M. Sc. PHYSICS
DEPARTMENT OF PHYSICS
BANARAS HINDU UNIVERSITY

Semester-wise distribution of Courses and Credits

SEMESTER – I

COURSE	TITLE	CREDITS	REMARKS
MPC-101:	MATHEMATICAL PHYSICS	4	
MPC-102:	COMPUTATIONAL PHYSICS AND PROGRAMMING	3	
MPC-103:	QUANTUM MECHANICS-I	3	Course content reduced Credit changed from 4 to 3
MPC-104:	SEMICONDUCTOR DEVICES, INTEGRATED CIRCUITS AND COMMUNICATIONS	3	
MPL-101:	ELECTRONICS LABORATORY	4	
OR			
MPL-102:	GENERAL PHYSICS & OPTICS LABORATORY	4	
MPL-103:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2	

SEMETER – II

COURSE	TITLE	CREDITS	REMARKS
MPC-201:	CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS	4	
MPC-202:	ATOMIC, MOLECULAR PHYSICS AND LASERS	3	
MPC-203:	ELEMENTS OF SOLID STATE PHYSICS	3	
MPC-204:	ELEMENTS OF NUCLEAR PHYSICS	3	
MPME-201:	PHYSICS MINOR ELECTIVE - I	2	Course content reduced Credit changed from 3 to 2
MPL-201:	ELECTRONICS LABORATORY	4	
OR			
MPL-202:	GENERAL PHYSICS & OPTICS LABORATORY	4	
MPL-203:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2	

SEMESTER - III

COURSE	TITLE	CREDITS	REMARKS
MPC–301:	STATISTICAL MECHANICS - I	3	Course content reduced Credit changed from 4 to 3
MPC–302:	QUANTUM MECHANICS - II	3	
MPS–301(A):	ANALOG COMMUNICATION SYSTEMS	3	Course content reduced, Credits changed from 4 to 3 each and syllabi modified accordingly
MPS–301(B):	NUCLEAR PHYSICS:INTERACTIONS & MODELS	3	
MPS-301(C):	VIBRATIONAL & ROTATIONAL MOLECULAR SPECTROSCOPY	3	
MPS-301(D):	SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTIONS IN CRYSTALS	3	
MPS-301(E):	STRUCTURES PROPERTIES AND FUNCTIONS OF BIOMOLECULES	3	
MPS-301(F):	SOLAR AND ASTROPHYSICS	3	
MPME-301:	PHYSICS MINOR ELECTIVE - II	2	Course content reduced Credit changed from 3 to 2
MPE-302:	LASERS AND LASER APPLICATIONS	3	
MPE–303:	CHARACTERIZATION OF SOLIDS	3	
MPE–304:	MOLECULAR BIOPHYSICS	3	
MPE–305:	METHODS IN THEORETICAL PHYSICS	3	
MPE-306:	INSTRUMENTATION IN NUCLEAR AND PARTICLE PHYSICS	3	
MPE-307:	SCIENCE AND TECHNOLOGY OF SOLAR ENERGY, HYDROGEN ENERGY AND OTHER RENEWABLE ENERGIES	3	
MPL-301(A):	ELECTRONICS LABORATORY	6	
MPL-301(B):	NUCEAR PHYSICS LABORATORY	6	
MPL-301(C):	SPECTROSCOPY LABORATORY	6	
MPL-301(D):	SOLID STATE PHYSICS LABORATORY	6	
MPL-301(E):	BIO-PHYSICS LABORATORY	6	
MPL-301(F):	SPACE PHYSICS LABORATORY	6	

SEMESTER – IV

COURSE	TITLE	CREDITS	REMARKS
MPC-401:	STATISTICAL MECHANICS II	3	
MPS-401(A):	DIGITAL COMMUNICTION SYSTEMS	3	Course content reduced, Credits changed from 4 to 3 each and syllabi modified accordingly
MPS-401(B):	PARTICLE PHYSICS	3	
MPS-401(C):	MOLECULAR ORBITAL THEORY & ELECTRONICS SPECTRA OF MOLECULES	3	
MPS-401(D):	SOLID STATE PHYSICS: SPECIAL SOLIDS, SURFACES & PROPERTIES	3	
MPS-401(E):	METHODS AND TECHNIQUES TO STUDY BIOLOGICAL SYSTEMS	3	
MPS-401(F):	ATMOSPHERIC PHYSICS	3	
MPS-402(A):	MICROPROSCESSORS AND INTERFACING	3	
MPS-402(B):	WEAK INTERACTIONS & ELECTROWEAK UNIFICATION	3	
MPS-402(C):	PRINCIPLES & INSTRUMENTATION IN CONVENTIONAL & LASER SPECTROSCOPY	3	
MPS-402(D):	SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS	3	
MPS-402(E):	THEORETICAL MODELLING OF BIOLOGICAL SYSTEMS	3	
MPS-402(F):	INSTRUMENTATION FOR SPACE PHYSICS AND ASTROPHYSICS	3	
MPE-401:	EXPERIMENTAL TECHNIQUES & INSTRUMENTATION IN ATOMIC, MOLECULAR & OPTICAL PHYSICS	3	
MPE–402:	NANOSCIENCE AND TECHNOLOGY	3	
MPE-403:	PHYSICS OF ELECTRONIC MATERIALS & DEVICES	3	
MPE-404:	SATELLITE COMMUNICATION & REMOTE SENSING	3	
MPE-405:	QUANTUM FIELD THEORY:PATH INTEGRAL APPROACH	3	
MPE-407:	COMPUTATIONAL PHYSICS	3	
MPL-401(A):	ELECTRONICS LABORATORY	6	
MPL-401(B):	NUCLEAR PHYSICS LABORATORY	6	
MPL-401(C):	SPECTROSCOPY LABORATORY	6	
MPL-401(D):	SOLID STATE PHYSICS LABORATORY	6	
MPL-401(E):	BIO-PHYSICS LABORATORY	6	
MPL-401(F):	SPACE PHYSICS LABORATORY	6	
MPD-401:	PROJECTS AND DISSERTATION	2	

SUMMARY OF M.Sc. SYLLABUS IN PHYSICS

Semester	No. of Papers			Credits		
	Theory	**Practical**	**Total**	**Theory**	**Practical**	**Total**
I	4	2	6	13	6	19
II	5	2	7	15	6	21
III	5	1	6	14	6	20
IV	4	1	5	12	6	20
	Dissertation					
Total	**18+Dissertation**	**6**	**24**	**56**	**24**	**80**

* MINOR ELECTIVES:

SEMESTER:	PAPER NO.	TITLE	CREDITS	REMARKS
II	MPME-201:	PHYSICS MINOR ELECTIVE – I	2	
III	MPME-301:	PHYSICS MINOR ELECTIVE - II	2	

* Not for M.Sc. Physics students

Semester-wise distribution of Courses and Credits

SEMESTER – I

COURSE	TITLE	CREDITS
MPC-101:	MATHEMATICAL PHYSICS	4
MPC-102:	COMPUTATIONAL PHYSICS AND PROGRAMMING	3
MPC-103:	QUANTUM MECHANICS-I	3
MPC-104:	SEMICONDUCTOR DEVICES, INTEGRATED CIRCUITS AND COMMUNICATIONS	3
MPL-101:	ELECTRONICS LABORATORY	4
OR		
MPL-102:	GENERAL PHYSICS & OPTICS LABORATORY	4
MPL-103:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

SEMETER – II

COURSE	TITLE	CREDITS
MPC-201:	CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS	4
MPC-202:	ATOMIC, MOLECULAR PHYSICS AND LASERS	3
MPC-203:	ELEMENTS OF SOLID STATE PHYSICS	3
MPC-204:	ELEMENTS OF NUCLEAR PHYSICS	3
MPME-201:	PHYSICS MINOR ELECTIVE - I	2
MPL-201:	ELECTRONICS LABORATORY	4
OR		
MPL-202:	GENERAL PHYSICS & OPTICS LABORATORY	4
MPL-203:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

SEMESTER - III

COURSE	TITLE	CREDITS
MPC–301:	STATISTICAL MECHANICS - I	3
MPC–302:	QUANTUM MECHANICS - II	3
MPS–301(A):	ANALOG COMMUNICATION SYSTEMS	3
MPS–301(B):	NUCLEAR PHYSICS:INTERACTIONS & MODELS	3
MPS-301(C):	VIBRATIONAL & ROTATIONAL MOLECULAR SPECTROSCOPY	3
MPS-301(D):	SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTIONS IN CRYSTALS	3
MPS-301(E):	STRUCTURES PROPERTIES AND FUNCTIONS OF BIOMOLECULES	3
MPS-301(F):	SOLAR AND ASTROPHYSICS	3
MPME-301:	PHYSICS MINOR ELECTIVE - II	2
MPE-302:	LASERS AND LASER APPLICATIONS	3
MPE–303:	CHARACTERIZATION OF SOLIDS	3
MPE–304:	MOLECULAR BIOPHYSICS	3
MPE–305:	METHODS IN THEORETICAL PHYSICS	3
MPE-306:	INSTRUMENTATION IN NUCLEAR AND PARTICLE PHYSICS	3
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MPL-301(A):	ELECTRONICS LABORATORY	6
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MPL-301(C):	SPECTROSCOPY LABORATORY	6
MPL-301(D):	SOLID STATE PHYSICS LABORATORY	6
MPL-301(E):	BIO-PHYSICS LABORATORY	6
MPL-301(F):	SPACE PHYSICS LABORATORY	6

SEMESTER – IV

COURSE	TITLE	CREDITS
MPC-401:	STATISTICAL MECHANICS II	3
MPS-401(A):	DIGITAL COMMUNICTION SYSTEMS	3
MPS-401(B):	PARTICLE PHYSICS	3
MPS-401(C):	MOLECULAR ORBITAL THEORY & ELECTRONICS SPECTRA OF MOLECULES	3
MPS-401(D):	SOLID STATE PHYSICS: SPECIAL SOLIDS, SURFACES & PROPERTIES	3
MPS-401(E):	METHODS AND TECHNIQUES TO STUDY BIOLOGICAL SYSTEMS	3
MPS-401(F):	ATMOSPHERIC PHYSICS	3
MPS-402(A):	MICROPROSCESSORS AND INTERFACING	3
MPS-402(B):	WEAK INTERACTIONS & ELECTROWEAK UNIFICATION	3
MPS-402(C):	PRINCIPLES & INSTRUMENTATION IN CONVENTIONAL & LASER SPECTROSCOPY	3
MPS-402(D):	SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS	3
MPS-402(E):	THEORETICAL MODELLING OF BIOLOGICAL SYSTEMS	3
MPS-402(F):	INSTRUMENTATION FOR SPACE PHYSICS AND ASTROPHYSICS	3
MPE-401:	EXPERIMENTAL TECHNIQUES & INSTRUMENTATION IN ATOMIC, MOLECULAR & OPTICAL PHYSICS	3
MPE–402:	NANOSCIENCE AND TECHNOLOGY	3
MPE-403:	PHYSICS OF ELECTRONIC MATERIALS & DEVICES	3
MPE-404:	SATELLITE COMMUNICATION & REMOTE SENSING	3
MPE-405:	QUANTUM FIELD THEORY:PATH INTEGRAL APPROACH	3
MPE-407:	COMPUTATIONAL PHYSICS	3
MPL-401(A):	ELECTRONICS LABORATORY	6
MPL-401(B):	NUCLEAR PHYSICS LABORATORY	6
MPL-401(C):	SPECTROSCOPY LABORATORY	6
MPL-401(D):	SOLID STATE PHYSICS LABORATORY	6
MPL-401(E):	BIO-PHYSICS LABORATORY	6
MPL-401(F):	SPACE PHYSICS LABORATORY	6
MPD-401:	PROJECTS AND DISSERTATION	2

SUMMARY OF M.Sc. SYLLABUS IN PHYSICS

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	Theory	Practical	Total	Theory	Practical	Total
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*** MINOR ELECTIVES:**

SEMESTER:	PAPER NO.	TITLE	CREDITS
II	MPME-201:	PHYSICS MINOR ELECTIVE – I	2
III	MPME-301:	PHYSICS MINOR ELECTIVE - II	2

* Not for M.Sc. Physics students

SEMESTER – I

MPC-101: MATHEMATICAL PHYSICS Credits: 4

Theory of Functions of a Complex Variable:

Analyticity and Cauchy-Reimann Conditions, Cauchy's integral theorem and formula, Taylor's series and Laurent's series expansion, Analytic Continuation, Zeros and singular points, Multivalued functions, Branch Points and Cuts, Reimann Sheets and surfaces, Conformal Mapping, Residues, Cauchy's Residue theorem, Jordan's Lemma; Evaluation of definite integrals, Principal Value, Bromwitch contour integrals.

Fourier and Laplace Transforms:

Fourier transform, Sine, Cosine and Complex transforms with examples, Definition, Properties and Representations of Dirac Delta Function, Properties of Fourier Transforms, Transforms of derivatives, Parseval's Theorem, Convolution Theorem, Momentum representation, Transfer Functions, Applications to Partial differential equations, Discrete Fourier transform, Introduction to Fast Fourier transform, Laplace transform, Properties and examples of Laplace Transform, Convolution theorem and its applications, Laplace transform method of solving differential equations.

Group Theory:

Concept of a group (additive and multiplicative), Matrix representation of a group, Reducible and irreducible representation of a group.

Reference Books:

1. Mathematical Methods for Physicists: Arfken.
2. Mathematics for Physicists and Engineers: Pipes.
3. Complex Variables and applications : R.V. Churchill
4. The use of Integral Transform : I.N. Sneddon
5. Mathematical Methods in Physical Sciences: Boas.
6. Group Theory: Wigner

MPC-102: COMPUTATIONAL PHYSICS AND PROGRAMMING Credits: 3

Fortran:

Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Numerical Methods of Analysis:

Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, Solution of simultaneous linear equations: Matrix inversion method, Interpolation: Newton and Lagrange formulas, Numerical differentiation, Numerical Integration, Trapezoidal, Simpson and Gaussian quadrature methods, Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

Simulation:

Generation of uniformly distributed random integers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method, Metropolis algorithm, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

Reference Books:

1. Computational Methods in Physics and Engineering: Wong.
2. Computer Oriented Numerical Methods: Rajaraman.
3. Computer Programming in FORTRAN 77: Rajaraman.
4. Applied Numerical Analysis: Gerald.
5. A Guide to Monte Carlo Simulations in Statistical Physics: Landau and Binder.
6. Numerical Recipes: Teukolsky, Vetterling and Flannery.

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MPC-103: QUANTUM MECHANICS –I Credits: 3

Linear Vector and Representation Theory:

Linear vector space, Dirac notations of Bra - Ket notation, Matrix representation of Observables and states, Determination of eigenvalues and eigenstate for observables using matrix representations, Change of representation and unitary transformations, Coordinate and momentum representations.

Theory of Angular Momentum:

Symmetry, invariance and conservation laws, relation between rotation and angular momentum, commutation rules, Matrix representations.

Scattering Theory:

Differential and total Scattering cross-sections laws, partial wave analysis and application to simple cases; Green Function, Born approximation validity and simple applications.

Approximation Methods:

Time-independent Perturbation theory (non-degenerate and degenerate), Zeeman effect (Normal), Stark effect, Variational method and applications to helium atom and simple cases; WKB approximation. Time dependent Perturbation theory, Fermi's Golden rule.

Reference Books:

1. Quantum Mechanics: L.I. Schiff.
2. Modern Quantum Mechanics: J.J. Sakurai.
3. Introduction to Quantum Mechanics : C.J. Joachain and B.H. Bransden.
4. Introduction of Quantum Mechanics: D.J. Griffiths.
5. Principles of Quantum Mechanics: P.A.M.Dirac.

MPC-104: SEMICONDUCTOR DEVICES INTEGRATED CIRCUITS AND COMMUNICATIONS

Credits: 3

Semiconductor Devices:

Metal/Semiconductor Contact, MOS Junction (Accumulation, Depletion and Inversion).

Integrated Circuits:

Fabrication of ICs (Planar, Monolithic, Active and Passive Including MOS).

Op-Amp (IC-741):

Internal Structure (Block Diagram) Slew Rate, Frequency Response and Compensation, Applications (Linear and Non-Linear).

Timer (IC-555):

Internal Structure (Block Diagram) Operation, Astable, Monostable and Applications.

Phase Locked Loops (IC-565):

Internal Structure (Block) Diagram) Application as Frequency Multiplication, Division FSK and FM Demodulation.

Digital ICs:

TTl, MOS and CMOS Gates, Parrallel Binary adder/subtractor, BCD Addition/Subtraction, Encoder, Decoder, MUX, DE-MUX, Flip-Flops, Shift Resister, Counter, Memory Concept, RAM and ROM.

Communication:

Radio Wave Propagation through Ground, Stratosphere and Ionosphere. Radiation from short electric doublet. Monopole and Dipole Antenna, Antenna parameters, Antenna Arrays.

Reference Books:

1. Integrated Electronics: Millman and Halkias.
2. Physics of Semiconductors Devices: Sze.
3. Op-Amps and Linear Integrated Circuits: Gayakwad.
4. Digital Fundamental: Floyed.
5. Electronic Communication Systems: Kennedy
6. Linear Integrated Circuits: Choudhary and Jain.
7. Digital Electronics: Jain.

MPL-101: ELECTRONICS LABORATORY **Credits: 4**

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-102: GENERAL PHYSICS & OPTICS LABORATORY **Credits: 4**

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect
10. Frank-Hertz experiment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-103: COMPUTATIONAL PHYSICS & PROGRAMMING LABORATORY Credits: 2

Students assigned the computer laboratory work will perform in Semester - I at least four (04) experiments of the following:

1. Jacobi Method of Matrix Diagonalization
2. Solution of transcendental or polynomial equations by the Newton Raphson method
3. Linear curve fitting and calculation of linear correlation coefficient
4. Matrix summation, subtraction and multiplication
5. Matrix inversion and solution of simultaneous equation
6. Lagrange interpolation based on given input data
7. Numerical integration using the Simpson's method
8. Numerical integrationg using the Gaussian quadrature method
9. Solution of first order differential equations using the Rung-Kutta method
10. Numerical first order differentiation of a given function
11. Fast Fourier Transform
12. Monte Carlo integration
13. Use of a package for data generation and graph plotting.
14. Test of randomness for random numbers generators

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER – II

MPC-201: Classical Electrodynamics and Plasma Physics Credits: 4

Electrodynamics:

Four Potential and Four Field:

Vector and Scalar Potential and Solution to Wave Equation for Retarded Potential and Lienard Wie'chert Potential, Concept of four-vector and Electromagnetic field tensor in four dimensions, Maxwell's Equations in terms of field tensor, Dual Filed Tensor.

Acceleration of Charged Particles:

Electric and Magnetic fields due to a Uniformly Moving charge and An Accelerated Charge, Linear and Circular Acceleration and Angular Distribution of Power Radiated, Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Electromagnetic Mass of the Electron.

Dynamics of Charged Particles in E and B Fields:

Motion of Charged Particles in electromagnetic Field: Uniform E and B Fields, Non-uniform Fields Diffusion Across Magnetic Fields, Time Varying E and B Fields.

Plasma Physics:

Elementary Concepts: Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement, Firt, Second, and Third Adiabatic Invariants (Pinch Effect, Magnetic Mirrors), Formation of Van Allen Belt.

Hydrodynamical Description of Plasma:

Fundamental equations, Hydromagnetic Waves: Magnetosonic and Alfven Waves, Magnetoconvection and Sun Spots, Bipolar magnetic Regions and Magnetic Buoyancy, Magnetised Winds (Solar Wind).

Wave Phenomena in Magnetoplasma:

Polarisation, Phase Velocity, Group Velocity, Cut-offs, Resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic.

Reference Books:

1. Classical Electricity and Magnetism: W.K.H. Panofsky and M. Phillips.
2. Plasma Physics: A Bittencourt.
3. Plasma Physics and Controlled Fusion: F.F. Chen.
4. Classical Electrodynamics: J.D. Jackson.

MPC-202: ATOMIC, MOLECULAR PHYSICS AND LASERS Credits: 3

Atomic Physics:

Dipole selection rules (examples with derivation), Natural and Doppler Broadening, Spin-orbit coupling, Lamb shift and Retherford experiment, Hyperfine structure of lines, Normal and specific mass shifts, Anomalous Zeeman effect, Paschen-Back and Stark Effects, Applications of Resonance Spectroscopy: ESR and NMR .

Molecular Physics:

Rotational spectra of diatomic molecule as a rigid and non rigid rotator. Vibrational spectra of a diatomic molecule as a harmonic and anharmonic oscillator. A brief discussion of formation and derivation of molecular states . Vibrational structure of electronic transition : progression, sequence , Deslandre table. The Franck Condon principle .Dissociation energy. A brief discussion of Intensity alternation and missing lines in rotational spectra. Raman effect and vibrational and rotational Raman spectra of diatomic molecules.

Lasers:

Requisites for producing laser light, Longitudinal and transverse cavity modes, Mode selection, Q-switching and Mode locking Beam Characteristics in Plane and Confocal cavity resonators.

Reference Books:

1. Physics of Atoms and Molecules: B.H. Bransden and C.J. Joachain.
2. Lasers - Theory and Applications: K. Thyagrajan and A.K. Ghatak.
3. Introduction to Atomic Spectra: H.E. White.
4. Introduction to Atomic Spectra: H.G. Kuhn.

MPC-203: ELEMENTS OF SOLID STATE PHYSICS Credits: 3

Structure and Symmetry:

Structural description of liquids and solids (amorphous and crystalline), External symmetry elements and concept of point groups, Direct periodic lattices, Basic concept of aperiodicity, Reciprocal lattice and diffraction conditions and its relation with Brillouin zones, Intensity of Bragg scattering from a unit cell and extinction conditions.

Lattice Vibrations:

Interatomic forces and lattice dynamics of crystals with up to two atoms per primitive basis, Quantization of elastic waves.

Electronic Properties of Solids:

Electrons in periodic potential, Band Theory, Tight Binding, Cellular and Pseudo potential methods, Symmetry of energy bands, density of states, Fermi surface, De Haas von Alfen effect, Elementary ideas of quantum Hall effect, Cyclotron resonance and magnetoresistance, Introduction to superconductivity.

Reference Books:

1. Introduction of Solids: L.V. Azaroff
2. Crystallography Applied to Solid State Physics: A.R. Verma and O.N.Srivastava
3. Principels of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky
4. Solid State Physics-Structure and Properties of Materials : M.A. Wahab
5. Solid State Physics: N.W. Ashcroft and N.D. Mermin.

MPC-204: ELEMENTS OF NUCLEAR PHYSICS Credits: 3

Detectors and Accelerators:

Outline of interaction of charged particles and of Gamma-rays with matter.
Detectors: Gas Filled counters (ionization Chamber), Scintillation counter, Spark Chambers, Cerenkov detectors.
Accelerators: Ion Sources, Synchrotron, Introduction of Modern Colliders (LHC and RHIC), Storage Ring.

Nuclear Reactions:

Discussion of Direct and Compound nuclear reaction mechanisms, expressions for scattering and reaction cross sections in terms of partial wave amplitudes, Resonances, Discussions and Applications of Breit-Wigner single level formula, compound nucleus theory.

Nuclear Decay:

Electromagnetic interactions in nuclei, Multipole transitions in nuclei, Parity and angular momentum selection rules, Internal conversion, Fermi theory of beta-decay, Curie plots, Comparative half life, Allowed and forbidden transitions, Detection and properties of neutrino.

2-Body Problem:

Deuteron problem, Tensor force, S and D states, Neutron-Proton and proton-proton scattering, Effective range theory, Spin-dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces, Isospin formalism.

Particle Physics:

Basic interactions in nature, Elementary particles, Quantum numbers and conservation laws, Concept of isospin, Quarks and colors, Quark model, Eightfold way, Mesons and Baryons, Bound states and resonance states.

Reference Books:

1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nuclear Structure: Pal.
4. Introductory Nuclear Physics: Wong.
5. Nuclear Theory: Elton.
6. Nuclear Interactions: de Benedetti.

MPME-201: PHYSICS MINOR ELECTIVE – I

Credits : 02

Basic Nuclear Processes and Interactions:

α, β and γ decay, Characteristics of nuclear radiations, Radioactive law and source activity.

Fundamental Interactions:

Classification in terms of strength and range, Elementary particles and their classification.

Radiation Dose and Radiation Protection:

Concept of radiation dose and its units, Types of Doses, Typical doses from natural sources.

Electromagnetic Spectrum and Related Concepts:

Blackbody spectrum and its significance, Planck's hypothesis and failure of classical concepts, deBroglie wavelength and concept of duality, Photoelectric effect as a proof of quantum.

Statistics of Particles:

Concept of statistical distribution, Classical and quantum statistics, Maxwell Boltzmann statistics as classical limit. Applications of different particle statistics.

Reference Books:

1. A Primer in Applied Radiation Physics: F.A. Smith.
2. Introduction to Experimental Nuclear Physics: R.M. Singru.
3. Radiation Biophysics: E.L. Alpen.
4. Atom, Radiation and Radiation Protection: J. Turner.

MPL-201: ELECTRONICS LABORATORY Credits: 4

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-202: GENERAL PHYSICS & OPTICS LABORATORY Credits: 4

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect and Kerr Effect
10. Frank-Hertz experiment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-203: COMPUTATIONAL PHYSICS & PROGRAMMING LABORATORY

Credits: 2

Students assigned the computer laboratory work will perform in Semester – II at least four (04) experiments (other than what they have done in Semester – I) of the following:

1. Jacobi Method of Matrix Diagonalization
2. Solution of transcendental or polynomial equations by the Newton Raphson method
3. Linear curve fitting and calculation of linear correlation coefficient
4. Matrix summation, subtraction and multiplication
5. Matrix inversion and solution of simultaneous equation
6. Lagrange interpolation based on given input data
7. Numerical integration using the Simpson's method
8. Numerical integrating using the Gaussian quadrature method
9. Solution of first order differential equations using the Rung-Kutta method
10. Numerical first order differentiation of a given function
11. Fast Fourier Transform
12. Monte Carlo integration
13. Use of a package for data generation and graph plotting.
14. Test of randomness for random numbers generators

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER-III

MPC-301: STATISTICAL MECHANICS – I   Credits: 3

Review:

Canonical and Grand-Canonical ensembles, Partition Function, Thermodynamic Functions, Statistical Mechanics of Ideal Bose and Fermi gases.

Quantum Statistical Mechanics:

Density matrices, Density matrix in statistical mechanics, Some simple applications (Harmonic oscillators, Free particles in a box.

Statistical Mechanics of Interacting Systems:

Cluster expansion for a classical gas, Mayer cluster expansion, Equation of state, Low temperature behaviour of Imperfect Bose and Fermi gases, Low lying states, super fluidity in liquid He-II.

Ising model, mean-field theory in zeroth and first approximation, exact solution in one-dimension.

Reference Books:

1. Statistical Mechanics: R.K. Patharia
2. Statistical Mechanics: Kerson Huang
3. Statistical Mechanics: L.D. Landau, E.M. Lifshitz
4. A Modern Course in Statistical Physic, 2nd Edition: L.E. Reichl.

MPC-302: QUANTUM MECHANICS – II Credits: 3

Identical Particles:

Permutation symmetry, symmetrization postulates, Slater determinant Addition of angular momentum and Clebsch-Gordon Coefficient.

Relativistic Quantum Mechanics:

Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynman interpretation of antiparticles, Gama-matrics and their properties, Convariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Plane wave solution, Two component theory of neutrino, Spin & Helicity, Relativistic Hydrogen atom problem.

Field Quantization:

Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, cononical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem in quanitizing electromagnetic field, Gupta & Bleuler method.

Reference Books:

1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
3. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
4. Modern Quantum Mechanics: J.J.Sakurai.
5. Principles of Quantum Mechanic: R. Shankar.

MPS-301 (A): ANALOG COMMUNICATION SYSTEMS Credits: 3

Microwave Electronics:

Microwave characteristic features and Application. Waveguides and Cavity Resonators. Basic Principle of Klystron (Applegate diagram). Two cavities and Single cavity Klystron, Reflex Klystron, Semiconductor Gunn diode characteristics (Transferred Electron oscillator). Microwave antenna. Detection of microwave, Dielectric constant measurement.

Analog Signal Transmission:

Frequency Modulation and Demodulation circuits, FM transmitter & Receivers functioning(BLOCK diagram) and Characteristic Features, Pulse modulation, Sampling processes, PAM, PWM and PPM modulation and demodulation, Quantization processes, Companding and Quantization noise. PCM, Differential PCM and Delta Modulation systems, Comparison of PCM and DM, Time division multiplexing.

Signals, Systems and Noise:

Elements of communication systems, Fourier representation of periodic and non-periodic signal Power spectral density, Impulse and step response of systems. Time and frequency domain analysis of systems, Ideal and Real filters, Noise in communication systems, Representation of narrow band noise Signal to noise ratio, Noise equivalent band width noise figure.

Reference Books:

1. Communication System: Simon Haykin.
2. Electronics communication: D. Roddy and J. Coolen.
3. Microwave and radar engineering: M. Kulkarni.
4. Digital and analog communication systems: K.San Shanmugam.
5. Microwave: K.C. Gupta.

MPS-301(B): NUCLEAR PHYSICS: INTERACTIONS AND MODELS **Credits: 3**

N-N interaction:

Phenomenological N-N Potentials (Soft core & hard core) and meson theoretical potentials, Polarization in N-N, electron-nuclei scattering, Form factors and nuclear charge density, simple ideas of deep –inelastic scattering and brief review of the parton model of nucleon structure.

Nuclear Models:

Properties of Single particle states, Energy, spin and parities, Population of excited states in nuclei, Qualitative discussion and estimates of reduced transition rates, Magnetic moments and Schimidt Lines.

Collective model and nuclear fission, vibrational excited states, Permanent deformation and collective rotations: Energy levels and electromagnetic properties of even-even and odd-A deformed nuclei, Deformed nuclear shell model and idea of equilibrium deformation, Behaviour of nuclei at high spin, Back-bending.

Reference Books:

1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nucleon-nucleon Interaction: Brown and Jackson.
4. Introductory Nuclear Physics: S.S.M. Wong.
5. Nuclear Structure: M.K.Pal.
6. Particle Physics : A Very Short Introduction : F.E. Close

MPS-301(C): VIBRATIONAL AND ROTATIONAL MOLECULAR SPECTROSCOPY

Credits: 3

Symmetry and Group Theoretical Treatment:

Molecular symmetry and Group Theory. Matrix Representations of symmetry elements of a Point Group. Reducible and irreducible Representations, Character Tables for C_{2v} and C_{3v} point groups. Normal modes of vibration and their distribution into symmetry species of the molecule. Infrared and Raman Selection rules, Overtone and Combination Bands, Concept of multiple potential minima and inversion of NH_3.

Vibration-Rotation Energy Levels and Spectra:

Rotational Energy of Spherical, Prolate and Oblate Symmetric Rotors, Rotational Raman and IR Spectra of linear molecules and Determination of their Geometry. Influence of Nuclear Spin on Rotational Raman Spectrum, Rotation-Vibration Band of a Diatomic Molecule, Parallel and Perpendicular type Bands in Linear and symmetric Rotor Molecules. Qualitative description of Type A, B and C bands in Asymmetric Rotor Molecules.

Reference Books:

1. Chemical Applications of Group Theory : F.A. Cotton.
2. Fundamentals of Molecular Spectroscopy : C.N. Banwell.
3. Introduction to Molecular Spectroscopy : G.M. Barrow.
4. Modern Spectroscopy : J.M. Hollas.

MPS – 301(D): SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTION IN CRYSTALS Credits: 3

Crystallography:

Elementary concepts of space group and its relevance to crystal structure. Principal of powder diffractometer, Interpretation of powder-photographs. Analytical indexing: Ito's method. Application of powder method.

Interpretation of oscillation photograph, X-ray method of orienting crystals about a crystallographic direction. Bernal chart, Indexing of reflection. Fourier representation of electron density, the phase problem, Patterson function.

Imperfection of Crystals:

Mcchanism of plastic deformation in solids, stress and strain fields of screw and edge dislocations, elastic energy of dislocation, forces between dislocations, stress needed to operate Frank-Read source. Partial dislocations and stacking faults in close-packed structures.

Electron Microscopy:

Kinematical theory of diffraction contrast and lattice imaging.

Reference Books:

1. Crystallography for Solid State Physics: Verma and Srivastava
2. X-ray Crystallography: Leonid V. Azaroff.
3. Elementary Dislocation Theory: Weertman andWeertman
4. Crystal Structure Analysis: R. Buerge.
5. Electron Microscopy of Thin Crystals: Peter B. Hirsh

MPS-301(E): STRUCTURES, PROPERTIES AND FUNCTIONS OF BIOMOLECULES

Credit:03

Bonding:

Covalent bond, electrostatic interaction, hydrogen bond, Bonded and non-bonded interactions, cooperative phenomena, hydrophobic and hydrophilic interactions.

Sugars and metabolites:

Molecules of biological interest, structures of sugars, ATP and ADP, energetics, photosynthesis,.

Lipids and Membranes:

Structures of membranes, transport across membranes.

Nucleic Acids:

Double helical structure of DNA, Watson-Crick Model, Conformational parameters of nucleic acids and their constituents, DNA Types: B, A and Z DNA, DNA super coiling, RNA and its Types, Genetic Code.

Proteins and their structures:

Structures and properties of amino acids, primary, secondary, tertiary and quaternary structures of proteins, protein folding.

Enzymes:

Mechanism of enzyme action, enzyme kinetics, effects of temperature and pH, Lock and Key model, Induced-fit model, Conformations.

The Cell:

Introduction to the Cells, cell organelles, cell types and cell functions, structures and functions of neurons, neurotransmitters.

Transfer of genetic information:

Replication, transcription, reverse transcription and protein synthesis, Central Dogma.

Reference Books:

1. Essential of Biophysics: P. Narayanan, New Age International, 2000
2. Biological Physics; Energy, Information, Life : P. Nelson, W.H. Freeman, 2003
3. Molecular and Cellular Biophysics: Meyer B Jackson, 2006
4. Applied Biophysics: A Molecular Approach for Physics Scientist : Tom Waigh, Wiely-Interscience, 2007.
5. Molecular Biology of the Cell: Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walte, Garland Science**.**

MPS-301(F): SOLAR AND ASTROPHYSICS Credit-3

Sun & Solar Phenomena:

Structure of the Sun: Solar interior, solar atmosphere, photosphere, chromosphere, corona; Small & large scale Solar structures, Sun spots and their properties, Prominences, Solar Flare: classifications, phases & flare theory; Solar cycle, Solar magnetic field.

Solar Wind:

Observed and derived properties of solar wind, Solar wind formation: Fluid theory for static as well as expanding isothermal solar atmosphere, Spatial configuration of magnetic field frozen into solar wind, Termination of solar wind, Heliosphere.

Overview of the Universe:

Qualitative description of astro-objects (from planets to large scale structures): length mass and time scales, Evolution of structures in the universe; Red shift, Expansion of the universe.

Astrophysical Processes:

Simple orbits, Kepler's laws, Flat rotation curve of galaxies and implications for dark matter, Role of gravity in different astrophysical systems; Radiative Process: Radiation theory and Larmor formula, Different radiative processes.

Stellar Physics:

Star formation, Stellar evolution, Supernovae, H-T diagram, Compact Stars.

Galactic Physics:

Milky way galaxy, Spiral and elliptical galaxies, Active galaxy, Black holes.

Reference Books:

1. Astrophysics of the Sun: Harold Zirin, Cambridge University Press, Cambridge, U.K.
2. Solar System Astrophysics: J.C. Brandt & P.W. Hadge
3. Guide to the Sun: Kenneth J. H. Philips, Cambridge University Press, U.K.
4. An Introduction to Modern Astrophysics: W. Carroll & D. A. Ostlie, Addison Wesley
5. The Physics of Astrophysics Vol I & II: Frank H. Shu, University Science Books, USA
6. Astrophysical Concepts: M. Harwitt, Springer-Verlag, New York

MPME-301: PHYSICS MINOR ELECTIVE – II Credits : 02

Spectroscopic Techniques:

Dispersion and resolution, Grating and prism spectrometer.

UV/Vis and IR absorption and Raman spectroscopy, Identification of functional groups, Time-resolved spectroscopy and study of biological samples

Laser as a source of radiation and its characteristics, Laser fluorescence and absorption spectroscopy.

Structural Characterization Techniques:

Basic concept of X-ray Diffraction, Basic principles and applications of scanning electron microscopy (SEM) and transmission electron microscopy, Scanning Probe Microscopy.

Detection Techniques:

General characteristics of and types of detectors.

Photon Based Detectors:

Photomultiplier tube (PMT), Photodiode (Single and array), Charge coupled device (CCD).

Particle Based Detectors:

Channel electron multiplier, G.M. Counter, Cherekov detector, Solid state detector

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.

MPE-302: LASERS AND LASER APPLICATIONS Credits: 3

Basic Principle and Different Lasers:

Principle and Working of CO2 laser and Qualitative Description of Longitudinal and TE laser systems. Threshold condition for Oscillation in Semiconductor Laser. Homostructure and Heterostructure p–n junction lasers, Nd-YAG lasers. Principle of Excimer Laser. Principle and Working of Dye Laser. Free Electron Laser.

Non Linear Processes:

Propagation of Electromagnetic Waves in Nonlinear medium, Self Focusing, Phase matching condition, Fiber Lasers, Stimulated Raman Scattering and Raman Lasers, CARS, Saturation and Two photon Absorptions.

Novel Applications of Laser:

Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Condensation.

Reference Books:

1. Laser Spectroscopy and Instrumentation : W. Demtroder.
2. Principles of Lasers : O. Svelto.
3. Laser Cooling and Trapping : P.N. Ghosh.
4. Frontiers in Atomic, Molecular and Optical Physics : S.P. Sengupta.

MPE-303: CHARACTERIZATION OF SOLIDS   Credits: 3

Structural Characterization:

Intense X-ray Sources : Synchrotron Radiation, General theory of X-ray scattering and diffraction, Reciprocal space of perfect and imperfect crystals, X-ray diffraction characterization of imperfections in crystals, Basic concepts of small angle X-ray scattering and its application in evaluation of shape and size of surface particles. Neutron scattering and diffraction with reference to light elements and magnetic structures.

Electronic Characterization:

LEED (Low Energy Electron Diffraction) for Surface Structure, Surface Topography, Elementary Concepts of Scanning and Scanning Tunneling Microscopic Techniques (SEM, STM) X-ray Photoelectron Spectroscopy (XPS/ESCA) for chemical analysis. Methods.RBS (Rutherford Back Scattering) and SIMS (Secondary Ion Mass Spectroscopy). Defect related electronic states characterization by C-V characteristics of electronic junction devices, Temperature stimulated current and capacitance (TSC/TSCAP), Deep Level Transient Spectroscopy (DLTS), Electronic Beam Induced Current (EBIC) and Light Beam Induced Current (LBIC).

Spectroscopic Characterization:

Double Beam IR Spectrometers, Basic Concepts of Raman Spectroscopy in Solids, Sensitive Detectors such as CCD Camera, Concept of Space Group and Point Group, Identification and Analysis of Optic and Acoustic Modes in Solids. Electronic Absorption Study for Band Gap Determination.

Reference Books:

1. Analytical Techniques for Thin Film - Treatise on Material Science and Technology, Vol. 27: K.N. Tu and R. Rosenberg (ed.).
2. Electron Microprobe Analysis: S.J. B. Reed.
3. Topics in Applied Physics, Vol. 4: R. Gomer (ed.).
4. Analysis of High Temperature Materials: O. Van Der Biest (ed.).

MPE-304: MOLECULAR BIOPHYSICS Credits: 3

Basic Concepts in Biophysics:

Elementary ideas about the DNA structure, sugar-phosphate backbone, nucleosides and nucleotides, three dimensional DNA structure, RNA. Proteins: primary, secondary, tertiary and quaternary structures, enzymes and their catalytic activity, DNA and protein folding, DNA denaturation, replication, mutation, intercalation, neurotransmitters, membranes.

DNA and its Role:

Forces stabilizing DNA and protein structure, Theoretical quantum chemical and molecular mechanical methods, Treatment of intermolecular interactions, conformations, hydrogen bonding, stacking and hydrophobic interactions, importance of electrostatic interactions, biomolecular recognition, drug design.

Experimental Techniques:

Application of experimental techniques of light scattering, absorption and fluorescence spectroscopy, Nuclear magnetic resonance, Interaction of UV radiation with DNA, Photodimerization, Photodynamic action.

Reference Books:

1. Essentials of Biophysics: P. Narayanan.
2. Basic Molecular Biology: Price.
3. Quantum Mechanics of Molecular Conformations: Pullman (Ed.).
4. Non-linear Physics of DNA: Yakushevich.
5. Biological Physics: Nelson.

MPE-305: METHODS IN THEORETICAL PHYSICS Credits: 3

Path-integral Formalism:

Path-integral formalism in Quantum mechanics, applications to free particle and linear harmonic oscillator; Connection with statistical mechanics.

Foundations in Quantum Mechanics:

Statistical interpretation of Schrodinger's wave functions, Hidden variable and Copenhagen interpretation; EPR paradox and Bell's theorem; Geometrical phase and Aharanov-Bohm effect; Quantum measurement, No-clone theorem, schrodinger's Cat and Quantum Zeno paradox.

General theory of Relativity and Cosmology:

Tensors, metrics and geodesics, dyadics, covariant and contravariant derivatives, Christoffel's symbol and Levicivita symbol; Einstein's equation and Schwarzchild's solution; Applications in cosmology, Black-holes.

Constraints and Gauge Theory:

Hamilton Method, Constraints (first class and second class); Gauge theory, gauge invariance and related physics.

Reference Books:

1. Techniques and Applications of Path Integration: L.S. Schulman.
2. Introduction to Quantum Mechanics: D.J. Griffiths.
3. Gravitation and Cosmology: S. Weinberg.
4. Classical Dynamics: E.C.G. Sudarshan and N. Mukunda.
5. Lectures on Quantum Mechanics: P.A.M. Dirac.

Credits: 3

MPE-306: INSTRUMENTATION IN NUCLEAR AND PARTICLE PHYSICS

Standard Radioactive Sources:

Units, Fast electron, Heavy charged particle, Radiation, Neutron sources

General Properties of Radiation Detectors:

Simplified detector model, Current and pulse modes of operation, pulse height spectra, energy resolution, detection efficiency, dead-time, coaxial cables, Pulse shaping, General characteristics of single and multichannel methods.

Linear and Logic Pulse Functions:

Fast and slow pulses, Liner and logic pulses, instrument standards, Function of pulse-processing units, Components common to many applications, pulse counting systems.

Background and Detector Shielding:

Sources of background, Background in gamma-ray spectra, Active methods of background reduction.

Counting Statistics and Error Estimation:

Characterization of data, statistical models and applications

Reference Books:

1. Radiation Detection and Measurement: G. F. Knoll

2. Nuclear Physics Techniques: W. R. Leo

3. Introduction to Nuclear and Particle Physics (2nd Edition): A. Das and T. Ferbel

MPE-307: SCIENCE AND TECHNOLOGY OF SOLAR ENERGY, HYDROGEN AND OTHER RENEWABLE ENERGIES Credits: 3

Solar Energy: Fundamental and Material Aspects:

Fundamentals of photovoltaic Energy Conversion Physics and Material Properties, Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Solar Energy: Different Types of Solar Cells:

Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief description of single crystal silicon and organic and Polymer Solar Cells, Elementary Ideas of Advanced Solar Cells e.g. Tandem Solar cells, Solid Liquid Junction Solar Cells, Nature of Semiconductor, Principles of Photo-electrochemical Solar Cells.

Hydrogen Energy: Fundamentals, Production and Storage:

Relevance in relation to depletion of fossil fuels and environmental considerations. Solar Hydrogen through Photoelectrolysis, Physics of material characteristics for production of Solar Hydrogen. Brief discussion of various storage processes, special features of solid hydrogen storage materials, Structural and electronic characteristics of storage materials. New Storage Modes.

Hydrogen Energy: Safety and Utilization:

Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Various type of Fuel Cells, Applications of Fuel Cell, Elementary concepts of other Hydrogen-Based devices such as Hydride Batteries.

Reference Books:

1. Solar Cell Devices-Physics :Fonash
2. Fundamentals of Solar Cells Photovoltaic Solar Energy :Fahrenbruch & Bube
3. Phoptoelectrochemical Solar Cells: Chandra
4. Hydrogen as an Energy Carrier Technologies Systems Economy : Winter & Nitch (Eds.)
5. Hydrogen as a Future Engery Carrier : Andreas Zuttel, Andreas Borgschulte and Louis Schlapbach

MPL-301(A): Electronics Laboratory **Credits: 6**

Students will be required to perform six (06) experiments of the following:

1. Microwave characteristics and measurements
2. Nonlinear applications of Op amplifier
3. PLL characteristics and its applications
4. PAM, PWM and PPM Modulation and demodulation.
5. PCM / delta modulation and demodulation
6. Fiber optic communication
7. Experiments on MUX, DEMUX, Decoder and shift register
8. Arithmetic operations using microprocessors 8085 / 8086
9. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
10. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
11. PPI 8251 interfacing with microprocessor for serial communication.
12. Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(B): NUCLEAR PHYSICS LABORATORY Credit 6

Students will be required to perform seven (07) experiments of the following:

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector
2. Alpha Spectroscopy with Surface Barrier Detector
3. Determination of the range and energy of alpha particles using spark counter
4. Study of gamma ray absorption process
5. X-Ray Fluorescence
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux
7. To Study the Solid State Nuclear Track Detector
8. Fission Fragment Energy Loss Measurements from Cf252
9. Gamma - Gamma Coincidence studies
10. Compton Scattering: Energy Determination
11. Compton Scattering: Cross-Section Determination
12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique
13. Identification of particles by visual range in Nuclear Emulsion
14. Study of Rutherford Scattering

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(C): SPECTROSCOPY LABORATORY Credits: 6

Students will be required to perform six (06) experiments of the following:

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Determination of metallic component of an inorganic salt
4. Emitter of electric discharge through air in a tube with minute leak
5. Emitter of electric discharge through air in an evacuated tube
6. Measurement of optical spectrum of alkaline earth atoms
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement of Band positions and determination of vibrational constants of N2 molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I2 vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(D): SOLID STATE PHYSICS LABORATORY Credits: 6

Students will be required to perform five (05) experiments of the following:

1. Measurement of lattice parameter and indexing of powder photograph
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor
5. Rotation / oscillation photograph and their interpretation
6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature
7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes
8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field
9. Synthesis/Fabrication of Cabon Nanotubes by Spray Pysolysis method and its verification through xray diffraction.
10. To build crystal structures and to calculate its powder diffraction pattern using material Studio software and to analyze structures and diffraction patterns.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(E): BIOPHYSICS LABORATORY Credit: 06

1. Optimization of structures of N9H and N7H tautomers of guanine. Comparison of total energies.
2. Optimization of normal structure of lysine in gas phase and zwitterionic structure in aqueous media.
3. Optimization of geometries of cis- and trans-conformers of 2′-deoxyadenine.
4. Study of infrared spectrum of adenine experimentally and theoretically.
5. Determination of viscosity of a given biopolymer (agarose) at different temperatures and different concentrations (0.025 and 0.1 wt%) using Oswald's viscometer and determination of activation energy.
6. Determination of surface tension of a given biopolymer (agarose).
7. Molecular geometry optimization of cystein and cystine.
8. Study of Ramachandran diagrams of mono and dipeptides.
9. Absorption and fluorescence spectra of tryptophan.
10. Separation of DNA and estimation of the size of DNA molecules by Agarose gel electrophoresis.
11. Determination of different constants/exponents associated with biopolymers.

Note: Addition and deletion in the list of experiments may be made from time to time by the Department.

MPL-301 (F) SPACE PHYSICS LABORATORY Credit-6

Students will be required to perform six (**6**) experiments of the following:

1. **Antenna and its parameters:**
   To plot the Radiation pattern of Dipole, Yagi, Folded dipole and Loop antenna and to make comparative study between them.

2. **Analog Communication:**
   (a) To study the operation of Amplitude Modulation and Demodulation.
   (b) To study the variation of Modulation index with modulating voltage and frequency.
   (c) To observe the linearity curve of the modulator.
   (d) To observe the spectrum of AM-signal.
   (e) To study and trace the operation of envelop-detector.

3. (a) To study the modulation characteristic of Frequency Modulation.
   (b) To calculate modulation sensitivity of frequency modulator.
   (c) To calculate the non-linearity of frequency modulator.
   (d) To trace frequency demodulation curve.

4. **Global Positioning Systems (GPS) and its application:**
   (a) To study and observe Signal to noise ratio (SNR) plot window of GPS satellites.
   (b) To study and observe the sky plot using azimuth and Elevation window of GPS.
   (c) To calculate ionospheric pierce point (IPP) for any three GPS satellites over Varanasi.

5. **Atmospheric Weather parameters using AWS data:**
   (a) To study the diurnal variation of atmospheric temperature and pressure using AWS.
   (b) To study the monthly variation of atmospheric temperature and pressure.
   (c) 3-day average variation of atmospheric temperature and pressure.
   (d) 5-day average variation of atmospheric temperature and pressure.

6. (a) To study the diurnal variation of atmospheric Humidity and Solar Flux using AWS.
   (b) To study the monthly variation of atmospheric Humidity and Solar Flux.
   (c) 3-day average variation of atmospheric Humidity and Solar Flux.
   (d) 5-day average variation of atmospheric Humidity and Solar Flux.

7. **Digital Communication:**
   (a) To study and observe the pulse amplitude modulation (PAM) and draw the variation of modulation index with modulating voltage.
   (b) To study and observe the pulse width modulation (PWM) and demodulation.
   (c) To study and observe the pulse code modulation (PCM) and demodulation.

Note: Addition and deletion in the list of experiments may be made from time to time by the Department.

SEMESTER – IV

MPC-401: STATISTICAL MECHANICS – II Credits: 3

Critical Phenomena and Phase Transition:

Phase transitions and thermodynamic functions. Thermodynamic limit and its importance. Mean field theory, Landau theory. Correlation functions, Ornstein-Zernike theory, Critical behaviour, Critical exponents, Scaling and Universality, Upper and lower critical dimensions. Renormalization group: basic idea, flows, fixed points, Application to 1-D and 2-D Ising models.

Time Dependent Phenomena:

Dynamic correlation and response functions. Example of damped harmonic oscillator. Diffusion. Brownian motion and Langevin equations. Correlation and response of damped Brownian oscillator. General properties of correlation and response functions, Linear response theory. Dissipation: The fluctuation-dissipation theorem, The Kubo formula, Fokker-Planck Equation.

Reference Books:

1. Statistical Mechanics: Patheria.
2. Statistical Physics I and II: Kubo, Toda and Ashitsume.
3. Modern Theory of Critical Phenomena: Ma.
4. Statistical Mechanics: Landau and Lifshitz.
5. Lectures on Phase Transitions and Rnormalization Group: Goldenfeild.

MPS-401 (A) DIGITAL COMMUNICATION SYSTEMS Credits: 3

Information Theory and Coding:

Introduction, Amount of information, Average information, Binary cyclic codes, Error detecting and correcting codes in communication channels. Rate of information and capacity of discrete memory less channels. Shannon Theorem and Shannon Hartley theorem. Linear block codes. Application of information theory, bandwidth and S/N Trade off, threshold effect.

Digital Signal (Data) Transmission:

Introduction, Base band and pass band data transmission, Base band binary PAM system, Optimum receiver for binary digital modulation schemes, Binary ASK, FSK, PSK and differential PSK signals schemes. Brief idea about M-ray signaling schemes, Serial data communication in computers, USARI 8251, MODEM.

Fiber Optic Communication:

Basic optical communication system, wave propagation in optical fiber media, step and graded index fiber, material dispersion and mode propagation, losses in fiber, optical fiber source and detector. Digital optical fiber communication system, First/Second generation system, Data communication network.

Reference Books:

1. Digital and Analog Communication System: K.San Shanmugam
2. Communication System: Simon Haykin
3. Optical fiber Communication: G. Keiser.

MPS-401(B): PARTICLE PHYSICS Credits: 3

Particle Phenomenology:

Pion-nucleon scattering, isospin analysis and phase shifts, resonances and their quantum numbers, Production and formation experiments, Relativistic kinematics & invariants, Mandelstam variables, Phase space, Decay of one particle into three particles, Dalitz Plot.

Strong Interactions and Symmetries:

Uses of symmetry, space time and internal symmetries, Lie groups generators and Lie algebra, Casimir operators, SU(2) irreducible representation, weight diagram, diagonal generators, SU(3) generators, U and V spin, Raising and Lowering operators, Root diagram, Weight diagram, Dimensionality multiplets of SU(n), Baryons and meson multiplets, Symmetry breaking and Gell-Mann-Okubo mass formula.

Physics of Quarks and Gluons:

Charm, bottom and top quarks and higher symmetry. Quark-Gluon interaction, Experimental tests of Quantum Chromodynamics.

Reference Books:

1. Nuclear and Particle Physics: W. Burcham and M. Jobes.
2. Quarks and Leptons: Halzen and Martin.
3. Unitary symmetry and Elementary Particles: D.B.Lichtenberg.
4. Symmetry Principles in particle Physics: Emmerson.
5. Introduction to High Energy Physics: Perkins.
6. Particles and Nuclei: B. Povh, K. Rith, C. Scholz and F. Zetsche.

MPS-401(C): MOLECULAR ORBITAL THEORY AND ELECTRONIC SPECTRA OF MOLECULES

Credits: 3

Atomic and Molecular Orbital Theories:

Elementary idea of Atomic Orbitals in Hartree-Fock Theory, Qualitative description of ab-initio methods, LCAO treatment of H_2^+ and H_2 molecules. Molecular charge distribution and Dipole moment. Hellman-Feynman Theorem and concept of force. Hybrid Atomic Orbitals in H_2O, CH_4, C_2H_2, and C_2H_4. Concept of lone pairs. Huckel method and its application to Ethylene, Butadiene and Benzene. Changes in molecular geometry on electronic excitation.

Spectroscopy of Diatomic and Polyatomic Molecules:

Dissociation Energy of Diatomic Molecules, Coupling of Electronic and Rotational motion in Diatomic Molecules and Rotational structure of $^1\pi$ - $^1\Sigma$ and $^1\Sigma$-$^1\Sigma$ transitions. Vibronic interaction and Herzberg Teller theory for absorption spectrum of benzene vapour. Single vibronic level spectroscopy and lifetime of vibronic levels in benzene, Quantum yield, Kasha Rule and the concept of non-radiative transitions in molecules. Jablanski diagram.

Reference Books:

1. Molecular Orbital Theory: A. Streitweiser.
2. Valence : C.A. Coulson.
3. High Resolution Spectroscopy: Hollas
4. Laser Spectroscopy and Instrumentation: W. Demtroder.

MPS- 401 (D): SOLID STATE PHYSICS: SPECIAL SOLIDS, SURFACES AND PROPERTIES Credits: 3

Aperiodic and Semiperiodic System:

Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solid and quasicrystals: Fibonaccy sequence, Penrose lattices.

Films and Surface:

Difference of behaviour of thin films from bulk. Boltzmann Transport equation for a thin film. Determination of distributing function for thin films and qualitative estimates of electrical conductivity. Scanning tunneling and Atomic Force Microscopy.

Magnetic Properties:

Weiss theory of ferromagnetism, Heisenberg model and molecular field theory. Spin waves and magnons. Ferri and antiferro-magnetic order. Domains and Bloch wall energy.

Reference Books:

1. Solid State Physics: Kittel
2. Thin Films: Heavens
3. Physics of Thin Films: K.L. Chopra
4. Science of Fullerenes and Carbon Nanotubes

MPS-401(E): METHODS AND TECHNIQUES TO STUDY BIOLOGICAL SYSTEMS

Credit:03

Spectroscopic Techniques:

Application of Spectroscopic Techniques: (UV/VIS and IR Absorption, Raman, Fluorescence and NMR) to Biological Systems.

Imaging:

Ultrasonography (USG), Magnetic Resonance Imaging (MRI). Computed tomography (CT) scan and Positron emission tomography.

Diffusion and Electroanalytical Techniques:

Diffusion, Chromatography and Gel Electrophoresis, pH Measurement

Bulk and Surface Techniques:

Polarimetry, Optical Rotary Dispersion (ORD), Circular Dichroism (CD), Light Scattering and Size of Aggregates, Applications of Electron Microscopy to Biological Systems, Elementary Idea of Nano-Bio Systems.

Diffraction Techniques:

Elementary Idea of Production and Characteristics of X-ray, Applications of X-ray Diffraction, Neutron Diffraction and Electron Diffraction to Biological Systems.

Reference Books:

1. Essential of Biophysics: P. Narayanan, New Age International, 2000
2. Biophysics: V. Pattabhi, N. Gautam, Narosa, 2002
3. Biological Physics; Energy, Information, Life : P. Nelson, W.H. Freeman, 2003
4. Applied Biophysics: A Molecular Approach for Physics Scientist : Tom Waigh, Wiely-Interscience, 2007
5. Methods in Modern Biophysics: B. Nolting , Spring, 2005,
6. Principles and Techniques of Practical Biochemistry, K. Wilson and J. Walker, 5th Edition, Cambridge University Press, 2000.

MPS-401(F): SPECIAL PAPER II: ATMOSPHERIC PHYSICS: Credit-3

Lower atmosphere:

Its composition, constituents, dynamics; Diurnal and seasonal variations of Temperature, Pressure and Humidity; Clouds morphology, cloud microphysics.

Aerosols:

Aerosol Optical Depth, Effects of Aerosols in Indo-Gangetic basin.

Synoptic systems in different seasons:

Winter: western disturbances, Fog, cold wave; Summer: thunderstorm, dust storm, heat wave, cyclones; Monsoon: onset, withdrawal.

Ozone:

temporal & spatial variation of ozone, Ozone hole and its impact on climate.

Ionosphere:

its structure & formation; Ionospheric irregularities: Sporadic E and Spread-F irregularities and their distribution; Ionospheric Scintillations, Aurora Borealis: morphology of auroral region, distribution of auroral emissions.

Magnetosphere:

Its structure, Bow shock, Magnetopause, Magnetopause current, Stand-off distance of stagnation point, Microstructure of magnetopause; Shape of magnetospheric cavity, Magnetotail; Planetary magnetospheres. VLF waves, Whistlers & its applications.

Reference Books:

1. Atmospheric Physics: J.V. Iribrine & H.R. Cho, D. Reidel Pub. Company, Holland
2. An introduction to Meteorology: S. Petterssen, McGraw-Hill Book Company, USA
3. The Physics of Atmosphere: John Houghton, Cambridge University Press, U.K.
4. The Earth’s Ionosphere: Plasma Physics & Electrodynamics: M.C. Kelley, Academic Press, Elsevier, USA
5. Introduction to Space Physics: Ed. M.G. Kevilson & C.T. Russell, Cambridge University, Press, UK.
6. Element of Space Physics: R.P. Singhal, Prentice Hall of India, New Delhi

MPS-402(A): MICROPROCESSORS AND INTERFACING Credits: 3

Microprocessor:

Architecture and Internal operation of Intel 8085. Instructions. Opcodes. Operands and mnemonics. Constructing machine language codes for instructions. Instruction execution timing diagram. Instruction word size and addressing modes. Instruction set. Stacks subroutines and Interrupts. I/O Interfacing and data transfer scheme. Machine programming instruction and directive, assembly language programming. Architecture and Internal Operation of Intel 8086. Pin description for minimum and maximum modes, Addressing modes. Instruction set, brief idea about architecture of microprocessor 80286, 80386, 80486 and Pentium. Introduction to Microcontroller.

Microprocessor based Measurement/ Control Circuits:

Transducers, D/A and A/D Converters, PPI 8255 Data acquisition and storage, Microprocessor based traffic light controller, Temperature and water label indicator/ controller. DC and stepper motor speed measurements. Waveform generation and frequency measurement.

Reference Books:

1. Fundamentals of Microprocessors and Microcomputers: B. Ram
2. Microprocessor System the 8086/8088 Family: Liu Yu-Cheng and G.A. Gibson
3. Microprocessor, Architecture, Programming and Application: R.S. Gaonker.
4. Introduction to Microprocessor: A.P. Mathur
5. Microprocessor and Interfacing: D.V.Hall

MPS-402(B): WEAK INTERACTIONS AND ELECTROWEAK UNIFICATION

Credits: 3

Weak Interactions:

Leptonic, semileptonic and nonleptonic weak decays. Selection rules, Nuclear Beta decay and form of current, current interaction, Feynman Diagrams, V-A theory, Fermi and G-T selection rules, Parity violation in weak interaction, (Cobalt Sixty Experiment), CP-Violation in Kaon Decay, Decay of Pions and Muons, Calculation of Lifetime for Pions and Muons.

Unification of Interactions:

Non-Abelian Gauge Field Theory, Spontaneous Symmetry Breaking, Higgs Mechanism, Goldstone Theorem, General idea of electro-weak unification, Experimental Evidence of Electro-Weak Unification

Reference Books:

1. Nuclear and Particle Physics: W.E. Burcham and M.Jobes.
2. Introduction to Elementary Particles: Griffths.
3. Quarks and Leptons: Halzen and Martin.
4. Gauge Theory of weak Interactions: Greiner and Muller.

MPS-402 (C): PRINCIPLES AND INSTRUMENTATION IN CONVENTIONAL AND LASER SPECTROSCOPY

Credits: 3

Light Sources, Detectors and Spectroscopic Techniques:

Synchrotron Radiation Source, Dye Laser as a versatile spectroscopic light source, Grating spectrographs and spectrometers based on Czerry-Turner mountings. Thermal Detector, Photomultiplier Tube and Photodiode , Charge Coupled Detector (CCD), Principle and Working of a Double Beam infrared spectrophotometer, Raman Spectrometer. Principle and Working of Fourier Transform Spectrometers. Photoacoustic Spectroscopy, Matrix Isolation Spectroscopy.

Non-Conventional Spectroscopic Techniques:

Two-photon spectroscopy, Saturation Spectroscopy, CARS, Experimental techniques of MPI spectroscopy, Optogalvanic spectroscopy and Supersonic Beam Spectroscopy with emphasis on measurement of molecular parameters.

Reference Books:

1. Laser Spectroscopy: W. Demtroder.
2. High Resolution Spectroscopy: J. M. Hollas.
3. Modern Spectroscopy: J.M. Hollas.
4. Spectrophysics: A. Thorpe.

MPS-402 (D): SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS Credits: 3

Interacting Electron Gas:

Hartree and Hartree-Fock Methods, Screening, Dielectric Functions and its Properties.

Electron-Phonon Interactions:

Interaction of Electron with Acoustic and Optical Phonons, Cooper Pairing due to Phonon, BCS Theory of Superconductivity, Ginzberg- Landau Theory of Superconductivity and Application to type II superconductors, Vortices and Abrikosov Phase.

Optical Properties:

Interactions of Electrons and Phonons with Photons, Elementary ideas on Direct and Indirect Transitions, Polaritons. Electron Localiztion in Disordered System:

Electron Localization, Density of States, Mobility Edge, Anderson Localization, Hopping Conductivity.

Reference Books:

1. Introduction to Solid State Physics: Madelung.
2. Quantum Theory of Solid State: Callaway.
3. Quantum Theory of Solid State: Kittel.

MPS-402(E): THEORETICAL MODELLING OF BIOLOGICAL SYSTEMS Credit: 03

Quantum Chemical Methods and Related Concepts

Born-Oppenheimer approximation, Concept of molecular orbitals, Hartree-Fock theory, semi-empirical and ab-initio methods, density functional theory, tautomers, intermolecular interactions, potential energy surfaces, molecular recognition, electron density distribution, electrostatic potential, solvent effect, stacking interactions, molecular mechanics.

Chemical Kinetics:

Chemical reaction, transition state theory, rate constants.

Statistics of Biopolymers:

Elements of statistical mechanics, molecular weight averages, end-to-end distance, radius of gyration, interaction among polymer segments & solvent molecules and its effect on the end-to-end distance, lattice model of polymers and its application to coil-globule transition in polymers, protein folding and DNA melting.

Mechanics of Biopolymers :

Structural and elastic properties of DNA and proteins, Force-induced transitions in biopolymers and their modeling.

Computer Simulation:

Monte Carlo and molecular dynamics simulations, Algorithms and simple applications.

Reference Books:

1.Quantum Chemistry: I.N. Levine, Prentice-Hall , 1994

2.Ab Initio Molecular Orbital Theory, W.J. Hehre, L.Radom, P.V.R. Schleyer, J.A. Pople, John Wiley, 1986

3.Coulsons's Valence: R. McWeeny, Oxford University Press

4.Understanding Molecular Simulation: D. Frenkel and B. Smit, Academic Press

5. Biological Physics; Energy, Information, Life : P. Nelson, W.H. Freeman, 2003

MPS-402(F): SPECIAL PAPER III: INSTRUMENTATION IN SPACE PHYSICS & ASTROPHYSICS

Credit-3

Photoemissive materials:

Theory of Photoemission, Spicer's three step photoemission model; Development of photocathode in X-rays, Ultraviolet, Visible and Infra-red wavelength region; Negative electron affinity (NEA) photocathode, alternative routes to enhanced photocathode performance.

Detecting Photons:

Photomultiplier tubes, Photodiodes, Hybrid photodiodes; Charge-Coupled Device (CCD); Micro channel plates, Sensitivity and dynamic range, Time resolution, Energy resolution and Image resolution of photo-detectors.

Radio waves Detection:

Techniques to study Ionosphere: Ionosondes, Insitu measurements, VHF (Scintillation) receivers; VLF receiver, Whistler diagnostics.

Astronomical Techniques:

Image formation, Diffraction, Aberrations; Telescope structures and mountings; X-ray telescopes & detectors; Gamma rays telescopes and detectors.

Reference Books:

1. Photoemissive material: Preparation, properties & uses: A.H. Sommer, Wiley, NewYork.
2. Physics of semiconductor devices: S.M. Sze & K.K. Ng, A John Wiley and Sons, INC Publications.
3. Ionospheric techniques and phenomena: Alain Giraud, A. Giraud & M. Petit, Springer Pub.
4. Space science: Editors: L.K. Harra & K.O. Mason, Imperial College Press; Singapore.
5. Telescopes and Techniques: An Introduction to practical Astronomy: C.R. Kitchin, Springer UK
6. Observational Astrophysics: R.C. Smith, Cambridge University Press.

MPE-401: EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION IN ATOMIC, MOLECULAR AND OPTICAL PHYSICS Credits: 3

Experimental Techniques:

AES (Auger electron spectroscopy), PES (Photo electron spectroscopy), EELS (Electron energy loss spectroscopy), PIXE (Particle induced x-ray emission), BFS (Beam-foil spectroscopy), TOF (Time-of-flight) spectroscopy, SRS (Synchrootron radiation spectroscopy), technique of coincidence detection, High vacuum generation, Ultra-fast pulse generation and detection.

Instrumentation:

Principle and working of CEM (Channel electron multiplier), MCP (one-and two-dimensional micro-channel plates), PMT (Photo-multiplier tubes), SBD (Surface barrier detectors), Si(Li), HPGe, NaI photon detectors, electrostatic and magnetic charged particle energy analyzers (45o-parallel plate, and cylindrical mirror analyzer (CMA), TOF-spectrometer, MCA (multi-channel analyzer), TAC (Time-to amplitude converter), CFD (Constant fraction discriminator), ionization pressure gauges (Pirani and Penning).

Reference Books:

1. Electron Spectroscopy: Theory, Techniques and Applications: CR Brundle and AD Baker.
2. Synchrotron Radiation : Techniques and Applications: C. Kunz.
3. Low Energy Electron Spectroscopy: KD Sevier.
4. Radiation Detectors: WH Tait.
5. Advances in Image Pickup and Display, Vol. 1: P. Schagen.

MPE-402: NANO SCIENCE AND TECHNOLOGY Credits: 3

Nanoparticles: Synthesis and Properties:

Method of Synthesis: RF Plasma Chemical Methods, Thermolysis, Pulsed Laser Methods, Biological Methods: Synthesis using micro-organisms, Synthesis using Plant Extract, Metal Nanoclusters, Magic Numbers, Modeling of Nanoparticles, Bulk to Nano Transitions.

Carbon Nanostructures:

Nature of Carbon Clusters, Discovery of C60, Structure of C60 and its Crystal, Superconductivity in C60, Carbon Nanotubes: Synthesis, Structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications.

Quantum Wells, Wires and Dots:

Preparation of Quantum Nanostructures, Size Effects, Conduction Electrons and Dimensionality, Properties Dependent on Density of States.

Analysis Techniques for Nano Structures/ Particles:

Scanning Probe Microscopes (SPM), Diffraction Techniques, Spectroscopic Techniques, Magnetic Measurements

Bulk Nanostructure Materials:

Methods of Synthesis, Solid Disorders Nanostructures, Mechanical Properties, Nanostructure Multilayers,

Metal Nanocluster, Composite Glasses, Porous Silicon.

Reference Books:

1. Introduction to Nanotechnology: Poole and Owners
2. Quantum Dots : Jacak, Hawrylak and Wojs
3. Handbook of Nanostructured Materials and Nanotechnology : Nalva (editor)
4. Nano Technology/ Principles and Practices: S.K. Kulkarni
5. Carbon Nanotubes: Silvana Fiorito
6. Nanotechlongy: Richard Booker and Earl Boysen

MPE-403: PHYSICS OF ELECTRONIC MATERIALS AND DEVICES Credits: 3

Physical Mechanisms:

Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Schokley Read theory of recombination, Switching in Electronic Devices.

Devices:

(i) Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-V measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics, Surface/Interface States, Role of interface States in Junction Diodes. Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices), MESFET, MOSFET.

(ii) Microwave Devices: Tunnel Diode, MIS Tunnel Diode, Degenerate and Non-degenerate semiconductor, MIS Switch Diode, MIM Tunnel diode. IMPATT Diode. Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred Electron devices.

(iii) Photonic Devices: LED and LASER, Photo detectors, Solar-cells.

Reference Books:

1. Physics of Semiconductor Devices: S.M. Sze.
2. Semiconductor Devices Basic Principles: Jaspreet Singh.
3. Physics and Technology of Semiconductor Devices: A.S. Grove.
4. Metal/Semiconductor Schottky Barrier Junction and their Applications: B.L. Sharma.
5. Metal/Semiconductor Contact: Rhoderick.

MPE-404: SATELLITE COMMUNICATION AND REMOTE SENSING Credits: 3

Satellite Communication

Principle of Satellite Communication: General and Technical characteristics, Active and Passive satellites, Modem and Codec.

Communication Satellite Link Design: General link design equation, Atmospheric and Ionospheric effect on link design, Earth station parameters.

Satellite Analog Communication: Baseband analog signal, FDM techniques, S/N and C/N ratio in FM in satellite link.

Digital Satellite Transmission: Advantages, Elements of Digital satellite communication, Digital base band signal, Digital modulation Technique, Digital link Design, TDM, TDMA, Some Applications (VSAT, GPS, LEO mobile communication).

Remote Sensing

Concept and Foundations of Remote Sensing: Electromagnetic Radiation (EMR), Interaction of EMR with Atmosphere and Earth surface, Application areas of Remote Sensing.

Characteristics of Remote Sensing Platforms & Sensors: Ground, Air & Space platforms, Return Beam Vidicon, Multi-spectral Scanner.

Microwave Remote Sensing: Microwave sensing, RADAR: SLAR & applications, LIDAR: basic components & applications.

Earth Resource Satellites: Brief description of Landsat and Indian Remote Sensing (IRS) satellites.

Text and Reference Books

1. Satellite Communication – D.C. Agrawal & A. K. Maini.
2. Satellite Communication – T. Pratt and C. W. Bostiern
3. Satellite Communication Systems-M. Richharia, MacGraw Hill.
4. Introduction to Remote Sensing – J. B. Campbell.
5. Manual of Remote Sensing: Vol I & II, Edited by R. N. Colwell, American Society of Photogrammetry.

MPE-405: Quantum Field Theory: Path Integral Approach Credits: 3

Path integral quantization and Feynman rules: Scalar and Spinor Fields:

Introduction to Path Integrals, Generating functional for scalar fields, Functional integral, Free particle Green's function, Generating functional for interacting fields: ϕ4 theory. Effective action for ϕ4 theory. Two point functions, Four point functions, Grassman variable, Fermionic functional integrals and generating functional.

Path Integral Quantization: Gauge Fields:

Propagator and gauge condition in QED. Photon propagator, Propagator for transverse photon. Scattering cross section for some elementary process in QED.

Renormalization:

Divergence in ϕ4 theory, Dimensional regularization. Renormalization of ϕ4 theory. Divergence in QED. Electron self-energy, Vacuum polarization. WT identities. Anomalous magnetic moment of electron. Renormalization group equations.

Reference Books:

1. An introduction of QFT: M. peskin and D. Schroeder.
2. Quantum Filed Theory: L.H. Ryder.
3. Quantum Field Theory: C. Itzykson and J.B. Zuber.
4. Field Theory: Modern Primer: P. Ramond.
5. Relativistic Quantum Field: J.D. Brojken and S.D. Drell.
6. Introduction to QFT: F. Mandle and G. Shaw.

MPE-407: Computational Physics Credits: 3

Stochastic Processes:

Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion

Percolation theory

Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics

Simulations of physical models

Elementary ideas of: (a) Time-average and Molecular dynamics: Dynamical equations and physical potentials; Verlet algorithm (b) Ensemble average and Monte Carlo methods; Metropolis algorithm. Introduction to the simulations of: (a) Ising model in magnetism (b) Bak-Tang-Wiesenfeld model in studies of self-organized criticality.

Combinatorial optimization problems

Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique.

References

1. Understanding Molecular Simulation (Academic Press), D. Frenkel & B. Smit

2. Introduction to Percolation Theory (Taylor-Francis), D. Stauffer

3. Equilibrium Statistical Physics (World Scientific), M. Plischke & B. Bergersen

4. Numerical Recipes in C: The Art of Scientific Computing (Cambridge University Press), W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling

MPL-401(A): ELECTRONICS LABORATORY Credits: 6

Students will be required to perform six (06) experiments of the following, other than those performed in Semester-III:

1. Microwave characteristics and measurements

2. Nonlinear applications of Op amplifier

3. PLL characteristics and its applications

4. PAM, PWM and PPM Modulation and demodulation.

5. PCM / delta modulation and demodulation

6. Fiber optic communication

7. Experiments on MUX, DEMUX, Decoder and shift register

8. Arithmetic operations using microprocessors 8085 / 8086

9. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086

10. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086

11. PPI 8251 interfacing with microprocessor for serial communication.

12. Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(B): NUCLEAR PHYSICS **Credits: 6**

Students will be required to perform seven (07) experiments of the following, other than those performed in Semester III:

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector.

2. Alpha Spectroscopy with Surface Barrier Detector.

3. Determination of the range and energy of alpha particles using spark counter.

4. Study of gamma ray absorption process.

5. X-Ray Fluorescence.

6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux.

7. To Study the Solid State Nuclear Track Detector.

8. Fission Fragment Energy Loss Measurements from Cf252.

9. Gamma - Gamma Coicidence studies.

10. Compton Scattering: Energy Determination.

11. Compton Scattering: Cross-Section Determination.

12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique.

13. Identification of particles by visual range in Nuclear Emulsion.

14. Study of Rutherford Scattering.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(C): SPECTROSCOPY LABORATORY Credit - 6

Students will be required to perform six (06) experiments of the following, other than those performed in Semester III:

1. Verification of Hartmann formula for prism spectrogram

2. Measurement of optical spectrum of an alkali atom

3. Determination of metallic component of an inorganic salt

4. Emmiter of electric discharge through air in a tube with minute leak

5. Emitter of electric discharge through air in an evacuated tube

6. Measurement of optical spectrum of alkaline earth atoms.

7. Measurement of Band positions and determination of vibrational constants of AlO molecule

8. Measurement of Band positions and determination of vibrational constants of N_2 molecule

9. Measurement of Band positions and determination of vibrational constants of CN molecule

10. Measurement and analysis of fluorescence spectrum of I_2 vapour

11. Determination of characteristic parameters of an optical fiber

12. Measurement of Raman spectrum of CCl_4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(D): SOLID STATE PHYSICS LABORATORY　　　　Credit - 6

Students will be required to perform four (04) experiments of the following, other than those performed in Semester III:

1. Measurement of lattice parameter and indexing of powder photograph

2. Identification of unknown sample using powder diffraction method.

3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature.

4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor.

5. Rotation / oscillation photograph and their interpretation.

6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature.

7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes.

8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field.

9. Synthesis/ Fabrication of Carbon Nanotubes by spray paralysis method and its verification through Xray diffraction.

10. To build crystal structures and to calculate its powder diffraction pattern using material Studio software and to analyze structures and diffraction patterns.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(E): BIOPHYSICS LABORATORY Credits: 06

1. Computer simulation of Coil-Globule transition in biopolymers.
2. Computer simulation of thermal denaturation of DNA.
3. Electronic spectra (UV absorption and fluorescence) of adenine.
4. Electronic spectra (UV absorption and fluorescence) of guanine.
5. Extraction of urease from Cajanus indicus and determination of its activity.
6. Separation of Protein and estimation of the size by Agarose gel electrophoresis..
7. Spectroscopic study of chlorophyll extracted from natural sources.
8. Theoretical study of electronic spectra of adenine and guanine.
9. Electronic spectra (UV absorption and fluorescence) of phenylalanine.
10. Electronic spectra (UV absorption and fluorescence) of tyrosine.
11. Study of hydrogen bonding in the glycine-water system by Raman spectroscopy.

Note: Addition and deletion in the list of experiments may be made from time to time by the Department.

MPL-401 (F) SPACE PHYSICS LABORATORY Credit-6

Students will be required to perform six (0**6**) experiments of the following:

(1) Characteristics of RADAR:
To observe the effect of different RADAR parameters in detecting two targets on an active radar screen using radar simulation software.

(2) AEROSOL Characteristics:
To study the distributions of particulate matter (PM): $PM_{1.0}$, $PM_{2.5}$, PM_{10} at different locations by using the GRIMM MODEL 1.107 AEROSOL SPECTROMETER.

(3) Fiber Optics Communication:
(a) To study the numerical aperture (NA) of the optical fiber provided with the kit using 660 nm wavelengths LED.
(b) To measure the propagation loss and binding loss of the fiber.
(c) To study PWM and pure width demodulation.
(d) To study PPM and pulse position demodulation.

(4) OZONOMETER:
To measure the total ozone column and water vapor column as well as aerosol optical thickness (AOT) at 1020 nm using a hand-held multiband Sun-photometer MICROTOPS II.

(5) Characteristic of detectors using simulation tools:
(a) To determine the electric field configuration of a GEM detector by MAXWELL-2D simulation of given dimension.
(b) To plot the contour of potential and electric field using GARFIELD-9.

(6) Satellite Communication and its characteristics:
(a) To set up an active and a passive satellite communication link.
(b) To measure the balanced analog signal parameters link frequency response of analog channel.
(c) To measure C/N ratio.
(d) To measure S/N ratio.

Note: Addition and deletion in the list of experiments may be made from time to time by the Department.

MPD-401: PROJECTS AND DISSERTATION Credits: 2

The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics.