aitchison and A.J.G.Hey, 4E (2Vol Set), CRC Press, 2021.
4. Lapton and Quarks by L.B. Okum, 1E, , Elsevier Academic Press 1992.
5. Gauge theory of elementary Particles by T.P. Cheng and L.F. Li, Oxford Science Publications, 1984.
6. Weak interaction of Leptons and Quarks by P.H. Bucksbaum and E. D. Cummins, Cambridge University Press, 1983.
7. Introduction of High Energy Physics by D. H. Perkins, 4E, Cambridge University Press, 2012.
8. An introduction to Quarks and Partons by F. E.Close, Academic Press, 1979.

SEMESTER-II

Course Code: MPE-205 Elective Paper **Full Marks: 100, Credit: 4**
Course Name: Electrodynamics
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Students get a knowledge of Maxwell'sequations, Lineard-Wiechart potential,
CO2	Study related to electric and magnetic fields due to a uniformly moving charge
CO3	Get knowledge of angular distribution of power radiated, Synchrotron radiation and Cerenkov radiation,Reaction force of radiation.
CO4	Understanding of Lorentz transformation in four dimensional space,Four vectors and their transformation

Course Details:

Unit I- Maxwell's equations, Wave equations for vector and scalar potential and solutions, Lineard-Wiechart potential.

Unit II- Electric and Magnetic fields due to a uniformly moving charge and an accelerated charge, Power radiated by a point charge, Linear and circular acceleration,angular distribution of power radiated, Synchrotron radiation and Cerenkov radiation, Reaction force of radiation.

Unit III - Lorentz transformation in four dimensional space, Four vectors (x, del, p, *J,* A) and their transformation under LT, Electromagnetic field tensor F, Maxwell's equations in terms of F, Dual field tensor, Transformation of electric and magnetic field.

Text and Reference Book:

1. Introduction to Electrodynamics by D.J. Griffiths, 3E, Prentice-Hall of India Private Limited, 2002.
2. Electricity and Magnetism (In SI Units): Berkeley Physics Course Vol 2, E.M. Purcell, 2E McGraw Hill, 2017.
3. The Feynman Lectures on Physics - Vol. 2, Richard P. Feynman, Robert B. Leighton, Matthew Sands, Pearson Education Limited, 2012.
4. Electricity and Magnetism, D.C. Tayal, 4E, Himalaya Publishing House Pvt. Ltd., 2019.

SEMESTER-II

Course Code: MPL-206 **Full Marks: 100, Credit: 4**
Course Name: Laboratory-II

Course outcomes (CO): At the end of the lab course, the student will be able to learn:

CO1	Get knowledge of experimental technique to measurement of inductance and capacitance and study of LCR series and parallel
CO2	Come to know about I-V characteristics of Silicon controlled rectifier,Uni-junction transistor, MOSFET characteristics.

Name of Experiments:-

1. Measurement of inductance and capacitance and study of LCR series and parallel
2. I-V characteristics of Silicon controlled rectifier
3. I-V characteristics of Uni-junction transistor
4. MOSFET characteristics.
5. Measurement of inductance and capacitance using AC bridges
6. AC Experiments Measurements of L and C and Series and parallel Resonant circuits.
7. Rigidity modulus of a brass wire.

SEMESTER-III

Course Code: MPC-301 **Full Marks: 100, Credit: 4**
Course Name: Atomic and Molecular Physics
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	know about different atom model and will be able to differentiate different atomic systems, different coupling schemes and their interactions with magnetic and electric fields.
CO2	Have gained ability to apply the techniques of microwave and infrared spectroscopy to elucidate the structure of molecules.
CO3	Be able to apply the principle of Raman spectroscopy and its applications in the different field of science & Technology.
CO4	To become familiar with different resonance spectroscopic techniques and its applications.
CO5	To find solutions to problems related different spectroscopic systems.

Course Details:

Unit I- Atomic Spectra: Quantum States of an electron in an atom, Hydrogen Spectrum, Spin-orbit interaction and fine structure , Term symbols, equivalent and non equivalent electrons, spectra of alkali elements, Normal and anomalous Zeeman effect, Paschen-Back effect, Stark effect, LS and JJ Couplings, hyperfine structure, line broadening mechanisms

Unit II- Molecular Spectra: Types of molecules, diatomic, linear, symmetric top, asymmetric top and spherical top molecules, Microwave Spectroscopy- Rotational spectra of diatomic molecules (rigid and non rigid rotor model), microwave spectrometer

Unit III- Infrared Spectroscopy- Vibrational Spectra, Diatomic molecule as a simple harmonic and anharmonic oscillator, energy levels and infrared spectra, molecule as vibrating rotor, P, Q and R branches, IR spectre of polyatomic systems

Unit IV- Raman Spectra, Principle of mutual exclusion, Structure determination Raman Spectroscopy.

Text and Reference books:

1. Introduction to Atomic Spectra by H.E. White, McGraw Hill, 1934
2. Fundamentals of Molecular Spectroscopy by, C.N. Banwell, E.M. McCash, 4E, McGraw Hill, 2017.
3. Introduction to Molecular Spectroscopy by G.M.Barrow, McGraw Hill, 1962.
4. Modern Physics by R Murugeshan, Kiruthiga Sivaprasath, 18E, S. Chand Publishing, 2019
5. Elements of Spectroscopy by S.L. Gupta, V. Kumar, R.C. Sharma, 27E, Pragati Prakashan, Meerut, 2015.

SEMESTER-III

Course Code: MPC-302 **Full Marks: 100, Credit: 4**
Course Name: Fibre Optics and Photonics
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Get knowledge of Fibers and photonics, their working principles and applications.
CO2	This course provides students with a working knowledge of optical physics, including diffraction and physical optics, atomic physics and optical spectroscopy, laser physics and photonics. It gives information about various applications.

Course Details:

Unit I- Modal propagation in Optical Fiber:
Modal propagation characteristics of step index and graded index fibers, weakly guided step index fibers, losses in fibers, material dispersion , numerical techniques of the analysis of simple optical waveguides in weak guidance approximation.

Unit II- Fiber Optics Technology:
Waveguide dispersion and design consideration, optical materials, fabrication, cabling and installation of optical fibers, optical joints and couplers, integrated optical waveguide types, modes in asymmetric planar waveguide, channel and strip waveguides.

Unit III- Periodic Optical Fibers:
Guided and defect modes in periodic optical waveguides, optical filters and monochromator, Bragg's reflection waveguides and Bragg's filters, Helically cladded optical fibers and their applications, Modes selection in different fibers.

Unit IV- Optical Solitons and Application of Fiber Optics:
Analysis of optical solitons and their applications, leaky modes, Optical Amplification and Si – doped waveguides, Application of fiber optics in non- communication and sensors.

Unit V- Photonic Band Gap Materials:
Photonic crystal, Photonic crystal fibers, Photonic band gap structure, Analytical and numerical study of photonic band gap fibers and their dispersion characteristics, reflectance, transmittance in PBG fibers, negative refractive materials, optical filters from photonic band gap and its application in loss bonds and high Q cavities.

Text and Reference books:

1. Optical Fiber Communications: Principles and Practice by M. Senior, 3E, Pearson Education Limited, 2010.
2. Introduction to fiber optics by Ajoy Ghatak and K. Tyagrajan, 1E, Cambridge University Press, 2012.
3. Optoelectronics: Principles and Practice by Wilson, John Hawkes, 3E, Pearson Education Limited, 2018.
4. Fiber optic communication technology by D.K. Mynbav and L.L. Scheiner, Prentice hall, 2001.

SEMESTER-III

Course Code: MPC-303 **Full Marks: 100, Credit: 4**

Course Name: Quantum Mechanics-II

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	The primary goal of this course is to develop an understanding of some of the more advanced topics and techniques used in quantum mechanics.
CO2	The candidate should have knowledge about: - Fundamental concepts and the mathematical formalism used in the general formulation of quantum mechanics (QM)

Course Details:

Unit I- Approximation method for stationary states: Perturbation theory (non degenerate and degenerate case), Variational method, WKB method.

Unit II- Time-dependent perturbation theory: Fermi golden rule, Harmonic Perturbation. Semi-classical theory of radiation: Transition probability for absorption and induced emission (stimulated), Electric dipole approximation, Selection rules, Forbidden transitions. Transition probability for spontaneous emission Einstein's A and B coefficients.

Unit III- Scattering: Differential scattering cross section and total scattering cross section, scattering in the Lab and CM frames, scattering amplitude, Born approximation., Partial wave analysis for elastic scattering, phase shift, optical theorem, scattering by a perfectly rigid sphere and by an attractive; square well potential.

Unit IV- Relativistic wave equations: Klein-Gordan equation, its interpretation and free particle solution, Free particle Dirac equation. and plane wave solution, alpha and beta matrices, covariant form of Dirac equation. Gamma matrices, spin and magnetic moment of electron, interpretation of negative energy states.

Text and Reference books:

1. Introduction to Quantum Mechanics by D.J. Griffiths, 2E, Pearson Education, India, 2004.
2. Quantum Physics (In SI Units) BY E. Wichmann, Berkeley Physics Course Vol 4, McGraw Hill, 2017.
3. The Feynman Lectures on Physics BY Richard P. Feynman, Robert B. Leighton, Matthew Sands, Vol. 3, Pearson Education Limited, 2012.
4. A Textbook of Quantum Mechanics by P.M. Mathews and K. Venkatesan, 2E, McGraw-Hill Education (India) Pvt Limited, 2010.
5. Quantum Mechanics Concepts & Applications by N. Zettili, 2E, John Wiley & Sons Inc. 2009.
6. Quantum Mechanics by L.I. Schiff, 4E McGraw-Hill Education (India) Pvt Limited, 2017.
7. Introduction to Quantum Mechanics by D.J.Griffiths, 3E, Cambridge University Press 2018.
8. Quantum Mechanics by J.L.Powell and B.Crasemann, Addison-Wesley, 1961.
9. Quantum Mechanics by E.Merzbacher, 3E, John Wiley & Sons Inc. 2011.

SEMESTER-III

Course Code: MPE-304 **Full Marks: 100, Credit: 4**

Course Name: Materials Characterizations

Course outcomes (CO): At the end of the course, the student will be able to learn :

CO1	Characterization techniques to analyze the Structural Properties
CO2	Characterization techniques to analyze the Surface Properties
CO3	Characterization techniques to analyze the Thermal Properties
CO4	Characterization techniques to analyze the Optical Properties
CO5	Characterization techniques to analyze the Magnetic Properties

Course Details:

Unit I- Introduction to materials and techniques; Spectroscopic methods- UV-visible and vibrational spectroscopy- Infrared and Raman spectroscopy, Electron spectroscopy

Unit II- Optical microscopy, Electron microscopy, SEM, TEM, X-ray photoelectron spectroscopy, Auger electron spectroscopy, Scanning Probe Microscopies: STM, AFM

Unit III- Thermal analysis- TGA, DTA, DSC, DMA, TMA, DETA

Unit IV- NMR, RBS, Positron Annihilation Spectroscopy, Mossabauer Spectroscopy

Text and Reference books:

1. Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods by Y. Leng, 2E, John Wiley & Sons, 2008.
2. Materials Characterisation Techniques by S. Zhang, Lin Li, A. Kumar, CRC Press, 2008.
3. Instrumental Analysis by D.A. Skoog, F.J. Holler, S. R. Crouch, 6E, Thomson Brooks, 2007.
4. Surface Analysis: The Principal Techniques by J.C. Vickerman, I. Gilmore, 2E., John Wiley & Sons, Inc.2009.
5. Thermal Methods of Analysis by W. W. Wendlandt, John Wiley, 1974.

SEMESTER-III

Course Code: MPE-305 **Full Marks: 100, Credit: 4**

Course Name: Physics of Nano Materials

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Gain knowledge about the Nanomaterials, their properties, behavior, interaction and use of them over many discipline of science.
CO2	The emphasis of the course is to understand the physics of Nanomaterials in detail and to explore the wide application.

Course Details:

Unit I- Physics of the Solid State: Crystal structures, Band and free electron theory of solids, Idea of band structure, Density of state in bands, Diffusive transport, scattering mechanisms, Surfaces, Interfaces and Layered Systems.

Unit II - Quantum Nature of Nanoworld: Introduction of Nanomaterials, Characteristic or Critical lengths in mesoscopic systems e.g. mean free path, scattering length, coherence length etc; Idea of quantum well, Quantum wire & and Quantum dots; One and Two dimensional electron systems: general properties, Quantum confinements, Variation of density of states and band gap with dimensionality, Optical properties of semiconductor and metal nanomaterials, Surface Plasmon Resonance in Metal Nanoparticles. Carbon Nanostructures (Fullerenes, Carbon Nanotubes and Graphene) and their Renewable Energy Applications.

Unit III - Nano fabrication: Synthesis of nanomaterial (0, 1& 2 Dimensional) by Top down and Bottom-up Approaches; Ball Milling. Lithography, etching. epitaxial growth, physical and chemical vapour deposition (PVD & CVD) methods, Microwave, Hydrothermal and Solvo-thermal synthesis methods, Chemical synthesis of nanomaterial etc.

Unit IV - Characterization of Nano materials: Structure (X-Ray and electron Diffraction}; Determination of Particle size, Crystallography, atomic and surface structures, Microscopy (Scanning and Transmission electron microscopy, atomic force microscopy, Scanning tunnelling microscopy); Spectroscopy (X-ray Photoelectron Spectroscopy, lnfrared and Raman Spectroscopy**).**

Text and Reference Books:

1. Introduction of Nanotechnology by Charles P Poole Jr and FJ Owens Wiley India, 2020.
2. Nanotechnoology forMicroelectronics and optoelectronics by J.M.M.Duart, R.J.M.Palma and F.A. Rueda, Elsevier, 2002.
3. Solid State Physics by Charles Kittel, 8E, John Wiley & Sons Inc. 2012.
4. Physics of low dimensional semiconductors by John H. Davies, Cambridge University Press, 1997.
5. Nano particles and nanostructured films: Preparation, Characterisation and Application, Ed. J. H. Fendler, John Wiley, 2008.

SEMESTER-II

Course Code: MPL-306 **Full Marks: 100, Credit: 4**
Course Name: Laboratory-III
Course outcomes (CO): At the end of the lab course, the student will be able to:

CO1	Student understand the measurement procedure to evaluate resistivity of semiconductor bandgap, Hall coefficient of given semiconductor, thermal and electrical conductivity of copper, Lorentz number, polarizability of non polar liquid, dipole moment of polar liquid, dielectric constant of solid(Wax).
CO2	Get knowledge to plot B-H curve of a ferromagnetic material.
CO3	Students have an experimental knowledge of density measurements, hardness testing and optical absorption measurement.

Name of Experiments:-

- Measurement of resistivity of semiconductor by four probe method and determination of band gap.
- Measurement of Hall coefficient of given semiconductor to estimate charge carrier.
- Measurement of thermal and electrical conductivity of copper and determinationof Lorentz number.
- B-H curve of a ferromagnetic material.
- Measurement of polarizability of nonpolar liquid and dipole moment of polar liquid.
- Dielectric constant of solid(Wax) by Lecher wire.

SEMESTER-IV

Course Code: MPC- 401 **Full Marks: 100, Credit: 5**

Course Name: Nuclear & Particle Physics

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail
CO2	Students have a basic knowledge of nuclear size ,shape , binding energy.etc and alsothe characteristics of nuclear force in detail.
CO3	Be able to gain knowledge about various nuclear models and potentials associated.
CO4	Grasp knowledge about Nuclear reactions, Fission and Fusion and their characteristics.
CO5	Acquire knowledge about nuclear decay processes and their outcomes. Have a wide understanding regarding alpha, beta and gamma decay.

Course Details:

Unit I- Nuclear Forces: Nuclear two body problem, simple theory of deuteron, spin dependence and non central nature of nuclear forces, nucleon-nucleon scattering, scattering length and effective range theory, exchange force and meson theory of nuclear force.

Unit II- Nuclear Reactions: Q value and threshold energy, compound nuclear and direct reaction mechanisms, nuclear reaction cross-sections, resonance phenomenon, Breit-Wigner one level formula.

Unit III- Nuclear models: Liquid drop model, Semi-emperical mass formula, Bohr-Wheeler theory of fission, Evidences of shell structure, Shell model, spin-orbit coupling, predictions of shell model, Collective model.

Unit IV- Nuclear Decay: Beta decay, Fermi theory of beta decay Allowed and Forbidden transitions, Fermi and Gamow-Teller selection rules, Parity violation in beta decay Neutrino detection Gamma decay, Multipole transitions, angular momentum and parity selection rules, Internal conversion, Nuclear isomerism

Unit V- Elementary Particle Physics: Four fundamental interactions, classification of elementary particles, Hadrons and Leptons, Symmetry and Conservation laws, CP violation and CT invariance, SU(2) and SU(3) multiplets, Eight fold way, Quark model, Gell-Mann Okubo mass formula for hadrons, Basic ideas of standard model.

Text and Reference books:

1. Introductory Nuclear Physics by K. S. Krane, Wiley India Private Limited, 2008.
2. Concepts of Nuclear Physics by B. L. Cohen, McGraw Hill, 2017.
3. Nuclear Physics by S.N. Ghoshal, S. Chand Publishing, 2019.
4. Introduction to Elementary Particles by D. J. Griffiths, John Wiley & Sons Inc. 1987.

SEMESTER-IV

Course Code: MPC- 402 **Full Marks: 100, Credit: 5**

Course Name: Electronics II

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	To develop an overall approach for students from construction of control rectifier , inverter, choppers, study its specification, the functionality, design and practical applications
CO2	To become familiar with power devices and their application in various field

Course Details:

Unit I- Analog Communication Electronics: Amplitude modulation, generation of AM waves, demodulation of AM waves, DSBSC modulation, generation of DSBSC waves, coherent detection of DSBSC waves, SSB modulation, generation and detection of SSB Waves, Vestigial sideband modulation.

Unit II- Frequency modulation, Frequency spectrum for sinusoidal FM. Non-sinusoidal modulation,Phase modulation, Comparison of PM & FM. Varactor diode modulators, Reactance modulator,FM transmitter, Armstrong indirect method, FM detectors, Foster-Seeley discriminator, Ratio detector

Unit III- Digital Communication: Sampling theorem, sampling of Low Pass and Band , pass signals, Pulse Modulation-PAM, PWM, PPM, ideal sampling, Natural sampling, Flat- top sampling,. Quantization of signals; Quantization, PCM, Differential PCM, Delta modulation, Adaptive Delta modulation, CVSD, Line encoding; unipolar, polar, bipolar, Manchester encoding

Unit IV - Digital Modulation Techniques: Amplitude Shift Keying (ASK), Phase Shift Keying (PSK) -Binary (BPSK), Differential (DPSK), Quadrature (QPSK) & M-ARY Quadrature Amplitude Shift Keying (QASK), QAM, Frcquency Shift Keying (FSK).

Text and Reference books:

1. Principles of Communication System by Taub and Schilling, 4E, McGraw Hill Education, 2017.
2. Communication Systems by Simon Haykin, 4E, John Wiley & Sons, Inc. 2006.
3. Electronic Communications by Dennis Roddy and John Coolen, 4E, Pearson Education, 2008.
4. Modern Digital and Analog Communication systems by B P Lathi, 4E, Oxford Univ. Press, 2011.
5. Electronic Communication system by R Blake, 2E, Cengage india edition, 2001.
6. Communication System Engineering by Proakis and Salehi, 2E, Pearson Education, 2018.
7. Advanced Electronic Communication Systems by WayneTomasi, 6E, Pearson Education, 2006.
8. Electronic Communication System by George Kennedy and Bernard Davis, Tata

McGraw Hill Publ. 1999.

SEMESTER-IV

Course Code: MPC- 403 **Full Marks: 100, Credit: 5**

Course Name: Condensed Matter Physics -II

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Appreciate the different types of bonding in solids and of interactions in soft matter.
CO2	Be able to solve problems in reciprocal space (phonons and electron band structure).
CO3	Students can numerically model disordered materials and explain how the properties change with varying degrees of disorder.
CO4	Students can explain the electrical properties of crystals in terms of the free-electron gas model as well as electronic band structure, and calculate these properties for simple crystals in the reciprocal space.

Course Details:

Unit I - Transport Properties of Solids: Boltzmann transport equation, resistivity of metals and semiconductors, Fermi surfaces –determination, Landau levels, de Hass van Alphen effect, Quantum Hall effect- Integral quantum Hall effect and Magnetoresistance.

Unit II - Dielectric Properties of Solids: Dielectrics and ferroelectrics, macroscopic electric field, local field at an atom, dielectric constant and polarizability, ferroelectricity, antiferroelectricity, piezoelectric crystals, ferroelasticity, electrostriction.

Unit III - Optical properties: Optical constants and their physical significance, Reflectivity in metals, plasmonic properties of metals, determination of band gap in semiconductors: direct and indirect band gap, defect mediated optical transitions, excitons, photoluminescence, Electroluminesence

Unit IV - Magnetism: Types of magnetic materials, Quantum theory of paramagnetism, Hund's rule, Ferromagnetism, antiferromagnetism: molecular field, Curie temperature. Domain theory, Magnetic Anisotropy, Magnetic interactions, Heitler-London method, exchange and superexchange, magnetic moments and crystal-field effects, spin-wave excitations and thermodynamics, antiferromagnetism, Magnetostriction.

Unit V - Electron Phonon Interaction: Interaction of electrons with acoustic and optical phonons, Polaron, Superconductivity: Manifestation of energy gap, Cooper pairing due to phonons, BCS theory of superconductivity, Ginzsburg-Landau theory and application to Josephson effect, High temperature superconductors.

Text and Reference books:

1. Introduction to solid State Theory by O. Madelung, Springer Series in Solid-State Sciences (SSSOL, volume 2) 1978.
2. Quantum theory of Solids by J. Callaway, 2E, Elsevier 1991.
3. Introduction to Solid State Physics by C. Kittel, 8E, Wiley India Private Limited, 2012.
4. Solid State Physics by A.J. Dekker, Macmillan India Limited, 1993.
5. Solid State Physics by R.K. Puri, V.K. Babbar, S. Chand Publishing, 2015
6. Elementary Solid State Physics by M.Ali Omar, 1E, Pearson India, 2002.
7. Principles of Condensed Matter Physics by P.MChaikin and T.C. Lubensky, Cambridge

University Press, 1995.
8. Solid state physic by N.W. Aschroft and N.D. Mermin, 2E, CENGAGE Learning Asia, 2016.
9. Introduction to Solids by L. Azaroff, McGraw Hill Education, 2017.

4. Theoretical Solid State Physics by Huang

SEMESTER-IV

Course Code: MPE- 404 **Full Marks: 100, Credit: 5**

Course Name: Physics of Lasers and Laser applications

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	The students will learn about introductory concepts of lasers and interaction of radiation with matter and various types of lasers and laser spectroscopy and their applications.
CO2	Provide students with a basic understanding of laser operation
CO3	Describe how pulsed laser beams can be obtained from a laser cavity.
CO4	Describe optical components that can be used to tailor the properties of the laser
CO5	Understand the laser applications in daily life.

Course Details:

Unit I- Properties of laser beams, Basic elements of a laser, Population inversion, gain and Threshold, Three level and four level laser, mate equations, CW operation of laser, optical resonators, cavity modes, mode selection, pulsed operation of laser, Q-switching and mode locking, Pulse shortening picoseconds and femto-second operation.

Unit II- Different laser systems, Ruby laser, He-Ne laser, Nd:YAG laser, CO_2 laser, Semiconductor diode laser, Dye lasers, Excimer lasers

Unit III- Laser induced fluorescence spectroscopy, Laser applications in metrology, optical communication, materials processing and holography, LIDAR, Medical applications.

Text and Reference books:

1. Lasers: Theory and Applications by K.Thyagarajan and A. K.Ghatak, 2E, Laxmi Publications Pvt Ltd, 2019.

2. Principles of Lasers by O. Svelto, 5th Ed., Springer, 2010)
3. Laser Spectroscopy, W. Demtroder (3rd Ed., Springer, 2003)
4. Lasers by A.E.Siegmann, University Science Books, 1986.
5. Laser Physics by P.W.Milonni and J. H. Eberly, John Wiley & Sons, Inc. 2010.

SEMESTER-IV

Course Code: MPE- 405 **Full Marks: 100, Credit: 5**

Course Name: Plasma Physics

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	define plasma state, give examples of different kinds of plasma and explain the parameters characterizing them
CO2	analyze the motion of charged particles in electric and magnetic fields
CO3	explain the concept of quasi neutrality and describe plasma interaction with surfaces
CO4	formulate kinetic and fluid descriptions of plasma, and understand the applicability of the appropriate approximations (ideal MHD, single fluid description, many fluid model).
CO5	discuss plasma resistivity and diffusion in plasma based on the charged particle motion

Course Details:

Unit I- Plasma as a state of matter, Debye shielding, Motion of charged particles in uniform electric and magnetic field.

Unit II- Time varying and space dependent electric and magnetic fields, Diffusion of electrons and ions in weakly ionised plasma without and with magnetic field, Plasma confinement, Magnetic mirror, First, second and third adiabatic invariants.

Unit III- Plasma oscillations, Magneto hydro dynamics, pinch effect, Hydro magnetic waves and magneto sonic waves

Text and Reference Book:

1. Fundamentalsof PlasmaPhysics by J.A.Bittencourt, 2E, Co-Edition FAPESP, 1995.
2. Classical Electrodynamics by J.D. Jackson, 3E, John Wiley, 1998.
3. Introduction to plasma physics by R.J. Goldston and P.H.Rutherford, CRC Press, 1995.
4. Introduction to plasma theory by D.R.Nicholson, John *Wiley* & Sons, 1983.
5. Introduction to Electrodynamics by David J. Griffiths, 4E, Prentice-Hall of India, New Delhi, 2013.