SHRI GURU RAM RAI UNIVESITY

(Estd. By Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 3 of 2017)

PATEL NAGAR, DEHRADUN-248001, UTTARAKHAND, INDIA

SYLLABUS

(2021)

Program/course: M.Sc. PHYSICS

M.Sc. PHYSICS (SEMESTER I)

Course Code	Course Title	Credit	Marks for		Total Marks
			IA*	EE**	
MPHC101	Classical Mechanics	4	40	60	100
MPHC102	Mathematical Physics	4	40	60	100
MPHC103	Electrodynamics and Astrophysics	4	40	60	100
MPHC104	Electronics	4	40	60	100
MPHL105	Laboratory Course I	3	40	60	100
MPHL106	Laboratory Course II	3	40	60	100
	Total	22	240	360	600

*INTERNAL ASSESSMENT **EXTERNAL EXAMINATION

M.Sc. PHYSICS (SEMESTER II)

Course Code	Course Title	Credit	Marks for		Total Marks
			IA*	EE**	
MPHC201	Atomic and Molecular Physics	4	40	60	100
MPHC202	Solid State Physics	4	40	60	100
MPHC203	Statistical Physics	4	40	60	100
MPHC204	Quantum Mechanics	4	40	60	100
MPHL205	Laboratory Course I	3	40	60	100
MPHL206	Laboratory Course II	3	40	60	100
	Total	22	240	360	600

*INTERNAL ASSESSMENT **EXTERNAL EXAMINATION

M.Sc. PHYSICS (SEMESTER III)

Course Code	Course Title	Credit	Marks for		Total Marks
			IA*	EE**	
MPHC301	Advanced Quantum Mechanics	4	40	60	100
MPHC302	Nuclear Physics	4	40	60	100
MPHP303	Seminar	3	40	60	100
MPHE304 0R MPHE305 0R MPHE306 0R MPHE307 0R MPHE308	Condensed Matter Physics 0R Digital and Communication Electronics 0R Laser Physics 0R Astrophysics 0R High Energy Physics	Students have to select any two elective papers out of five 2x4 =8	40X2=80	60X2 = 120	200
MPHL309	Laboratory Course (Based on E304/305/306/307/308)	3	40	60	100
MPHS310 0R MPHS311	SELF STUDY COURSES: Physics Of Nano Materials 0R Quantum Electrodynamics	Students have to select any one paper out of two (3)	40	60	100
	Total	22 (Excluding Self - Study Course)	240 (Excluding Self-Study Course)	360(Excluding Self-Study Course)	600(Excluding Self Study Course)

*INTERNAL ASSESSMENT **EXTERNAL EXAMINATION

M.Sc. PHYSICS (SEMESTER IV)

Course Code	Course Title	Credit	Marks for		Total Marks
			IA*	EE**	
MPHC401	Computational Physics	4	40	60	100
MPHC402	Particle Physics	4	40	60	100
MPHL403	Laboratory Course	3	40	60	100
MPHD404	Dissertation	9	60	240	300*
MPHS405 0R MPHS406	SELF STUDY COURSES: Environmental Physics 0R Bio Physics	Students have to select any one paper out of two (3)	40	60	100
	Total	20 (Excluding Self -Study Course)	180 (Excluding Self -Study Course)	420 (Excluding Self -Study Course)	600 (Excluding Self -Study Course)

Max. Marks for each paper (Except dissertation/ project): 100 (40 – Sessional Tests + 60 - End Term Test).

Sessionals: may be in the form of Mid Term Test, Assignment, Classroom Seminar & Laboratory Work, Internship, Industrial / Institutional visits, winter / Summer Training based report Writing & Presentation, Report based on workshop organized by Department etc.

*The distribution of marks for the Dissertation will be as below:

Periodical Presentation	60 Marks
Dissertation	180 Marks
Viva Voce	60 Marks
Total	**300 Marks**

The dissertation/ project report shall be evaluated jointly by the supervisor and one external examiner.

Summary of the Credit

Year	Semester	Max Credit
1	1	22
	2	22
2	3	22
	4	20
Total		**86**

The 2- Year Master's Programme will have the following components:

Category wise classification of the Credit

Category		Credit	Number of Subjects
CC	Departmental Core Course	56	15
DSE	Discipline Specific Course	11	3
GEC	Generic Elective Course	7	2
SSC*	Self-study course	3	1
SEM	Seminar	3	1
PRJT/THESIS	Project/Dissertation	9	1
Total		**86 (Excluding Self -Study Course)**	**23**

Grand Total Credits: 86 **(Excluding Self -Study Course)**

***Self-study course (SSC):** Maximum 06 credits (one minimum 03 credits course shall be mandatory but not to be included while calculating grades). Students have to opt self-study courses either in third semester or in fourth semester. This will be conducted and evaluated at Departmental level.

Subject Code	MPHC101	Subject Title	Classical Mechanics						
LTP	4 0 0	Credit	4	Subject Category	CC	Year	1st	Semester	I

Course Outline:

The main aim of the course is to introduce Newtonian mechanics, Hamiltonian problems, Central force, rigid body dynamics, and canonical transformations.

Course Objective:

The aim and objective of the course on Classical Mechanics is to train the students in Lagrangian and Hamiltonian formalisms for applications in the modern branches of physics such as Quantum Mechanics, Condensed Matter Physics, Astrophysics, etc.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Lagrangian formulation and Variational Principle: Mechanics of particles and system of particles, conversion law, constraints, degree of freedom, generalized coordinates, D'Alembert's principle, Lagrange's equations of motion from D'Alembert's principle, application of Lagrange's equation of motion to a particle and system of particles, conservation theorem, Hamilton's variational principle, Euler- Lagrange's differential equation.

Unit II

Hamilton's formalism: Need of Hamilton's procedure, Legendre's transformation and Hamilton's equation of motion, physical significance of H, cyclic coordinates, Hamilton's equation in cylindrical and spherical coordinates and applications, applications of Hamilton's equation of motion to a particle and system of particles

Unit III

Principle of least action: Canonical or contrast transformation, their advantages and examples, condition for a transformation to be canonical, infinitesimal contact transformation (ICT) Poisson brackets: Definition and properties, Invariance with respect to Canonical transformation, equation of motion in Poisson's Bracket form, Jacobian's form.

Unit IV

Mechanics of Rigid Bodies and Theory of Small Oscillations: Coordinates of rigid body motion, Euler's angle, and angular momentum of a rigid body moments and products of inertia, principle axis transformation, Euler's equation of motion of a rigid body, stable and unstable equilibriums. Lagrange's equation of motion for small oscillators, normal coordinates and normal mode frequency of vibrations, free vibration of linear triatomic molecules.

Learning Outcome

1. Understand the concepts of motion of system of particles in frames of references.
2. Use generalised coordinates and variational principle to solve physics problems.
3. Understanding the scattering problems and frame transformations.
4. Understanding canonical transformations for deriving equations equation of motion.
5. Understand harmonic oscillations and normal mode frequency of vibrations.

Text book [TB]:

1. Gupta K.C., "Classical Mechanics of particles and Rigid Bodies", Wiley Eastern (2001).
2. Goldstein H., Classiacal Mechanics, Pearson Education Asia Pte Ltd. House (2002).

Reference books [RB]:

1. Rana N. C and Joag P S, Classical Mechanics, Tata McGraw-Hill (1991)

Subject Code	**MPHC102**	**Subject Title**	Mathematical Physics						
LTP	4 0 0	**Credit**	4	**Subject Category**	CC	**Year**	**1st**	**Semester**	I

Course Outline:

The course covers an introduction to special functions, group theory, complex variables, Matrix and tensors, and partial differentiation.

Course Objective:

The main objective of the course on Mathematical Physics is to impart knowledge about various mathematical tools/ techniques employed to study physics problems. Using these tools MSc student would understand and handle theoretical treatments to study physics problems if he/she chooses to pursue research in physics as a career.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Differential Equations: Special equations of Mathematical Physics, Series Solution, Bessel functions of first and second kind, generating function, Integral representation and recurrence relations for Bessel's functions of first kind, orthogonality; Legendre functions: generating function, Recurrence relations and special properties, Orthogonality; Legendre polynomials: recurrence relations, Parity and orthogonality, Hermite functions, Laguerre functions.

Unit II

Complex Variable: Introduction, Function of complex variable, Analytic functions, Cauchy's integral theorem and Cauchy's integral formula, Taylor and Laurent's expressions, residues at various poles, theorem of residues, Contour integration.

Unit III

Matrix and Tensors: Inverse and Trace of Matrix, Unitary Matrices, Orthogonality, Eigen values-Eigen vectors and Diagonalistaion of matrices, Coordinate transformation, Covariant and contravariant Tensors, addition, multiplication and contraction of tensors, Associated tensors.

Unit IV

Partial Differential Equations: Partial differential equations, Separation of variables. One dimensional wave and heat equation, two-dimensional heat equation and Laplace equation.

Unit V

Group Theory: Definition, Classification of groups, subgroup, cyclic group, isomorphism and homomorphism, classes, vector spaces, representation theory of finite groups, Reducible and Ir-reducible representations, Schur's Lemmas and orthogonality theorem, Characters of representations.

Learning Outcome

1) Understand special functions to solve the physics problems
2) Understand the use of complex variables for solving definite integral.
3) Understand and use the matrix and tensors.
4) Solve partial differential equations using boundary value problems
5) Understand and use the group theory.

Text book [TB]:

1. Harper C. Analytical Mathematics in Physics, Prentice Hall (1999).
2. Boas M.L. Mathematical Methods in the Physical Sciences, John Wiley & Sons, NewYork (1983).

Reference books [RB]:

1. Arfken G. and Weber H.J., Mathematical Methods for Physicists, Academic Press (2005).

Subject Code	MPHC103	Subject Title	Electrodynamics and Astrophysics						
LTP	4 0 0	**Credit**	4	**Subject Category**	CC	**Year**	**1st**	**Semester**	I

2. Rajput B. S., Mathematical Physics, Pragati Prakashan (2002).

Course Outline:

The course covers topics in classical electrodynamics and explains astronomical features.

Course Objective:

This course gives an overview on various topic of classical electrodynamics including Maxwell equations, gauge invariance, classical radiation from accelerating charges. To develop observation skills to be able to explain astronomical features and stellar system.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Maxwell's equations and Electromagnetic waves: Maxwell's equations and their physical significance. Equation of continuity and relaxation time, Vector and scalar potentials, Lorentz and Coulomb gauge, electromagnetic energy and Poynting's theorem, electromagnetic wave equations in free space, their plane wave solutions. Concept of Retarded potentials, Lienard Wiechert potentials, Multipole expansion of EM fields, Electric dipole radiations, field due to oscillating electric dipole, magnetic dipole radiations, electric quadrupole radiation

Unit II

Radiations from moving charges: Fields produced by moving charges, radiations from an accelerated charged particle at low velocities, radiations from a charged particle with co-linear velocity and acceleration. Radiations from an accelerated charged particle at low velocities in circular orbits-Larmor formula, Radiations from an accelerated charged particle at relativistic velocities in circular orbits relativistic generalization of Larmor Formula.

Unit III

The Solar System: Aspects of the sky: Concept of Celestial Coordinates and spherical astronomy. Astronomical telescopes. The early years of solar system, the solar system today. Study of Planets: Classification of the Planets, Orbits, Laws of planetary motion, Physical features, surface features, Internal Structure, Atmosphere, Satellites and Rings. Minor Bodies in Solar System: Asteroids, Meteors and Meteorites**:** Discovery of minor planets (Asteroids), their orbits and physical nature. Origin of the minor planets. Meteors and Meteorites. Observation of meteor showers and sporadic meteors. Orbits of sporadic meteoroids and meteor showers. Meteorites, its types and composition. Meteorite craters. Comets- Discovery and designation. Periodic comets. Physical nature. Spectra. Brightness variation. Gas production rates, dust and ion tails. Nature of dust particles and origin of comets.

Unit IV

Stellar System: Sun As A Star: History of Sun, Sun’s interior, the photosphere, the solar atmosphere (Chromosphere & corona). Salient features of sunspots, sun’s rotation & solar magnetic field, explanation for observed features of sunspots. Distances of stars from the trigonometric. secular. and moving cluster parallaxes. Stellar motions. Magnitude scale and magnitude systems. Atmospheric extinction. Absolute magitudes and distance modulus. color index. The Hertzberg- Russell Diagram: The colour, Brightness or luminosity, the population of star. Elementary idea of Binary & Variable Stars. Nuclear fission, Nuclear fusion, condition for nuclear reaction in stars. Types of galaxies, Structure and features of the Milky Way Galaxy.

Learning Outcome

1. Appreciate the structure of electrodynamics
2. Understand the formulation of Maxwell's equations.

3. Apply Maxwell's equations to solve problems of classical electrodynamics.
4. Understand the concept of modern astrophysical observations.
5. Demonstrate an understanding of our present picture stellar system.

Text book [TB]:

1. Modern Electrodynamics by A. Zangwill, Cambridge, 2013.
2. Introduction to Electrodynamics by D. Griffiths

Reference books [RB]:

1. P. Puri: Classical Electrodynamics (Tata McGraw Hill, 1990)
2. J.B. Marion: Classical Electromagnetic Radiation
3. Landau and Lifshitz: The Classical theory of Fields (Pergman Press)

Subject Code	MPHC104	Subject Title	Electronics						
LTP	4 0 0	Credit	4	Subject Category	CC	Year	1st	Semester	I

Course Outline:

The course covers an introduction basic electronic component, circuits to power and operational amplifiers, and optoelectronics.

Course Objective:

The main objective of the course on electronic is to impart knowledge and keen understanding of the basic power amplifiers components, circuit representations and integrations, device structures, principle of operations, and analysis.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Power amplifiers: Types of power amplifiers-series fed class A amplifier-series fed transformer coupled class B: push pull circuits-harmonic distortion in amplifiers-class C and D amplifiers-design considerations.

Unit II

Feedback in amplifiers: Feedback principle-effect of feedback on stability-nonlinear distortion input and output impedance-bandwidth-different types of feedback. Criteria for oscillation-phase shift, Wein bridge, crystal oscillator-frequency stability, astable, mono stable and bistable multivibrators, Schmitt trigger-bootstrap sweep circuits.

Unit III

Operational amplifiers: Differential amplifier-ideal and real op-amp-input and output impedance frequency response-applications: amplifiers, mathematical operations, active filters, waveform generators-analog computations-comparators-S and H circuit-voltage regulator.

Unit IV

Optoelectronics: Optical fibers: graded index step index fibers-refractive index profiles-propagation of optical beams in fibers-mode characteristics and cut off conditions-losses in fibers-signal distortion group delay material and wave guide dispersion. Optical sources: Light emitting diodes-LED structureinternal quantum efficiency-injection laser diode comparison of LED and ILD.

Optical detectors: PN junction photo diodes-PN photo detectors-avalanche photo diode-performance comparison.

Learning Outcome

1. Be able to understand power and operational amplifiers.
2. Gain exposure to technologies used for fabrication of Integrated Circuits.
3. Be able to understand diode and photo diodes.
4. Gain perspective of advanced semiconductor devices.

Text book [TB]:

1. Millman & Halkias: Integrated Electronics (McGraw Hill)
2. Semiconductor Electronics by A.K. Sharma, New Age International Publisher (1996)
3. Laser and Non-linear optics by B.B. Laud., Wiley Eastern Limited (1985)

Reference books [RB]:

1. Introduction to Semiconductor Devices by M.S. Tyagi, John Wiley & Sons
2. Semiconductor Devices - Physics and Technology by S.M. Sze, Wiley (1985)
3. Optical electronics by Ajoy Ghatak and K. Thygarajan, Cambridge Univ. Press.

Subject Code	**MPHL105 MPHL106**	**Subject Title**	**Laboratory Course – I Laboratory Course – II**						
LTP	0 0 6	**Credit**	3	**Subject Category**	CC	**Year**	1st	**Semester**	I

<u>Course Outline:</u>

The laboratory course covers the experiments based on LCR, UJT, and transistor characteristics.

<u>Course Objective</u>:

To teach the student's properties of various semiconductor and transistor characteristics by having the students perform hands on experiments supervised by a specialized instructor.

<u>Course Pre/Co- requisite (if any</u>): no pre-requisite

<u>Detailed Syllabus</u>

List of experiments: At least 5 experiments are to be performed:

1. Study of LCR circuit
2. Transistorized LCR bridge
3. Study of UJT
4. Study of MOSFET
5. Study of NPN and PNP transistor characteristics
6. Study of DIAC
7. Study of TRIAC
8. e/m by Zeeman Effect
9. Study of IC- Based Power supply
10. Measurement of wavelength of He-Ne laser using interference and diffraction pattern

<u>Learning Outcome</u>

At the end of the course, the student will be able to

1. Gain understanding study of LCR circuit.
2. Gain exposure of properties of UJT and MOSFET.
3. Gain experience in NPN and PNP transistor characteristics.
4. Gain exposure study of DIAC and TRIAC.
5. Gain understating of Zeeman effect, IC-based power supply and diffraction pattern by laser.

Subject Code	**MPHC201**	**Subject Title**	Atomic and Molecular Physics						
LTP	0 0 6	**Credit**	3	**Subject Category**	CC	**Year**	1st	**Semester**	I

Course Outline:

The laboratory course covers the experiments based on semiconductors, oscillator, amplifier and different network theorems.

Course Objective:

To teach the students properties of semiconductors, oscillator, amplifier and different network theorems by having the students perform hands on experiments supervised by a specialized instructor.

Course Pre/Co- requisite (if any): no pre-requisite

Detailed Syllabus

List of experiments: At least 5 experiments are to be performed:

1. Study of FET
2. R.C. coupled amplifier
3. T.C. coupled amplifier
4. Study of feedback amplifier
5. Study of Hartley oscillator
6. Study of Colpitt oscillator
7. Study of Wien bridge oscillator
8. Design and study of different network theorems
9. Design and study of phase shift oscillator
10. Study of operational amplifier

Learning Outcome

At the end of the course, the student will be able to

1. Gain competence in the basics of FET.
2. Gain exposure in various amplifiers.
3. Gain understanding of properties of FET.
4. Gain experience in in various oscillators.
5. Gain exposure in and study of phase shift oscillator, operational amplifier, and different network theorems.

Subject Code	MPHC202	Subject Title	Solid State Physics						
LTP	400	Credit	4	Subject Category	CC	Year	1st	Semester	II

<u>Course Outline:</u>

The course covers an introduction to atomic spectroscopy, molecular spectroscopy, and spin resonance spectroscopy.

<u>Course Objective</u>:

The main objective of the course on atomic and molecular physics is to impart knowledge about various atomic spectroscopy. Using these tools MSc student would understand and handle various spectroscopic concepts to study physics problems if he/she chooses to pursue research in physics as a career.

<u>Course Pre/Co- requisite (if any)</u>: no essential pre-requisite

<u>Detailed Syllabus</u>

UNIT I

Atomic Spectroscopy: Hydrogen, Helium and Alkali spectra, Vector atom model of Hydrogen atom, Relativistic correction, Spin-orbit coupling, Hydrogen fine structure, Spectroscopic terms, LS coupling, Pauli exclusion principle, Interaction energy for LS coupling, Lande interval rule, jj coupling, interaction energy for jj coupling, Hyperfine structure.

UNIT II

Atom in Magnetic and Electric Field: Zeeman effect, Magnetic moment of a bound electron, Magnetic interaction energy in weak field. Paschen-Back effect, Magnetic interaction energy in strong field, Stark effect, First order Stark effect in hydrogen. Quantum mechanical treatment of both the effects.

UNIT III

Molecular Spectroscopy: Rotational and vibrational spectra of diatomic molecule, Raman Spectra, Born-Oppenheimer approximation, Vibrational coarse structure, Franck-Condon principle, Condon parabola. Rotational fine structure of electronic-vibration transitions, Electronic spectra.

UNIT IV

Spin Resonance Spectroscopy: Electron spin resonance and nuclear magnetic resonance spectroscopy

<u>Learning Outcome:</u>

1) Understand the atomic spectra of one and two valance electron atoms
2) Describe LS-jj coupling.
3) Understand rotational, vibrational, and electronic of molecules.
4) Describe the Raman spectra of molecules.
5) Understand electron spin and nuclear magnetic resonance spectroscopy.

<u>Text book [TB]</u>:

1. C.N. Banwell, E.M. McCash, Fundamentals of molecular spectroscopy, Tata McGraw Hill, (2007).
2. R. Kumar, Atomic and Molecular Physics, Campus Books International (2013).

Reference books [RB]:

1. B.H. Bransden & C. J. Joachin Physics of Atoms and Molecules.2nd Edition Prentice Hall (2003).
2. H.E. White, Introduction to Atomic Spectra, McGraw Hill, (1934).

LTP	4 0 0	**Credit**	4	**Subject Category**	CC	**Year**	**1st**	**Semester**	II

Course Outline:

This course covers the basic concepts to describe the structural and physical properties of crystalline substances.

Course Objective:

To study the structure and some of the basic properties of the solid materials. This course includes detail description of lattice dynamics, crystal, electronic structure and Brillouin zone of materials.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Crystal Structure: Periodic arrays of atoms, Primitive lattice cell, fundamental types of lattices, index system for lattice planes, Simple crystal structure, Atomic radii, coordination number, Cesium chloride structure. Hexagonal Close Packed Structure, Diamond Structure, cubic Zinc Sulphide structure, point group.

Unit II

Reciprocal lattice: diffraction waves by crystals, Bragg's law, Scattered wave amplitude, Laue equations. Brillouin zones, reciprocal lattice to SC lattice, B C C lattice, F C C lattice, structure factor of B C C structure, F C C lattice, Atomic form factor.

Unit III

Crystal Binding and Elastic Constants: Ionic Crystal, Covalent Crystal, Metals, Hydrogen bonds, analysis of elastic springs, elastic compliance and stiffness constants, Elastic waves in cubic crystals, Experimental determination of elastic constants.

Unit- IV

Lattice Vibrations: Vibrations of crystals with monoatomic basis, First Brillouin zone, Group Velocity, Long wavelength limit, Two atoms per primitive basis, quantization of elastic waves, Phonons, Phonon momentum, Inelastic scattering of photons by phonons.

Learning Outcome

1. Gain competence in understanding the crystal structure and system of the solids.
2. Understand diffraction waves by crystals.
3. Gain theoretical understanding of crystal binding.
4. Gain exposure to elastic constants.
5. Understand vibrations of crystals.

Text book [TB]:

1. Kittel C., Introduction to Solid State Physics, John Willey (2004).
2. Dekker A.J., Solid State Physics, Prentice Hall (1965).
3. Mayers H. P., Introduction to Solid State Physics, Taylor & Francis (1997).

Reference books [RB]:

1. S.O. Pillai, Solid State Physics
2. Ashcroft N.W. and Mermin N.D., Solid State Physics, Harcourt Asia Pvt. Ltd. (1976).

Subject Code	MPHC203	Subject Title	Statistical Physics						
LTP	4 0 0	Credit	4	Subject Category	CC	Year	1st	Semester	II

Course Outline:

The course covers classical and quantum statistics, ensemble theory, Bose and Fermi systems, phase transitions and critical phenomenon.

Course Objective:

The main objective of the course on statistical physics is to impart knowledge about macroscopic and mesoscopic systems employed to study physics problems.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Basic Postulates- Phase space, relation between eigen states and phase space volume, Liouville's theorem, ensembles, microcanonical, canonical and grand canonical ensembles, Maxwell's Boltzmann’s distribution and Gibb's formulation for canonical and grand canonical ensembles, partition function, their thermodynamic properties, laws of thermodynamics.

Unit II

Application of classical distribution to the ideal gases: Degrees of freedom, translational motion, Helmholtz free energy, Gibb's free energy, entropy and thermodynamic properties, Gibb's paradox, Sakur-tetrode equation.
Imperfect gases: Difference between ideal and real gas, imperfect gases, Vander Waal's equation, virial coefficients, condensation of gases, general properties of liquids, Fermi theory, liquid Helium, phase rule.

Unit III

Quantum Statistics: Drawbacks of M B distribution, Bose-Einstein’s and Fermi-Dirac distribution, symmetric and antisymmetric particles, partition functions, non-degenerate, weakly degenerate and strongly degenerate cases, B.E. condensation, application to He, pressure-energy relationship, electronic specific heat of solids and paramagnetism.

Unit IV

Black Body Radiation: Planck's distribution, pressure and energy relationship of photons, black body radiation, Rayleigh Jean's formula, Wein's law, Wein's displacement formula, absorption and emission of radiation, Stefan's law, high temperature measurements.

Learning Outcome

1. Understand important topics of statistical physics
2. Develop an analytic ability to solve problems relevant to statistical mechanics.
3. Describe the features of Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.
4. Understand B.E. condensation and application to He.
5. Understand black body radiation and absorption and emission of radiation.

Text book [TB]:

1. Reif F., Fundamentals of Statistical and Thermal Physics, McGraw Hill (1985).
2. Landau and Lifshitz: Statistical Physics

Reference books [RB]:

1. Pathria R.K., Statistical Mechanics, Butterworth-Heinemann (1996).
2. E.S. Raj Gopal: Statistical Mechanics and Properties of Matter.

Subject Code	MPHC204	Subject Title	Quantum Mechanics						
LTP	4 0 0	**Credit**	4	**Subject Category**	CC	**Year**	1st	**Semester**	II

Course Outline:

The course convers the introduction of quantum mechanics, perturbative techniques, variational principle, approximation, and Fermi Golden Rule all of which widely used in modern physics.

Course Objective:

To apprise the students regarding the quantum mechanics and its advanced concepts and their use in various situations pertaining to static and dynamic conditions.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Introduction: A brief review of foundations of quantum mechanics, basic postulates of quantum mechanics, uncertainty relations, Schrodinger wave equation, expectation value and Ehrenfest theorem. Relationship between space and momentum representation. One dimensional potential step, tunneling, Hydrogen atom, particle in a three-dimensional box.

Unit II

Matrix Formulation of Quantum Mechanics: Vector representation of states, transformation of Hamiltonian with unitary matrix, representation of an operator, Hilbert space. Dirac bra and ket notation, projection operators, Schrodinger, Heisenberg and interaction pictures. Relationship between Poisson brackets and commutation relations. Matrix theory of Harmonic oscillator.

Unit III

Symmetry in Quantum Mechanics: Unitary operators for space and time translations. Symmetry and degeneracy. Rotation and angular momentum; Commutation relations, eigenvalue spectrum, angular momentum matrices of J_+, J_-, J_z, J_2. Concept of spin, Pauli spins matrices. Addition of angular momenta, Clebsch-Gordon coefficients and their properties, recursion relations. Matrix elements for rotated state, irreducible tensor operator, Wigner-Eckart theorem. Rotation matrices and group aspects. Space inversion and time reversal: parity operator and anti-linear operator. Dynamical symmetry of harmonic oscillator, non-relativistic Hamiltonian for an electron with spin included. C. G. coefficients of addition for j =1/2, 1/2; 1/2, 1; 1, 1.

Unit IV

Approximation Methods for Bound State: Time independent perturbation theory for non-degenerate and degenerate systems up to second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman effect with electron spin. Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules. Time-dependent perturbation theory; transition probability (Fermi Golden Rule), application to constant perturbation and harmonic perturbation. Semi-classical treatment of radiation. Einstein coefficients; radiative transitions.

Learning Outcome

1. Gain understanding of foundations of quantum mechanics.
2. Understand Schrodinger wave equation and its various applications.
3. Gain theoretical understanding matrix formulation, Hilbert space and operators.
4. Gain exposure to symmetry in quantum mechanics.

5. Understand approximation methods for bound state and perturbation.

Text book [TB]:

1. David J. Griffiths, Introduction to Quantum Mechanics. 2nd ed. Upper Saddle River,NJ: Pearson Prentice Hall (2004).
2. Zettili N.,Quantum Mechanics: Concepts and Applications, 2nd Ed, John Wiley (2009).

Reference books [RB]:

1. Bransden B. H. and Joachain C. J., Quantum Mechanics, 2nd Ed, Pearson Education (2000).
2. Schiff L. I., Quantum Mechanics, 3rd Ed, McGraw Hill Book Co. (1990).

Subject Code	MPHL205	Subject Title	Laboratory Course I						
LTP	0 0 6	**Credit**	3	**Subject Category**	CC	**Year**	1st	**Semester**	II

Course Outline:

The laboratory course covers the experiments based on multivibrator, interferometer Michelson, Fabry Perot, and B-H curve.

Course Objective:

To teach the students optics and electronics phenomenon by having the students perform hands on experiments supervised by a specialized instructor.

Course Pre/Co- requisite (if any): no pre-requisite

Detailed Syllabus:

List of experiments:

1. Multivibrator: bistable / monostable / Astable
2. Design and study of FET amplifier
3.Design and study of MOSFET amplifier
4. Ionization potential of Mercury using gas filled diodes
5. Michelson interferometer
6. Fabry Perot interferometer
7. Fresnel's law
8. Determination of absorption coefficient of iodine vapour
9. B-H curve
10. Study of pin connection and biasing of various linear IC's and timers 555

Learning Outcome

At the end of the course, the student will be able to

1. Gain competence in bistable / monostable / Astable Multivibrator.
2. Gain exposure FET and MOSFET amplifier.
3. Gain exposure in measurement of Ionization potential.
4. Gain understanding of Michelson interferometer.
5. Gain experience in Fresnel's law
6. Gain exposure B-H curve.

<table>
<tr><td>Subject Code</td><td>MPHL206</td><td>Subject Title</td><td colspan="8">Laboratory Course II</td></tr>
<tr><td>LTP</td><td>0 0 6</td><td>Credit</td><td>3</td><td>Subject Category</td><td>CC</td><td>Year</td><td>1st</td><td>Semester</td><td>II</td></tr>
</table>

Course Outline:

The laboratory course covers the experiments based on amplitude modulation, Lecher wire experiment, magnetic susceptibility, ultrasonic waves and Planks constant.

Course Objective:

To teach the students modulation and demodulation, CRO, Ultrasonic waves, and Planks constant by having the students perform hands on experiments supervised by a specialized instructor.

Course Pre/Co- requisite (if any): no pre-requisite

Detailed Syllabus

List of experiments:

1. Study of amplitude modulation and demodulation
2. Study of frequency modulation and demodulation
3. Lecher wire experiment
4. Determination of magnetic susceptibility
5. Study of CRO.
6. Velocity of Ultrasonic waves
7. Linear Air track
8. Determination of Planks constant
9. Logic gate AND/OR /NAND/NOR/NOT gates
10. Design and study of UJT relaxation oscillator

Learning Outcome

At the end of the course, the student will be able to

1.Gain competence in the basics of modulation and demodulation.
2. Gain the exposer of measurement of magnetic susceptibility.
3. Gain understanding of properties of CRO.
4.Gain velocity of Ultrasonic waves.
5. Gain exposure in Determination of Planks constant.
6. Gain understanding of logic gates and UJT.

Subject Code	MPHC301	Subject Title	Advanced Quantum Mechanics							
LTP	4 0 0	**Credit**	4	**Subject Category**	CC	**Year**	2^{nd}	**Semester**	III

Course Outline: The course covers advance level in quantum mechanics.

Course Objective: The main objective of the course on Advanced Quantum mechanics is to impart knowledge about various approximation methods in physics and to give them ideas about laboratory and center of mass frame and study the scattering phenomena in both these frames.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Scattering Theory: General considerations: kinematics, wave mechanical picture, scattering amplitude, differential and total cross section. Green's function for scattering. Partial wave analysis: asymptotic behavior of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, Optical theorem. Phase shifts and its relation to potential, effective range theory. Application to low energy scattering; resonant scattering, Breit-Wigner formula for one level and two levels, non-resonant scattering. s-wave and p-wave resonances. Exactly soluble problems; Square-well, Hard sphere, coulomb potential. Born approximation; its validity, Born series.

Unit II

Identical Particles: The Schrodinger equation for a system consisting of identical particles, symmetric and anti-symmetric wave functions, elementary theory of the ground state of two electron atoms; ortho- and Para-helium. Spin and statistics connection, permutation symmetry and Young tableaux. Scattering of identical particles.

Unit III

Relativistic Wave Equations: Generalization of the Schrodinger equation; Klein-Gordon equation, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Hydrogen-like atom (to show it does not yield physical spectrum), non-relativistic limit. Extension of Klein-Gordon equation to spin 1 particles. Dirac Equation; relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices, and their properties, non-relativistic limit of Dirac equation. Covariance of Dirac equation and bilinear covariance, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, negative energy sea, hole interpretation and the concept of positron. Spin-orbit coupling, hyperfine structure of hydrogen atom.

Unit IV

Quantization of wave fields: The quantization of wave fields, Classical and quantum field equations, quantization of non-relativistic Schrodinger equation, second quantization, N-representation, creation and annihilation operators.

Learning Outcome:

1. Understand the relativistic quantum mechanical equations, namely, Klein-Gordon equation and Dirac equation
2. Understand second quantization and related concepts.
3. Understand about scattering in two different frames and can easily calculate scattering amplitude and scattering cross section.
4. Understand the wave functions of system of identical particles.

Text book [TB]:

1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics (TMH)
2. R.P Feynman and A.R.Hibbs; Quantum Mechanics and Path Integrals.
3. L. I. Schiff, Quantum Mechanics (McGraw Hill).

Reference books [RB]:

1. Thankappan, V.K., Quantum Mechanics, New Age International (2004).
2. Sakurai, J.J., Advanced Quantum Mechanics, Pearson Education (2007).
3. S. Davydov, Quantum Mechanics (Pergamon).

Subject Code	MPHC302	Subject Title	Nuclear Physics						
LTP	4 0 0	Credit	4	Subject Category	CC	Year	2^{nd}	Semester	III

Course Outline:

The course covers an introduction to nuclear properties and models, forces and detector, radioactive decay and nuclear reactions.

Course Objective:

The objective of the course is to provide an understanding about the general nuclear properties and knowledge of nuclear models: liquid drop model, shell model and collective model. To provide knowledge and understanding of scattering process and decay phenomenon**.**

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

General Properties & Models-: Nuclear size, nuclear angular momentum (Spin), Nuclear magnetic moments, statistics, Binding energy, Liquid drop model, Shell model, Collective model.

Unit II

Nuclear Forces and Detector – Ground state of deuteron, Low energy neutron-proton scattering and proton-proton scattering, Exchange and tensor forces, G.M. Counter, Electron & Proton Synchrotron.

Unit III

Radioactive decay: Radioactive decay equation equilibrium units, Gamow's theory of alpha decay and Geiger Nuttal law, Fermi's theory of beta decay, parity violation in beta decay, electromagnetic decays.

Unit IV

Nuclear Reactions- Q-value of nuclear reaction, Bohr's Theory of compound nucleus, scattering cross section of nuclear reaction (phase shift method), Breit Wigner single level resonance formula for scattering cross section.

Learning Outcome

1. Students will get an understanding of various decay phenomena and their process.
2. Understand about the magic number and spin parity related to shell model.
3. Knowledge of radioactive decay.
4. Understand the principle and application of G.M counter and synchrotron.

Text book [TB]:

1. B.R. Martin : Nuclear & Particle Physics
2. Tayal, D.C. , Nuclear Physics, Himalaya Publishing House, Mumbai
3. Nuclear & Particle Physics-B.R. Martin & G. Shaw

Reference books [RB]:

1. S.B. Patel : Nuclear Physics
2. M.K. Pal : Theory of Nuclear Structure

Subject Code	MPHP303	**Subject Title**	Seminar						
LTP	0 0 6	**Credit**	3	**Subject Category**	SEM	**Year**	***2nd***	**Semester**	III

Course Outline: This course is meant to develop skills of presentation and discussion of scientific/ research topics in a public forum.

Course Objective: The main objective of this course to analyze, construct and evaluate scientific information and research topics. Students will make a quality scientific presentation and speak in front of a scientific audience.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Presentation topic must be related to the student’s current research and innovation, nanoscience and technology, any material characterization and analytical techniques, and current thesis or project.

Learning Outcome:

1. Student will able to analyze, construct and evaluate scientific information.
2. Student will able to design and develop quality scientific presentation.
3. Student will able to present a quality scientific presentation.
4. Student will able to practice/evaluation of others scientific work for presentation.

Text book [TB]:

1. R. Williams, Non-Designer's Presentation Book, The: Principles for effective presentation design
2. N. Duarte, Slide: ology: The Art and Science of Creating Great Presentations

Reference books [RB]:

1. G. Reynolds, Presentation Zen: Simple Ideas on Presentation Design and Delivery

<table>
<tr><td>Subject Code</td><td>MPHE304</td><td>Subject Title</td><td colspan="7">Condensed Matter Physics</td></tr>
<tr><td>LTP</td><td>4 0 0</td><td>Credit</td><td>4</td><td>Subject Category</td><td>DSE</td><td>Year</td><td>2^{nd}</td><td>Semester</td><td>III</td></tr>
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Course Outline: The course covers the field of Condensed Matter Physics.

Course Objective: The main objective of the course on Condensed Matter Physics is to aware students about the defects in crystal, dielectric and magnetic properties, superconductivity, Nano Material Science and Technology etc.
Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Defects in crystals and Magnetism: Point defect, Impurities, Vacancies, Frenkel defects, Schottky defects. Concentration of Schottky defect and Frenkel defects, intrinsic and extrinsic vacancies, Colour centres, F-Centre, V-Centre, dislocation, Line defects, edge dislocation, screw dislocation, Burger vector. Dia, Para and ferromagnetism, Langevin theory of paramagnetic, Ferromagnetism, Weiss molecular theory, Ferromagnetic domains, Antiferromagnetism, Neel's theory, Two sub lattice model, ferrites.

Unit II

Energy Bands: Origin and Magnitude of the energy gap, Bloch function, Bloch theorem, Kronig penny model, Number of possible wave function in a band, crystal momentum, the concept of effective mass and holes, hole band construction, metal, insulator and semiconductor. Nearly free electron model, One dimensional free electron case, Nearly free electron case, energy bands in one dimension, tight binding approximation, energy surfaces, Wigner Seitz cellular method, Orthogonalized plane wave (OPW) method, Pseudo potential method, Limitations of band theory (Mott Transition)

Unit III

Superconductivity: Experimental Survey, Occurrence of super conductivity, destruction of superconductivity by magnetic field and temperature, Meissner effects, Type-I and Type-II superconductors, Isotope effect, Thermodynamics of Superconducting transition, London Equations, Coherence length, BCS Theory, Cooper pairs, Josephson superconductor tunneling, AC & DC Josephson effect, High temperature superconductors, critical fields and critical currents.

Unit IV

Dielectrics and ferroelectrics: Macroscopic description of dielectric constants, static, electronic and ionic, orientational polarizability of molecules, Complex dielectric constant, Dielectric loss and relaxation time, Polarization, Macroscopic electric field, depolarization fields, local electric field and atom, ferroelectric crystals, classification of ferroelectric crystals, soft optical phonons, landau theory of phase transition, Second and first order transition, antiferroelectricity, ferroelectric domains, piezoelectricity.

Unit V

Nano Material Science and Technology: History, Origin, Quantum dots, Synthesis, Applications and advantages, Quantum wires, Quantum well & application, Fullerenes, Carbon nanobuds, carbon nanotubes as quantum wires, Areas of Nanotechnology, nanomaterials, nanoelectronics, nanobiotechnology, nanofabrication, Micro Electro Mechanical systems (MEMS)

Learning Outcome:

1. Understand the physics behind dielectric properties of the solids.
2. Understand the magnetic properties of solids
3. Understand the defects present in the crystals
4. Understanding of BCS Theory related to Superconductor.
5. Student will able to pursue the research work in the field of material science.

Text book [TB]:

1. Handbook of Nano Structured Materials and Nano Technology: Nalva

2. Nano Technology: Richard Booker and Earl Boysen

3. Introduction to Solid State Physics: Kittel

Reference books [RB]:

1. Principle of condensed matter Physics: Chaikimand Luben sky
2. Solid State Physics: Kubo and Ngamia
3. Elements of Solid-State Physics: Srivastava
4. Introduction to Solid State Physics: Madelung
5. Introduction to Solid State Physics: Paterson
6. Solid State Physics: N W Ashcroft & N David Mermin
7. Solid State Physics: Ajay Kumar Saxena
8. Solid State Physics: A.J. Dekker

Subject Code	MPHE305	Subject Title	Digital and Communication Electronics						
LTP	4 0 0	**Credit**	4	**Subject Category**	DSE	**Year**	**2**	**Semester**	III

Course Outline:

The course covers an introduction to Boolean algebra, Sequential circuits and communication electronics

Course Objective:

The objective of the course is to provide an understanding about Boolean algebra and knowledge of Combinational and Sequential logic circuits, modulation and demodulation techniques used in communication system and to aware students about RADAR system.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Boolean Algebra ,Logic Gates & Combinational Circuits: Binary codes (Weighted, BCD,2421, Gray code, Excess 3 code, Error detecting code, Error correcting codes, ASCII, EBCDIC), De-Morgan's Theorem, Sum of Products (SOP), Product of Sums (POS), Minterms &Maxterms, Karnaugh maps and minimization. Logic Gates: AND, OR, NOT, NAND, NOR, XOR, XNOR. Adders, Subtractor, Serial adder/ Subtractor, Parallel adder/ Subtractor, Carry look ahead adder, BCD adder, Magnitude Comparator, Multiplexer, Demultiplexer, Encoder, Decoder, Parity-checker, Code converters

Unit II

Sequential Circuits: Flip flops: Latches, RS, JK, T, D and Master-Slave, Characteristic table and equation. Edge triggering, Level Triggering. Registers & Counters: Asynchronous/ Ripple counters, Synchronous counters, Modulo–n Counters, Shift registers, Universal shift register, Shift counters, Ring counters.

Unit III

Modulation -Amplitude Modulation-Theory, Plate Modulated class C amplifier, Balanced Modulator, Single Side Band modulation (phase shift method), Frequency modulation – Theory, Reactance tube modulator, transistor reactance modulator, FET reactance modulator. Digital Modulation, PAM, PPM, PWM, Principle of PCM**, Demodulation-** Envelope diode detector, Foster Seeley phase discriminator, Ratio Detector. **Transmitters & Receivers-** A.M Transmitter, F.M. transmitter, TRF Receiver, Super heterodyne receiver, amplitude limiting.

Unit IV

Transmission Lines– TL Equations and their solutions, characteristic impedance, lossless open and short-circuited lines, standing wave ratio and refection coefficient, stub matching, **Antenna** – Radioactive field strength, power and radiation patterns of an elementary electric doublet and linear antenna, effects of ground reflection. Hertz antenna, Yagi antenna, loop antenna, direction finding, Resonant & Non resonant Antenna, Antenna array (Broad side & End fire arrays), Horn Antenna, Parabolic reflectors, Lens Antenna.

Unit V

Radar Systems- Principle of Radar, Basic arrangement of Radar system, Azimuth and Range measurement, operating**,** Characteristics of systems, Radar transmitters and Receivers, Duplexers, Indicator unit, maximum range of a Radar set.

Learning Outcome

1. Understand the use of K-map to simplify the Boolean algebra expression.
2. Knowledge of flip flops, counter, register and its logic circuit.
3. Understand about the application of modulation and demodulation techniques.
4. Understand about the significance of communication process which are very useful in daily life.
5. Understand the principle and application of RADAR system.

Text book [TB]:

1. A. Anand Kumar : Fundamentals Of Digital Circuit
2. Thomas L. Floyd: Digital Fundamentals
3. Gupta & Kumar – Handbook of Electronics
4. A. Ghatak & K. Tyagrajan – Fiber optics & Lasers.

Reference books [RB]:

1. 1.Malvino& Leach: Digital Principles and Applications
2. Morris Mano: Digital Design
3. F.E. Terman – Radio Engineering
4. G. Kennedy & B. Davis – Electronic Communication Systems

Subject	MPHE306	**Subject**	**Laser Physics**

Code		Title							
LTP	4 0 0	Credit	4	Subject Category	DSE	Year	2nd	Semester	III

Course Outline: The course covers the field of Laser Physics.

Course Objective: The main objective of the course on Laser physics is to aware students about the laser and its types and phenomena of laser spectroscopy, optical fibres and principles of holography.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Basic principles and modulators: Basic principles and theory of absorption and emission of radiation, Einstein's coefficients, line-broadening mechanisms, rate equations for three and four level laser systems, population inversion, spatial and temporal coherence, Electro optic effect, longitudinal and transverse phase modulation, consideration of modulator designs and circuit aspects, acoustic optic effect, Raman and Bragg regimes, acoustic optic modulators, magneto-optic effect, optical directional couplers and optical switches, phase modulators.

Unit II

Types of lasers, Optical sources and detectors: Gas lasers, He-Ne, argon ion, N_2, CO_2 lasers; dye lasers, solid state, Semiconductor lasers: Ruby, Nd:YAG and Nd:glass lasers, diode lasers, spin flip lasers, laser spikes, mode locking Q-switching, Laser devices, LED structures, liquid crystal diodes, photoelectric, photovoltaic and photoconductive methods of detection of light, photodiodes: structure, materials and working, PIN photodiodes, avalanche photodiodes, micro channel plates, photo detector, noise responsivity and efficiency, photomultipliers, image intensifier tubes, Videocon and CCD.

Unit III

Non- linear optics and Fiber optics: Theory of non-linear phenomenon, second and third harmonic generation, phase matching, parametric generation, self-focusing, Basic characteristics of optical fibers, structure and fundamentals of waveguides, step and graded index fibers, signal degradation in optical fibers, absorption scattering, radiation and core cladding losses, Design considerations of a fiber optical communication system, analogue and digital modulation, optical fiber amplifiers.

Unit IV

Laser spectroscopy: Laser fluorescence spectroscopy using CW and pulsed lasers, Single photon counting. Laser Raman spectroscopy, multiphoton processes, photo acoustic and photon electron spectroscopy, stimulated Raman spectroscopy, Coherent anti-stokes Raman spectroscopy.

Unit V

Holography: Basic principles, construction and reconstruction of holograms, applications of holography, laser interferometry, laser applications in industry and medicines

Learning Outcome:

1. Understand the principle of laser.
2. Understand about the non-linear optics.
3. Understand the various applications of laser in research field.
4. Student will able to use photodetector, LED etc. for practical purposes.
5. Student will able to describe basics of optical fiber.

Text book [TB]:

1. K.R. Nambiar: Lasers: Principles, types and Applications

Reference books [RB]:

1. Lasers: Ghatak and Thyagrajan
2. O. Svelto: Principles of Lasers
3. Optoelectronics: Hawks

Subject	MPHE 307	**Subject**	Astrophysics

Code		Title							
LTP	4 0 0	Credit	4	Subject Category	DSE	Year	2nd	Semester	III

Course Outline: The course covers the field of Astrophysics.

Course Objective: The main objective of the course on astrophysics is to impart knowledge about the physics of stars and aware students about photometry, spectroscopy, interstellar matter, classification of galaxies and cosmology.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Physics of the Stars: Apparent and Mean Position of stars. Effects of atmospheric refraction, aberration, parallax, precession, nutation and proper motion on the coordinates of stars. Reduction from apparent to mean places and vice versa. Spectra of Stars. Distribution of stars in space. Statistical parallaxes. Solar motion and its determination. Peculiar velocities. Single and Two star stream hypothesis. Velocity ellipsoid. Comparison with solar neighborhood. Bottlinger’s diagram. HR diagram, HD and MK spectral classification of stellar spectra. Explanation of stellar spectra in terms of Boltzmann and Saha equations. Spectroscopic parallax.

Unit II

Fundamental Equations, Detectors, Photometry and Spectroscopy: Equation of mass distribution. Equation of hydrostatic equilibrium. Equation of energy transport by radiative and convective processes. Equation of thermal equilibrium. Stellar models: Russell- Voigt theorem. Dimensional discussions of mass-luminosity law. Polytropic configurations. Homology transformations. Detectors for optical and infrared regions. Application of CCD's to stellar imaging, photometry and spectroscopy. Techniques of observations of astronomical sources from space in infrared, X-ray and gamma-ray regions of the electromagnetic spectrum. Astronomical photometry and spectroscopy. Simple design of an astronomical photometer. Observing technique with a Photometer Correction for atmospheric extinction. Radio Astronomy Techniques. Electro-magnetic spectrum. Radio window. Design and construction of a simple radio telescope. Receiver systems. Design and construction of a simple radio interferometer.

Unit III

Galactic System and Extragalactic Systems: Interstellar Matter, Oort limit. Interstellar extinction. Estimate of color excess. Visual absorption. Interstellar reddening law and Polarisation. Spin temperature. Interstellar magnetic fields. Stromgren's theory of H II regions. Physical processes in planetary nebulae. Galactic Structure: General galactic rotational law. Oort’s theory of galactic rotation. Determination of Oort’s constants. Spiral structure of our Galaxy from optical and radio Observations. Size and mass of our galaxy. Classification of galaxies and clusters of galaxies. Hubble sequence. Galaxy interactions.

Determination of the masses and extragalactic distances. Active Galaxies: Active galaxies and galactic nuclei. Properties of Radio galaxies and Quasar.

Unit IV

Super dense Objects: Mechanism of Mass transfer in Binary Stars. Use of polytropic models for completely degenerate stars. Mass-radius relation. Non-degenerate upper layers and abundance of Hydrogen. Stability of white dwarfs. Final cooling of white dwarfs. Accretion by white dwarfs and its consequences. Pressure ionisation and mass-radius relation for cold bodies. Formation, features and properties of Neutron stars, Pulsars and black holes.

Unit V

Gravitation & Cosmology: Conceptual foundations of GR and curved space-time: Principle of equivalence, Connection between gravity and geometry, Form of metric in Newtonian, limit Metric tensor and its properties, Einstein's field equations, observational tests of general relativity. Models of the universe: Steady State Models. Standard Model: The expanding universe, Hubble's law. Microwave background radiation Friedman-Robertson-Walker models, the early universe, Elementary ideas on structure formation. Implications of the dark matter in modern cosmology.

Learning Outcome:

1. Understand about the concept of Black holes.
2. Understand about the stellar evolution
3. Understand about the types of binary stars
4. Use fundamental equations to calculate stellar energy and mass distribution in research field.

Text book [TB]:

1. W.M.Smart: Text book of Spherical Astronomy
2. K.D.Abhyankar: Astrophysics:Stars and Galaxies (Tata McGraw Hill Publication)
3. Baidyanath Basu: Introduction to Astrophysics.
4. Harold Zirin: Astrophysics of the Sun.

Reference books [RB]:

1. D.Mihalas: Galactic Astronomy
2. S.Chandrasekhar: Principles of Stellar Dynamics
3. A.Unsold: New Cosmos.
4. R.Bowers and T.Deeming: Astrophysics (John and Barlett.Boston).

Subject Code	MPHE 308	**Subject Title**	High Energy Physics						
LTP	4 0 0	**Credit**	4	**Subject Category**	DSE	**Year**	**2nd**	**Semester**	III

Course Outline: The course covers the introduction of Classical, quantization of fields and gauge invariance.

Course Objective: The main objective of the course on high energy physics **is** to impart knowledge about the Scattering Matrix and Feynman Rules, Classical and quantum field equations, color gauge invariance and QCD.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I:

Classical and Quantum Field Equations: Coordinates of the field, Classical Lagrangian Equation, Classical Hamiltonian Equations, Quantum Equations for the Field, Fields with more than one component, Complex Field, Quantization of the Non-relativistic Schrodinger Equation, Classical Lagrangian and Hamiltonian Equations, Quantum Equations, The N-representation, Creation and Destruction Operators, Number Operators, Anti-commutation Relations, Equations of Motion, Physical Implications of Anti-commutation, Representation of Anti-commuting operators

Unit II:

Quantization of fields and Renormalization of QED: Quantization of Dirac field covariant anti-commutation relations, Quantization of electromagnetic field. Interaction Lagrangian for the fields, QED Lagrangian. Self-energy correction, vacuum polarization and vertex correction, classification of Divergences, Renormalization of mass and charge, wave function renormalization.

Unit III:

Scattering Matrix and Feynman Rules: The S-Matrix reduction of S- Matrix chronological product, Wicks theorem Furry's theorem Covariant perturbation theory interaction Lagrangian for QED, Feynman Diagrams and Feynman rules for QED in configuration and momentum space, Electron- Positron scattering, Coulomb scattering of Electrons, electron – positron annihilation , Compton scattering. Symmetries and conservation laws, Norther's Theorem, U (1) Gauge Invariance, Baryon and Lepton number conservation, the concept of gauge invariance; Global and Local gauge invariance, spontaneous Breaking of Global gauge invariance, Goldstone Bosons, the Higgs mechanism, Generalized local gauge invariance-Abelian and non-Abelian gauge invariance.

Unit IV

Color gauge invariance and QCD: The standard model of fundamental interaction, general mass terms, Cabibbo Angle, Kobayashi- Maskawa matrix and CP violation, The SU (5)

Grand unified theory, The generators of SU (5), The choice of Fermion representations spontaneous breaking of SU (5) symmetry Fermion masses and mixing angles.

Unit V

Weinberg- Salam theory of electroweak unification, the matter fields, the gauge fields, the gauging of SU (2) XU (1), The vector bosons, The fermions sector, Helicity states, parity, charge conjugation Fermion masses, Fermion assignments in the electroweak model, spontaneous symmetry break down, Fermion Mass generation. The classic predictions of SU (5) Grand Unified, Theory, quark and Lepton masses, The SO(N), The SO (10) Grand Unified Theory, Fermion Masses in SO (10), Neutrino Mass in SO (10).

Learning Outcome:

1. Understand about the quantization of fields.
2. Understand about the application of scattering Matrix and Feynman Rules.
3. Student will able to describe about the Global and Local gauge invariance.
4. Student will able to pursue the research work in the area of high energy physics.
5. Student will aware about classical predictions of SU.

Text book [TB]:

1. Donald H. Perkins: Introduction to High energy physics
2. Quantum electrodynamics , A.I. Akhiezer and Berestetski
3. Modern Elementary Particle Physics G. L. Kane (Addison- Wesley 1987).

Reference books [RB]:

1. Theory of photons and electrons, J.M. Jauch and E. Rohrlich
2. Relativistic Quantum field, J.D. Bjorken and S. D. Drell.
3. A Modern Introduction to Particle Physics, Riazuddin and Fayyazudin.
4. Gauge Theories of Strong, Weak and Electromagnetic Interactions, C. Quigg (Addison – Wesley)

Subject	MPHL 309	**Subject**	Laboratory Course

Code		Title							
LTP	0 0 6	**Credit**	3	**Subject Category**	DSE	**Year**	**2nd**	**Semester**	III

Course Outline: This Lab course covers the different experiments related to Condensed Matter Physics, Electronics, Laser Physics, Astrophysics, and High Energy Physics.

Course Objective: The main objective of this Lab. course is to impart practical knowledge in different fields such as solid state physics, electronics, Laser physics etc. to the students.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Condensed Matter Physics:

List of experiments: At least 5 experiments are to be performed

1. Determination of elastic constant of crystals by optical methods
2. Study of fluorescence spectra of a given compound
3. Study of color centers
4. Determination of lattice parameters using powder method.
5. Determination of hall coefficient using Hall effect
6. Determination of Energy gay of a semiconductor by four probe method
7. ESR
8. Dielectric constant

Electronics:

List of experiments: At least 5 experiments are to be performed

1. Study of regulated power supply (723).
2. Study of Timer (555).
3. A to D and D to A convertor
4. 1 of 16 Decoder/Encoder
5. Study of Multiplexer/Demultiplexer
6. Study of Comparator and Decoder
7. Study of different flip- flop circuits (RS, JK, D type, T-type, Master slave).
8. Study of Digital combinational and sequential circuits
9. Study of Microprocessor (8085)
10. Study of SCR, DIAC, TRIAC

11. Study of IC- Based Power supply

12. Microwave experiment.

13. Shift Registers

14. Fiber Optics communication

Laser Physics:

List of experiments: At least 5 experiments are to be performed

1. Study of the vibrational levels of Iodine.

2. Measurement of the fluorescence spectra of Uranyl Nitrate Hexahydrate.

3. Determination of the intrinsic life time for a dye molecule.

4. Determination of change in dipole moment in excited state using Solvatochromic shift method.

5. Measurement of non-radiative decay rate for a known sample.

6. Determination of the quantum yield of known samples using steady state spectroscopy.

7. Study of electro optic effect

8. Study of Acousto-optic effect

Astrophysics:

List of experiments: At least 5experiments are to be performed

1. Study of Hubble's law (from given data)

2. Study of constant density neutron star

3. Study of the static parameters of a Neutron Star model with inverse square density distribution

4. Study of star cluster from a given data

5. Study of Extinction coefficients

6. Study of variability of stars

High Energy Physics:

List of experiments: At least 5 experiments are to be performed

1. Characteristic curve of a GM Detector and Absorption coefficient of a using aluminum GM Detector. 2. Energy spectrum of gamma rays using gamma ray spectrometer.

3. Absorption coefficient of aluminum using gamma-ray spectrometer.

4. Characteristics of Scintillation Detector.

5. Study of gamma-gamma unperturbed angular correlations.

6. Study of particle tracks using a Nuclear Emulsion Detector.

7. Classification of tracks in interaction with Nuclear Emulsion and determination of excitation energy.   8. Mossbauer spectrometer

Note: Students have to perform those experiments which are related to their chosen elective Paper

Learning Outcome:

1. Student will gain practical knowledge in the field of Condensed Matter Physics.
2. Student will able to use electrical circuits for various purposes.
3. Student will able to gain practical knowledge in the field of Laser physics.
4. Student will able to gain practical knowledge in the field of Astrophysics.
5. Student will able to gain practical knowledge in the field of High energy physics.

Subject	MPHS	**Subject**	Physics of Nano Materials

Code	310	**Title**							
LTP	0 0 0	**Credit**	3	**Subject Category**	SSC	**Year**	2^{nd}	**Semester**	III

Course Outline: The course covers various phenomena of Nano science and Nano technology.

Course Objective: The main objective of the course on Physics of Nano Materials is to impart knowledge about the physics in quantum well, quantum wire and quantum dot and to aware the students about size, shape-controlled synthesis of nanomaterials and their future applications in industry.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Nanoparticles: Synthesis and Properties: R F Plasma Chemical Methods, Thermolysis, Pulsed laser Methods, Biological Methods, Synthesis using micro-organisms, Synthesis using Plant extract, Metal Nanoclusters, Magic Numbers, modeling of Nano Particles, Bulk of Nano Transitions.

Unit II

Carbon Nano Structures: Nature of Carbon Clusters, Discovery of C60, Structure of C60 and its crystal, Superconductivity in C60, Carbon Nano Tubes: Synthesis, structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary concept of its applications

Unit III

Quantum Wells, Wires and Dots: Preparation of Quantum Nano Structures, 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.

Unit IV

Bulk Nano Structure Materials: Methods of Synthesis, Solid Disorders Nano Structures, Mechanical Properties, Nano Structure Multilayers, Metal Nano Cluster, Composite Glasses, Porous Silicon.

Learning Outcome:

1. Understand the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.
2. Understand the properties of nanostructures with their size, shape and surface characteristics.
3. Student will able to pursue the research work in the area of nano technology.

Text book [TB]:

1. Edward L. Wolf: Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, 2nd ed., Wiley-VCH (2015)
2. Handbook of Nano Structured Materials and Nano Technology: Nalva

Reference books [RB]:

1. Introduction to Nano Technology: Poole and Owners
2. Quantum Dots: Jacak, Hawrylak and Wojs

Subject Code	MPHS 311	**Subject Title**	Quantum Electrodynamics						
LTP	0 0 0	**Credit**	3	**Subject Category**	SSC	**Year**	2^{nd}	**Semester**	III

Course Outline: The course covers introduction of relativistic quantum fields.

Course Objective: The main objective of the course on Quantum Electrodynamics is to impart knowledge about the relativistic quantum mechanical equations, namely, Dirac equation and to aware students about second quantization and related concepts.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Dirac equations, Properties of Dirac Matrices, Projection Operators, Traces< Feynman’s theory of Position.

Unit II

Second quantization of Klein Gordon field, Creation and annihilation operators, commutation relations, Quantisation of electromagnetic field, Creation and annihilation operators, commutation relation, Fock space representation, interaction fields. Dirac (interaction) picture, S-matrix and ita expansion. Ordering theorems, Feynman graph and Feynman rules. Application to some problems, like Rutherford Scattering and Compton scattering, calculations of cross sections using Feynman graphs.

Learning Outcome:

1. Understand about the application of scattering Matrix and Feynman Rules.
2. Student will able to pursue the research work in the area of quantum electrodynamics.
3. Student will able to draw and explain Feynman graphs for different interactions.

Text book [TB]:

4. Mathews, P.M. and Venkatesan K.A., Textbook of Quantum Mechanics, Tata McGraw Hill (2004).
5. Schweber, Bethe and Hoffman: Mesons and Fields

Reference books [RB]:

1. Bjorken and Drell: Relativistic Quantum Fields
2. Muirhead: The Physics of Elementary Particles

Subject	MPHC401	**Subject**	Computational Physics

Code		Title							
LTP	4 0 0	Credit	4	Subject Category	GEC	Year	2nd	Semester	IV

Course Outline: The course covers the introduction of computational techniques used in physics problems.

Course Objective: The main objective of the course on computational physics is to impart knowledge about how to solve physics problems through different numerical techniques and use computer programming for analysis of data.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Roots of functions, interpolation, extrapolation, integration by trapezoidal and Simpson's rule, Runge-Kutta Method, Least square fitting method.

Unit II

Eigenvalues and eigenvectors of matrices, power and Jacobi method, solution of simultaneous linear equations Gaussian elimination, Pivoting, Iterative method, matrix inversion.

Unit III

Flowchart and algorithms-Problem analysis flowchart of some basic problems. The concept and properties of algorithmic languages, elementary algorithm development algorithm involving decision and loops.

Unit IV

C-Programming : selection of C programming loops and control, constructs, arithmetic and logic operators, Strings, arrays, pointers, floats and other types, input, output, control constructs, recursion structures, sub Programmes and modules.

Learning Outcome:

1. Student will able to use different numerical methods to solve problems using computer programs.
2. Understand about C Programming.
3. Student will able to apply flowchart and algorithm in physics problems.
4. Understand the appropriate numerical methods to solve interpolation based problems.
5. Students will able to use different numerical methods and programming in research work in future.

Text book [TB]:

1. MK Jain, S.R.K. Iyengar, RK Jain: Numerical Methods
2. Reema Thereja: Programming in C

Reference books [RB]:

Subject Code	MPHC402	**Subject Title**	Particle Physics

1. V Rajaraman: Computer Programming in c.
2. Let us C: Yashwant Kanetkar

LTP	4 0 0	Credit	4	Subject Category	CC	Year	2	Semester	IV

Course Outline: The course covers an introduction to Elementary particles, fundamental interaction and Quark model.

Course Objective: The objective of the course is to provide an understanding about the elementary particles and knowledge of conservation laws, interaction and its properties and Quark structure of the particles.
Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Classification and Properties of Elementary Particles: Elementary Particles, their classification on the basis of their mass and spins (Leptons, Mesons, Baryons) and field quanta. Their general properties (mass, spins, life time and their production and decay modes), Antiparticles.

Unit II

Conservation Laws and Gauge Invariances: Conservation of Energy, Linear and Angular momentum, Spin, Charge, Lepton No., Baryon No. Isospin, Hypercharge, Parity, Strangeness, Charge conjugation, Time Reversal, CP, CPT theorem, Global and Local gauge invariances.

Unit III

Fundamental Interaction: Qualitative ideas (Relative strengths, Ranges, Characteristic times and Mediators) of Gravitational, Electromagnetic, Strong and Weak Nuclear interactions. General idea of Electro-week and Grand unifications.

Unit IV

Quark Model: Eight fold way, Quarks as building blocks of hadrons, six quarks (u,d,s,c,t and b), Antiquarks, General properties of quarks (Charge, Mass, Color - A new degree of freedom, quark confinement, Asymptotic freedom) Evidences for Quarks (Lepton scattering, Hadron Spectroscopy, Jet production), Quark compositions of Mesons and Baryons. General idea of Standard Model. Idea of Higgs Boson.

Learning Outcome:

1. Understand about the properties of particle and antiparticle
2. Students will get an understanding about the concept of Strangeness, Parity, Time Reversal, Hypercharge and so on.
3. Knowledge of range, strength of fundamental interaction.
4. Understand the quark model and conservation laws.

Text book [TB]:

1. Nuclear & Particle Physics-B.R. Martin & G. Shaw
2. Introduction to Elementary Particle Physics-D. Griffiths (John Wiley & sons)

Reference books [RB]:

1. Introduction to Nuclear & Particle Physics-VK Mittal, R.C. Verma& S.C.Gupta (Prentice Hall of India, Pvt.Ltd., New Delhi, 2009) (All units approx.)
2. Elementary Particle Physics-Gasiorowicz (John Wiley & sons,).

Subject Code	MPHL 403	Subject Title	Laboratory Course						
LTP	0 0 6	Credit	3	Subject Category	GEC	Year	2nd	Semester	IV

Course Outline: The course covers the introduction of C programming and numerical techniques.

Course Objective: The main objective of the course is to impart knowledge about the use of algorithm, flowchart and C programming in solving different problems of physics.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

List of experiments:

1. Study of computational softwares.

2. Study of numerical techniques.

3. Computer programming.

Learning Outcome:

1. Student will able to use computer programming for solving problems in different field of physics.
2. Student will able to use different numerical methods to solve problems using computer programs.
3. Student will able to use computer programming for simulation and data analysis.
4. Student will able to use flowchart and algorithm to solve various problems.

Subject Code	MPHD404	**Subject Title**	Dissertation							
LTP	0 0 18	**Credit**	9	**Subject Category**	**PJRT**	**Year**	**2nd**	**Semester**	**IV**	

<u>Course Outline:</u> The course covers the preliminary research oriented topics both in theory and experiment.

<u>Course Objective:</u> The main objective of the course is to carry out extensive research. Student will able to identify gap, development of methodology for problem solving, interpretation of findings, presentation of results and discussion of findings in context of national and international research.

<u>Course Pre/Co- requisite (if any):</u> no essential pre-requisite

<u>Detailed Syllabus</u>

This course will be based on preliminary research oriented topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the students. At the completion of the project by the semester end, the student will submit Project Report in the form of dissertation which will be examined by the examiners. The examinations shall consist of presentation and comprehensive viva-voce.

<u>Learning Outcome:</u>

1. Student will able to understand and obtain practical experience of the research process.
2. Student will able to apply principles of research design to solve the problems in the field of research.
3. Student will able to create, analyze and critically evaluate various research solutions.
4. Student will able to establish links between theory and methods within their field of study.

<table>
<tr><td>Subject Code</td><td>MPHS 405</td><td>Subject Title</td><td colspan="7">Environmental Physics</td></tr>
<tr><td>LTP</td><td>0 0 0</td><td>Credit</td><td>3</td><td>Subject Category</td><td>SSC</td><td>Year</td><td>2nd</td><td>Semester</td><td>IV</td></tr>
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Course Outline: The course covers essentials of environmental physics.

Course Objective: The main objective of the course on environmental physics. is to impart knowledge about the environmental changes like pollution and degradation etc. It also deals with remote sensing and interaction of light with matter.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere. Composition of air. Green House Effect, Transport of Matter, Energy and momentum in Nature. Stratification and stability of atmosphere. Laws of motion, hydrostatic equilibrium.

Unit II

Solar and Terrestrial: Physics of Radiation, Interaction of light with matter, Rayleigh and Mie scattering, laws of radiation (Kirchhoff's law, Plank's law, Wien's displacement law etc.), solar and terrestrial spectra, and UV radiation. Ozone depletion problem, I R absorption.

Unit III

Environmental Pollution and Degradation: Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors Governing air, water and noise Pollution, Air and water quality standards. Waste Disposal. Gaseous and particulate matters, wet and dry deposition.

Unit IV

Environmental Changes and Remote Sensing: Energy sources and combustion processes. Renewable Sources of energy: Solar energy, wind energy, bioenergy, hydropower, fuel cells, Nuclear energy.

Unit V

Global and regional Climate: Elements of whether and climate. Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, viscous forces. Inertia forces, Reynolds number, enhanced Greenhouse effect, Global Climate Models.

Learning Outcome:

1. Student will aware about Greenhouse effect, composition of air.

2. Student will aware about air and water quality standards.
3. Student will aware and apply the technology to remove pollution for environmental safety.
4. Student will aware about the factors which causes ozone layer depletion etc.

Text book [TB]:

1. Clare Smith : Environmental Physics
2. J. Haltiner and R.T. Williams : Numerical Weather Prediction (John Wiley)
3.

Reference books [RB]:

1.Egbert Boeker & Rienk Van Groundelle : Environmental Physics (John wiley)
2. J.T. Hougtion : The Physics of Atmosphere (Cambridge Univ.Press.)

Subject Code	MPHS406	Subject Title	Bio Physics						
LTP	0 0 0	**Credit**	3	**Subject Category**	**SSC**	**Year**	**2nd**	**Semester**	IV

Course Outline: The course covers the introduction of methods of Bio physical analysis

Course Objective: The main objective of the course is to impart knowledge about the organization of molecule like protein and separation and characterization of bio molecules using centrifugal, electrophoretic and chromatographic techniques.

Course Pre/Co- requisite (if any): no essential pre-requisite

Detailed Syllabus

Unit I

Introduction to Bio Physics: Molecular Organization, Different levels, Organization of Proteins- Primary, Secondary, tertiary and quaternary structures, Osmosis, Diffusion and Donnan Equilibrium.

Unit II

Conformational Analysis: Nucleic acids and their organization in living cells; interactions of Nucleic acids.

Unit III

Methods in Biophysical Analysis: CD, ORD & Fluorescence Spectroscopy, Raman Spectroscopy, Separation and Characterization of bio molecules using centrifugal, electrophoretic and chromatographic techniques. Absorption and Emission Spectroscopy- Principles and applications of visible, UV, IR, NMR, ESR and MS Spectroscopy. Characterization of macromolecules using X-ray diffraction analysis. Use of analytical microscopy in elucidating the structure function relationship in- Prokaryotes: Electron Microscopy, Phase Contrast and Fluorescence microscopy and scanning tunneling microscopy. Radio Isotope Techniques: Detection and measurement of radioactivity, Geiger Muller Counters, Scintillation counting, Autoradiography and RIA; Applications of isotopes in biological studies

Learning Outcome:

1. Student will able to describe about organization of proteins.
2. Student will able to understand about absorption and emission Spectroscopy of bio molecules.
3. Student will able to understand about separation and Characterization of bio molecules using centrifugal, electrophoretic and chromatographic techniques.
4. Student will able to understand the applications of isotopes in biological studies.

<u>Text book [TB]</u>:

1. Vasantha Pattabhi: Biophysics
2. B.S. Yadav: Textbook of Biophysics

<u>Reference books [RB]:</u>

1. David Freifelder: Physical Biochemistry
2. Willard Merrit, Dean and Settle: Instrumental methods of analysis