SCHEME OF EXAMINATION

&

DETAILED SYLLABUS

For

M.SC Physics
(w.e.f. 2019 – 2020)

FACULTY OF SCIENCE

Kalinga University, Naya Raipur, Chhattisgarh

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1.	Postgraduates will pursue higher studies in related fields including management and carry out research.
PEO2.	Postgraduates will perform as employers in private/government institutions rising up to top positions.
PEO3	Postgraduates will become entrepreneurs.

PROGRAM OUTCOMES (POs)

PO1	**Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.
PO2	**Effective Communication:** Speak, read, write and listen clearly in person and through electronic media and make meaning of the world by connecting people, ideas, books, media and technology.
PO3	Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.
PO4	**Effective Citizenship:** Demonstrate empathetic social concern and equity-centered national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.
PO5	**Ethics:** Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.
PO6	**Environment and Sustainability:** Understand the issues of environmental contexts and sustainable development.
PO7	**Self-directed and Life-long Learning:** Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1.	Postgraduates will develop the critical analysis and problem-solving skills required in the application of principles of Physics.
PSO2	Escalating sufficient academic and realistic background/understanding of physics as per UGC framework
PSO3	Understanding fundamental concepts of classical and statistical mechanics to put in plain words the explanation of physical events with appreciable limitations
PSO4	Refreshing the concepts of electrodynamics, condensed matter physics, Nuclear & particle physics, atomic & molecular physics for better understanding of advanced physical concepts
PSO5	Understanding in detail the basic and advanced concepts of quantum mechanics because the nature is governed by regulations of quantum mechanics

PSO6	the essential features of electronic devices and related techniques to have a perceptive of many household electronic devices and Performing handful of experiments/projects as per program framework
POS7	Understanding advanced and special/elective subjects like plasma physics, lasers, advanced electronics and their applications for welfare of mankind
PSO8	Postgraduates will be prepared with a working knowledge of experimental/computational techniques and instrumentation required to work independently in research or industrial environments.
PSO9	Postgraduates will have strong capability in organizing and presenting the acquired knowledge coherently both in oral and written discourse.
PSO10	Postgraduates will successfully compete for current employment opportunities.

M. Sc. – PHYSICS

M. Sc. in Physics is a full time 2-year (4-semesters course). There will be four theory papers and two laboratory courses in 1st to 3rd semester and 4th Semester consist of four theory papers and one major project. In each semester, there will be two internal examinations/assessments. Semester wise course structure along with distribution of marks is as follows:

Semester – I

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY101	Mathematical Physics	4	-	70	30	100
MPHY102	Classical Mechanics	4	-	70	30	100
MPHY103	Electrodynamics	4	-	70	30	100
MPHY104	Electronics – I	4	-	70	30	100
MPHY105P	General & Optics Laboratory	-	4	70	30	100
MPHY106P	Electronics Laboratory – I	-	4	70	30	100
Total						**600**

Semester – II

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY201	Quantum Mechanics – I	4	-	70	30	100
MPHY202	Statistical Mechanics	4	-	70	30	100
MPHY203	Computational Methods & Programming	4	-	70	30	100
MPHY204	Electronics – II	4	-	70	30	100
MPHY205P	Fortran and Numerical Analysis Laboratory	-	4	70	30	100
MPHY206P	Electronics Laboratory – II	-	4	70	30	100
Total						**600**

Semester – III

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY301	Quantum Mechanics – II	4	-	70	30	100
MPHY302	Solid State Physics – I	4	-	70	30	100
MPHY303	Atomic & Molecular Physics	4	-	70	30	100
MPHY304 (Elective)	A. Astronomy & Astrophysics – I B. Nanotechnology: Principles & Practices - I C. Experimental Physics – I D. Lasers and Non – Linear Optics – I	4	-	70	30	100
MPHY305P	Solid State Physics Laboratory	-	4	70	30	100
MPHY306P	Minor Project	-	4	70	30	100
Total						**600**

Semester – IV

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY401	Plasma Physics	4	-	70	30	100
MPHY402	Solid State Physics – II	4	-	70	30	100
MPHY403	Nuclear & Particle Physics	4	-	70	30	100
MPHY404 (Elective)	A. Astronomy & Astrophysics – II B. Nanotechnology: Principles & Practices - II C. Experimental Physics – II D. Lasers and Non – Linear Optics – II	4	-	70	30	100
MPHY405P	Major Project	-	8	150	50	200
Total						**600**

Mark Distribution

Laboratory (MPHY105P, MPHY106P, MPHY205P, MPHY206P & 305P)

Laboratory Work	:	40 Marks
Lab Record	:	10 Marks
Comprehensive viva-voce	:	20 Marks
Internal assessment	:	30 Marks
Total	**:**	**100 Marks**

Minor Project (MPHY306P)

Minor Project Report	:	30 Marks
Presentation	:	20 Marks
Comprehensive viva-voce	:	20 Marks
Internal assessment	:	30 Marks
Total	**:**	**100 Marks**

Note: Minor Project of Semesters III is interest of field/elective course. Student has to opt for any one of the courses. The commencement of any one of the minor project is subjected to the availability of basic infrastructural facilities viz. expert faculty, laboratory etc.

Major Project (MPHY405P)

Dissertation	:	100 Marks
Presentation	:	20 Marks
Comprehensive viva-voce	:	30 Marks
Internal assessment	:	50 Marks
Total	**:**	**200 Marks**

Note: Major Project of Semesters IV is interest of field/elective course. Student has to opt for any one of the courses. The commencement of any one of the major project is subjected to the availability of basic infrastructural facilities viz. expert faculty, laboratory etc.

Semester – I

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY101	Mathematical Physics	4	-	70	30	100

Unit -I **9 Hrs**

Vector space and Matrices, Linear independence, Bases, dimensionality, Inner product, Linear transformation, matrices, Inverse, Orthogonal and Unitary matrices, Independent element of a matrix, Eigen values and eigen Vectors, Diagonalization, Complete orthonormal sets of functions,

Unit–II **9 Hrs**

Complex Variables: Cauchy- Riemann condition, analytic functions, Cauchy's theorem, Cauchy integral formula, Laurent series, singularities, residue theorem, contour integration, evaluation of definite integrals, problems.

Unit–III **9 Hrs**

Differential equations, first order differential equation, second order differential equation with constant coefficients, second order linear ODEs with variable coefficients, Solution by series expansion, non-homogenous differential equations and solution by the method of Green's functions.

Unit–IV **9 Hrs**

Special functions, Legendre, Bessel, Hermite and Laguerre functions with their physical applications, generating functions, orthogonality conditions, recursion relations,

Unit-V **9 Hrs**

Integral transforms, Fourier integral and transforms, inversion theorem, Fourier transform of derivatives, convolution theorem, Laplace Transform (LT), LT of Derivatives, Inverse LT, Fourier series; properties and applications, discrete Fourier transform.

TEXT AND REFERENCE BOOKS

1. Mathematical Methods for Physics, by G. Arfken.
2. Matrices and Tensors for Physicist, by A. W. Joshi.
3. Advanced Engineering Mathematics, by E. Kroyazig.
4. Special Functions, by E. B. Rainville.
5. Special Functions, by W.W. Bell.
6. Mathematical Method for Physicist and Engineers, by K. F. Relly, M. P. Hobson and S. J. Bence
7. Mathematics for Physicists, By Marry L. Boas.

Course Outcomes (COs):

CO1	To develop knowledge in mathematical physics and its applications.
CO2	To develop expertise in mathematical techniques those are required in physics.
CO3	To enhance problem solving skills.
CO4	To give the ability to formulate, interpret and draw inferences from mathematical solutions.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY102	Classical Mechanics	4	-	70	30	100

Unit–I **9 Hrs**

Preliminaries, Newtonian mechanics of one and many particle systems, Conservation laws, Constraints & their classification, Principle of virtual work, Generalized coordinates, D'Alembert's principle and Lagrange's equations, Velocity-dependent potentials and dissipation function, Gauge Function, Simple applications of the Lagrangian formulation, Hamilton's principle, Lagrange's equations from Hamilton's principle, Conservation theorems and Symmetry properties, Energy function and the conservation of energy.

Unit-II **9 Hrs**

The Hamiltonian formulation of mechanics, Legendre transformations and the Hamilton's equations of motion, Cyclic coordinates and Conservation Theorems, Hamilton's equations from Hamilton's principle, The principle of least action. Simple applications of the Hamiltonian formulation.

Unit- III **9 Hrs**

Canonical transformations with examples, the harmonic oscillator, Poisson's brackets, Equations of motion and conservation theorems in the Poisson Bracket formulation. Hamilton-Jacobi (HJ) theory: The HJ equation for Hamilton's principal function, Harmonic oscillator as an example of the HJ method, The HJ equation for Hamilton's characteristic function, the action-angle variables

Unit –IV **9 Hrs**

The Central force: Two-body central force problem and its reduction to the equivalent one-body problem, The equations of motion and first integrals, The equivalent one-dimensional problem and classification of orbits, The differential equation of the orbit, Closure and stability of orbits, The Kepler problem, Scattering in a central force field: Rutherford scattering.

Unit – V **9 Hrs**

Rigid body dynamics, The Euler angles, Euler's theorem on the motion of a rigid body, Rate of change of a vector, The Coriolis force, Angular momentum and Kinetic energy of motion about a point, The Euler equations of motion of rigid bodies. Formulation of the problem of small oscillations, the eigen-value equation and the principal axis transformation, Frequencies of free vibration and normal coordinates, free vibration of linear triatomic molecule.

TEXT AND REFERENCE BOOKS

1. Classical Mechanics, By N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991)
2. Classical Mechanics, by H.Goldstein (Addison Wesley, 1980)
3. Classical Mechanics, by H.Goldstein, C Poole & J Fafko (Pearson Education, Inc, 2002)
4. Mechanics, by A.Sommerfeld, (Academic press, 1952)
5. Introduction to Dynamics by Perceival and D.Richaeds (Cambridge University, press, 1982).

Course Outcomes (COs):

CO1 To give students a solid foundation in classical mechanics.
CO2 To introduce general methods of studying the dynamics of particle systems.
CO3 To give experience in using mathematical techniques for solving practical problems.
CO4 To lay the foundations for further studies in physics and engineering.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY103	Electrodynamics	4	-	70	30	100

Unit- I **9 Hrs**

Electrostatics: Coulombs law, Electric field and potential, Work and energy in electrostatics, Polarization, Bound charge and physical interpretation of Bound charge.

Magnetostatics: Biot-savart law, divergence of curl of B, Magnetization, Bound current and physical interpretation of Bound current, Ohms law, Faradays law and Maxwell's equation, Conservation law.

Unit – II **9 Hrs**

Scaler and Vector potential, Gauge transformations, Coulomb Gauge and Lorentz Gauge, Retarded potential, Jefimenko's equation, Lienard-Wiechert potential and fields for a point charge.

Unit –III **9 Hrs**

Radiation, dipole radiation, point charge, total power radiated by an accelerated charge- Larmor's formula and its relativistic generalization, angular distribution of radiation emitted by an accelerated charge, radiation emitted by a charge in arbitrary extremely relativistic motion, distribution in frequency and angle of energy radiated by accelerated charge.

Unit –IV **9 Hrs**

Bremsstralung: emission from single-speed electrons, thermal Bremsstralung emission and absorption, Synchrotron radiation: spectrum of synchrotron radiation, spectral index for power law electron distribution, transition from Cyclotron to Synchrotron emission, Cherenkov radiation.

Unit – V **9 Hrs**

Electrodynamics and Relativity: The Special Theory of Relativity, Einstein's Postulates, The Geometry of Relativity, The Lorentz Transformations, The Structure of Space-time, Relativistic Mechanics, Proper Time and Proper Velocity, Relativistic Energy and Momentum, Relativistic Kinematics, Relativistic Dynamics, Relativistic Electrodynamics, Magnetism as a Relativistic Phenomenon, How the Fields Transform, The Field Tensor, Electrodynamics in Tensor Notation, Relativistic Potentials, Special theory of relativity, Einstein postulates, Lorentz transformation, the Structure of space time, Relativistic mechanics and electrodynamics in tensor notation.

TEXT AND REFERENCE BOOKS

1. Jackson, classical electrodynamics.
2. Panofsky and Phillips: Classical electricity and magnetism.
3. Intro. to Electrodynamics: David J. Griffiths

Course Outcomes (COs):

CO1	Reviewing basics of electrostatics and magnetostatics to comprehend Maxwell's equations and their solution in various media.
CO2	Understanding radiations and related physics by moving charges, the concepts of retarded potentials and Abrahm-Lorentz method of self force.
CO3	Describing 4-vectors and Lorentz transformation in 4-dimensional space to revise invariance of charge & potential under Lorentz transformation and furthermore the motion of charged particles in electromagnetic fields.
CO4	Solving questions based on tutorial problems casing above topics/concepts.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY104	Electronics – I	4	-	70	30	100

Unit – I **9 Hrs**

Special Bipolar devices: Thyristors- the four-layer diodes and their basic characteristics, Shockley diode, three terminal thyristor, Diac & Triac, SCR, UJT, Field controlled Thyristors.

Unit – II **9 Hrs**

Unipolar Devices : JFET, MESFET and MOSFET, basic structure, working and device I-V characteristics, small signal equivalent circuit for Microwave performance, Introduction to MIS and MOS diodes, charge coupled devices (CCDs), basic structure and working principle, MOSFET-basic device characteristics, types of MOSFET.

Unit- III **9 Hrs**

Special Microwave Devices: Tunnel diode and backward diode- basic device characteristics, IMPATT diodes and their static and dynamic characteristics, Transfer electron devices- transferred electron effect, PIN diodes, Gunn diodes.

Unit – IV **9 Hrs**

Photonic Devices : Radiative transitions, LEDs, Visible and infrared SC lasers; Photo detectors; Photo conductor, & Photodiode, Solar cells, Solar radiation and ideal conversion efficiency, p-n junction solar cells, Hetero junction. Interface thin film solar cells.

Unit – V **9 Hrs**

Optical Modulators and Display Devices: Modulation of light- Birefringence, Optical activity, Electro-optic, Magneto-optic and Acoustic- optic effects, Materials exhibiting these properties, Non-linear optics.

Display devices: Luminescence, Photo-luminescence, Electro-luminescence, Liquid crystal displays, Numeric displays.

TEXT & REFERENCE BOOKS:

1. Semiconductor Devices – Physics and Technology, by S M Sze, Wiley (1985)
2. Introduction to semiconductor device, M.S. Tyasi, John Wiley and sons
3. Measurement, Instrumentation and experimental design in physics and engineering by M. Sayer and A. Mansingh, Prentice Hall India 2000
4. Optical electronics by Ajay Ghatak and K. Thyagarajah, Cam. Univ. Press.
5. Opto electronics – An introduction: J.Wilson and JFB Hawkes (Eastern Economy Edition).
6. Optical Communications: J.H. Franz and V.K. Jain (Narosa).

Course Outcomes (COs):

CO1 To become skilled at the basic concepts of JFET, BJT, MOSFET, MESFET and microwave devices.
CO2 To study and understand the various photonic devices including diode lasers and their applications.
CO3 To be acquainted with the concepts and applications of digital integrated circuits and operational amplifiers.
CO4 Describing memory devices and the devices based on electro/magneto/acousto-optic, piezoelectric, and surface acoustic effects.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY105P	General and Optics Laboratory	-	4	70	30	100
MPHY106P	Electronics Laboratory – I	-	4	70	30	100

General and Optics Laboratory (MPHY105P) **90 Hrs**

1. Determination of wavelength of mercury light by constant deviation spectrometer using Hartmann formula.
2. Ultrasonic velocity in a liquid as a function of temperature using ultrasonic interferometer.
3. Experiment on transmission line (A) Determination of characteristics impedance, (B) Study of voltage distribution.
4. Determination of the Curie temperature of ferromagnetic material.
5. Determination of forbidden gap of a diode by plotting reverse saturation current as a function of temperature.
6. Determination of short half-life of a given source which can be obtained from a mini generator or produced with a neutron source by activation.
7. X-ray diffraction by Telexometer.
8. Determination of ionization potential of Lithium/Mercury.
9. Determination of e/m of electron by Normal Zeeman Effect using Febry -Perot Etalon.
10. Determination of Dissociation energy of iodine (I_2) Molecule by photography, the absorption bands of I_2 in the visible region.
11. Measurement of wavelength of He-Ne Laser light using a ruler and thickness of thin wire by the laser.
12. To study Faraday Effect using He-Ne Laser.

Course Outcomes (COs):

CO1 To make the student familiarize with the basics of experimental physics.
CO2 To enable the students to explore the concepts involved in the thermodynamic processes.
CO3 To make the students understand the basics of modern optics.
CO4 To make the students verify experimentally the basic laws of physics.

Electronics Laboratory – I (MPHY106P) **90 Hrs**

1. Design & Study of Regulated Power supply.
2. Study of Transistor Amplifiers in CE, CB, and CC modes.
3. Study of Transistor Bias Stability.
4. Study of Astable, Monostable and Bistable Multivibrator.
5. Study of Silicon Controlled Rectifier.
6. Experiment of Uni – Junction Transistor and its application.
7. Experiment of FET and MOSFET characterization and application as an amplifier.
8. Study of Differential Amplifier.
9. Basic Logic gates and verification of their Truth- Tables.
10. Combinational logic gates and verification of De-Morgan’s Theorem.
11. Study of Basic Operational Amplifier (741).
12. Study of Opto- Electronics Devices.

Course Outcomes (COs):

CO1 Solving tutorial problems based on above topics.
CO2 Performing laboratory experiments/project on above topics/concepts to realize the physics behind them.

Semester – II

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY201	Quantum Mechanics – I	4	-	70	30	100

Unit – I **9 Hrs**

Inadequacy of classical mechanics, Plank quantum hypothesis and radiation law, Photoelectric effect, de-broglie's theory. Schrödinger equation, continuity equation, Ehrenfest theorem, admissible wave functions, stationary states, one-dimensional problems; walls and barriers, Schrödinger equation for harmonic oscillator and its solution, uncertainty relations, states with minimum uncertainty product.

Unit –II **9 Hrs**

Superposition principle, general formalism of wave mechanics, representation of states and dynamical variables, commutation relationship, completeness and normalization of eigen functions, Dirac-delta function, Bra & Ket notation, matrix representation of an operator, harmonic oscillator and its solution by matrix method, Heisenberg equation of motion.

Unit -III **9 Hrs**

Angular momentum in quantum mechanics, commutation relationships, eigen values, Spin angular momentum, Pauli`s matrices, addition of angular momentum, Clebsch-Gordon coefficients.

Unit – IV **9 Hrs**

Central force problem, spherically symmetric potentials in three dimensions, separation of wave equation, parity, three-dimensional square-well potential and energy levels, the hydrogen atom; solution of the radial equation, energy levels and stationery state wave functions, discussion of bound states, degeneracy.

Unit –V **9 Hrs**

Time– independent perturbation theory, non-degenerate case, first order and second perturbations with the example of an oscillator, degenerate cases, removal of degeneracy in second order, Zeeman effect without electron spin, first-order Stark effect in hydrogen, perturbed energy levels, correct eigen function, occurrence of permanent electric dipole moments.

TEXT AND REFERENCE BOOKS:

1. L.I. Schiff: quantum mechanics (McGraw-Hill).
2. S. Gasiorowicz, Quantum Physics (Wiley).
3. Landau and Lifshitz: Non-relativistic quantum mechanics.
4. B. Craseman and Z. D. Powell: quantum mechanics (Addison Wesley)
5. A.P. Messiah: Quantum Mechanics.
6. J.J. Sakurai: Modern Quantum Mechanics.
7. Mathews and Venkatesan: Quantum Mechanics.

Course Outcomes (COs)

CO1	Answering why and how quantum mechanics with understanding of basic postulates and solution of Schrodinger equation for one dimensional problems.
CO2	Having basic knowledge of linear vector space, Bra and Ket algebra, matrix theory and uncertainty relations.
CO3	Solving Schrodinger wave equation for three dimensional problems like H-atom, harmonic oscillator, square well potential and their application to atomic spectra, molecular spectra and deuteron.
CO4	Understanding angular momentum in quantum mechanics, its matrix representation and coupling, Pauli spin matrices and the concept of Clebsch-Gorden coefficients.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY202	Statistical Mechanics	4	-	70	30	100

Unit –I **9 Hrs**

Foundation of statistical mechanics : macroscopic and microscopic states, contact between statistics and thermodynamics, physical significance of Ώ (N, V, E), the classical gas, entropy of mixing and Gibb's paradox, phase space of classical system, Liouville`s theorem and its consequences, quantum states and phase space.

Unit – II **9 Hrs**

Elements of ensemble theory – A system in microcanonical, canonical, and grand canonical ensembles, partition functions, physical significance of statistical quantities, example of classical system, energy and energy-density fluctuations and mutual correspondence of various ensembles.

Unit - III **9 Hrs**

Formulation of quantum statistics – Quantum mechanical ensemble theory, density matrix, statistics of various quantum mechanical ensembles, system composed of indistinguishable particles.

Theory of simple gases –Ideal gas in various quantum mechanical ensemble, Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac distributions, statistics of occupation number. Monatomic and diatomic gases composed of particles with internal motion.

Unit - IV **9 Hrs**

Ideal Bose and Fermi gases -Thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation and, elementary excitations in liquid helium II, thermodynamic behavior of an ideal Fermi gas, the electron gas, nonrelativistic and relativistic degenerate electron gas, theory of white dwarf stars.

Unit – V **9 Hrs**

Statistical Mechanics of interacting systems – the method of cluster expansion for a classical gas, Virial expansion of the equation of state.

Theory of phase transition – general remark on the problem of condensation, Fluctuations: thermodynamic fluctuations, Brownian motion, Einstein and Lengevin theory of Brownian motion.

TEXT & REFERENCE BOOKS:

1. R. K. Pathria, Statistical Mechanics (Pergamon Press).
2. L. D. Landau & E. M. Lifshitz (Butter worth and Heinemann Press).
3. Federick Reif, Fundamental of statistical and thermal physics (McGraw-Hill publishers).
4. Kerson Huang, Statistical Mechanics (Wiley Eastern).

Course Outcomes (COs)

CO1	Understanding foundations of statistical mechanics and its association with thermodynamics to solve countless physical problems.
CO2	Describing Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics.
CO3	Explaining cluster expansion of a classical gas, dynamical model of phase transition and Landau theory of phase transition.
CO4	Elucidating thermodynamical fluctuations and Brownian motion on the basis of Langevin's theory and Fokker-Planck equation.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY203	Computational Methods & Programming	4	-	70	30	100

Unit –I **9 Hrs**

Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions. Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative method, matrix inversion.

Unit –II **9 Hrs**

Finite differences, interpolation with equally spaced and unevenly spaced points, curve fitting, polynomial least squares and cubic spline fitting. Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.

Unit –III **9 Hrs**

Numerical solution of ordinary differential equations, Euler and Runga-Kutta methods, predictor-corrector method, elementary ideas of solutions of partial differential equations.

Unit- IV **9 Hrs**

Elementary information about digital computer principles, compilers, interpreters and operating systems (Windows/Linux) Fortran programming, flow charts, integers and floating point arithmetic, expressions, built in functions.

Unit-V **9 Hrs**

Executable and non-executable statements, assignments, control and input-output statements, subroutines and functions; The statement functions, main features of functions and subroutines ,subprogram, function subprogram, overall structure of FORTRAN program, external statement, subroutine subprogram, common statement, equivalence statement, operations with files-open and close statement, Format statements, field specifications.

TEXT AND REFERENCE BOOKS

1. Sastry: Introductory Methods of Numerical Analysis.
2. Rajaraman: Numerical Analysis.
3. Antia: Numerical methods.
4. Raja Raman: FORTRAN programming.

Course Outcomes (COs):

CO1 Learning the essential components of programming in BASIC.

CO2 Understanding the computational skills of solving linear and non-linear algebraic/transcendental equations including simultaneous linear equations.

CO3 Being comfortable with the techniques of obtaining Eigen values & Eigen vectors of matrices, curve-fitting and numerical differentiation & integration.

CO4 Realizing the basic concepts of random variables, numerical solution of ordinary and partial differential equations.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY204	Electronics – II	4	-	70	30	100

Unit-I **9 Hrs**

Number system and its conversion, Combinational Logic –Basic logic gates: OR, AND and NOT gates, NOR and NAND gates, Boolean algebra, De-Morgan's theorems, exclusive OR gate, characteristics of logic families, saturated logic families: RTL, DCTL, non-saturated logic families: TTL and ECL, Unipolar logic families.

Unit –II **9 Hrs**

Sequential Logic, Flip-flops: RS Flip-flop, level clocking, Edge triggered Flip Flops, D Flip flops. JK Flip-flops, J.K.master slave Flip-flops, Registers: buffer, shift and control shift registers, counters: ripple synchronous & ring counters, tri-state registers, Buffer: controlled buffer Register, Bus organized structure, Latch, multiplexer, Demultiplexer, decoder, ALU Memories: RAM, ROM, PROM, EPROM, A/D and D/A converters.

Unit- III **9 Hrs**

Operational Amplifier- Basic Op Amp. Differential amplifier, the emitter coupled Difference Ampl, Transfer characteristics of a Diff. Ampl., an example of an IC Op Amp., off set error voltage and currents, measurement of Op Amp. Parameters, frequency response of Op-amp. Linear analog systems: Basic Op Amp. Applications, Analog integration and differentiation, Electronic analog computation, Non-linear analog systems: Comparators. Waveform generators.

Unit-IV **9 Hrs**

Microprocessors – Building concept of microprocessors, developing inside of microprocessor, Instruction codes, Instruction Register, Introducing RESET Pin, Introducing on chip oscillator, Interfacing I/O devices, Introducing Interrupt lines :Stack, Push, Pop operation, delay in servicing interrupts, multiply interrupts, location for interrupts .Introducing slow and fast data transfer, Status of microprocessor, interrupt pins, General purpose Register, flag Register, Increment/decrement register. Features of 8085 microprossor. Pin diagram of 8085, block diagram of 8085. CPU of a microprocessor, timing and control, system timings and interrupt timings of 8085, registers in 8085, interfacing memory and I/O devices- a preliminary ideas. Number system, Floating Point notation.

Unit – V **9 Hrs**

Instructions set of 8085, types of instructions- Data transfer group, Arithmetic logic, branch group, stack I/O machine control group, addressing mode of Intel 8085, examples of Assembly language programs of 8085, summing of two 8-bit numbers to result a 16-bit number, summing two 16-bit number, multiplying two 8-bit number to result a 16-bit product, block transfer of data from one memory block to other, BCD to hexadecimal data, finding the largest number in a series.

TEXT AND REFERENCE BOOKS:

1. Integrated Electronics: J.Millman R.C.C.Halkias.
2. Operational amplifier linear integrated circuits, by Romakanth A. Gayakwad PHI, second edition 1991.
3. Digital computer electronics- An introduction to microcomputers-A. P. Malvino.
4. Microprocessor architecture, programming applications with 8085/8086 by Ramesh S. Gaonkar, Willey-Eastern limited 1987.
5. Introduction to microprocessors – A. P. Mathur (Tata McGraw).
6. Microprocessors fundamentals- Schanmi Outling Service Author Pocer L. Tokheim.
7. Integrated circuits : K K Botkar (Khanna publications)
8. Digital Electronics : R P Jain (Tata McGraw Hill)
9. Microprocessors : B Ram

Course Outcomes (COs):

CO1	To understand the basic elements of communication electronics, microwave transmission and satellite communication.
CO2	To appreciate the construction, operation and application of microwave devices and radar.
CO3	Learning the operation of Intel 8085 microprocessor its interrupts.
CO4	Analyzing potential aspects of programmable interface devices and interfacing with D/A & A/D converters.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY205P	Fortran and Numerical Analysis Laboratory	-	4	70	30	100
MPHY206P	Electronics Laboratory – II	-	4	70	30	100

FORTRAN and Numerical Analysis Laboratory (MPHY205P) **90 Hrs**

1. To solve simultaneous Linear equation by Gauss Elimination method.
2. To calculate the root of a transcendental equation by Newton – Raphsons method.
3. Solving the system of linear simultaneous equation by Gauss Serdel method.
4. Numerical Integration by Simpson's 1/3 Rule.
5. Solving simultaneous Linear equation by Gauss-Jordon method.
6. Solution of Differential equation by Euler's Method.
7. To invert a given matrix by Gauss-Jordon Method.
8. Solution of Differential equation by Runga Kutte Method.
9. To fit the given data in a straight line by linear regression Method.
10. WAP to find the Largest of n number of series.
11. To calculate the standard deviation of a given set of data.
12. To write a program to compute the complex roots of a given polynomial of N^{th} degree by Grafffe's Method.
13. To write a program to compute the Eigen values of a given matrix.
14. To integrate a given function by: (a) Trapezoidal method or by (b) Gauss Quadrature.
15. To find solutions of Ist order, ordinary differential equation by Taylor method.

Course Outcomes (COs):

CO1 The lab will run similar to the Computational Techniques course.

CO2 The objective of the lab is to implement the numerical techniques developed in the course to problems of engineering interest.

Electronics Laboratory – II (MPHY206P) **90 Hrs**

1. Study of R-S, D/T, J-K Flip-Flops.
2. Study of counters: Ripple, Mode 3, Mode 5 counters.
3. Study of Shift Register.
4. Study of R-2R D/A Converter.
5. Study of Random Access Memory (RAM) Read Only Memory. (ROM)
6. Study of A/D Converter.
7. Experiment with Microprocessor: (a) Convert BCD in to HEXADECIMPL, (b) To transfer group of date blocks from one location to another location.
8. Experiment with microprocessor: (a) to write programs for addition of two 1 byte data giving results of 2 bytes. (b) To write programs for multiplication of two 1 byte data giving results of 2 bytes.
9. (a)To add 2 16-BIT numbers stored in locations from x x x x to x x x x + 3 and add them store the results from x x x x + 4 to x x x x+6 memory location. (b) To find the largest of n numbers of a series.
10. To arrange N numbers in an ascending orders.
11. Experiments with Microprocessor: (a) Convert BCD in to binary and vice-versa, (b) To transfer group of data blocks from one location to another location, (c) To write programs for addition of two 1byte data giving result of 2byte data, and (d) To write programs for multiplication of two 1 byte data giving result of 2byte data.
12. Logic gate study DTL and RTL.
13. Study of adder/Subractor.
14. Study of Op-Amp.-IC-741 is inverting/ non inverting amplifier and draw frequency response curve.
15. Construction of Schmitt triggers using IC-741 and study of its characteristics.
16. Study of Astable and monostable Multi Vibrator using IC 555.
17. Digital electronics experiments on bread board using IC-7400.

Course Outcomes (COs):

CO1 Solving tutorial problems based on above topics.

CO2 Performing laboratory experiments/project on above topics/concepts to realize the physics behind them.

Semester – III

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY301	Quantum Mechanics – II	4	-	70	30	100

Unit-I **9 Hrs**

Variational method, expectation value of energy, application to excited states, ground sate of He-atom, Vander-waals interaction, the W.K.B. approximation, approximate solutions, asymptotic nature of the solution, solution near turning point, connection formulae, energy levels of a potential well and quantization rule.

Unit -II **9 Hrs**

Theory of scattering: differential and total scattering cross section, wave mechanical picture of scattering & the scattering amplitude, Green's functions and formal expression for scattering amplitude, The Born approximation and its validity, Partial wave analysis, asymptomatic behavior of partial waves and phase shifts, optical theorem, scattering by a square well potential, scattering by a hard sphere, scattering by a Coulomb potential..

Unit – III **9 Hrs**

Time-dependent perturbation theory, first order perturbation, Harmonic perturbation, Fermi`s Golden rule, Ionization of a H-atom, absorption and induced emission, Selection rules. Identical particles, symmetric and anti-symmetric wave functions

Unit –IV **9 Hrs**

Relativistic quantum mechanics, formulation of relativistic quantum theory, the Klein-Gordon equation; plane wave solutions, charge and current densities, The Dirac equation for a free particle, matrices alpha and beta, Lorentz covariance of the Dirac equation, free particle solutions and the energy spectrum, charge and current densities.

Unit-V **9 Hrs**

The spin of the Dirac particle, Dirac particle in electromagnetic fields and the significance of the negative energy state, Dirac equation for a central field : Spin angular momentum, approximate reduction, spin –orbit energy, separation of equation, the hydrogen atom, classification of energy levels and negative energy states.

TEXT AND REFERENCE BOOKS –

1. L.I. Schiff: Quantum Mechanics (McGraw-Hill).
2. S. Gasiorowicz: Quantum Physics (Wiley).
3. Landau and Lifshitz: Quantum Mechanics.
4. B. Craseman and Z. D. Powell: Quantum Mechanics (Addison Wesley)
5. A.P. Messiah: Quantum Mechanics.
6. J.J. Sakurai: Modern Quantum Mechanics.
7. Mathews and Venkatesan: Quantum Mechanics.
8. Bjorken and Drell : Relativstic Quantum Mechanics.

Course Outcomes (COs):

CO1 Learning approximation methods for bound states, i.e. perturbation theory, variation method and WKB approximation method with their application to physical problems.

CO2 Understanding the concepts of time dependent perturbation theory, adiabatic and sudden approximation, absorption and induced emission, transition probability and Einstein's A and B coefficients.

CO3 Studying physical concepts of the theory of scattering and its applications.

CO4 Exploring the application of Schrodinger's and Dirac's relativistic equations in understanding negative energy states and hyperfine splitting of energy states.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY302	Solid State Physics – I	4	-	70	30	100

Unit- I **9 Hrs**

Electrons in Solids and Electronic Properties, Energy bands nearly free electron model, origin of energy gap and its magnitude, Bloch function, Kronig-Penny model, Wave equation of electron in periodic potential, restatement of Bloch theorem, crystal moment of an electron, solution of Central equation, Kronig-Penny model in reciprocal space, empty lattice Approximation, approximate solution near zone boundary, Number of orbitals in a band, metals and insulators.

Unit –II **9 Hrs**

Fermi surfaces and metals Effect of temperature on F-D distribution, free electron gas in three dimension. Different zone schemes, reduced and periodic zones, construction of Fermi surfaces, nearly free electrons, electron, hole, open orbits, Calculation of energy bands, Tight binding, Wigner-Seitz, cohesive energy, pseudo potential methods. Experimental methods in Fermi surface studies, quantization of orbits in a magnetic field, de Haas van Alphen Effect, External orbits, Fermi surface of copper.

Unit- III **9 Hrs**

Crystal vibration and thermal properties, Lattice dynamics in monoatomic and diatomic lattice: two atoms per primitive basis, optical and acoustic modes, quantization of elastic waves, phonon momentum, inelastic neutron scattering by phonons, Anhormonic crystal interactions-thermal expansion, thermal conductivity, thermal resistivity of phonon gas, umklapp processes, imperfections.

Unit –IV **9 Hrs**

Electron-Phonon interaction- superconductivity, Experimental survey: occurrence of superconductivity, Destruction of superconductivity by magnetic field, Meissner effect, heat capacity, energy gap, MW, and IR properties, isotope effect. Theoretical survey: thermodynamics of superconducting transition, London equation, Coherence length, Cooper pairing due to phonons, BCS theory of superconductivity, BCS ground state, flux quantization of superconducting ring, duration of persistent currents, Type II superconductors, Vortex states, estimation of Hc1 and Hc2, single particle and Josephson superconductor tunneling, DC/AC Josephson effect, Macroscopic quantum interference. High temperature superconductors, critical fields and currents, Hall number, fullerenes ring.

Unit – V **9 Hrs**

Semiconductor crystals, Band gap, equation of motion, physical derivation of equation of motion, holes, effective mass, physical interpretation of effective mass, effective masses of semiconductors Si and Ge, intrinsic carrier concentration, intrinsic mobility, impurity conductivity, donor and acceptor states, thermal ionization of donors and acceptors, thermo-electric effects.

TEXT AND REFERENCE BOOKS

1. C. Kittel: Introduction to Solid State Physics (Wiley and Sons).
2. J. M. Ziman: Principles of theory of solids (Cambridge Univ.Press).
3. Azaroff: X-ray crystallography.
4. Verma and Srivastava: Crystallography for Solid State Physics.
5. Buerger: Crystal Structure Analysis.
6. Thomas: Transmission Electron Microscopy.
7. Omar: Elementary solid-state physics.
8. Chalking and Lubensky: Principles of Condensed Matter Physics.
9. Madelung: Introduction to solid-state theory.
10. Callaway: Quantum theory of solid-state physics.
11. Huang: Theoretical Solid State Physics.

Course Outcomes (COs):

CO1	To understand interaction of x-rays with matter, x-ray diffraction for structure determination, defects in solids and the electron microscopic techniques.
CO2	Learning band theory of solids, classification of solids, concept of effective mass, Fermi surface and de Hass von Alfven effect.
CO3	Understanding atomic and molecular polarizability, quantum Hall effect, magneto resistance, superconductivity and the general idea of high T_c superconductivity.
CO4	Explaining magnetic properties of solids, Optical reflectance, Photo electromagnetic effect, Faraday effect and the elements of Raman effect in solids.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY303	Atomic & Molecular Physics	4	-	70	30	100

Unit-I **9 Hrs**

Quantum states of one electron atoms-atomic orbitals, Hydrogen spectrum, spin-orbit(l-s) interaction energy, fine structure of hydrogen spectrum including l-s interaction and relativistic correction, spectra of alkali elements, fine structure in alkali spectra, penetrating and non-penetrating orbits, intensity rules.

Unit-II **9 Hrs**

Pauli's principle, equivalent and non-equivalent electrons, ground state (basic level of different elements), two electron systems, interaction energy in L-S and J-J Coupling, Hyperfine structure, line broadening mechanisms (general ideas).

Unit–III **9 Hrs**

Normal and anomalous Zeeman effect, early discoveries and developments, vector models of one electron system in a weak magnetic field, magnetic moment of a bound electron, magnetic interaction energy, selection rules, intensity rules, Paschen-Back (PB) effect – principal series effect, Zeeman and PB effects in hydrogen, Stark effect- discovery, Stark effect in Hydrogen, orbital model, weak and strong effect in Hydrogen.

Unit-IV **9 Hrs**

Types of molecules: linear and diatomic molecules, symmetric top, asymmetric top and spherical top molecules. Rotational spectra of diatomic molecules: rigid rotator model, energy levels, Eigen functions, spectrum, comparison with observed spectrum and non-rigid rotator model, Intensities of spectral lines, microwave spectrometer, Raman spectrum; classical and quantum theory of Raman Effect, pure rotational Raman spectrum.

Unit –V **9 Hrs**

Vibrational spectra of diatomic molecules: simple harmonic model, energy levels and spectrum, comparison with observed spectrum and anhormonic model, Vibrating rotators, Interaction of rotations and vibrations, fine structures and P-Q-R branches, IR spectrometer, Vibrational Raman spectrum, Vibrational rotational Raman spectrum.

TEXT AND REFERENCE BOOKS:

1. Introduction to atomic spectra - H.E. White (T).
2. Fundamentals of molecular spectroscopy – C.N. Banwell and E.M McCash (T).
3. Spectroscopy vol. I, II and III – Walker and straughner.
4. Introduction to Molecular spectroscopy – G.M. Barrow.
5. Spectra of diatomic molecules – Herzberg.
6. Molecular spectroscopy – Jeanne L.Mc-Hale.

Course Outcomes (COs):

CO1	To explain the quantum states of one electron and two electron systems, interaction energy in LS & JJ couplings, hyperfine structure and broadening mechanisms.
CO2	Understanding the types of molecules, energy levels and intensity of their rotational spectra.
CO3	Understanding vibrational spectra of diatomic molecules with inputs of energy levels and operation of IR spectrometer.
CO4	Learning the concepts, techniques and instrumentation of ultraviolet, visible and infrared spectroscopy such as Raman, Photoelectron, Photo acoustic, Mossbauer and NMR spectroscopy.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY304 (Elective)	A. Astronomy & Astrophysics – I	4	-	70	30	100

Unit – I ASTRONOMICAL INSTRUMENTS & BASIC PHYSICS 9 Hrs.

Light and Its Properties, The Earth's Atmosphere and the Electromagnetic Radiation, Optical Telescopes, Radio Telescopes , The Hubble Space Telescope, Astronomical Spectrographs, Photographic Photometry, Photoelectric Photometry, Spectrophotometry, Detectors and Image Processing, Basic Physics: Concept of Radiation.

Unit – II MAGNITUDES, MOTIONS, DISTANCES OF STARS & SPECTRAL CLASSIFICATION OF STARS 9 Hrs.

Stellar Magnitude Sequence, Absolute Magnitude and the Distance Modulus, The Bolometric Magnitude, Different Marnitude Standards The UBV System and Six-color Photometry, Radiometrie Magnitude, The Colour-index of a Star, Luminosities of Stars and Stellar Parallax. Boltzmann's Formula, Saha's Equation of Thermal ionization, Harvard System of Spectral Classification: The Henry-Draper Catalogue, The Luminosity Effect on Stellar Spectra, Importance of ionization Theory in Astrophysics, Spectroscopic Parallax, The Hertzsprung-Russell Diagram.

Unit – III THE SUN 9 Hrs.

Sun, The Photosphere: Limb-darkening, Solar Granulation, Faculac, The Chromosphere, Solar Corona, Prominences, The 11-year Solar Cycle and Sunspots, The Solar Magnetic Fields, Theory of Sunspots, Solar Flares, Radio Emission from the Sun, Solar Wind, The Solar Neutrino Puzzle.

Unit – IV STARS & ITS LIFE CYCLES 9 Hrs.

End states of stars, degenerate states, White dwarfs, and Chandrasekhar limit, Neutron stars and Pulsars, Black holes. Binary stars and their classification, close binaries, Roche Lobes, Evolution of semidetached systems: Algols, Cataclysmic variables and X-ray binaries.

Unit – V GALACTIC NEBULAE & INTERSTELLAR MATTER 9 Hrs.

Classification and Galactic Distribution of Nebulae, Observational Techniques, Dark Nebulae, Reflection Nebulae, Diffuse Emission and Crab Nebula.

Large-scale Distribution of Interstellar Matter, Interstellar Lines, Interstellar Clouds, H I and H II Regions, Interstellar Shock Waves, Interstellar Cloud Collisions, Energy Balance in Interstellar Gas, The Intercloud Medium, interstellar Grains.

TEXT AND REFERENCE BOOKS:

1. Modern Astrophysics, B.W. Carroll and D. A. Ostlie, Addison-Wealey publishing Co.
2. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th edition, Saunders college publishing.
3. Theoretical Astrophysics, vol. – II: Stars and stellar systems, T. Padmanabhan, Cambridge university press.
4. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University science books.
5. The new cosmos, A. Unsold and B. Baschek, Newyork, Springer Velas.
6. Quasars and active galactic neuclei, A.K. Kembhavi and J.V. Narlikar, Cambridge university press.
7. Theoretical Astrophysics, vol. I: Astrophysical processes T.Padmanabhan, Cambridge university press.
8. Galactic Astronomy: Binney and Merrifield.
9. An Introduction to Astrophysics: B. Basu, PHI

Course Outcomes (COs):

CO1 Apply conservation laws to predict astrophysical phenomena.
CO2 Recognize the impact of high-energy phenomena upon the evolution of the Universe.
CO3 Assess astrophysical threats to the Earth and potential mitigation.
CO4 Present current astronomical research in written, visual, and verbal format to an audience of your peers.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY304 (Elective)	B. Nanotechnology: Principles & Practices - I	4	-	70	30	100

Unit – I Structure and Bonding **9 Hrs.**

Introduction, Arrangement of Atoms, Two Dimensional Crystal Structures, Three Dimensional Crystal Structures, Planes in the Crystals, Crystallographic Directions, Reciprocal Lattice, Quasi Crystals, Liquid Crystals, Bonding in Solids, Electronic Structure of Solids.

Unit – II Synthesis of Nanomaterials—I (Physical Methods) **9 Hrs.**

Introduction, Mechanical Methods, Methods Based on Evaporation, Laser Vapourization, Sputter Deposition, Chemical Vapour Deposition, Electric Arc Deposition, Ion Beam Techniques, Molecular Beam Epitaxy (MBE)

Unit – III Synthesis of Nanomaterials—II (Chemical Methods) **9 Hrs.**

Introduction, Colloids and Colloids in Solutions, Nucleation and Growth of Nanoparticles, Synthesis of Metal Nanoparticles by Colloidal Route, Synthesis of Semiconductor Nanoparticles by Colloidal Route, Langmuir-Blodgett (LB) Method Microemulsions, Sol-Gel Method, Hydrothermal Synthesis, Sonochemical Synthesis, Microwave Synthesis, Synthesis Using Micro-reactor or Lab-On-Chip.

Unit - IV Synthesis of Nanomaterials—III (Biological Methods) & Self-Assembly **9 Hrs.**

Introduction, Synthesis Using Microorganisms, Synthesis Using Plant Extracts, Use of Proteins, Templates Like DNA, S-Layers etc., Synthesis of Nanoparticles Using DNA, Further Reading, Self-Assembly: Introduction, Mechanism of Self Assembly, Some Examples of Self Assembly.

Unit – V Analysis Techniques **9 Hrs.**

Microscopes, Scanning Electron Microscope, Transmission Electron Microscope (TEM), Scanning Probe Microscopes (SPM), Diffraction Techniques, Spectroscopies, Magnetic Measurements, Mechanical Measurements.

TEXT AND REFERENCE BOOKS:

1. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Springer.
2. B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday, Textbook of Nanoscience and Nanotechnology, Springer-Verlag Berlin Heidelberg.
3. Pradeep T., Nano: The Essentials, 1st Edition, Mc Graw Hill, 2007.
4. Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale
5. Science and Technology, John Wiley & Sons, Ltd., 2005.
6. Yong Zhou, Nanomaterials and Nanotechnology, Nova Publishers 2009.
7. Charles P. Poole Jr and Frank J. Owens, Introduction to Nanotechnology, Wiley Interscience, 2007.
8. Chris Binns, Introduction to Nanoscience & Nanotechnology, 1st Edition, Willey- Publication, 2010.
9. Chattopadhay K.K., Introduction to Nanoscience and Nanotechnology, APH Publishing Corporation, 2006.
10. Parag Diwan, Handbook of Nanotechnology, Pentagon Press, 2009.

Course Outcomes (COs):

CO1 Explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.

CO2 Choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties.

CO3 Correlate properties of nanostructures with their size, shape and surface characteristics.

CO4 Appreciate enhanced sensitivity of nanomaterial based sensors and their novel applications in industry.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY304 (Elective)	C. Experimental Physics – I	4	-	70	30	100

Unit – I **9 Hrs**

Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test.

Unit – II **9 Hrs**

Dispersion and resolution of a prism and a grating spectrometer, Single and double monochromators, Photomultiplier tube, Charge coupled detectors (CCD).

Unit – III **9 Hrs**

UV and Visible absorption spectroscopy, IR and Raman spectroscopy, Electron Backscatter Diffraction, Wide Angle Diffraction, Reflectometry, Soft X-Rays and Magnetic Scattering, Spectroscopic Techniques.

Unit – IV **9 Hrs**

Element Distribution Analysis, Element Depth Profile Analysis, Stress Measurement Techniques, Stress and Strain, Substrate Curvature, Measurement Techniques and Fourier Transform Infrared Spectroscopy (FTIR) analysis.

Unit – V **9 Hrs**

Basics of nuclear magnetic resonance (NMR) and electron spin resonance (ESR) spectroscopy, Mössbauer spectroscopy, Microwave spectroscopy, Photoacoustic spectroscopy and their applications. Laser as a source of radiation and its characteristics, Laser fluorescence and absorption spectroscopy, Multiphoton ionization and separation of isotopes.

TEXT AND REFERENCE BOOKS:

1. Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.
2. Modern Spectroscopy: J.M. Hollas.
3. Transmission Electron Microscopy of Metals: Gareth Thomas
4. Elements of X-ray Diffraction: Bernard Dennis Cullity.
5. Atomic Force Microscopy/Scanning Tunneling Microscopy: M.T. Bray, Samuel H. Cohen and Marcia L. Lightbody.
6. Electron Spectroscopy: Theory, Techniques and Applications: CR Brundle and AD Baker.
7. Synchrotron Radiation: Techniques and Applications: C. Kunz.
8. Low Energy Electron Spectroscopy: KD Sevier.
9. Radiation Detectors: WH Tait.
10. Advances in Image Pickup and Display, Vol. 1: P. Schagen.
11. Metal Based Thin Films for Electronics: Editor(s): PD Dr. rer. nat. habil. Klaus Wetzig PD Dr. rer. nat. habil. Claus M. Schneider, First published:28 January 2005, Wiley-VCH Verlag GmbH & Co. KGaA

Course Outcomes (COs):

CO1 Assemble and document a relevant bibliography for a physics experiment.
CO2 Prepare a journal-style manuscript using scientific typesetting software.
CO3 Plan and conduct experimental measurements in physics while employing proper note-taking methods.
CO4 Calculate uncertainties for physical quantities derived from experimental measurements.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY304 (Elective)	D. Lasers and Non – Linear Optics – I	4	-	70	30	100

Unit – I Introduction:

Directionality, Intensity, Monochromacity, Coherence. Einstein's Quantum Theory of Radiation: Einstein coefficients, Momentum transfer, Lifetime, Possibility of amplification. Interaction of Radiation with Matter: Time Dependent Perturbation Theory, Electric Dipole Interaction, Quantum Electrodynamics, Creation and annihilation operators, Fock States, Quantization of the field, Zero-point energy, Coherent-state description of the electromagnetic field, Interaction of radiation with matter.

Unit – II Masers:

The two-level Maser system: Ammonia maser, Hydrogen maser, the three-level maser system. Theory of Some Simple Optical Processes: Waves and interference, Coherence, Coherence of the field and the size of the source, Visibility and the size of the source, Coherence and monochromacity, Kinetics of optical absorption, Shape and width of spectral lines, Line broadening mechanisms: Natural or intrinsic broadening, Collision broadening, Doppler broadening.

Unit – III Principles of Lasers:

Population inversion, Laser pumping: A two-level and three-level system, Resonators, Vibrational modes of a resonator, Number of modes per unit volume, Open resonators, Confocal resonator, Quality factor Q, Losses inside the cavity, The threshold condition, Quantum yield. Solid State Lasers: Ruby laser — a three-level system, Pumping power, Spiking. U^{3+} in CaF_2 laser: a four-level system. Neodymium lasers: (a) Nd:YAG laser, (b) Nd: Glass laser, HO^{3+}: YLF laser. Other types of solid state lasers.

Unit – IV Lasers:

Neutral atom gas lasers: Helium-Neon laser, Copper vapour laser. Ion lasers: Argon-ion laser, Krypton and mercury-ion lasers. Metal vapour laser: He-Cd laser, He-Se laser. Molecular gas lasers: CO_2 laser, Electroionization lasers, Gasdynamic laser, Vibronic lasers, Excimer lasers. Semiconductor Lasers: Central features of semiconductor lasers, Intrinsic semiconductor lasers, Doped semiconductors, Condition for laser action, Injection lasers, Injection laser threshold current, Advances in semiconductor lasers, C^3 laser. Liquid-, Dye- and Chemical Lasers: Liquid lasers, Dye lasers. Chemical lasers: HC1 laser, HF laser, DF-CO_2 laser, CO-chemical laser.

Unit – V Dynamics of the Laser Processes and Advances in Laser Physics:

Production of a giant pulse Q-switching: Mechanical shutter, Electro-optical shutters, Shutters using saturable dyes, Peak power emitted during the pulse. Giant pulse dynamics, Laser amplifiers, Mode locking, Ultra-short light pulses, Mode pulling, Hole burning, Distributed Feedback Lasers, Gamma ray Laser. Holography: Principle of holography: Recording of the hologram, Reconstruction of the image. Theory, Some distinguishing characteristics of holographs, Practical applications of holography, Advances in holography.

TEXT AND REFERENCE BOOKS:

1. B.B. Laud, Lasers and Nonlinear Optics, 2nd Edn. New Age International (P) Ltd., New Delhi, 1991.
2. Robert W. Boyd, Nonlinear Optics, 2nd Edn., Academic Press, New York, 2003
3. William T. Silvast, Laser Fundamentals, Cambridge University Press, Cambridge 2003
4. Nonlinear Optics – Basic Concepts D.L. Mills, Springer, Berlin 1998.

Course Outcomes (COs):

CO1 Demonstrate a detailed physical and mathematical understanding of a variety of systems and processes in a range of advanced topics in physics.

CO2 Apply the concepts and theories of a range of advanced topics in physics.

CO3 Demonstrate specialized analytical skills and techniques necessary to carry out advanced calculations in a range of advanced topics in physics.

CO4 Approach and solve new problems in a range of advanced topics in physics.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY305P	Solid State Physics Laboratory	-	4	70	30	100
MPHY306P	Minor Project	-	4	70	30	100

Solid State Physics Laboratory (MPHY305P)

1. Determination of band gap of semiconductor by four probe method.
2. Measurement of Hall Coefficient of given semiconductor: identification of type of semiconductor and estimation of charge carrier concentration.
3. To study Electron Spin (ESR) Resonance in given experimental material.
4. To study I-V characteristics of photovoltaic solar cell and find the efficiency.
5. To study the decay of photoconductivity of given sample and find out trap depth.
6. Study of decay of photoluminescence of a given sample.
7. Measurement of electrical conductivity using Impedance Spectroscopy technique.
8. To determine drift velocities of Ag^+ ion in AgI from temperature dependence of ionic transference number study.
9. Electrical conductivity of Ball milled/Mechano-chemical synthesized materials.
10. Structural analysis of powder sample by XRD and particle size determination using Scherrer's formula.
11. FTIR studies of solid samples.
12. Mechanoluminescence of sucrose crystals.
13. Thermoluminescence of irradiated samples.

Course Outcomes (COs):

CO1 Explain the basic concepts that are used to describe the structure and physical properties of crystalline substances.
CO2 Use physical models to perform calculations of the properties of solids.
CO3 Give an overview of an application related to the physical phenomena treated in the course.

Minor Project (MPHY306P)

Minor Project Report	:	30 Marks
Presentation	:	20 Marks
Comprehensive viva-voce	:	20 Marks
Internal assessment	:	30 Marks
Total	**:**	**100 Marks**

Note: Minor Project of Semesters III is interest of field/elective course. Student has to opt for any one of the courses. The commencement of any one of the minor project is subjected to the availability of basic infrastructural facilities viz. expert faculty, laboratory etc.

Course Outcomes (COs):

CO1 Carrying out a job oriented minor project as per program framework on a contemporary topic of public importance.
CO2 Preparing a Dissertation containing different aspects of the project with important conclusions.
CO3 Learning how to prepare a presentation to defend the selection and outcomes of the major project.
CO4 Understanding the important future applications of the minor findings during the course of the project work.
CO5 Undergoing a viva voce of the major project work.

Semester – IV

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY401	Plasma Physics	4	-	70	30	100

Unit – I **9 Hrs**

Occurrence of Plasmas in Nature, Definition of Plasma, Concept of Temperature, Debye Shielding, The Plasma Parameter, Criteria for Plasmas, Applications of Plasma Physics.

Unit – II **9 Hrs**

Uniform E and B Fields, Nonuniform B Field, Nonuniform E Field, Time-Varying E Field, Time-Varying B Field, Summary of Guiding Center Drifts, Adiabatic Invariants. Relation of Plasma Physics to Ordinary Electromagnetics, The Fluid Equation of Motion, Fluid Drifts, Perpendicular to B, Fluid Drifts Parallel to B, The Plasma Approximation

Unit – III **9 Hrs**

Representation of Waves, Group Velocity, Plasma Oscillations, Electron Plasma Waves, Sound Waves, Ion Waves, Validity of the Plasma Approximation, Electrostatic Electron Oscillations Perpendicular to B, Electrostatic Ion waves Perpendicular to B, The Lower Hybrid Frequency, Electromagnetic Waves with $B_0 = 0$, Electromagnetic Waves Perpendicular to B_0, Cutoffs and Resonances, Electromagnetic Waves Parallel B_0, Hydromagnetic Waves, Magnetosonic Waves, The CMA Diagram,

Unit – IV **9 Hrs**

Diffusion and Mobility in Weakly Ionized Gases, Decay of a Plasma by Diffusion, Steady State Solutions, Recombination, Diffusion across a Magnetic Field, Collisions in Fully Ionized Plasmas, The Single-Fluid MHD Equations, Diffusion in Fully Ionized Plasmas, Solutions of the Diffusion Equation, Bohm Diffusion and Neoclassical Diffusion.

Unit – V **9 Hrs**

Hydromagnetic Equilibrium, The Concept of β , Diffusion of Magnetic Field into a Plasma, Classification of Instabilities, Two-Stream Instability, The "Gravitational" Instability, Resistive Drift Waves, The Weibel Instability, The Meaning of f(v), Equations of Kinetic Theory, Derivation of the Fluid Equations, Plasma Oscillations and Landau Damping, The Meaning of Landau Damping, Physical Derivation of Landau Damping, Modes BGK and Van Kampening, Experimental Verification, Ion Landau Damp, Kinetic Effects in a Magnetic Field.

TEXT AND REFERENCE BOOKS:

1. Introduction to Plasma Physics: F.F Chen Plenum Pres New - York
2. Introduction to Plasma Theory: D. R. Nicholson, John - Wiley & Son
3. Fundamental of Plasma Physics: J. A. Bittencourt

Course Outcomes (COs):

CO1	Define, using fundamental plasma parameters, under what conditions an ionized gas consisting of charged particles (electrons and ions) can be treated as plasma.
CO2	Distinguish the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena.
CO3	Determine the velocities, both fast and slow (drift velocities), of charged particles moving in electric and magnetic fields that are either uniform or vary slowly in space and time.
CO4	Explain the physical mechanism behind Landau damping and make calculations in this area using kinetic theory.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY402	Solid State Physics – II	4	-	70	30	100

Unit- I **9 Hrs**

Plasmons, Polaritons, Dielectric function of the electron gas, Plasma optics, Dispersion relation for EM wave, Transverse optical modes in Plasma, Transparency of Alkali metals in the ultraviolet, Longitudinal Plasma oscillations, Plasmon, electrostatic screening and screened Coulomb potential, Mott metal-insulator transition, screening and phonons in metals, Polaritons, LST relation .

Unit –II **9 Hrs**

Dielectric and ferroelectrics, Maxwell's equations, polarization, macroscopic electric field, depolarization filed, E1;local electric field at an atom, Lorentz filed E2, fields of dipoles inside cavity E3; dielectric constant and polarizability, electronic polarizability; structural phase transition; ferro-electric crystals, classification; displacive transition, soft optical phonons, Landau theory of phase transitions, first and second order transition, anti-ferro-electricity, ferro-electric domain, piezoelectricity, ferro-elasticity, optical ceramics.

Unit –III **9 Hrs**

Magnetism, General ideas of dia- and para- magnetisms, quantum theory of paramagnetism, rare earth ions, Hund rule, iron group ions, crystal field splitting, quenching of orbital angular momentum, spectroscopic splitting factor, van vleck temperature dependent paramagnetism, Cooling by isentropic demagnetization, nuclear demagnetization, paramagnetic Susceptibility of conduction electrons.

Unit –IV **9 Hrs**

Ferromagnetism and anti-ferromagnetism, Ferromagnetic order, Curie point and exchange integral, temp dependence of saturation magnetization, saturation magnetization at absolute zero; magnons, quantization of spin waves, thermal excitation of magnons; neutron magnetic scattering, Ferrimagnetic order, Curie temp and susceptibility of ferrimagnets, iron garnets. Antiferromagnetic order, susceptibity below neel temp, antiferromagnetic magnons, ferromagnetic domains.

Unit – V **9 Hrs**

Optical Processes & Excitons and defects, Optical reflectance, excitons, Frenkel and Mott-Wannier excitons, Alkali Halides and Molecular crystals Defects: lattice vacancies, Schottkey and Frenkel point effects, colour centers, F and other centres, Line defect. Shear strength of single crystals, dislocations-edge and screw dislocations, Burger vectors, Stress fields of dislocations, low angle grain boundaries, dislocation densities, dislocation multiplication and slip, strength of alloys, dislocations and crystal growth, hardness of materials.

TEXT AND REFERENCE BOOKS

1. C. Kittel: Introduction to Solid State Physics (Wiley and Sons).
2. J.M.Ziman: Principles of theory of solids (Cambridge univ.press).
3. Azaroff: X-ray crystallography.
4. Verma and Srivastava: Crystallography for Solid State Physics.
5. Buerger: Crystal Structure Analysis.
6. Omar: Elementary solid state physics.
7. Chalking and Lubensky: Principles of Condensed Matter Physics.
8. Madelung: Introduction to solid state theory.
9. Callaway: Quantum theory of solid state physics.
10. Huang: Theoretical Solid State Physics.

11. Kittel: Quantum theory of solids.

Course Outcomes (COs):

CO1	Realizing the concept and mechanism of imperfections in solids and their several applications in understanding the properties of solids.
CO2	To understand experimental methods of observing imperfections and realizing the use of electron microscopy, scanning, tunneling and atomic force microscopy.
CO3	Understanding extensively the properties of thin films and surfaces and furthermore their potential applications.
CO4	Explaining the concepts of lattice dynamics to understand thermal conductivity and optical properties of solids.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY403	Nuclear & Particle Physics	4	-	70	30	100

Unit – I **9 Hrs**

Nucleon-nucleon interaction, Two-nucleon system, The ground state of the deuteron, Tensor forces, Nucleon-nucleon scattering at low energy, Scattering length, Effective range theory, Spin dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces, Iso-spin formalism, Exchange forces, Meson theory of nuclear forces and the Yukawa interaction.

Unit – II **9 Hrs**

Reaction energetics: Q-equation and threshold energies, Reactions cross sections, Resonance: Breit-Wigner single-level formula, Direct and compound nuclear reactions, Formal reaction theory: Partial wave approach and phase shifts, Scattering matrix, Reciprocity theorem,

Unit – III **9 Hrs**

Beta decay, Femi's theory of beta decay, Shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions, Selection rules, Parity violation, Two component theory of neutrino decay, Detection and properties of neutrino, Gamma decay, Multiple transitions in nuclei, Angular momentum and Parity selection rules, Internal conversion, Nuclear isomerism.

Unit –IV **9 Hrs**

Liquid drop model, Bohr-Wheeler theory of fission, Shell Model, Experimental evidence for shell effects, Single particle shell model, Spin-orbit interaction and magic numbers, Analysis of shell model predictions, Magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson.

Unit –V **9 Hrs**

Elementary particle Physics : The fundamental interactions, Classification of elementary particles, Leptons and Hadrons, Symmetries, groups and conservation laws, SU(2) and SU(3) multiplets and their properties, Quark model, Properties of Quarks, the standard model.

TEXT AND REFERENCE BOOKS:

1. Kenneth S. Kiane, Introductory Nuclear Physics, Wiley, New York, 1988.
2. Ghoshal, Atomic and Nuclear Physics vol.2.
3. P. H. Perking, Introduction to high energy physics, Addison-Wesley, London, 1982.
4. Griffiths, introduction to elementary particles, harper and row, New York, 1987.
5. G, E. Brown and A. D. Jackson, Nucleon-Nucleon interaction North-halland Amsterdam, 1976.
6. J. M. Longo, elementary particles, McGraw Hill, New York, 1971.
7. R. R. Roy and B. P. Nigam, Nuclear Physics, Wiley-Easterm Ltd. 1983.

Course Outcomes (COs):

CO1 Basic knowledge nuclear and particle physics. Knowledge and understanding of the elementary particle interactions. Capability of relating the theory predictions and measurements.

CO2 Understanding of various particle interactions and their interrelation. Relation of basic laws of particle physics and macroscopic physics phenomena. Usage of basic laws in determination of particle properties and properties of processes in the subatomic world.

CO3 Critical evaluation of theoretical predictions using results of measurements. Quantum mechanical reasoning in classification of processes in subatomic world.

CO4 Understanding of particle physics phenomena and measurement results explanation and evaluation.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY404 (Elective)	A. Astronomy & Astrophysics – II	4	-	70	30	100

Unit – 1 OUR GALAXY **9 Hrs.**

Rotation of the Galaxy. Differential Rotation, Determination of the Rotation Parameters in the Solar Neighbourhood, Radio Observation of the Galaxy at 21-cm Wave Length. TOF, The Rotation Curve of the Galaxy The General Rotation Law, Density Distribution of Gas and Spiral Structure of the Galaxy Radio and Optical Data, The General Structure of the Galaxy, The Mass of the Galaxy, Magnetic Field in the Galaxy, Cosmic Rays, Continuous Radio Emission in the Galaxy.

Unit – 2 EXTERNAL GALAXIES **9 Hrs.**

Classification of Galaxies, Distribution of Galaxia, Luminosity Distribution of Galaxies, Spectra of Galaxies, The Local Group of Galaxies, Distances of Galaxies, Nuclei of Galaxies, Theories of Spiral Structures of Disk Galaxies, Dwarf Galaxies, Compact Dwarf Galaxies (UCD), Compact Groups of Galaxies.

Unit – 3 CLUSTERS OF GALAXIES **9 Hrs.**

Clustering Nature of Galaxies, Morphological Classification of Clusters, cD Galaxies, Interacting Galaxies and Galaxy Mergers, X-Ray Emission from Galaxies and from Clusters of Galaxies: The Cooling Flow, Masses of Galaxies, Evolution of Galaxies, Dark Matter in Galaxies, Superclusters and Voids.

Unit – 4 RADIO GALAXIES & QUASARS **9 Hrs.**

Techniques of Identification of Radio Objects, Structures of Radio Galaxies, Classification of Radio Galaxies and Their Typical Characteristics, Energy Processes in Radio Galaxies, Radio Galaxies in Evolutionary Sequence, Some Important Radio Galaxies, Seyfert Galaxies. The Discovery of Quasars, Radio Properties, Optical Properties, The Redshift of Quasars, Active Galactic Nuclei.

Unit – 5 COSMOLOGY **9 Hrs.**

Redshift and the Expansion of the Universe, Matter Density in the Universe and the Deceleration Parameter, The Cosmological Principle: The Perfect Cosmological Principle, Fundamental Equations of Cosmology, The Current Theories: Some Important Models of the Universe, Observational Tests of Cosmological Models, The Cosmic Microwave Background Radiation.

TEXT AND REFERENCE BOOKS:

1. Modern Astrophysics, B.W. Carroll and D. A. Ostlie, Addison-Wealey publishing Co.
2. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th edition, Saunders college publishing.
3. Theoretical Astrophysics, vol. – II: Stars and stellar systems, T. Padmanabhan, Cambridge university press.
4. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University science books.
5. The new cosmos, A. Unsold and B. Baschek, Newyork, Springer Velas.
6. Quasars and active galactic neuclei, A.K. Kembhavi and J.V. Narlikar, Cambridge university press.
7. Theoretical Astrophysics, vol. I: Astrophysical processes T.Padmanabhan, Cambridge university press.
8. Galactic Astronomy: Binney and Merrifield.
9. An Introduction to Astrophysics: B. Basu, PHI

Course Outcomes (COs):

CO1 Apply conservation laws to predict astrophysical phenomena.

CO2 Recognize the impact of high-energy phenomena upon the evolution of the Universe.

CO3 Assess astrophysical threats to the Earth and potential mitigation.
CO4 Present current astronomical research in written, visual, and verbal format to an audience of your peers.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY404 (Elective)	B. Nanotechnology: Principles & Practices - II	4	-	70	30	100

Unit – I Types of Nanomaterials and Their Properties **9 Hrs.**

Introduction, Clusters, Types of Clusters, Semiconductor Nanoparticles, Excitons, Effective Mass Approximation, Optical Properties of Semiconductor Nanoparticles, Plasmonic Materials, Localized Surface Plasmon Resonance, Surface Plasmon Polariton, Nanomagnetism, Types of Magnetic Materials, Mechanical Properties of Nanomaterials, Structural Properties, Melting of Nanoparticles.

Unit – II Nanolithography **9 Hrs.**

Introduction, Lithography Using Photons, Lithography Using Particle Beams, Scanning Probe Lithography, Soft Lithography.

Unit – III Nanoelectronics **9 Hrs.**

Introduction, Coulomb Blockade, Single Electron Transistor (SET), Spintronics, Nanophotonics, Carbon Nanomaterials, Porous Material, Aerogels, Zeolites, Porosity Through Templates, Core-Shell Particles, Metamaterials, Bioinspired Materials.

Unit –IV Applications **9 Hrs.**

Introduction, Dye Sensitized Photovoltaic Solar Cell, Organic Photovoltaic Cells, Fuel Cell, Hydrogen Generation and Storage Hydrogen Storage and Release, Hybrid Energy Cells, Automobiles, Sports and Toys, Textiles, Cosmetics, Medical Field, Agriculture and Food, Domestic Appliances, Space, Defense and Engineering, Environmental Pollution and Role of Nanotechnology, Effect of Nanotechnology on Human Health.

Unit – V Practicals **9 Hrs.**

Introduction, Synthesis of Gold/Silver Nanoparticles, Synthesis of CdS Nanoparticles, Synthesis of ZnO Nanoparticles, Synthesis of TiO_2 Nanoparticles, Synthesis of Fe_2O_3 Nanoparticles, Synthesis of Porous Silicon, Introductory Photolithography, Introductory Nano (Soft) Lithography Using PDMS, Fabrication of Porous Alumina or Anodized Alumina (AAO) Template.

TEXT AND REFERENCE BOOKS:

1. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Springer.
2. B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday, Textbook of Nanoscience and Nanotechnology, Springer-Verlag Berlin Heidelberg.
3. Pradeep T., Nano: The Essentials, 1st Edition, Mc Graw Hill, 2007.
4. Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale
5. Science and Technology, John Wiley & Sons, Ltd., 2005.
6. Yong Zhou, Nanomaterials and Nanotechnology, Nova Publishers 2009.
7. Charles P. Poole Jr and Frank J. Owens, Introduction to Nanotechnology, Wiley Interscience, 2007.
8. Chris Binns, Introduction to Nanoscience & Nanotechnology, 1st Edition, Willey- Publication, 2010.
9. Chattopadhay K.K., Introduction to Nanoscience and Nanotechnology, APH Publishing Corporation, 2006.
10. Parag Diwan, Handbook of Nanotechnology, Pentagon Press, 2009.

Course Outcomes (COs):

CO1 Explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.
CO2 Choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties.
CO3 Correlate properties of nanostructures with their size, shape and surface characteristics.

CO4 Appreciate enhanced sensitivity of nanomaterial based sensors and their novel applications in industry.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY404 (Elective)	C. Experimental Physics – II	4	-	70	30	100

Unit – I **9 Hrs.**

Microstructural characterization, Electron Microscopy and Diffraction, Transmission Electron Microscopy (TEM) - Imaging, TEM - Selected Area Electron Diffraction, in situ-SEM Methods, Electron Backscatter Diffraction,

Unit – II **9 Hrs.**

Diffraction Techniques: Fundamental of material characterization using x-ray technique, intensity data collection, data reduction profile fitting and refinement (Lebail & Rictveld). Small angle x-ray scattering (SAXS) to study shape and size distributions.

Unit – III **9 Hrs.**

Thin film preparation techniques: Physical Vapor Deposition, Chemical Vapor Deposition, Non-Vacuum Based Deposition, Combustion method, RF Magnetron Sputtering, Thin film characterization.

Unit – IV **9 Hrs.**

Introduction, Mechanical Methods, High Energy Ball Milling, Melt Mixing, Methods Based on Evaporation, Physical Vapour Deposition with Consolidation, Ionized Cluster Beam Deposition, Laser Vapourization (Ablation), Laser Pyrolysis, Sputter Deposition, DC Sputtering, RF Sputtering, Magnetron Sputtering, ECR Plasma Deposition, Chemical Vapour Deposition (CVD) Electric Arc Deposition, Ion Beam Techniques (Ion Implantation, Molecular Beam Epitaxy (MBE)

Unit – V **9 Hrs.**

Introduction, Colloids and Colloids in Solutions, Interactions of Colloids and Medium, Colloids in Vacuum, Colloids in a Medium, Effect of Charges on Colloids, Stearic Repulsion, Synthesis of Colloids, Nucleation and Growth of Nanoparticles, Synthesis of Metal Nanoparticles by Colloidal Route, Synthesis of Semiconductor Nanoparticles by Colloidal Route, Langmuir-Blodgett (LB) Method Microemulsions, Sol-Gel Method, Hydrothermal Synthesis, Sonochemical Synthesis, Microwave Synthesis, Synthesis Using Micro-reactor or Lab-On-Chip.

TEXT AND REFERENCE BOOKS:

1. Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.
2. Modern Spectroscopy: J.M. Hollas.
3. Transmission Electron Microscopy of Metals: Gareth Thomas
4. Elements of X-ray Diffraction: Bernard Dennis Cullity.
5. Atomic Force Microscopy/Scanning Tunneling Microscopy: M.T. Bray, Samuel H. Cohen and Marcia L. Lightbody.
6. Electron Spectroscopy: Theory, Techniques and Applications: CR Brundle and AD Baker.
7. Synchrotron Radiation: Techniques and Applications: C. Kunz.
8. Low Energy Electron Spectroscopy: KD Sevier.
9. Radiation Detectors: WH Tait.
10. Advances in Image Pickup and Display, Vol. 1: P. Schagen.
11. Metal Based Thin Films for Electronics: Editor(s): PD Dr. rer. nat. habil. Klaus Wetzig PD Dr. rer. nat. habil. Claus M. Schneider, First published:28 January 2005, Wiley-VCH Verlag GmbH & Co. KGaA.

Course Outcomes (COs):

CO1	Assemble and document a relevant bibliography for a physics experiment.
CO2	Prepare a journal-style manuscript using scientific typesetting software.
CO3	Plan and conduct experimental measurements in physics while employing proper note-taking methods.

CO4 Calculate uncertainties for physical quantities derived from experimental measurements.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY404 (Elective)	D. Lasers and Non – Linear Optics – II	4	-	70	30	100

Unit – I Non-Linear Optics **9 Hrs.**

Harmonic generation, Second harmonic generation, Phase matching, Third harmonic generation Optical mixing, Parametric generation of light, Self-focusing of light.

Unit – II Multiphoton Processes **9 Hrs.**

Multiquantum photoelectric effect, Two-photon processes, Theory of two Photon Processes, Experiments in two-photon processes, Violation of the square law dependence, Doppler-free two-photon spectroscopy, Multiphoton processes, Three-photon processes, Second harmonic generation, Parametric generation of light, Parametric light oscillator, Frequency up conversion, Phase conjugate Optics.

Unit – III Laser Spectroscopy **9 Hrs.**

Rayleigh and Raman scattering, Stimulated Raman effect, Hyper-Raman effect, Classical treatment, Quantum mechanical treatment, Coherent anti-Stokes Raman scattering (CARS), Spin-flip Raman laser, Free-electron laser (FEL), Photo-acoustic Raman spectroscopy (PARS), Brillouin scattering, Saturation Absorption spectroscopy, Doppler-free Two Photon Spectroscopy.

Unit – IV Some Laser Induced Phenomena **9 Hrs.**

Modulation of an electron wave by a light wave, Laser induced collision processes -Pair excitation, Multi-photon ionization. Single atom detection with lasers: Fluorescence methods, Ionization methods. Laser cooling and trapping of neutral atoms.

Unit - V Applications of Lasers **9 Hrs.**

Some experiments of fundamental importance, Ether drift, Absolute rotation of the earth, "Counting of atoms", Isotope separation, Plasma, Thermonuclear fusion, Lasers in chemistry, Communication by laser, Ranging, Atmospheric Optics, Lasers in astronomy, Lasers in biology, Lasers in medicine, Lasers in industry.

TEXT AND REFERENCE BOOKS:

1. B.B. Laud, Lasers and Nonlinear Optics, 2nd Edn. New Age International (P) Ltd., New Delhi, 1991.
2. Robert W. Boyd, Nonlinear Optics, 2nd Edn., Academic Press, New York, 2003
3. William T. Silvast, Laser Fundamentals, Cambridge University Press, Cambridge 2003
4. Nonlinear Optics – Basic Concepts D.L. Mills, Springer, Berlin 1998.

Course Outcomes (COs):

CO1 Demonstrate a detailed physical and mathematical understanding of a variety of systems and processes in a range of advanced topics in physics.

CO2 Apply the concepts and theories of a range of advanced topics in physics.

CO3 Demonstrate specialized analytical skills and techniques necessary to carry out advanced calculations in a range of advanced topics in physics.

CO4 Approach and solve new problems in a range of advanced topics in physics.

Subject Code	Name of the Subject	Teaching/Credit Scheme		Examination		
		L + T	P	Theory/ Practical	Internal	Total
MPHY405P	Major Project	-	8	150	50	200

Major Project (MPHY405P)

Dissertation	:	100 Marks
Presentation	:	20 Marks
Comprehensive viva-voce	:	30 Marks
Internal assessment	:	50 Marks
Total	**:**	**200 Marks**

Note: Major Project of Semesters IV is interest of field/elective course. Student has to opt for any one of the courses. The commencement of any one of the major project is subjected to the availability of basic infrastructural facilities viz. expert faculty, laboratory etc.

Course Outcomes (COs):

CO1 Carrying out a job oriented major project as per program framework on a contemporary topic of public importance.
CO2 Preparing a Dissertation containing different aspects of the project with important conclusions.
CO3 Learning how to prepare a presentation to defend the selection and outcomes of the major project.
CO4 Understanding the important future applications of the major findings during the course of the project work.
CO5 Undergoing a viva voce of the major project work.