Course Structure for M.Sc. (Physics) programme

Programme duration: 2 years. Total Credits: 80

I-Semester

Code	Paper Title	Course Type	Credits				% Assessment	
			L	P	T	Total	Internal	Term End
PY 1.1 FT	Mathematical Methods of Physics	F	3:0	-	-	3	40	60
PY 1.2 CT	Classical Mechanics	C	3:0	-	-	3	40	60
PY 1.3 FT	Quantum Mechanics – 1	F	3:0	-	-	3	40	60
PY 1.4 CT	Computational Physics	C	2:0	0:1	-	3	40	60
PY 1.5 OE	Open Elective	E	-	-	-	3	40	60
PY 1.6 CL	Physics Lab – 1	C	-	0:2	-	2	40	60
PY 1.7 CL	Electronics Lab – 1	C	-	0:2	-	2	40	60
PY 1.8 ET	Inter-disciplinary elective	E	-	-	-	3	40	60
	Total		**22 credits**					

II Semester

Code	Paper Title	Course Type	Credits				% Assessment	
			L	P	T	Total	Internal	Term End
PY 2.1 FT	Electromagnetic Theory	F	3:0	-	-	3	40	60
PY 2.2 FT	Statistical Physics	F	3:0	-	-	3	40	60
PY 2.3 CT	Electronics	C	3:0	-	-	3	40	60
PY 2.4 CT	Condensed Matter Physics	C	3:0	-	-	3	40	60
PY 2.5 E	Elective – I	E	3:0	-	-	3	40	60
PY 2.6 CL	Physics Lab – 2	C	-	0:2	-	2	40	60
PY 2.7 CL	Electronics Lab – 2	C	-	0:2	-	2	40	60
PY 2.8 ES	Seminar	E	-	-	0:1	1	40	60
	Total		**20 credits**					

III Semester

Code	Paper Title	Course Type	Credits				% Assessment	
			L	P	T	Total	Internal	Term End
PY 3.1 CT	Atomic, Molecular and Laser Physics	C	3:0	-	-	3	40	60
PY 3.2 CT	Nuclear Physics	C	3:0	-	-	3	40	60
PY 3.3 CT	Quantum Mechanics – 2	C	3:0	-	-	3	40	60
PY 3.4 E	Elective – II	E	3:0	-	-	3	40	60
PY 3.5 E	Elective – III	E	3:0	-	-	3	40	60
PY 3.6 CL	Physics Lab-3 (Condensed matter Physics)	C	-	0:2	-	2	40	60
PY 3.7 CL	Physics Lab-4 (Nuclear Physics)	C	-	0:2	-	2	40	60
PY 3.8 ES	Special Topic: Nobel Prize winning work	E	-	-	0:1	1	40	60
	Total		**20 credits**					

IV Semester

Code	Paper Title	Course Type	Credits				% Assessment	
			L	P	T	Total	Internal	Term End
PY 4.1 EP	Project Work	E	-	10:0	-	10	40	60
PY 4.2 EP	Project Seminars	E	-	-	3:0	3	40	60
PY 4.3 EP	Project Report	E	-	-	2	2	40	60
PY 4.4 EP	Self-Study course	E	-	-	3:0	3	40	60
	Total		**18 credits**					

Course type details: F: Foundation course; C: Core course; E: Elective course
Credit details: L: Lecture; P: Practical / Laboratory; T: Tutorials;
Credit of x:0 will have x contact hours;
Credit of 0:x will have 2x contact hours;

Inter-disciplinary electives

1. Physics for everyone (Only for students of other Departments)
2. Physics in everyday life (Only for students of other Departments)
3. Philosophy of Physics
4. Physics and Technology
5. Nanoscience for everyone
6. Basics of programming

List of Electives for Elective – 1

1. Experimental Techniques – I (PY 2.5E_ET)
2. Liquid Crystals (PY 2.5E_LC)
3. Radiation detection and measurement principles (PY 2.5E_RDMP)
4. Programming and Interfacing (PY 2.5E_PI)
5. Energy Physics (PY 2.5E_EP)

List of Electives for Elective – 2 and Elective – 3

1. Semiconductor Devices (PY 3.E_SD)
2. Advanced Condensed Matter Physics (PY 3.E_ACM)
3. Elements of Particle Physics (PY 3.E_PP)
4. Organic Electronics (PY 3.E_OE)
5. Nanoscience & Nanotechnology (PY 3.E_NS)
6. Magnetism (PY 3.E_M)
7. Spintronics (PY 3.E_S)
8. Superconductivity (PY 3.E_SC)
9. Laser Physics (PY3.E_LP)
10. Optoelectronics (PY 3.E_OE)
11. Methods of Computational Physics (PY 3.E_MCP)
12. Experimental Techniques – II (PY 3.E_ET2)
13. Physics of Soft Matter (PY 3.E_PSM)
14. Introduction to Biophysics (PY 3.E_BP)
15. Colloids and Interface Science (PY 3.E_CI)

Syllabus for M.Sc. (Physics) Programme

I – Semester

Mathematical Methods of Physics (PY 1.1 FT)

Unit –I: Integral Transforms **(7 hours)**
Fourier series, Fourier transforms their properties & applications.

Unit – II: Differential Equations **(10 hours)**
Ordinary Differential Equations of 1st and 2nd order; Partial differential equations; Boundary value problems;

Unit – III: Linear Algebra and Tensors **(10 hours)**
Basic properties of matrices (Review only), Orthogonal matrices, Hermitian and Unitary matrices, Similarity and unitary transformations, Diagonalization of matrices, Definition of Tensors, Contraction, Direct products,, quotient rule, Pseudo tensors, Dual tensors, Levi Cevita symbol, irreducible tensors.

Unit – IV: Group Theory **(8 hours)**
Finite Groups, multiplication table, conjugate elements and classes, subgroups, direct product groups, isomorphism and homomorphism, permutation groups, distinct groups of given order, reducible and irreducible representations. Introduction to continues groups, Lie groups.

Unit – 5: Functions of complex variables **(10 hours)**
Cauchy-Riemann conditions, analytical functions, integration in complex plane, Singularities, Taylor series representation, Poles and Residues, Laurent Expansion, Cauchy residue theorem, Applications of the residue theorem;

Text books:

1. Mathematical Methods of Physicists — George Arfken and Hans J.Weber
2. Mathematics for Physicists — Dennery & Kryzywicki

Reference Books:

1. Ordinary differential equations — R.L.Rabenstein
2. Complex Variables & Applications — R.V.Churchill
3. Partial Differential Equation for Scientists — G.Stephenson
4. Theory of Finite Groups — L.Jansen and M.Boon

Classical Mechanics (PY 1.2 CT)

Unit – 1: **(12 Hours)**
A brief review of Newtonian mechanics; De-Alembert's Principle, Lagrangian Formalism – constraints in dynamical systems, generalized Coordinates, Lagrange's equation and its solutions in some simple cases.

Unit – 2: **(12 Hours)**
Hamiltonian formalism – dynamical equations, conservation laws, Hamiltonian of a charged particle in electromagnetic field; Poisson brackets and their properties – equations of motion.

Unit – 3: **(12 Hours)**
Canonical transformation, Hamilton-Jacobi Theory and action angle variables; Theory of small oscillations – normal modes of the system.

Unit – 4: **(9 Hours)**
Two body central force problem, scattering due to central force fields; rigid body motion – infinitesimal rotations, Coriolis force, Equations of motion.

Text books:

1. Classical Mechanics H. Goldstein
2. Classical Dynamics Jog & Rana

Reference books:

1. Mechanics Landau-Lifshitz
2. Classical Mechanics A. K. Raichaudhuri
3. Classical Dynamics J. B. Marion

Quantum Mechanics – 1 (PY 1.3 FT)

Unit – I: Need for quantum description of nature: Failures of classical theories
Stern-Gerlach experiment, Black body radiation, Photoelectric effect, Dependence of Cp, Cv on degrees of freedom, Interference patterns of double slit experiment, Debroglie hypothesis, dual nature of matter

Unit – II: Wavefunctions
Waves, superposition and phases, Basic postulates of quantum mechanics, Wavefunction and review of simple forms of wavefunctions and their superpositions.Statistical interpretation of wave functions, normalization and expectation values. Fourier transforms, delta functions, gaussians and their relevance in quantum mechanics.Momentum space wavefunction.The uncertainty principle, Commutation relationships, Dispersion of a gaussian. Schrodinger equation.

Unit – III: 1-dimensional problems
Bound states and scattering states, Infinite and finite square wells, Potential barrier, Harmonic oscillator (both series method and the ladder method), Delta function potential and finite step. Reflection and transmission coefficients. S matrix and M matrix.

Unit – IV: Quantum mechanics in 3-dimensions
The commutation relationships in 3 dimension,. 3-D Schrodinger equation, Extension from 1-d to 3-d for free particle and harmonic oscillator. Degeneracy and rotational invariance, Central potentials, Hydrogen atom, Identical particles, Periodic potentials, Metals, insulators and semiconductors

Unit – V: Notations, mathematical formalisms and other interesting quantum phenomena
Dirac notation, Linear algebra, Quantum entanglement, quantum computation, EPR paradox, Bells theorem

Text books:

1. Introduction to Quantum Mechanics by David Griffiths (Pearson Education)
2. Quantum Physics of Atoms, Molecules, Solids Nuclei and Particles by Robert Martin Eisberg, Robert Resnick (Wiley)

Reference books:

1. Principles of Quantum Mechanics by R. Shankar (Springer)
2. A Textbook of Quantum Mechanics by Piravonu Mathews, K. Venkatesan (Tata McGraw Hill)

Computational Physics (PY 1.4 CT)

Unit – I: Need of Computational Tools **(5 hours)**
Example of problems in physics requiring computational approach; Basic computer architecture and latest advancements.

Unit – II: Basics of Programming and Programming tools **(10 hours)**
Use of C or Python in physics and related problems, Data visualization and related.

Unit – III: Error Analysis and Curve fitting **(5 hours)**
Error and Uncertainties. Error propagation. Curve fitting and introduction to data processing.

Unit – IV: Numerical Methods **(15 hours)**
Roots of algebraic and transcendental equations – iterative methods such as bisection method, inverse interpolation and Newton – Raphson method; Matrix algebra, solution of simultaneous linear equations by matrix inversion methods; Interpolation – linear interpolation, Lagrangian interpolation, Newton's interpolation; Numerical Integration and Differentiation (Numerical Methods implemented using C or Python).

Unit – V: Monte Carlo Methods **(10 hours)**
Generation of (pseudo)random numbers. Monte Carlo integration. Solution of problems in physics.

Text books:
1. Numerical Recipes using C — W.H.Press et.al
2. Computational Physics: Problem Solving with Python — Rubin H. Landau et al.

Reference Books
1. Computational Methods for Physics — Joel Franklin
2. Computational Physics — V.K.Mittal, R.C.Verma & S.C.Gupta, Ane's Student Edition

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Open Elective (PY 1.5 OE):

Students will take this course from other Departments.

Physics Lab – 1 (PY 1.6 CL)

List of general Physics Experiments. Any 8 experiments to be done in a semester.

1. Study of the characteristics of a Gyroscope and determination of rotation rates
2. Study of Mercury spectrum using Grating Spectrometer
3. Study of diffraction of Laser light by slits and circular aperture
4. Characterization of polarized light using Quarter and Half Wave Plates
5. Measurement of refractive index of a gas using Michelson Interferometer
6. Estimation of wavelength of sodium light by setting up interference fringes
7. Study of temperature dependence of viscosity of a liquid
8. Study of Thermal Diffusivity of brass
9. Characteristics of temperature sensors: Pt – 100, Diode and Thermocouple
10. Determination of the velocity of Ultrasonic waves in solids/liquids.
11. Study of Normal and anomalous Zeeman Effect and determination of **g**.
12. Study of spectrum of copper.
13. Study of Stark effect.

14. Attenuation in OFC
15. Error analysis
16. Verification of Stefan's law for black body radiation
17. Energy band gap of a semi-conductor diode
18. Dispersive and resolving power of prism

Electronics Lab – 1 (PY 1.7 CL)

List of Experiments in Electronics. Any 8 experiments to be done in a semester.

1. Study of normal and zener diode characteristics.
2. Study of Half / Full / Bridge rectifier circuits with filters.
3. Setting up a Power Supply using a Zener Diode as Voltage Regulator.
4. Study of Bipolar Junction Transistor Static Characteristics.
5. Study of CE, CB and CC configuration of BJT circuit.
6. Study of Field Effect Transistor Characteristics.
7. Study of Diode Clipping and Clamping Circuits.
8. Study of RC phase shift, Hartley, Colpitts & Crystal Oscillators.
9. Study of Op-amp - Basic operational circuits.
10. Measurement of Op-Amp parameters.
11. Study of Differentiator and Integrator circuits.

PY 1.8 ET

Students have to choose one of the inter-disciplinary electives offered by any Science Department in the University including Department of Physics.

Semester – II

Electromagnetic Theory (PY 2.1 FT)

Unit – I: Electromagnetic waves (10 hours)
Maxwell's equations The wave equation and its solution – boundary conditions, reflection and transmission of EM waves, Fresnel formulae; Polarization of EM waves; Energy and momentum in EM waves; EM waves in matter (linear media); Absorptions and dispersion of EM waves in conducting media; Cauchy's formula for refractive index;

Unit – II: Wave guides for EM waves (5 hours)
Planar dielectric waveguides, Metallic rectangular waveguides, TE and TM modes, Rectangular metallic resonators.

Unit – III: Scalar and vector potentials (10 hours)
Coulomb and Lorentz gauge, wave equation for potentials; Hemiltonian in generalized potential form. Field equations and their solution. Retarded potentials – Lienard- Wiechert potentials.

Unit –IV: Radiation (10 hours)
Radiation from accelerated charges - Electric dipole radiation, Magnetic dipole radiation, Radiation from an arbitrary source, power radiated by a point charge.

Unit –V: Relativistic Electromagnetic theory (10 hours)
Review of special theory of relativity. Covariant formalism of Maxwell's equations, transformation laws and their physical significance, relativistic generalization of Larmor's formula, relativistic formulation of radiation by single moving charge.

Text Books:
1. Classical Electrodynamics: J.D.Jackson, John Wiley and Sons inc. NY
2. Introduction to electrodynamics, D.J. Griffths, PHI,
3. Elements of Electromagnetics, M.N.O.Sadiku

Reference Books:
3. Electromagnetic fields and waves. P. Lorrain and D. Corson, CBS
4. Electromagnetism I.S Grant and W.R Phillips, John Wiley and Sons Ltd.

Statistical Physics (PY 2.2 FT)

Unit – I: Review of thermodynamics and statistics (6 Hours)
Laws of thermodynamics and their consequences; Thermodynamic potentials – Maxwell's relations, Phase space - micro- and macro-states; Elementary statistical concepts: mean values, binomial and Gaussian distribution.

Unit – II: Statistical Thermodynamics (12 Hours)
Statistical Ensemble, Fundamental postulate of equilibrium statistics, Interactions between macroscopic systems: thermal and mechanical interactions, equilibrium between interacting systems, Boltzmann's entropy relation.

Unit – III: Ensembles (12 Hours)
Micro-canonical, canonical and grand-canonical ensembles and partition functions; chemical potential, Free energy and its connection with thermodynamic quantities.

Unit – IV: Application of statistical thermodynamics formulation (9 Hours)
Classical and quantum statistics; Blackbody radiation and Planck's distribution law; Ideal Bose and Fermi gases; Bose-Einstein condensation.

Unit – V: Phase transitions and non-equilibrium systems (6 Hours)
First and second order phase transitions; Diffusion equation: random walk and Brownian motion; introduction to non-equilibrium processes.

Text Books :

1. Statistical Mechanics ,R.K.Pathria and Paul D.Beale, 3rd Ed., Butterworth-Heinemenn, Elsevier, 2013 (Indian Print).
2. Thermal Physics , C. Kittel,
3. Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw Hill, New York.

Reference Books:

1. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University press (1987)
2. C. J. Thompson, Equilibrium Statistical Mechanics, Clarendon Press (1988)
3. K. Huand, Statistical Mechanics, IJIiley Eastern (1988)

Electronics (PY 2.3 CT)

Unit – I: Review of analog electronics
KVL, KCL and network theorems. Rectifiers and power supplies.

Unit – II: Operational Amplifiers
Differential amplifiers, Negative feedback, Barkhausen condition, inverting and non-inverting amplifiers, summing circuits, integrating and differentiating circuits,Op-amp filters. Oscillators: Phase shift oscillator, crystal oscillators.

Unit – III: Introduction to digital systems, number systems
Data representation and coding; Logic circuits, integrated circuits; Analysis, design and implementation of digital systems; Positional number system; Binary, octal and hexadecimal number systems; Methods of base conversions; Binary, octal and hexadecimal arithmetic; Representation of signed numbers; Fixed and floating point numbers; Binary coded decimal codes; Gray codes; Error detection and correction codes - parity check codes

Unit – IV: Boolean algebra
Basic postulates and fundamental theorems of Boolean algebra; Standard representation of logic functions - SOP and POS forms; Simplification of switching functions - K-map

Unit – V: Logical families
Introduction to different logic families; Operational characteristics of BJT in saturation and cut-off regions; Operational characteristics of MOSFET as switch; TTL inverter - circuit description and operation; CMOS inverter - circuit description and operation; Structure and operations of TTL and CMOS gates; Electrical characteristics of logic gates – logic levels and noise margins, fan-out, propagation delay, transition time, power consumption and power-delay product.

Unit – VI: Combinational Logic Modules and their applications
Decoders, encoders, multiplexers, demultiplexers and their applications; Parity
circuits and comparators; Arithmetic modules- adders, subtractors and ALU; Design examples.

Unit – VII: Sequential Logic systems and A/D D/A conversion

Basic sequential circuits- latches and flip-flops: SR-latch, D-latch, D flip-flop, JK flip-flop, T flip-flop; Timing hazards and races; Analysis of state machines using D flip-flops and JK flip-flops; ADC, DAC and their parameters.

Text books:
1. Digital Principles and Applications by Malvino and Leach (Tata McGraw Hill)
2. Integrated Electronics by Millman and Halkias (Tata McGraw Hill)
3. Op-amps and Linear Integrated Circuits by R Gayakwad (Prentice Hall)

Condensed Matter Physics (PY 2.4 CT)

Unit – I: Introduction to condensed matter physics (10 Hours)
Review of Symmetries in solid, Two dimensional and three dimensional Bravias lattices, Millers indices; X-ray Diffraction: Brags law, Laue's equation. Reciprocal lattice, Concept of Brillion Zone, Ewald construction, Structure factor.
Unit – II: Free electron model (10 Hours)
Drude's model, Summerfield model, Explanation of hall-effect; Failure of free electron model; Energy bands in solids: Periodic potential, Bloch theorem, Crystal Momentum, Band index.
Unit – III: Lattice vibrations (5 Hours)
Elastic waves, vibrational modes in a continuous medium, Debye and Einstein models of specific heat. Lattice waves and phonons.
Unit – IV: Magnetic properties of solids (10 Hours)
Quantum theory of paramagnetism; Curie's law, Hund's rules. Paramagnetism in rare earth and iron group ions. Ferromagnetism: Curie-Weiss law. Heisenberg exchange interaction.
Unit – V: Semiconductor Physics (10 Hours)
Direct and indirect band gap semiconductors, concept of effective mass. Intrinsic carrier concentration and mobility. Effect of doping. Dielectric and superconducting properties of properties of solid:

Text Books:
1. Solid State Physics- C Kittle, Wiely Eastern
2. Solid State Physics, J.D. Patterson and B.C. Bailey; Springer (2007).

Reference Books:
1. Elementary Solid State Physic- Ali Omar, AdisonWiesly
2. Solid State Physics- A J Dekkar, MacMillan India Ltd
3. Solid State Physics-F W Asckroft and N D Mermin-Saunders College (1976)

Elective – I (PY 2.5 E)

To be chosen by the students from the list of elective courses offered by the Department for that semester.

Physics Lab – 2 (PY 2.6 CL)

List of General Physics experiments. Any 8 experiments to be done in a semester.
1. Determination of work function of a metal by Photoelectric effect experiment
2. Study of temperature dependence of Hall coefficient of semiconductors on temperature

3. Studies on Microwaves using X – Band Microwave apparatus
4. Studies on radiation pattern of Antennas at microwave frequencies
5. Study of the characteristics of a Fabry – Perot Etalon
6. Study of Photoconductivity in CdS
7. Resistivity measurement of a semiconductor by Four – Probe method
8. Study of dielectric constant and determination of Curie temperature of a Ferroelectric material
9. Measurement of dielectric constant of materials at varying frequencies.
10. Determination of dipole moment of an organic molecule.
11. Study of relaxation time of a Bulb.
12. Inversion Temperature of a thermocouple
13. Law of combination of metals for a thermocouple.
14. Determination of temperature coefficient of copper.
15. Determination of k/e using a transistor.
16. Determination of ionization potential of Argon.
17. Computer based data acquisition and interfacing of photo diode and verification Beer-Lambart's Law.
18. Interfacing of temperature sensors to computer and temperature measurements.

Electronics Lab – 2 (PY 2.7 CL)

List of Experiments in Digital Electronics. Any 8 experiments to be done in a semester.

1. Study and Verification of Basic and Universal gates.
2. Realization of logic functions with the help of universal gates.
3. Design & Implementation of half and full adder using XOR & NAND gates.
4. Realization of SR, JK, D and T flip-flops.
5. Design and implementation of code converters using logic gates.
6. Design and implementation of 4-bit binary adder/subtractor.
7. Design and implementation of comparator using logic gates and IC 7485.
8. Design and implementation of odd/even parity checker / generator.
9. Design and implementation of multiplexer and de-multiplexer using logic gates and study of IC 74150 and IC 74154.
10. Design and implementation of encoder and decoder using logic gates and study of IC 7445 and IC 74147.
11. Design and implementation of 4-bit ripple counter and 'mod' counter.

Seminar (PY 2.8 ES)

Each student will be required to deliver a seminar on a topic of his interest in Physics.

Semester – III

Atomic, Molecular and Laser Physics (PY 3.1 CT)

Unit – I: Atomic Spectra (10 Hours)
Characteristic parameters of the spectral lines, Review of vector atom model. Fourier transform spectroscopy. Zeeman effect; Stark Effect.

Unit – II: Molecular Spectroscopy (15 Hours)
Rotational Spectroscopy, Vibrational Spectroscopy, Rotational-Vibrational Spectroscopy. Raman Spectroscopy – Raman effect, Rotational Raman Spectra, vibrational Raman Spectra, structure determination using Raman spectroscopy.

Unit – III: Electron Spectroscopy of atoms (10 Hours)
Atomic structure, electronic angular momentum, many electron atoms, angular momentum of many electron atoms, Photo-electron spectroscopy;

Unit – IV: X-ray Spectroscopy and Spin Spectroscopy (5 Hours)
Electron spectroscopy of molecules. Introduction to – Spin resonance spectroscopy, NMR

Unit –V: Lasers (5 Hours)
Spontaneous and stimulated emission, Einstein A & B coefficients; Optical pumping, population inversion, rate equation; Modes of resonators and coherence length; Types of Lasers with examples.

Text Books :

1. Foundations of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, McGraw Hill, 1994.
2. Physics of atoms and molecules, 2nd ed., B.H.Bransden and C.J.Joachain, Prentice Hall, 2003.
3. Lasers, A. E. Siegman, University Science Books, 1986
4. Lasers Fundamentals and Applications, K.Thyagarajan and Ajoy Ghatak, Macmillan Publ. India, 2nd ed., 2011

Reference Books:

1. Molecular Quantum Mechanics, 3rd ed., P.W.Atkins and R.S.Freidman, OUP, 1997.
2. G. K. Woodgate, Elementary Atomic Structure, Clarendon Press (1989).

Nuclear and Particle Physics (PY 3.2 CT)

Unit – I: Introduction, Basic Nuclear Constituents and Properties
Geiger, Marsden and Rutherford’s experiments to study the nucleus. Measurement of Nuclear Sizes, Binding Energy, Nuclear mass, Semi empirical formula, valley of stability, Drip Lines.

Unit – II: Nuclear Forces and Nuclear Structure Models
Quark picture, Deuteron bound state, Nuclear scattering. Nucleon mean potential, approximation by specific solvable potentials, single particle energy levels, magic number, moments, excited states and other predictions from shell model, Collective model.

Unit – III: Radioactive decay and reactions and Astro-nuclear physics
Alpha decay, Beta decay, Gamma decay, Nuclear reactions Nuclear Fission, Fusion. Fusion in Stars, Nucleosynthesis, Neutrinos and Neutrino flavor oscillations, Dirac and Majarona neutrinos, Mass hierarchy problem.

Unit – IV: Applications of nuclear physics/ Brief introduction to particle physics
Fusion reactors: Tokomak, Radioactive dating, Mössbauer Spectroscopy, Applications in medicine: Basics of heavy ion therapy for cancer treatments. The lepton and quark family, conservation laws, relativistic kinematics.

Text Books:
1. Introduction to Nuclear and Particle Physics by Ashok Das and Thomas Ferbel (World Scientific)
2. Introductory Nuclear Physics by Kenneth Krane (Wiley)

Reference Books:
1. Introduction to elementary particles by David Griffiths (Wiley)
2. Quarks and Leptons: An Introductory Course in Modern Particle Physics by Halzen and Martin (Wiley)

Quantum Mechanics – 2 (PY 3.3 CT)

Unit – I: Scattering Theory
Partial wave analysis, phase shifts, born approximation

Unit – II: Approximate methods
Variational principle, Ground state of He, Hydrogen Ion molecule, WKB approximation, Adiabatic approximation

Unit – III: Perturbation theory
Time-Independent perturbation theory, Non-degenerate and degenerate cases, fine structure of Hydrogen, Time dependant perturbation theory, two level systems, Einstein’s coefficients

Unit – IV: Quantum theory of radiation
Classical radiation field, creation, annihilation operators, quantized radiation field, emission and absorption of photons by atoms.

Unit – V: Relativistic quantum mechanics
Dirac equation, relativistic covariance, bilinear covariants, quantization of Dirac field, Klein-Gordon equation.

Text Books:
1. Introduction to Quantum Mechanics by David Griffiths (Pearson Education)
2. Advanced Quantum Mechanics by J. J Sakurai (Pearson Education)

Reference Books:
1. Advanced Quantum Mechanics by Freeman Dyson (World Scientific)
2. Relativistic Quantum Mechanics by Walter Greiner (Springer)

Elective – II (PY 3.4 E)

To be chosen by the students from the list of elective courses offered by the Department for that semester.

Elective – III (PY 3.5 E)

To be chosen by the students from the list of elective courses offered by the Department for that semester.

Physics Lab – 3 (PY 3.6 CL)

List of Experiments in Condensed Matter Physics. Any 8 experiments to be done.

1. Metal-Insulator Transition in a Thin Film of Strontium Doped Lanthanum Manganite
2. Ferromagnetic – Paramagnetic transition in Nickel by electrical resistivity measurement.
3. Study of hysteresis loop in magnets using B-H Loop tracer
4. Measurement of the electrical and thermal conductivity of Copper to determine its Lorentz number
5. Thin film deposition using Vacuum Coating Unit.
6. Carrier density measurement by Hall Effect in metals and semiconductors
7. Estimation of band gap in semiconductors by four probe method.
8. Study of variation of Dielectric Constant of a dielectric sample with temperature
9. Measurement of magnetoresistance
10. X-ray diffraction and pattern analysis
11. Study of Piezoelectric effect.
12. Calibration of Lock-in- Amplifier.
13. Measurement of self-inductance using Lock – in Amplifier.
14. Van der Paw method of measurement of resistance.
15. Thermoluminescence in solids.
16. Deposition of organic thin films using spin coating and thickness measurement.
17. Measurement of resistance using Leakage method.
18. Phase transitions in quasi two dimensional systems (Langmuir monolayers or ultrathin films at air-solid interface)

Physics Lab – 4 (PY 3.7 CL)

List of Experiments in Nuclear Physics. Any 8 experiments to be done.

1. Life time of cosmic muon
2. Characteristics of GM Counters
3. Characteristics of Silicon Photo – Multipliers (SiPM)
4. Efficiency of NaI Scintillation detector for Gamma Rays
5. Efficiency of Plastic Scintillation detector for Beta Rays
6. Study of nuclear counting statistics
7. Linear and mass attenuation coefficient using gamma ray source
8. SiPM Spectrometers : detection of Gamma Rays
9. Energy calibration of Gamma Ray Spectrometer (study of linearity)
10. Determination of range and end point energy of Beta particles
11. Energy loss measurement of heavy charged particles (Alpha particles)
12. Study of Compton scattering
13. Low energy X – Ray measurements using Proportional counters
14. Particle Physics simulation with Geant4 (Computer simulation)

Special Topic: Nobel prize winning work (PY 3.8 ES)

Students have to give seminars on recent Nobel Prize winning work.

Semester – IV

Project Work and Project Seminars (PY 4.1 EP – PY 4.4 EP)

Each student will carry out an investigative project and submit a dissertation thesis on the topic under the guidance of a faculty advisor from the Department. A student may carry out the project in another Laboratory/Institute with the permission of the Department. Such students must have a faculty mentor from the Department. The project will also include a self-reading course on the topic of project. The project supervisor will decide the self-reading course depending on the project. The progress of the project and reading course will be monitored by periodic seminars. The final evaluation will be through an open seminar and evaluation of the Thesis by a Departmental Committee.

Syllabus of elective courses

Physics in Everyday life

Unit – 1:
Physics in Earth's Atmosphere: Sun, Earth's atmosphere as an ideal gas; Pressure, temperature and density, Pascal's Law and Archimedes' Principle, Coriolis acceleration and weather systems, Rayleigh scattering, Red sunset, Reflection, refraction and dispersion of light, Total internal reflection, Rainbow.
Unit – 2:
Physics in Human Body: The eyes as an optical instrument, Vision defects, Rayleigh criterion and resolving power, Sound waves and hearing, Sound intensity, Decibel scale, and temperature control.
Unit – 3:
Physics in Sports: The sweet spot, Dynamics of rotating objects, Running, Jumping and pole vaulting, Motion of a spinning ball, Continuity and Bernoulli equations, Banana shot: Magnus force, Turbulence and drag.
Unit – 4:
Physics in Technology: Microwave ovens, Lorentz force, Global Positioning System, CCDs, Lasers, Displays, Optical recording, CD, DVD Player, Tape records, Electric motors, Hybrid car, Telescope, Microscope, Projector etc.

Text Book

1. University Physics by F. W. Sears, M. Zemansky, R. A. Freedman, and H. D. Young, Pearson Education
2. Fundamentals of Physics by D. Halliday, R. Resnick, J. Walker, John Wiley & Sons

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Philosophy of Physics

Unit – I: Basic tools of Logic
(15 Hours)
Propositions, Observation, concept, theory. Meaning of knowledge and process of knowledge generation. Inductive and deductive logic, evolution of symbolic Logic. Truths and proofs. Otology and epistemology in knowledge.

Unit – II: Space time and motion
(10 Hours)
Definition of time, prediction, and simultaneity. Equation of motion and realism. Generalized formulations and reality. Principle of correspondence. Absolute and Relative space time. Newton's Determinism.

Unit – III: Philosophy in quantum mechanics
(10 Hours)
Measurement, Identity, observer observable paradox, Non Locality, space time in Quantum mechanics and entanglement, correlation. Vector spaces and reality. Concept of free will. Probability, sets and Godales theorem.

Unit – IV: Contemporary issues in physics and philosophy
(10 Hours)
Relation of statistics and mechanics. Duality and questions in non-deterministic approach of reality. Bohr, Bohm, Einstein logic in physics. Inclusiveness in metaphysics.

Textbooks

(1) J. T. Cushing (1998) Philosophical Concepts in Physics (Cambridge: Cambridge University Press).

(2) M. Lange (2002) An Introduction to Philosophy of Physics (Oxford: Blackwell).

Reference Books

(1) L. Sklar (1992) Philosophy of Physics (Boulder: Westview Press).
(2) The Logic of Scientific Discovery, Karl Popper
(3) Newton: Philosophical Writings. Edited by Andrew Janiak. Cambridge University Press, 2004.
(4) G.W. Leibniz and Samuel Clarke: Correspondence. Edited by Roger A review. Indianapolis/Cambridge: Hackett Publishing Co., (2000).

Semiconductor Devices

Unit – I: Semiconductor fundamentals **(10 Hours)**

Crystal structure, Fermi level, energy-band diagram, carrier concentration in different semiconductors.

Unit – II: Semiconductor Physics **(10 Hours)**

Diffusion of carriers, Low dimensional Heterostructure, Hall effect, Hall effect in low dimensions.

Unit – III: Devices **(15 Hours)**

p-n junction: Basic equations and Characteristics, Bipolar transistor: transistor action and dependence on device structure. Schottky diodes, Tunnel Diode, Field Effect Transistor: Metal Oxide Field Effect Transistor and characteristics. Metal Semiconductor Contacts: rectifying and non-rectifying contacts, Hybrid devices.

Unit – IV: Device Processing Technology **(10 Hours)**

Oxidation, diffusion, ion-implantation, deposition, lithography, etching and interconnect, Thin film techniques.

Text books:

1. D. A. Neamen, Semiconductor Physics and Devices, 3rd Ed., McGraw Hill, 2003.
2. Sze, Simon M. and Ng, Kwok K., Physics of Semiconductor Devices, 3rd. Edition, Wiley, 2007.

References:

1. B. G. Streetman, Solid State Electronic Devices, 5th Ed., Prentice Hall, 2000.
2. R. S. Muller, Device Electronics for Integrated Circuits, 3rd Ed., John Wiley & Sons, 2002.

Magnetism

Unit – I: Introduction to Magnetism **(8 Hours)**

Basic terms, Classification of magnetic materials, magnetism in atoms, Atomic diamagnetism, Atomic paramagnetism, Hund's rule.

Unit – II: Solid State Magnetism **(12 Hours)**

Model of Free Electrons, Pauli Paramagnetism, Sponteneously spin split states, magnetism of 3d Transition Metals and Alloys. Transport in magnetic materials: Magnetotransport in metals,Anisotropic magnetoresistance, Giant magnetoresistance, Colossal Magnetoresistance.

Unit – III: Magnetic Interactions **(10 hours)**

Direct exchange, Indirect exchange. **Collective Magnetism:** Ferromagnetism, Antiferromagnetism, Ferrimagnetisms, Helical Order, Spin Glasses.

Unit – IV: Broken Symmetry **(10 hours)**
Different models of magnetic behavior, phase transition and magnetic excitations.Magnetic anisotropies and induced magnetic anisotropy. **Low dimensional Magnetism:** Magnetic nanoparticles, Superparamagnetism, Magnetic nano wires, Thin films and multilayer

Unit – V: Magnetic Measurements **(5 hours)**
Measurement of susceptibility, Magnetization measurement, Vibrating Sample Magnetometer, SQUID Magnetometer, Magneto-Optic-Kerr effect

Text Books:
1. Magnetism in Condensed Matter, Stephen Blundell,Oxford University, 2001
2. Fundamentals of Magnetism, Mathias Getzlaff, Springer-Verlag Berlin Heidelberg, 2008
3. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2009

Reference Books:
1. Introduction To Magnetic Materials, B. D. Cullityand C. D. Graham,John Wiley & Sons, Inc., Hoboken, New Jersey, 2009.
2. Magnetism: Materials and Applications,Edited by Etienne du TREMOLET de LACHEISSERIE, Damien GIGNOUX, Michel SCHLENKER,Springer,2008.
3. Theory of Magnetism byYoshida, Springer

Spintronics

Unit – I: Introduction to Spintronics **(10 Hours)**
Historical view, Quantum Mechanics of spins, Bloch Sphere, Spin-orbit interaction, exchange interaction. Spin relaxation; spin relaxations in nano dots.

Unit – II: Transport in magnetic materials **(5 Hours)**
Magneto-transport in metals, Anisotropic magnetoresistance, Giant magnetoresistance, Colossal Magnetoresistance, Spintronic materials.

Unit – III: Nanomagnetism **(10 Hours)**
Physics of low dimensional structures, Density of states in low dimensions, Micromagnetic formulation: Magnetic energy contributions, LLG equation, Domain walls in low dimensions

Unit – IV: Spin transfer torque **(10 Hours)**
Qualitative description of spin transfer torque, spin transfer driven magnetization dynamics, Current driven switching of magnetization, domain wall scattering. **Spin injection:** Spin current, Spin injection, spin accumulation, Henley effect, Spin Hall effect, Heterostructures for spintronic devices.

Unit – V: Spintronic Devices **(10 Hours)**
Spin Valve transistor, Spin FET, Spin – tunneling devices (TMR devices), Magnetic Memories: GMR technology, MRAM, New memory technologies in proposal. Introduction to oxide spintronics. Spin based computing: Basic principle, proposed methods of computing: NMR, Superconducting junctions.

Text Books:
1. Principles of Nanomagnetism,Alberto P. Guimaraes,Springer, 2009.
2. Magnetism: Materials and Applications,Edited by Etienne du TREMOLET de LACHEISSERIE, Damien GIGNOUX, Michel SCHLENKER,Springer, 2008.
3. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2009.
4. Introduction to Spintronics,SupriyoBandyopadhyay and Marc Cahay, CRC press, 2008.

References:

1. Spin Waves: Theory and Applications,Daniel D. Stancil,Anil Prabhakar Springer Science, 2009.
2. Relaxation Processes in Micromagnetics, Harry Suhl, Oxford University Press, 2007.
3. Spin ElectronicsD. Awschalom, Robert A. Buhrman, James M. Daughton, Stephan von Molnár, Michael L. Roukes (Editors), Springer, 2004.

Experimental Techniques – I

Unit – I: Measurements **(10 Hours)**
Measurement of low resistance: two probe, three probe and four probe methods, Lock-in amplifier; measurement of capacitance High frequency measurements.

Unit – II: Vacuum technology **(10 Hours)**
Basic concepts, design of vacuum chamber, pumps; measurement of pressure: Gauges

Unit – III: Cryogenics **(10 Hours)**
Production of low temperature, measurement of low temperature. Low temperature device construction.

Unit – IV: Data acquisition **(15 Hours)**
Basic tools of interfacing, ports, processing, packages and programming.

Text books:

1. Experimental Physics: Modern Methods, R. A. Dunlap, Oxford University Press, 1988.
2. Data Acquisition Systems, Di Paolo Emilio, Maurizio, Springer 2013.
3. Vacuum technology and applications, D. J. Hucknall, Butterworth-Heinemann, 1991.

References:

1. Building Scientific Apparatus, Moore,Davis and Coplan Cambridge University Press, 2009.
2. The Art of Electronics by Horowitz and Hill, Cambridge University Press, 2006

Organic Electronics

Unit – I: Introduction to Organic Electronic **(10 Hours)**
Electronic transport in crystalline organic materials and conductive polymers.

Unit – II: Organic Semiconductors **(10 Hours)**
Different classes of polymers, Polymer composites and their advantages.

Unit – III: Devices **(10 Hours)**
Organic transistor, Organic Field Effect Transistor, Organic Light Emitting Diode, Organic Solar Cells, Sensors. Organic optoelectronics and Display devices.

Unit – IV: Molecular Electronics **(5 Hours)**
Molecular materials, Optical and electronic properties, Grafting and Probe based Techniques.

Unit – V: Introduction to Organic Spintronics **(10 Hours)**
Spin filtering in organic molecules, Organic Spin FET. Fabrication methods: Flexibles substrates, Spin coating, Thermal evaporation, Photo and e-beam lithography.

Text Books:

1. Electronic Processes in organic crystals and polymers, Pope and Swenburg, 2 nd Ed., Oxford,1999
2. Organic Electronics: Materials, Manufacturing, and Applications, Hagen Klauk (Editor), Wiley, 2006

References:

1. Organic Electronics, Tibor Grasser, Gregor Meller, Springer, 2009.
2. Organic Thin Film Transistor Integration: A Hybrid Approach, Flora Li, Arokia Nathan, Yiliang Wu, Beng S. Ong, John Wiley & Sons, 2013.
3. Semiconductor Device Physics and Design, Umesh Kumar Mishra, Jasprit Singh, Springer, 2007.

Superconductivity

Unit – I: Basic properties of Superconductors (10 hours)

Persistent currents, perfect diamagnetism and Meissner effect; Type – I and Type –II semiconductors, heat capacity in superconductors.

Unit – II: Theories of Superconductivity (15 hours)

London equations, Ginsburg-Landau theory, BCS theory: Attractive interaction and the formation of Cooper pairs. BCS wave function and coherence; vortex lattice; phase coherence and rigidity in the superconducting state.

Unit – III: Tunnel Junctions using superconductors (10 hours)

Josephson Effect: AC and DC Josephson effect; Other tunneling effects in superconductors

Unit – IV: Unconventional superconductors and technology (10 hours)

High-temperature superconductors. Alternative pairings, Applications of superconductors.

Text Books:

1. Introduction to Superconductivity, Michael Tinkham. Dover 2nd Edition, (1996).
2. High Temperature Superconductivity: An Introduction, Gerald Burns, Academic Press, 1991.

References:

1. Superconductivity, Vitaliĭ Lazarevich Ginzburg, E. A. Andryushin, World Scientific, 2004.
2. Superconductivity, J. B. Ketterson, S. N. Song Cambridge University Press, 1999.

Nanoscience and nanotechnology

Unit – I: Low dimensional Physics (10 hours)

Wave-functions in crystalline materials including metals and semiconductors; Band theory of solids; Quantum confinement.

Unit – II: Diffusion of charges (10 hours)

Charge carriers in solids; Ions and colloidal particles in solution.

Unit – III: Synthesis and characterization of nanoparticles (15 hours)

Synthesis by Sol-Gel, Solution combustion and electrochemical techniques. Characterization by scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, X-ray and neutron scattering, UV-visible and IR spectroscopy.

Unit – IV: Thin films technology **(10 hours)**
Thermal evaporation, pulse laser deposition, magnetron sputtering, chemical vapour deposition, electrochemical deposition.

Text books:
1. Solid State Physics by N. W. Ashcroft and D. N. Mermin. Published by Cengage Learning India Private Limited, (2011).
2. Low dimensional physics by John H. Davies. Published by Cambridge University Press (1997).
3. Thin film phenomenon by K. L. Chopra. Published by Malabar Robert E. Krieger Publishing Company (1979).
4. Handbook of semiconductor electrodeposition by R. K. Pandey, S. N. Sahu and S. Chandra. Published by Marcel Dekkar, Inc. (1996).
5. The textbook of Nanoscience and Nanotechnology by T. Pradeep. Published by TataMcGraw Hill.

Reference book:
1. Materials Characterization by Yang Leng. Published by Wiley-VCH (2013).
2. Principles of instrumental analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch. Published by Thomson Brooks/Cole, (2007).

Experimental techniques – II

Unit – I: Spectroscopic techniques and their applications **(10 Hours)**
UV, visible, FTIR, Raman spectroscopy for solids and molecules. Mass spectroscopy.

Unit – II: Electron and Spin Spectroscopy **(10 Hours)**
Auger electron spectroscopy, Mossbauer, and NMR spectroscopies; Microscopy and their applications.

Unit – III: Microscopy **(10 Hours)**
Scanning electron Microscopy, Scanning probe microscopy Elemental analysis and their applications.

Unit – IV: Scattering techniques and their applications **(15 Hours)**
X-ray, neutron, and dynamic light scattering.

Text books:
1. Fundamentals of molecular spectroscopy by C. N. Banwell
2. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM by R. Egerton.
3. Scanning probe microscopy by N. Tomczak, K. E. Johnson Goh
4. Neutrons, X-rays and light: scattering methods applied to soft condensed matter by T.Zemb, P. Lindner

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Liquid Crystals

Unit – I: Introduction to liquid crystals
Thermotropic liquid crystals, phases exhibited by calamatic, discotic and bent core molecules; Lyotropic liquid crystals, micelles; hexagonal, cubic and lamellar phases of amphiphilic molecular systems; phase transitions and critical phenomena in liquid crystals

Unit – II: Elastic properties of Liquid crystals
Elastic continuum theory;

Unit – III: Electrical properties of liquid crystals
Liquid crystals in electric and magnetic fields, electro-hydrodynamic instabilities, Kerr effect, electro-optical effects; Dielectric response in liquid crystals;

Unit – IV: Applications of liquid crystals
Liquid crystal displays, thermometers.

Text Books:

1. Liquid crystals: Nature's delicate phase of matter by Peter J. Collings; Princeton University Press.
2. Liquid cyrstals by S. Chandrashekar
3. Soft matter physics- An introduction by Maurice Kleman and Oleg D. Lavrentovich

References:

1. The physics of liquid crystals by P. G. de Gennes and J. Prost

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Physics of soft matter

Unit – I: Introduction to soft matter **(5 hours)**
Overview of soft matter, entropy in disordered systems; forces, energies, and time scales in soft matter

Unit – II: Colloidal systems **(10 hours)**
Surface phenomenon and stability of colloidal systems; The Poisson–Boltzmann Equation, DLVO theory: van der Waals versus Electrostatic Interactions, Solutions of Colloidal Particles.

Unit – III: Liquid Crystals **(10 hours)**
Introduction to liquid crystals, Classification of liquid crystals, Electric and Magnetic Field Effects, Biological Importance of Liquid Crystals.

Unit – IV: Polymers **(10 hours)**
Single-chain conformations, The ideal (or Gaussian) Chain, Pair Correlation Function and Radius of Gyration, The Flory Chain, Chains in Interaction, The Mean Field Approach, Scaling Laws for Athermal Solutions.

Unit – V: Self-assembly and interface science **(10 hours)**
Thermodynamics of self-assembly, formation of aggregates, critical micellar concentration, soluble monolayer and Gibbs adsorption, insoluble (Langmuir) monolayers, characterization of Langmuir monolayers; interactions in lamellar flexible systems, elasticity of neutral membranes.

Text Books:

1. Soft condensed matter by R. A. L. Jones, Oxford University Press
2. Polymer Physics by Tanaka Fumihiko, Cambridge University Press
3. Liquid Crystals: Nature delicate phase of matter by P. J. Collings, Princeton University Press

References:

1. Intermolecular and surface forces by Jacob N. Israelachvili. Published by Academic Press.
2. The physics of liquid crystals by P. G. de Gennes and J. Prost. Published by Oxford Science Publications.
3. Soft matter physics- An introduction by Maurice Kleman and Oleg D. Lavrentovich. Published by Springer.

4. Fundamentals of Polymer Physics and Molecular Biophysics by Himadri Bohidar; Cambridge University Press (2015)

Laser Physics and Coherent Optics

Unit – I: Introduction
Introduction to laser physics; Light-matter Interaction;

Unit – II:
Light amplification; Optical Cavity Resonators; Threshold Condition; Rate Equations; Optimal Conditions for Laser Operation;

Unit – III:
Line broadening; Hole Burning; Q-Switching; Mode Locking; Single Mode Lasers;

Unit – IV:
He-Ne Laser; Nd-YAG Laser; excimer Laser; Semiconductor Laser;

Unit – V:
Statistical properties of thermal radiation; partially coherent light; partial polarization; quantum states of light.

Reference Books:
1. Optical Electronics, Ajoy Ghatak and K.Thyagarajan, CUP, 2003.
2. Photonics, Amnon Yariv and Pochi Yeh, 6th ed., OUP, 2009.
3. Fundamentals of Photonics, B.E.A.Saleh and M.C.Teich, 2nd ed., Wiley Interscience, 2007.

Colloids and Interface Science

Unit – I: Surface phenomenon (10 hours)
Surface tension, adhesion and capillarity: effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; Young-Laplace equation of capillarity; Stability of equilibrium solutions; Contact angle and Young's equation; Free energy of adhesion; hydrophilic and hydrophobic surfaces: Caxie-Baxter and Wenzel models

Unit – II: Colloids (5 hours)

Colloids, surfactants/amphiphiles and their applications; Emulsions, foams and gels and their respective applications; Ostwald ripening; Percolation;

Unit – III: Stability of colloidal solutions (15 hours)
Brownian motion versus gravity and viscosity; steric versus electrostatic colloid stabilization; Van der Waals forces, interactions in aqueous solutions: Electrostatic double layer: Poisson-Boltzmann equation, Debye length, zeta potential, DLVO theory or colloidal stability, hydrophobic and hydrophilic interaction and hydration pressure. Destabilization of colloids: aggregation, flocculation, sedimentation and centrifugation; Depletion attraction; Characterization of colloids: scattering, microscopy, and rheology.

Unit – IV: Thermodynamics of adsorption and self-assembly (10 hours)

Thermodynamics of self-assembly, formation of aggregates, soluble monolayer and Gibbs adsorption, insoluble (Langmuir) monolayers, characterization of Langmuir monolayers; interactions in lamellar flexible systems, elasticity of neutral membranes.

Unit – V: Nanofluidics **(5 hours)**
Stability of thin (< 100 nm) films; self-organization in confined systems; atomistic models for nanofluidics: fluids in nanochannels, biological Nano-fluidic devices; ion pumps, aquaporins and plasmadesmata, flow of ions through ion channels.

Text Books:
1. Foundations of Colloids Science by Rober J. Hunter; Oxford University Press
2. Colloid and Interface Science by Pallab Ghosh; PHI learning Pvt. Lmt.
3. An introduction to colloids and interface science: The bridge to Nanoscience by John S. Berg; World Scientific
4. Capillarity and wetting phenomenon: Drops, bubbles, pearls, waves by P. G. de Gennes, F. Brochard-Wyart and D. Quéré; Springer

References:
1. Intermolecular and surface forces by Jacob Israelachvili; Academic press.

Energy Physics

Unit – I:
[11 hours]
Sources of Energy: A brief survey of various energy sources, present and future needs, energy conservation, renewable and non-renewable energy sources of the world. Estimated reserves of on renewable energy sources. Problems and viable solutions of energy utilisation in ecological and sociological perspectives. Solar Radiation: Sun as source of radiation, spectral composition, solar constant, the basic earth-sun angles, solar time and equation of time. Effect of earth’s atmosphere on solar radiation, terrestrial insolation and its measurement.

Unit – II:
[12 hours]
Thermodynamics of Energy Conversion: Principles of energy conversion, conversion between different forms of energy. Thermodynamics of various conversion processes and their comparison in terms of efficiency. Thermodynamic engine cycles: Carnot, Rankine Otto, Sterling, Diesel cycles and their efficiency. Comparison of Carnot and other cycles. Generation of electric power from heat. Brief sketch of machines such as turbines, compressors and pumps.
Heat transport processes: Conduction, forced convection, radiation, boiling and condensation.

Unit – III:
[11 hours]
Direct Electrical Conversion of Solar Energy: Photo voltaic effect, solar photo emissive and photo voltaic cells. Solar cell characteristics, efficiency and spectral response of solar cells. Description and comparison of different types of solar cells, homojunction and hetrojunction cells. Factors off action efficiency of solar cells, solar panels and their performance.

Unit – IV:
[11 hours]
Solar Radiation Collectors: Conversion of solar radiation into heat. Liquid flat plate collectors, thermal losses, energy balance equation and thermal analysis. Flat plate air collectors, types of solar air heaters, performance and applications. Focusing type collectors, need for focusing, solar disc and theoretical solar image. Solar concentrators and receiver geometries, characterisation of focusing collectors, optical

loss, energy balance equation and thermal analysis. Brief discussions on storage and utilisation of solar energy.

Text Books:

1. Renewable Energy: Sorenson.
2. Principles of Energy Conversion : A Culp.
3. Treatise on Solar Energy : H P Garg.
4. Solar Energy Utilisation : G D Rai.
5. An Introduction to Solar Energy for Scientist and Engineers : Sol Wieder.
6. Fundamentals of Solar Cells : Fahrenbruch and Bube.
7. Solar Cell device Physics : Fonasn.
8. Physics of Semiconductor Devices : S M Sze.
9. An Introduction to Energy Conversion : V Kadambi.