Revision: 03

SYLLABUS

For

MASTER OF SCIENCE (M.Sc.)

in

PHYSICS

[As per CBCS pattern recommended by UGC]

SCHOOL OF APPLIED SCIENCES (SOAS)

UNIVERSITY OF SCIENCE & TECHNOLOGY, MEGHALAYA

Techno City, 9th Mile, Baridua,Ri-Bhoi,Meghalaya-793101

DEPARTMENT OF PHYSICS
(SCHOOL OF APPLIED SCIENCES)
UNIVERSITY OF SCIENCE & TECHNOLOGY, MEGHALAYA
ACADEMIC YEAR: 2018-19

About the department:

The department of Physics was established in 2016 with the aim of educating students in the diverse fields of Physics and there by inculcating the scientific temperament for the overall development of the society through science, and technology.

About the programme:

Physics deals with the laws of nature at its most fundamental level. The application of natural laws governed by force and motion, matter and energy, space and time etc. leads to new discoveries in science. These discoveries in science generate the technological advances that continue to drive the economic engines of the world. It not only contributes to the development of scientific as well as technological infrastructure but also provides trained personnel needed to take advantage of such scientific advances and discoveries. In order to produce such skilled human resources we are providing the degree of Master of Science in Physics at University of Science & Technology, Meghalaya (USTM). The course contents are delivered to the students through an excellence teaching-learning, competitive and research environment. For the Master degree course, a number of specializations are offered such as Condensed Matter Physics, High Energy Physics, Laser and Non-linear Optics, Electronics etc. The department frequently takes guidance from different educational and research centers like CSIR-NEIST, NIT Silchar, Gauhati University, IIT-G, Tezpur University etc. to excel the programme into national and international standard.

Programme Objectives:

The curriculum for M.Sc. in Physics (MSP) is designed to equip the students with advanced knowledge in diverse areas of physics. To achieve this specific objective, core subjects like mathematical physics, quantum mechanics, classical mechanics, electronics, plasma physics, computational physics, atomic and molecular physics, condensed matter physics, statistical physics, general theory of relativity and astrophysics have been included in the syllabus. The department also offers elective papers in condensed matter physics, electronics and communication technology, high energy physics and laser & nonlinear optics etc. The syllabus for MSP programme is developed on the basis of UGC model syllabus (CBCS) and at par with IIT and central university curricula. After completing a four-semester master degree course in physics, a student will be adequately gather knowledge for a career in physics or in a related field in academia, industry and research laboratories.

Programme Outcomes (POs): After due completion of the programme students will be able to

- **PO 1.** Apply the knowledge of principles and concepts of physics to solve practical problems.
- **PO 2.** Employ numerical methods and interpret mathematical models of physical problems.
- **PO 3.** Develop skills to design, plane and execute experiments and interpret the results.
- **PO 4.** Develop communication skills to impart the knowledge to the both specialized and non-specialized public, with an emphasis towards societal development.

Programme Specific Outcomes (PSOs): At the end of the programme the students will be specifically able to

- **PSO 1.** Understand the concepts of physics, particularly in Classical Mechanics, Quantum Mechanics, Electronics, Electromagnetism, Atomic, Molecular and Laser physics, Nuclear Physics etc. and impart the knowledge how the fundamental laws of nature are realized.

PSO 2. Gain the knowledge of certain advanced subjects such as Condensed Matter Physics, High Energy Physics, Astro and Particle Physics, Laser and Nonlinear Optics etc.

PSO 3. Learn to carry out hands on experiments related to the subjects cited above and develop the skills to operate advance machineries.

PSO 4. Develop the knowledge to identify cutting edge research problems and also develop methodologies to solve them.

Programme Structure: The M.Sc. in Physics programme is a two year course, divided into four semesters. The programme is minimum of 88 credits and for the award of the degree students require to complete the credits as per the university norms.

Years	**Odd Semester**	**Even Semester**
First Year	Semester I	Semester II
Second Year	Semester III	Semester IV

PROGRAMME STRUCTURE

Semester-I

Course Code	Title of the Course	Credit	Nature (T/P)	Marks Allotment		
				IA	End Sem.	Total
MSP-101	Mathematical Physics-I **(CC-1)**	4	T	30	70	100
MSP-102	Classical Mechanics **(CC-2)**	4	T	30	70	100
MSP-103	Quantum Mechanics – I **(CC-3)**	4	T	30	70	100
MSP-104	Electronics **(CC-4)**	4	T	30	70	100
MSP-105	Physics Laboratory-I **(CC-5)**	4	P	30	70	100
	Total	**20**		**150**	**350**	**500**

Semester-II

MSP-201	Electromagnetics & Plasma Physics **(CC-6)**	4	T	30	70	100
MSP-202	Computational Physics **(SEC-1)**	2	T	15	35	50
MSP-203	Condensed Matter Physics **(CC-7)**	4	T	30	70	100
MSP-204	Atomic, Molecular and laser Physics **(CC-8)**	4	T	30	70	100
MSP-205	Physics Laboratory-II **(CC-9)**	4	P	30	70	100
MSP-206	Computational Physics Practical **(SEC-1-P)**	2	P	15	35	50
	Total	**20**		**150**	**350**	**500**

Semester-III

MSP-301	Mathematical Physics – II **(CC-10)**	4	T	30	70	100
MSP-302	Quantum Mechanics – II **(CC-11)**	4	T	30	70	100
MSP-303	Nuclear Physics **(CC-12)**	4	T	30	70	100
MSP-304	Discipline Specific Elective **(DSE-1)**					
A	Condensed Matter Physics-I	4	T	30	70	100
B	Electronics and Communication Technology-I					
C	High Energy Physics					
D	Laser and Nonlinear Optics-I					
MSP-305	Physics Laboratory-III **(CC-13)**	4	P	30	70	100
MSP-306	Elements of modern Physics **(GE-1)**	4	T	30	70	100
	Total	**24**		**180**	**420**	**600**

Semester-IV

MSP-401	Statistical Physics **(CC-14)**	4	T	30	70	100
MSP-402	General Theory of Relativity & Astrophysics **(CC-15)**	4	T	30	70	100
MSP-403	Discipline Specific Elective **(DSE-2)**					
A	Condensed Matter Physics-II	4	T	30	70	100
B	Electronics and Communication Technology-II					
C	Advanced High Energy Physics					
D	Laser and Nonlinear Optics-II					
MSP-404	Project **(CC-16) (Dissertation)**	8	P	60	140	200
MSP-405	Concepts of Physics **(GE-2)**	4	T	30	70	100
	Total	**24**		**180**	**420**	**600**

Non-Credit Compulsory course

HVP-740	Human Values and Professional Ethics	--	T	15	35	50

IA= Internal Assessment; **T**= Theory; **P**= Practical (*Fieldwork/Dissertation/Project etc.*)
CC= Core Course; **DSE**= Discipline Specific Elective; **GE**=Generic Elective (Multidisciplinary Course)
SEC=Skill Enhancement Course

Paper Code: MSP-101

MATHEMATICS PHYSICS-I

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Understand and apply the mathematical skills to solve quantitative problems in the study of physics. CO 2. Learn about special type of matrices that are relevant in physics. CO 3. Will enable students to apply integral transform to solve mathematical problems of interest in physics. CO 4. Learn the fundamentals and applications of Fourier series, Fourier and Laplace transforms, their inverse transforms etc as an aid for analyzing experimental data. CO 5. Formulate and express a physical law in terms of tensors, and simplify it by use of coordinate transforms.

Unit: 1

Linear Vector Spaces & Matrices: Scalar Products, real & Complex Vector Space, Metric Spaces, linear operator, algebra of linear operators, Norms, Infinite dimensional Vector Space, Hilbert Space, applications in Physics.

Matrices: Cayley-Hamiltonian Theorem, matrix representation of operators, unitary & hermatian matrices, diagonalization of matrices, Eigen values & Eigen vectors. [14L]

Unit: 2

Transformation Laws: Covariant & contra-variant vectors and tensors; associate tensors, algebra of tensors, symmetric & anti-symmetric tensors, metric tensor, Christoffel's symbol & their transformation laws, covariant derivatives of tensors. [10L]

Unit: 3

Complex Variables: Analytic function, Cauchy-Riemann conditions and their applications. Complex integrals, Cauchy's integral and residue theorem, Cauchy's integral formula, Taylor and Laurent expansion of Complex function, Principal value of an integral. [12L]

Unit: 4

Differential & integration: Sturm-Liouville theory, Dirac Delta function, partial differential equation, One dimensional wave equation, Laplace's equation & its solution, Green's function and their application, integral equation & their classification. [10L]

Unit: 5

Integral Transform: Laplace, inverse Laplace transform & convolution, Fourier Transform, Shift theorem & convolution, solution of differential equations with the help of Laplace & Fourier transform. [8L]

Books recommended:

1. Mathematical Methods for Physicists : George B. Arfken and Hans J. Weber
2. Mathematical Physics : B. D. Gupta
3. Mathematical Physics : H. K. Dass
4. Mathematical Physics : Satya Prakash
5. Mathematical Methods for Physicists : Tai L. Chow

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Paper Code: MSP-102

CLASSICAL MECHANICS

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Know the concept of classical mechanics. CO 2. Understand the foundations of chaotic motion. CO 3. Have deep knowledge on Lagrangian & Hamiltonian dynamics. CO 4. Know the theory of small oscillation. CO 5. Have brief knowledge on fluid motion.

Unit: 1

System of particles, central force motion, two body collision, scattering in laboratory and centre of mass frame, special theory of relativity, Lorentz transformation, relativistic kinetic, mass-energy equivalence. [10L]

Unit: 2

Lagrange's equation of motion and their application to physical problems, constraints, principle of virtual work and D' Alembert's principle, Lagrange's multiplier method and its application, Hamilton's equation of motion, principle of least action, derivation of Hamilton's equation from Variational Principle and its application. [12L]

Unit: 3

Mechanics of rigid bodies, kinematics of a rigid body, Euler angles, inertia tensor, eigenvalues of inertia tensor, orthogonal transformations, finite & infinitesimal rotation, moving frame of reference, Euler equation, spinning top, gyroscope. [12L]

Unit: 4

Canonical transformation and Hamilton-Jacoby theory, Simplectic approach to canonical transformation, Poisson bracket & their properties, application of Poisson bracket to mechanics, Liouville's theorem, solution of Kepler's problem by Hamilton-Jacobi method, action-angle variable and harmonic circulator problem. [12L]

Unit: 5

The theory of small oscillation, normal Co-ordinates, normal modes application to coupled oscillation, two coupled pendulum, double pendulum diatomic & tri-atomic molecules. [8L]

Unit: 6

Introduction to non-linear system, concept of catastrophe, chaos, fractals, physical examples. Phase-space dynamics, fixed point stability analysis. [5L]

Books Recommended:

a. Classical Mechanics : H. Goldstein
b. Classical Mechanics : Rana NC&Joag P.S.
c. Classical Mechanics : A. K. Raychandhuri
d. Chaos &Non linear Dynamics : R. C. Hibron
e. Introduction Classical Mechanics : R. G. Takawale& P. S. Puranik.

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Paper Code: MSP-103

QUANTUM MECHANICS-I

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Gain the aspects of historical developments of quantum mechanics and interpretation of wave particle duality CO 2. Gain the idea of development of central concept and principles of quantum mechanics such as Schrödinger equation, wave functions, and its statistical interpretation CO 3. Have the solution of Schrödinger equation for simple systems in one and three dimensions CO 4. The ideas of probability, evolution of time, expectation values, and uncertainty of quantum systems. CO 5. Gain the knowledge of angular momentum, spin and their rules for quantization.

Unit: 1

Review of wave particle duality, uncertainty principle, time dependent and time independent Schrödinger equations, application of Schrödinger equation in one-, two- & three-dimensional potential well, step potential barrier, harmonic oscillator, hydrogen atom. [12L]

Unit: 2

Basic postulates of quantum mechanics, Hilbert space and wave function, observables and operators, Eigen values and Eigen functions of an operator, commutation of operators, matrix formulation, expectation values, orthogonality, completeness, Dirac bra and ket notation, position and momentum representation of states, dynamical variables, Dirac function, Harmonic oscillator and its solution by Matrix method, Heisenberg equation of motion. [16L]

Unit: 3

Indistinguishable and identical particles in Quantum Mechanics, symmetric and anti-symmetries wave function, combination of wave function for a system of particles, spin statistics connection, exchange interaction and exchange energy. [10L]

Unit: 4

Angular momentum in Quantum Mechanics, Commutation relations of angular momentum Eigen function of orbital angular momentum, Matrix representation of angular momentum, operation Papules spin matrices and their properties, addition of angular momentum and Clebsch–Gordan coefficients. [14L]

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Books Recommended:

1. Principles of Non relativistic and relativistic quantum mechanics, Prof. K. D. Krori, PHI learning Private Ltd. (2012)
2. Quantum Mechanics G. Aruldhas, PHI Private Ltd.

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Paper Code: MSP-104

ELECTRONICS
[CR – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Understand the basic knowledge of various semiconductor devices such as BJT, FET and MOSFET. CO 2. Acquire knowledge on Operational Amplifier and its applications. CO 3. Know the building blocks of digital systems and the logic families. CO 4. Analyze the transmission of multiple signals through different modulation techniques. CO 5. Develop knowledge on signal transmission through different antenna types.

Unit: 1

Review of current flow mechanism in junction diode, static & dynamic resistance, semiconductor devices; diodes, junctions, transistors, field effect devices, homo and hetero junction devices, device structure, device characteristics, frequency dependence and application, Zener diode as voltage regulator and current application of diodes, load line optoelectronic devices; solar cells, photo detectors, LEDs, noise in electronic circuits, Noise sources. [16L]

Unit: 2

Operational Amplifier: Typical operational amplifier, application of inverting & non inverting amplifier, voltage follower, differential amplifier, differential mode & common mode operation.
Filter theory, low pass, high pass, active filter, filter transformation, Quality factor, band-width. [10L]

Unit: 3

Digital Electronic: Introduction to various digital signal standards, interfacing of signals between various logic level signals, Gates, Flip flops, counters, registers, comparators, A/D and D/A converters, microprocessor flow chart, Micro controller, assembly language. [10L]

Unit: 4

Modulation: Modulation Techniques: Amplitude modulation & Frequency modulation, Heterodyne & Super heterodyne demodulation, pulse modulation: PAM. [6L]

Unit: 5

Communication System: Fundamentals of signal transmission antennas: dipole antenna, antenna type & antenna parameter, antenna array, radio-wave, propagation, tropospheric & ionospheric propagation, surface wave. [10L]

Books Recommended:

1. OPAMS & linear integrated Circuits : Ramakant A Gaykwad
2. Modern Digital Analog Communication System : B. P. Lathi
3. The art of electronics : Paul Horourtz & Winfeld Hill
4. Electronic devices & Circuit theory : R. L. Boylestad
5. Electronic Communication System : G. kennedy& B. Darid
6. Analog the digital Conversion : Walt Kester

Paper Code: MSP-105

PHYSICS LABORATORY-I

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to have the knowledge of CO 1. Semiconductor and their properties. CO 2. The magnetrons and its applications. CO 3. Physics of propagation of ultrasonic through liquid, ideas of ultrasonography used in medical science. CO 4. Working of LASERs and determination of LASER wavelength, applications of LASERs in different domains of engineering and technology. CO 5. Knowledge of rectifiers and amplifiers and their fabrication for operations etc.

1. Determination of the Hall-coefficient and carrier concentration in a semiconductor.
2. Determination of the 'e/m' ratio of electron by magnetron valve method.
3. To calculate the energy band-gap in a semiconductor by using four-probe method.
4. To calculate the energy band-gap in a semiconductor by using p-n junction diode.
5. To determine the wavelength of He-Ne laser source by diffraction method.
6. To evaluate the velocity of ultrasonic wave in a liquid (water) by using ultrasonic interferometer.
7. Determination of the velocity of ultrasonic wave in a liquid (kerosene oil) by using diffraction apparatus.
8. To study the performance of an inverting amplifier using an operational amplifier.
9. To study the performance of a non-inverting amplifier using an operational amplifier.
10. To study the performance of a half-wave rectifier using semiconductor diode.
11. To study the performance of a clipper and clamper circuit.

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Paper Code: MSP-201

ELECTROMAGNETICS & PLASMA PHYSICS

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Gain a clear understanding of Maxwell's equations and electromagnetic boundary conditions. CO 2. Know that laws of reflection, refraction are outcomes of electromagnetic boundary conditions. CO 3. Grasp the idea of electromagnetic wave propagation through wave guides and transmission lines. CO 4. Extend their understanding of special theory of relativity by including the relativistic electrodynamics. CO 5. Understand the rather complex physical phenomena observed in plasma.

Unit: 1

Electrostatic Boundary Value problems: Solution of problems involving Laplace's & Poisson's equations in spherical, cylindrical & rectangular Co-ordinates, Green's function. [6L]

Unit: 2

Review of Maxwell's equation, Potential formulation, gauge transformation, Coulomb & Lorentz gauge, gauge invariance, reflection & transmission of e.m. wave, Fresnel's equations, propagation & reflection of e. m. wave at a conducting surface, rectangular wave guides. [8L]

Unit: 3

Electromagnetic radiation: Retarded potentials, electric and magnetic dipole radiation, Lienard-Wiechert potential, electromagnetic fields of a moving point charge, power radiated by a moving point charge, bremsstrahlung, Cherenkov radiation. [6L]

Unit: 4

Scattering of e. m. wave: Thomson & Raleigh Scattering, normal & anomalous dispersion. [4L]

Unit: 5

Non relativistic motion of a charged particle in a uniform field and in a slowly varying field, gradient drift, magnetic mirrors. [4L]

Unit: 6

Relativistic Electrodynamics: Four vectors, field tensor, transformation of e. m. fields under Lorentz transformation, invariance of Maxwell's equation. [6L]

Unit: 7

Plasma Physics: Propagation of plane e. m. wave in low Pressure ionized gases, angular frequency, Debye screening length, propagation of transverse wave in a perfectly conducting fluid embedded in a magnetic field (frozen in lines of force), MHD (Alfven) waves, Pinch effect. [8L]

Books Recommended:

1. Introduction to Electrodynamics : David J. Griffiths
2. Foundation of Electromagnetic Theory : J. R. Reitz, F. J. Milford & R. W. Christy
3. Classical Electrodynamics : J. D. Jackson
4. Introduction to Plasma Physic : F. F. Chen
5. Elementary Plasma Physics : C. L. Longmire.
6. The Feynman Lecture on Physics Vol.-II : R. Feynman, R. Leigaton & M. Sands.

Paper Code: MSP-202

COMPUTATIONAL PHYSICS

[Credit – 2]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Have deep knowledge on C programming. CO 2. Have introductory knowledge of MATLAB. CO 3. Learn various numerical methods to solve mathematical problems. CO 4. Find solutions of numerical problems through computational software.

Unit: 1

Computer Programming: Overview of C, Features of C, Structure of C Program, Compilation & Execution of C Program, Identifiers, Variables, Expression, Keywords, Data Types, Constants, Scope and Life of Variables, Operators, Precedence and Associativity of Operators, Types Conversion in Expression, Basic Input/Output And Library Functions. Control Statement: Branching, Looping, Go to, Break, Continue. Arrays ,String and String standard function. The Need of a Function, User Defined and Library Function, Prototype of a Function, Calling of a Function, Function Argument, Call by Value, Call by Reference, Pointers- The & and * Operators, Pointers Expressions, Pointers v/s Arrays, Pointer to Functions. Introduction to MATLAB. [20L]

Unit: 2

Numerical Analyses:

(i) Introduction to numerical analysis, the need for numerical analysis and its limitation.

(ii) Solution of linear systems**:** Gauss eliminator & Gauss- Jordan elimination.

(iii) Solution of nonlinear equations **:** Solution of roots of simple equation, general method of solving transcendental equation, bisection method, Newton-Raphson method advantages & disadvantages, Propagator of errors.

(iv) Solution of differential equations**:** Method(s) of solving first order linear differential equations, need for higher order method, Range Kutta method.

(v) Numerical integration**:** The concept of numerical integration, integration as quadrature trapezoidal & Simpson's rule.

(vi) Interpolation & curve fitting**:** Polynomial interpolation using hag range's method, error analysis, precision and accuracy, curve fitting & principle of least squares

(vii) Few examples for conducting computer laboratory class. [30L]

Books Recommended:

1. Numerical Methods : Scarbraugh
2. Introductory Method of Numerical Analysis : S. Sastry
3. Numerical Methods : E. Balagurusamy
4. Computer Oriented Numerical Methods : V. Rajaram
5. Numerical Reeipes Example Book (FORTRAN) : W. Vetterling& W. Prem

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CONDENSED MATTER PHYSICS

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Learn about crystalline state of solids and X-ray diffraction CO 2. Learn about various types of crystal bonding and lattice dynamics CO 3. Learn about dielectric properties of solids CO 4. Learn about energy bands in solids and free electron theory of metals CO 5. Learn about magnetic properties and various aspects of semiconductors

Unit: 1

Crystalline State of solids: Elements of crystallography, symmetry operations, Bravais lattice, Weigner Seitz Cell, indices of lattice direction & Planes, relation for inter planar spacing.

X-ray diffraction by crystal, atomic scattering factor, the geometrical structure factor & its calculation, reciprocal lattice, Brillouin Zones, Debye-Scherrer method. [10L]

Unit: 2

Crystal bonding: Ionic, covalent, molecular, hydrogen & van der Waals bond, electrostatic energy of ionic crystals, Madelung constant. [6L]

Lattice dynamics: Vibration of linear monatomic & di-atomic lattices, normal modes, dispersion relations, Phonons, inelastic scattering of photons & neutrons by phonons, normal & Umklapp process, Lattice specific heat, Electron specific heat. [10L]

Unit: 3

Dielectric Properties: Ionic & electronic polarization, complex di-electric constant, dielectric loss & dielectric relaxation, Debye equations, Ferroelectric transition, Ferroelectric domains, antiferroelectricity. [8L]

Unit: 4

Free electron theory of metals: The drude model, electrical and thermal conductivity, the Boltzmann equation & the mean free Path, Matthiessen's rule, density of states. [4L]

Energy bands in solids: Bloch theorem, Kronig Penney model, crystal momentum & effective mass of electron in a crystal, concept of hole, distinction between metals, insulator & semiconductors. [6L]

Unit: 5

Semiconductors: Intrinsic & extrinsic semiconductors, number density of carriers in extrinsic & intrinsic semiconductors, Fermi level, Hall effect in metals & semi conductors [6L]

Magnetic Properties: Quantum theory of diamagnetism & paramagnetic, Weiss theory of ferromagnetism, ferromagnetic domains, antiferromagnetism, magnetic resonance, ESR & NMR. [8L]

Unit: 6

Superconductivity: Type -I and Type –II superconductors, London equation. [2L]

Books Recommended:

1. Solid state Physics : A. J. Dekker
2. Introduction the solid state Physics : C. Kittel
3. Solid State Physics : S. O. Pillai
4. Solid State Physics : Ascroft/Mermin
5. Crystallography applied to solid state Physics : A. R. Verma & O. N. Srivastava.
6. Intermediate Quantum theory of crystalline solids : A. O. E. Animalu
7. Elements of solid state Physics : J. P. Srivstava

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Paper Code: MSP-204

ATOMIC & MOLECULAR PHYSICS, PHYSICS OF LASER

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Know about the emission and absorption spectra of the atoms. CO 2. Know about the different energy levels in atoms and various coupling schemes. CO 3. Understand about the spectra of molecules CO 4. Know the Born-Oppenheimer approximation and its application on molecular spectroscopy. CO 5. Understand laser and its properties, different types of Lasers, applications of Lasers.

Unit: 1

Atomic physics: Atomic emission and absorption spectra, fine structure of hydrogen atom, relativistic correction for energy levels of hydrogen atom, mass correction, spectra of helium and alkali atoms, hyperfine structure, Lande interval rule, L-S and J-J coupling schemes, energy levels, selection rules. [10L]

Zeeman Effect, Paschen back effect, Stark effect, calculation of Zeeman pattern and intensity distribution in complex spectra. [8L]

Breadth of spectral lines: Natural broadening, Doppler broadening and stark broadening. [4L]

Unit: 2

Molecular physics: spectra of diatomic molecule; pure rotation, pure vibration, vibration-rotation and electronic spectra, Born-Oppenheimer approximation and its application to molecular spectroscopy, formation of bands, structure of bands, molecular orbital theory, Intensity distribution, Frank Condon Principle. [10L]

Raman spectroscopy: Theory of Raman Effect, vibrational Raman spectra, selection rule, stokes and anti-stokes line, rotational Raman spectra, selection rule. [8L]

Electrons spin resonance (ESR) and nuclear magnetic resonance (NMR) spectroscopy, chemical shift, elements of Mossbauer spectroscopy. [5L]

Unit: 3

Laser: Properties of laser, spontaneous and stimulated emission, Einstein’s coefficients, light amplification, population inversion, optical pumping, laser oscillations, resonator modes, longitudinal and transverse laser modes, He-Ne laser. [8L]

Application of laser: holography and optical communication (basic principles only). [3L]

Books Recommended:

1. Introduction to atomic physics : H. E. White
2. Atomic spectra and atomic structure : G. Herzberg
3. Fundamentals of molecular spectroscopy : C. N. Banwell and E. M. McCash
4. Lasers: Theory and application : K. Thyagarajan and A. K. Ghatak
5. Atoms, molecules and quanta : A. E. Ruark, HC. Urey

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Paper Code: MSP-205

PHYSICS LABORATORY-II

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Learn the skill to measure the wavelength of a given laser by using Michelson's Interferometer and able to verify Heisenberg's uncertainty principle using a plane transmission grating and He-Ne Laser. CO 2. Will get the knowledge to find the value of Plank's constant and photoelectric wave function of the material of the cathode using photoelectric cell. CO 3. Will be able to analyze the B-H curve for a given ferromagnetic material using CRO and determine the loss of energy due to hysteresis and understand the concept of dielectric constant and hence able to estimate the value of dielectric constants of different dielectric materials. CO 4. Learn to measure the numerical aperture and propagation loss in an optical fiber using He-Ne laser source. CO 5. Learn the technique to measure the wavelength separation of sodium D-lines using a diffraction grating and able to study the I-V characteristics of a solar cell.

List of Experiments:

1. To measure the wavelength of a given laser by using Michelson's Interferometer.
2. To verify Heisenberg's uncertainty principle using a plane transmission grating and He-Ne Laser.
3. Find the value of Plank's constant and photoelectric wave function of the cathode material using photoelectric cell.
4. Analyze the B-H curve for a given ferromagnetic material using CRO and determine the loss of energy due to hysteresis.
5. Measure the numerical aperture and propagation loss in an optical fiber using He-Ne laser source.
6. Determination of dielectric constant of different dielectric metarials.
7. To determine the Rydberg constants by observing Balmer series of Hydrogen, using spectrometer.
8. To determine the splitting of sodium D-lines using transmission grating and spectrometer.
9. To Determine the I-V characteristics and thus to determine the ripple factor of solar cell.

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Paper Code: MSP-206

COMPUTATIONAL PHYSICS PRACTICAL

[Credit – 2]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Students will be able to execute the computer programming (C, C^{++}), CO 2. Use conditional statements for simple programming with loop, array etc., CO 3. Solve differential as well as numerical integrations through C or C++ programming, CO 4. Solve numerical problems of nonlinear equations through C or C++ programming.

LIST OF EXPERIMENTS

1. Running a C program, input/output statements used in a program, declaration of variabls and use of data types to find the area of rectangle/circle triangle,
2. Use of a conditional statements, Part-I using if and else to check a number is even or odd,
3. Use of a conditional statements, Part-II using if, else if and else to calculate of grade of students,
4. Use of a conditional statements, Part-III, using switch case to check an alphabet is vowel or consonant,
5. Program to check a number is prime or not using looping statement,
6. Use of user defined function with/without return type and with/without arguments,
7. The use of array in a program
8. String and string manipulative functions in a program
9. Determination of use of pointer in a program/ function
10. Difference between call by value and call by reference

Recommended Books:

1. Let us C, by E. Balaguruswami
2. Introduction to Numerical Analysis, S. S. Sastry, 5th Edition, 2012, PHI Learning Pvt. Ltd.
3. Elementary Numerical Analysis, K. E. Atkinson , 3rd Edition, Willey India
4. A first course in numerical methods, U. M. Ascher & C. Greif, 2012, PHI Learning Pvt. Ltd.

Paper Code: MSP-301

MATHEMATICAL PHYSICS - II

[Credit – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Understand the basics of group theory and its applications. CO 2. Have a detail understanding of Special functions and polynomials. CO 3. Learn the mathematical technique to solve integral equations. CO 4. Learn to apply Path Integral method to various physics problems. CO 5. Understand the basic concept of Linear Algebra.

Unit: 1

Group theory: Definition of groups, subgroups, homomorphism, isomorphism, Schurz's Lemmas and orthogonality theorem, characters of representation, reducible and irreducible representation; unitary group; special unitary group; Lorentz group, Lie Groups SU (2), SU (3), adjoint representation, regular representation, fundamental representation. [12L]

Unit: 2

Special functions and polynomials: Legendre, Hermite and Laguerre polynomials, Rodrigues's formula, generating function, recurrence relation, orthogonality, series expansion of a function in term, complete set of Legendre function, Bessel's function, generating function, recurrence formula. [10L]

Unit: 3

Integral equations: General classifications of integral equations, Voltera and Fredholm equation of first and second kind, linear, non-linear and homogeneous equations, advantages of integral equation over differential equation, transformation of differential equation to integral equation, Example: Schrödinger equation and linear harmonic equation. [14L]

Unit: 4

(a) Path integral method: Path integral method for a free particle, path integral for a general quadratic function, simple application to a free particle and harmonic oscillator, path integral for a partition function [10L]

(b) Linear Algebra: Vector space, linear transformations, determinants, inner product space [4L]

Books Recommended:

1. Harper, C., Introduction to Mathematical Physics, (Prentice Hall, 2009).
2. Arfken, G. B., and Weber, H. J., Mathematical Methods for Physicists, (Elsevier Ltd, Oxford, 2005).
3. B. D. Gupta, Mathematical Physics.
4. H. K. Dass. Mathematical Physics.
5. Satya Prakash, Mathematical Physics.
6. Tai L. Chow, Mathematical Methods for Physicists.
7. Joshi, A. W., Group Theory for Physicists, (Wiley Eastern, 1997).
8. Hoffman, K. and Kunze, R., Linear Algebra, (Prentice Hall India)

Paper Code: MSP-302

QUANTUM MECHANICS-II

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Describe model physical system using common approximation approaches for dynamical calculations. CO 2. Explain the relativistic quantum mechanical equations, namely, Klein-Gordon equation and Dirac equation. CO 3. Describe second quantization and related concepts. CO 4. Explain the formalism of relativistic quantum field theory. CO 5. Draw and explain Feynman graphs for different interactions.

Unit: 1

Approximation Method: Time independent perturbation theory, non-degenerate and generate case, first order and second order perturbation, first-order Stark effect in hydrogen atom, WKB approximation, Ritz-variation method. [10L]

Time dependent perturbation theory, transition probability, transition to continuum of states, Fermi's Golden rule, Einstein's coefficients, spontaneous and stimulated emission. [8L]

Unit: 2

Relativistic Quantum Mechanics: Relativistic wave equations – Klein Gordon and Dirac equations, concept of negative energy and vacuum, non relativistic limit of Dirac equation, prediction of electron spin and its relation with magnetic moment, Dirac matrices, elementary idea about field quantization. [16L]

Unit: 3

Scattering Theory: Differential scattering cross-section, scattering by a potential, partial wave analysis and phase shift. [8L]

Unit: 4

Path integral approach to quantum mechanics, Feynman's path integral method, Equaleness of Feynman and Schrödinger equation. [4L]

Recommended Books:

1. Schiff, L.S., Quantum Mechanics, (Tata McGraw-Hill, 2004)
2. Zettili, N., Quantum Mechanics, (John Wiley & Sons, 2001)
3. Quantum Mechanics G. Aruldhas, PHI Private Ltd.
4. Ghatak, A. K. and Lokanathan, S., Quantum Mechanics: Theory and Applications, (Springer, 2002)
5. Dirac, P. A. M., Principles of Quantum Mechanics, (Oxford University Press).

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Paper Code: MSP-303

NUCLEAR PHYSICS

[Credit -4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Have knowledge of nuclear size, shape, binding energy etc. and also the characteristics of nuclear force in detail. CO 2. Have an understanding of the nuclear decay modes, radioactive decay, and the interaction of nuclear radiation with matter; and develop an insight into the building block of matter along with the fundamental interactions of nature. CO 3. Gain knowledge about various nuclear models and potentials associated, grab knowledge about nuclear reactions, fission and fusion and their characteristics. CO 4. Have broad understanding of basic experimental nuclear-detection techniques, CO 5. Understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail.

Unit: 1

Basic nuclear properties: Nuclear size, nuclear form factor, nuclear radius and charge distribution, mass and binding energy, angular momentum, spin, parity, isospin.

Bound state problems: properties of deuteron ground state with square well potential, magnetic dipole moment and electric quadruple moment of deuteron.

Scattering Problem: Low energy n-p and p-p scattering, partial wave analysis, scattering length, scattering cross section, nature of nuclear forces. [16L]

Unit: 2

Beta-decay: Fermi's theory of beta decay, Curie's plot, parity violation in beta-decay and Wu's experiment, concept of neutrino mass and oscillations (solar and atmospheric neutrino puzzles), concept of double beta decay and Majorana neutrino, radioactive dating. [10L]

Unit: 3

Nuclear Models: Liquid drop model: Binding energy, semi empirical mass formula, nuclear stability, shell model, wood-Saxon with spin orbit interaction, extreme single particle model its successes and failure in predicting ground state spin, parity. [10L]

Unit: 4

Nuclear Reactions: Types of nuclear reactions, conserved quantities of nuclear reaction, energies of nuclear reaction, Q value, exoergic & endoergic reactions, nuclear fusion and fission reactions, Bohr wheeler theory of nuclear fission. [8L]

Unit: 5

Nuclear detectors: GM counter, proportional, scintillation, ionization counters and solid state detectors. [4L]

Unit: 6

Basics of Particle Physics: Symmetries and conservation laws, Quantum numbers, Elementary idea of meson theory of nuclear forces, classification of elementary particles, SU(2) and SU(3), CPT theorem, CP violation, Gell-Mann Nishijima relation, quark model, strange mesons and baryons, hadron classification by isospin and hypercharge. [10L]

Books Recommended:

1. K. S. Krane, Introductory Nuclear Physics, (John Wiley, New York, 1987).
2. Bernard L. Cohen, Concept of Nuclear Physics, (Tata McGraw-Hill Education Private Ltd, 2011).
3. Roy R. R. and Nigam, B. P., Nuclear Physics: Theory and Experiment, (New Age International, 1967)
4. Halzen, F. and Martin, A. D., Quarks and Leptons, (John Wiley, 1984).
5. Beiser, A. and Mahajan, S., Concept of Modern Physics, (Tata McGraw-Hill Pvt Ltd, 2009).
6. Introductory Nuclear Physics, S. S. M. Wong.
7. Nuclear Physics: Theory and Experiment, D. C. Tayal.
8. Concept of Nuclear Physics: B. Coben.
9. Atomic and Nuclear Physics (Vol. 2) – S N Ghoshal.
10. Concepts of Modern Physics - Arthur Beiser.

Paper Code: MSP-304 (A)

CONDENSED MATTER PHYSICS-I

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Learn about advanced electrical properties of solids. CO 2. Learn about advanced magnetic properties of solids. CO 3. Learn about advanced optical properties of solids. CO 4. Learn about superconductivity. CO 5. Learn about critical phenomena of solids.

Unit: 1

(a) Electrical properties of solids:

Review of Free electron theory of metals, band theory of solids, Fermi surface and Brillouin zones; insulators, concept of effective mass and law of mass action, tight binding approximation, LCAO method, Dielectric constant, polarizability, Kronig-Kramer relations. [10L]

(b) **Magnetic properties of solids:**

Basics of magnetism, magneto-conductivity, cyclotron resonance, quantization of energy levels in presence of magnetic field, quantum Hall effect, de Haas-van Alphen effect, spin Shubnikov-de Haas effect, spin para magnetron (Pauli's theory giant magneto resistance). [10L]

Unit: 2

Optical properties of solids:

Optical constants, dispersion relation of optical constants from Maxwell's equations, optical absorption and emission in semiconductors, exciton absorption, impurity and inter-band transitions, luminescence, Frank Condon principle, photoluminescence and thermoluminescence, crystal defects and their role in crystal growth. [12L]

Unit: 3

Superconductivity:

Thermodynamics of superconductivity, Rutger's formula, Cooper pairs, Isotope effect, Concept of penetration depth & coherence length, London equations, electron-phonon interaction, BCS theory, Pippard's equation, flux quantization, A.C. & D.C. Josephson effects, High temperature super conductors, SQUIDS, super conducting magnets, Application and limitations of HTSC. [14L]

Unit: 4

Critical Phenomena:

Phase transitions in different systems, first order and second order phase transitions, thermodynamics and statistical mechanics of phase transition, examples of critical phenomena: liquid-gas, paramagnetic-ferromagnetic, normal to superconductor, and superfluid transitions, phase diagrams, critical point exponents and exponent inequalities. [10L]

Books Recommended:

1. Intermediate Quantum theory of Crystalline Solids : A.O.E. Animalu
2. Solid state and semi conductor physics : J.P. Mekelvey
3. Solid state physics : A.J. Dekker
4. Interdiction in solid state physics : C. Kittel
5. Fundamentals of Solid State Physics - J Richard Christman.
6. Burns, G., Solid State Physics,
7. Introduction to Superconductivity, 2nd edition, (Dover Publications, 2004) M. Tinkham,
8. Superconductivity, (Cambridge University Press, 1999) J.B. Ketterson, and S.N. Song.

Paper Code: MSP-304 (B)

ELECTRONICS AND COMMUNICATION TECHNOLOGY-I

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Understand the basics and principles of analog signal transmissions. CO 2. Analyze the conversion of analog to digital transmission of signals through different digital modulation technique. CO 3. Know the important parameters of transmission lines at radio frequencies. CO 4. Have knowledge on microwave generation and amplification through microwave devices.

Unit: 1

Analog signal transmission: Principles of modulation, amplitude modulation, frequency spectrum for sinusoidal A.M, generation of A.M. waves, collector modulator, balanced modulator, A.M transmitter (block diagram approach), detection of A.M waves – Square law detector, frequency and phase modulation, frequency spectrum for sinusoidal F.M. [14L]

Unit: 2

Digital transmission of analog signals: Introduction to pulses, sampling analysis, types of sampling, types of analog pulse modulation, PAM, PDM, PPM, SNR in pulse systems, pulse code modulation (PCM), digital modulation techniques: amplitude shift keying (ASK), phase shift keying (PSK), frequency shift keying (FSK) and differential phase shift keying (DPSK) and their generation and detection (qualitative). [16L]

Unit: 3

Transmission lines: Introduction to typical transmission lines- co-axial, two wire, microstrip, coplanar and slot lines, description of transmission line propagation, phase and group velocities, standing waves, lossless line at radio frequencies, VSWR, slotted-line measurements at radio frequencies. [14L]

Unit: 4:

Microwave propagation and devices: Introduction to rectangular and circular wave guides, solution of wave equations in cylindrical coordinates, TE and TM modes, power transmission and loss in circular wave guides, microwave generation and amplification. [12L]

Books Recommended:

1. Communication Systems –R.P. Singh and S.D. Sapre,TMH
2. Electronic Communications – Dennis Roddy and John Coolen, PHI
3. Electronic Communication System – G. Kennedy
4. Microwave devices and circuits –Samuel Y Liao, Pearson Education.
5. Principles of Communication Systems –H. Taub and D. L. Schilling(2nd edition) TMH
6. An Introduction to Analog and Digital Communications –Simon Haykin, 2nd Ed., Wiley
7. Communication Sytems –B. P. Lathi, BSP.
8. Electronic Communication Systems – Wyane Tomasi, Pearson Education.

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Paper Code: MSP-304 (C)

HIGH ENERGY PHYSICS
[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail. CO 2. Understand conceptually the content of the Standard Model and the idea of symmetries (electroweak unification and the Higgs boson only mentioned). CO 3. Use basic Feynman diagrams to illustrate the electromagnetic, weak and strong forces, understand conceptually cross section, helicity/handedness, width and branching ratio and be able to perform calculations of simple particle interactions using the above and basic relativistic energy momentum formulae. CO 4. Understand and use the concept of universality, understand conceptually the key aspects of the electromagnetic force, illustrating the idea with basic calculations of electron-electron scattering and electron-positron annihilation. CO 5. Understand conceptually the key aspects of the strong force, including asymptotic freedom and quark confinement, illustrating the ideas with basic calculations of the meson masses and electron-positron annihilation to quarks.

UNIT: 1

Introduction to elementary particles: Natural units, Classification of elementary particles, strong, weak and electromagnetic interactions; Four fundamental interactions and their characteristics in terms of decay lifetimes, strengths, ranges; conservation laws and decay modes, symmetry principles & quantum numbers, strangeness and parity determination of pions and strange particles, invariance under charge (C), parity (P) and time (T) operators, non-conservation of parity in weak interactions. [18L]

UNIT: 2

Quark model: Quark hypothesis of Gell-Mann and Zweig, properties and types of quarks, quark model of mesons and baryons, eight fold way of classification, elementary idea of Lie groups, spin SU(2) and flavour SU(3) symmetry, concept of colour charge, colour factors. [10L]

UNIT: 3

Introduction to Quantum Field Theory: Concept of fields, Lagrangian of a field, Euler-Lagrange equation, Canonical quantization of a one dimensional classical system, the method of second quantization, quantization of scalar fields, quantization of Dirac fields, quantization of vector fields, Noether's theorem. [12L]

UNIT: 4

Many particle systems: Non-relativistic quantum systems, free fields, Klein-Gordon equation, non-relativistic many particle systems, relativistic free scalar fields, Dirac equation, antiparticles, free Dirac fields. [10L]

Books recommended:

- Halzen, F. and Martin, A. D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, (Wiley India, 2008).
- Griffiths, D., Introduction of Elementary Particles, (Wiley-VCH Verlag, 2008).
- Ryder, L. H., Quantum Field Theory, (Cambridge University Press, 1996).
- Peskin, M. E. and Schroeder, D. V., Introduction to Quantum Field Theory, (Westview Press, 1995).
- Palash Pal and Amitabha Lahiri, Quantum Field Theory
- Weinberg, S., The Quantum Theory of Field, Vol. I, II, III (Cambridge University Press, 2000).

Paper Code: Msp-304 (D)

LASER AND NONLINEAR OPTICS-I

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Concept of properties of LASERs and understanding of their designing parameters. CO 2. Idea of different types of LASERs, their working principles and applications. CO 3. Development of nonlinear optics and its advantages over linear counterpart. CO 4. Knowledge of different nonlinear optical effects or phenomena and their applications. CO 5. Spectroscopic aspects of nonlinear optics and its applications in advanced communications.

Unit-1

Overview on lasers, three- and four- level lasers, laser designing: resonators, modes of resonators (longitudinal, transverse), Q-switching, mode locking in lasers, confocal and planar resonators, loss inside cavity, threshold condition. [10L]

Unit-3

Types of laser: solid state lasers, ruby laser (pumping power, spiking), Nd:Yag laser, fiber laser, gas lasers, cooper vapour laser, Ideas of Ar^+,He-Cd,CO_2 and excimer lasers, semiconductor lasers: laser materials, laser structure, condition for laser output, modern diode laser, quantum cascade lasers, vertical-cavity surface emitting lasers. [12L]

Unit-4

Nonlinear optics: introduction, propagation of electromagnetic wave in nonlinear optical media, nonlinear optical susceptibility, non-linear processes: harmonic generation, second harmonic generation, sum and difference frequency generation, third-harmonic generation, phase-matching technique, parametric generation, self focusing or lensing. [14L]

Unit-5

Multi-photon Processes: multi-quantum photoelectric effect, two- and three-photon processes, experiments, parametric and phase conjugation optics. [8L]

Unit-6

Nonlinear spectroscopy: Rayleigh and Raman scattering, inelastic scattering processes, Stokes anti-Stokes coupling, stimulated Raman scattering, stimulated Brillouin scattering, and their applications in communication. [10L]

Books recommended:

1. Laser Fundamentals: W.T silfvast, Cambridge university Press.
2. Lasers: Theory and Application: Thyagrajan & Ghatak, Maemillian India.
3. Nonlinear Optics: R.W Boyd. Academic Press.
4. Laser and Nonlinear Optics: B. B Land, New Age International.
5. Essentials of Laser & Nonlinear Optics: G. D. Baruah, Pragati Prakashan

Paper Code: MSP-305

PHYSICS LABORATORY-III

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Learn the characteristic of a G. M. counter and develop the skill to determine its operating voltage, hence verify the inverse square law for the given radioactive sample. CO 2. Learn the determination of end point energy of beta particles by half thickness method by GM Counter. CO 3. Learn the estimation of efficiency of the G.M. detector for (a) Gamma source & (b) Beta Source. CO 4. Develop the knowledge to examine the statistical properties of radiation detection and to show that for CO 5. Develop a knowledge to determine the spot size and angle of divergence of a given laser source. CO 6. Get the concept of determination of magnetic susceptibility of ferromagnetic substance by Quinck's method. CO 7. Acquire the knowledge of determination of Boltzmann constant by using Boltzmann kit. CO 8. Get detail ideas of determination of the Lande g-factor using Electron Spin Resonance.

1. Determination of the spectroscopic splitting factor of a given sample using electron spin resonance spectrometer.
2. Determination of absorption coefficient of a given sample using UV-VIS spectroscopy.
3. Study of gamma ray absorption and determination of gamma ray energy.
4. Estimation of efficiency of the G.M. detector for (a) Gamma source & (b) Beta Source.
5. Measurement of short half-life of radioactive sample by G. M. counter.
6. Study the characteristic of a G. M. Counter and determine its operating voltage. Hence, verify the inverse square law for the given radioactive sample.
7. Determination of spot size and angle of divergence of a given laser source.
8. Magnetic susceptibility of ferromagnetic substance by Quinck's method.
9. Determination of Curie temperature of a given ferromagnetic material.
10. Determination of Boltzmann constant by using Boltzmann kit.
11. One or two experiments from Electronics.

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ELEMENTS OF MODERN PHYSICS

(Generic Elective course for allied departments)

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Attain the knowledge on Special Theory of Relativity. CO 2. Have preliminary ideas on Quantum Mechanics. CO 3. Have knowledge of LASER Spectroscopy. CO 4. Have knowledge on Solid State Physics CO 5. Gain knowledge on Nuclear Physics

Unit: 1

Relativity: Reference systems, inertial frames, Galilean invariance, Postulates of special theory of relativity, Lorentz transformation, length contraction, time dilation, addition of velocities, mass-energy equivalence. [8L]

Unit: 2

Quantum Mechanics: Inadequacy of classical theory, Basic postulates of quantum mechanics, wave functions and operators, Expectation values, angular momentum in quantum mechanics, commutation relation, matrix representation of angular momentum. [8L]

Schrodinger equation and it's applications to particle in one- and three-dimensional boxes, reflection, transmission and tunnel effect, harmonic oscillator, hydrogen atom. [5L]

Unit: 3

Laser Physics: Properties of laser, spontaneous and stimulated emission, Einstein's coefficients, light amplification, population inversion, optical pumping, Laser oscillations, resonator modes, longitudinal and transverse laser modes, He-Ne laser. [8L]

Application of laser: holography and optical communication (basic principles only). [2L]

Unit: 4

Solid State Physics: Crystal Structure, lattice and basis, fundamental translational vectors, unit cell, Wigner-Seitz cell, X-ray diffraction, Bragg's law, Neutron diffraction. longitudinal and transverse laser modes, He-Ne laser. [5L]

Bonding in solids: Concept of ionic, covalent, Van der Walls, metallic, and hydrogen bonding. Band theory of solids, semiconductors, intrinsic and extrinsic (p-type, n-type) semiconductors, Superconductivity: Meissner effect, type-I and type-II superconductors, London equation. [10L]

Unit: 5

Nuclear Physics: Classification of nuclei: isotopes, isobars, isotones, and isomers, properties of nucleus, binding energy, nuclear fission, fusion and chain reaction, atomic bomb and nuclear reactors. [6L]

Nuclear models: liquid drop model and shell model, Nuclear detectors: GM counter and Scintillation counter, Accelerator: Linear Accelerator, Cyclotron, Synchrotron. [8L]

Books Recommended:

1. Concept of Modern Physics, Arthur Beiser, McGraw Hill.
2. Modern Physics, R Murugeshan and Kiruthiga Sivaprasath, S. Chand Publication.
3. Elements of Quantum Mechanics, K. Singh and S.P. Singh, S. Chand Publication.
4. Nonlinear Optics, B. B. Laud
5. Lasers, K. Thyagarajan
6. Nuclear Physics, D C Tayal

Paper Code: MSP-401

STATISTICAL PHYSICS

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Understand the basic concept of statisticical mechanics to describe systems containing huge numbers of particles. CO 2. Know & understand the fundamental postulate of equilibrium statistical mechanics. CO 3. Understand & be able to apply Classical Thermodynamics to simple problems. CO 4. Understand & be able to apply the Micro-Canonical, Canonical, & Grand Canonical Ensembles to appropriate physical systems. CO 5. Understand the quantum statistical physics of fermions & bosons, also be able to apply Fermi & Bose Statistics to various many particle systems.

Unit: 1

Classical statistical mechanics : Statistical basis of thermodynamics; the microstate and the macrostate; probability; probability distribution function; postulates of equal a priori probability; phase space; Liouville theorem. [8L]

Concept of ensembles, microcanonical; canonical and grand canonical ensembles; system in grand canonical ensembles, partition function; principle of equipartition energy. [6L]

Energy of Harmonic oscillator; partition function for canonical ensemble; energy fluctuations in the canonical ensemble; partition function and Thermodynamic function for grand canonical ensemble; density fluctuations in the grand canonical ensemble; theory of paramagnetism; negative temperature. [10L]

Unit: 2

Quantum statistical mechanics: Basic principles; inadequacy of classical theory; density matrix and its physical significance; quantum mechanical ensembles, postulates of quantum statistical mechanics. [8L]

Maxwell Boltzman, Bose-Einstein and Fermi-Dirac statistics distinction between classical and quantum statistics properties ideal Bose gas, Bose-Einstein condensation, thermodynamics of black body radiation. [10L]

Ideal Fermi gas; equation of state; properties of ideal Fermi gas; degenerate and non-degenerate Fermi gas, electrons in metals; Neuron star. [4L]

Fluctuations; Gaussian distribution; Brownian motion; diffusion equation, approach to equilibrium: the Fokker –Planck equation, introduction to non-equilibrium processes.

Critical Phenomena and phase transition; Phase diagram; properties of liquid Helium II, two fluid hydrodynamics, Tisza's two fluid model, super fluidity. [12L]

Books Recommended:

1. Statistical Mechanics : R.K. Pathria and P.D. Beale
2. Statistical Mechanics : K. Huang
3. Statistical Physics : F. Reif
4. Statistical Physics : L. Landau and E.M. LifShitz

Paper Code: MSP-402

GENERAL THEORY OF RELATIVITY AND ASTROPHYSICS

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Development of fundamental principles of the general theory of relativity. CO 2. Meaning of basic concepts like the equivalence principles, inertial frames and how gravity is understood as a manifestation of a curved space-time. CO 3. Knowledge on motion in the gravitational field, time dilation and frequency shifts, bending of light, gravitational waves and cosmological models with expanding space. CO 4. Idea of stellar distances and celestial coordinates, Idea of different magnitudes of the stars and their calculations CO 5. Evolution of the whole universe, formation of galaxies and stars, Hertzsprung Russell diagram and stellar demise, the Big Bang cosmological model, and the evidence to support it.

General Theory of Relativity

Unit -1:

Introduction: A brief review of special theory of relativity, equality of gravitational and inertial masses, equivalence principle, principle of general covariance. [10L]

Unit- 2:

Tensor analysis: covariant and contravariant tensors, metric tensors, parallel displacement and covariant differentiation, affine connection and its relation to metric tensors, curvature tensor and its symmetries, Bianchi identities. [12L]

Unit-3:

Geodesics: Equation of motion of particles, weak fields and Newtonian approximation, time and distance in general theory, gravitational red and blue shifts, Einstein field equation, Schwarzschild solution, Mach's principle, radial motion towards centre. [10L]

Astrophysics

Unit- 4:

The celestial sphere, co-ordinate system concept of time, solar and sidereal time, magnitude scale colour index, apparent absolute and instrumental magnitude, HR diagram of stars and star clusters. [8L]

Unit- 5:

Formation of stellar structures: galaxies and star clusters, collapse, freefall collapse.

Production of Energy in stellar interior, degenerate star, while dwarf, Chandrasekhar limit, formation of neutron star and pulsars, black holes and evidence of black holes. [10L]

Unit- 6:

Evolution of the universe, cosmic microwave background radiation, synthesis of light elements, cosmological models. [6L]

Books Recommended:

1. Gravitation and Cosmology by Steven Weinberg (Oxford University, 2008)
2. Introducing Einstein relativity by Ray D'Inverno (Clarendon press 1992)
3. General Theory of relativity by P.A.M. Dirac (John Wiley, 1975)
4. The classical theory of field by L.D Landau and E.M. Lifshitz (Pergamon , 1975)
5. Astrophysics: Stars and Galaxies, K. D. Abhyankar, Universities Press
6. An Introduction to Stellar Astrophysics, Francis LeBlanc, Wiley
7. Introduction to stellar structure : S. Chandra Sekhar
8. Astrophysics for physicists : Arnab Rai Choudhury
9. Astrophysics : Baidyanath Basu

Paper Code: MSP-403 (A)

CONDENSED MATTER PHYSICS-II

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Learn about advanced semiconductor physics. CO 2. Learn about p-n junction based devices. CO 3. Learn about physics of thin films. CO 4. Learn about soft matter physics. CO 5. Learn about different experimental techniques in condensed matter physics.

Unit: 1

Semiconductor physics: Density of states and statistics of impurity semi conductors, scattering mechanism and mobility of charge carriers, transport carriers, the continuity equation, surface recombination steady state and transient photo-conductivity, theory of simplified model of abrupt p-n junction, p-n junction rectifier and transistor, mechanism of break down in p-n junction. [12L]

Unit: 2

P-N junction based devices: Tunnel diodes metal semiconductor junctions, semi conductor homo and hetero junctions, I-V characteristics of junctions, some opto-electronic devices, photo-generation at p-n junction, photo voltaic effect, Gunn effect, semi conductor diode laser. [10L]

Unit: 3

Physics of thin films: Thin and thick films and, their differences, deposition techniques of thin film-vacuum evaporation, sputtering, chemical vapour deposition, molecular beam epitaxy.

Nucleation and growth process, epitaxial growth techniques for measuring this film thickness, size effect-change of electrical resistivity of thin films of metal, F-S theory, application of thin film-active devices, solar cells, transducers. [12L]

Unit: 4

Soft condensed matter physics: Liquid crystals, conducting polymers, introductory idea of nanomaterial, synthesis of nanomaterials: top down and bottom up approaches – different techniques, Bohr exciton, strong and weak confinement, quantum well, wire and dot, widening of band gape, size dependent absorption spectra, blue shift. [12L]

Unit: 5

Ideas of Experimental techniques in condensed matter physics: XRD, XRF, TEM, SEM, AFM, Absorption spectrometer, FTIR. [8L]

Books Recommended:

1. Intermediate quantum theory of crystalline solids : A.O.E Animalu
2. Solid state and semi conductor physics : J. P. Mekelvy
3. Nanostructures and nanomaterial's : Synthesis, properties and applications : G.Cao ay Y. Wang
4. Thin Film : A.K. Goswami
5. Introduction to Solid State Physics: A J Dekker
6. Solid State Physics: Gupta & Kumar

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ELECTRONICS AND COMMUNICATION TECHNOLOGY-II

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Understand the basic concepts of electromagnetic waves and its propagation in free space. CO 2. Know the different parameters, patterns and the types of antennas used in communication system. CO 3. Understand different types of linear beam tubes for microwave generation. CO 4. Analyze and calculate the range, angle or velocity of objects using the RADAR detection technique. CO 5. Know the different optoelectronic devices and fiber optics for optical communication.

Unit: 1

Antennas: Wire and Aperture Antennas**,** the retarded potential, Hertzian dipole, power radiated, radiation resistance, antenna characteristics, antenna patterns, radiation intensity, directive gain, power gain, effective area and Friis equation, the radar equation.

Some Practical Antennas: Half-wave dipole antenna, quarter-wave monopole antenna, small loop antenna, aperture antenna, antenna arrays. [14L]

Unit: 2

Microwave tubes: Introduction, Multicavity Klystron, velocity modulation and beam bunching, reflex klystron, magnetron, working of magnetron, travelling wave tubes, other micro wave tubes. [10L]

Unit: 3

Radar systems: Basic principles, fundamentals, performance factor, antennas and scanning, display methods, pulsed radar systems, MTI, Beacons, CW, Doppler radar. [8L]

Unit: 4

Introduction to optoelectronics: LCD materials, LDR, photodiode, Phototransistor, LED, Optical Fiber, LASER etc., Different types of Optical Fiber, working principle, characteristics and parameters, and applications. [10L]

Books Recommended:

1. Microwaves by K.C.Gupta; New Age International Publishers.
2. Electromagnetic waves and Radiation system by E.C.Jordan and K.G.Bamain; Prentice-Hall India2nd Ed, 2009.
3. Microwave circuits and passive Devices by M.L.Sisodia and G.S.Raghuvanshi; New Age International Publishers.
4. Elements of Engineering Electromagnetics by N. N. Rao; PHI, 6^{th} Ed,2007.
5. Antenna Theory and Practice by Rajeswari Chatterjee
6. Antennas and Wave Propagation by G. N. Raju
7. Antenna Theory by Balanis
8. Analog and Digital Communication; S. Haykin, Wiley, Reprint 2009.

Paper Code: MSP-403 (C)

ADVANCED HIGH ENERGY PHYSICS

[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Be familiar with the limiting procedure of Quantum Field Theory and be able to perform simple calculations for these phenomena, also have a deep understanding of the concept of Quantum Chromodynamics in including calculation of scattering amplitudes of electron-proton inelastic scattering. CO 2. Understand concept of electro-weak interaction in detail, also learn about the qualitative as well as quantitative study of neutrino-nucleon scattering. CO 3. Understand conceptually the key aspects of the weak force, illustrating the ideas with basic calculations of muon decay and two family neutrino mixing, also understand qualitatively the CKM matrix and its consequences. CO 4. Know about the questions that the Standard Model does not answer or explain, current ideas on possible physics beyond the Standard Model, and current constraints from searches for new physics. CO 5. Get idea of neutrino oscillation and neutrino mass, also understand the basics concepts of Higgs Mechanism, Grand Unified theory and String theory, and know about the current experimental status of High Energy Physics.

Unit: I

Quantum Electrodynamics: Feynman rules, Mott scattering, Compton scattering using Feynmen rules for QED. [6L]

Unit: II

Structure of hadrons: Probing charge distribution with electrons, form factors, elastic electron-proton scattering, inelastic electron-proton scattering, Partons and Bjorken scaling,

Quantum chromodynamics: Dual role of gluons, gluon emission cross section, scaling violation: The Altarelli Parisi Equation, Feynman Rules for Chromodynamics. [12L]

Unit: III

Weak Interactions: V-A theory, nuclear β-decay, neutrino-quark scattering, Cabibbo angle, weak mixing angle, CP violation and the CKM matrix, Gauge theory: Local and global gauge theory, non-Abelian gauge theory, spontaneous symmetry breaking, Higg's mechanism, Goldstone theorem. [14L]

Unit: IV

Unification of interactions and beyond standard model: Electro-weak interaction, Weinberg-Salam model, grand unified theories, proton decay, neutrino oscillations and neutrino masses, elements of super-symmetry (qualitative idea only), elements of string theories (qualitative idea only), present experimental status of particle physics. [14L]

Books recommended:

1. Griffiths, D., Introduction of Elementary Particles, (Wiley-VCH Verlag, 2008)
2. Halzen, F. and Martin, A. D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, (Wiley India, 2008)
3. Ryder, L. H., Quantum Field Theory, (Cambridge University Press, 1996).
4. Lectures on Quantum Field Theory, Ashok Dass (World Scientific, 2008).
5. The Quantum Theory of Fields, Volume 1: Foundations, Steven Weinberg (Oxford University Press, 2005).
6. The Quantum Theory of Fields, Vol.2: Modern Applications, S. Weinberg (Oxford Univ. Press, 2005).
7. Introduction to Elementary Particle Physics, A. Bettini (Cambridge University Press, 2008)

Paper Code: MSP-403(D)

LASER AND NONLINEAR OPTICS-II

[CR – 4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Idea of LASER induced phenomena like pair excitation, LASER cooling etc. CO 2. Fundamental importance of LASERs in different domains like plasmas, nuclear fusions, atmospheric optics, biology, medical etc. CO 3. Knowledge of quantum mechanical treatment of nonlinear optics CO 4. Third order nonlinearity in different materials and applicability of those materials CO 5. Developments of nonlinear fiber optics that revolutionalize the communication techniques.

Unit: 1

Laser Spectroscopy: Coherent anti-Stokes Raman scattering (CARS), spin-flip Raman laser, free-electron laser (FEL), photo-acoustic Raman spectroscopy (PARS), Brillouin scattering, Saturation absorption spectroscopy. [10L]

Unit: 2

Some Laser Induced Phenomena: Modulation of an electron wave by a light wave, laser induced collision processes- pair excitation, multi-photon ionization, single atom detection with lasers, laser cooling and trapping of neutral atoms. [8L]

Unit: 3

Applications of lasers: Overview on experiments of fundamental importance, isotope separation, plasma, thermonuclear fusion, communication by laser, ranging, lasers in atmospheric optics, astronomy, biology, medicine and in industry. [10L]

Unit: 4

Quantum-mechanical theory of the nonlinear optical susceptibility, nonlinear optics in two-level approximation, probability amplitude and density matrix approximation for linear and nonlinear susceptibilities, electromagnetically induced transparency. [10L]

Unit: 5

Third-order nonlinear materials (Atomic vapours, dyes, organic materials, semiconductors, etc.), experimental techniques for nonlinear refraction and absorption, Z-scan (transmission measurement), pump-probe experiment. [8L]

Unit: 6

Nonlinear Fiber Optics: optical fibers, pulse propagation in optical fibers, wave propagation in linear dispersive and nonlinear medium, Solitons in optical fibers. [4L]

Book Recommended:

1. Nonlinear Optics: R.W Boyd. Academic Press, NY.
2. Quantum Optics, M.O. Scully, M.S. Zubairy, Cambridge University Press, UK.
3. Handbook of Nonlinear Optics: Richard L. Sutherland, Marcel Dekker, NY.
4. Laser and Nonlinear Optics: B. B Laud, New Age International.
5. Nonlinear Fiber Optics: G. P. Agrawal, Academic Press, NY.
6. Lasers Fundamentals and Applications: Thyagarajan, K., Ghatak, Ajoy, Springer.

PAPER CODE: MSP-404

M.Sc. Final Project

[CR-8]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. To develop skills in research and methods available, towards addressing specific project objectives, and to identify noble research area and carry out literature survey. CO 2. Able to analyze research literatures, and able to learn different software packages depending upon the nature of project. CO 3. Would be able to design the methods and carry out the procedure as per the project. CO 4. Able to prepare and present a Research Seminar. CO 5. Able to produce clear and concise written dissertation.

Paper Code: MSP-405
CONCEPTS OF PHYSICS
(Generic Elective course for other departments)
[Credit-4]

COURSE OUTCOMES
Upon successful completion of the course students will be able to CO 1. Know how the nature works under its governed theories CO 2. Have concepts of heat and thermodynamics. CO 3. Brief knowledge on electricity and magnetism. CO 4. Brief knowledge of geometrical optics. CO 5. Have a preliminary idea about Quantum Mechanics.

Unit 1: Mechanics

Physics: A way to understand how nature works, method followed by physicists- theory and experiment, some path breaking discoveries of physics.

Laws of motion, gravitational field and potential, escape velocity, Keplar’s laws, satellite. [8L]

Unit 2: Oscillations

Wave motion, idea of wavelength, frequency and velocity of waves, transverse and longitudinal waves, equation for plane progressive waves, velocity of sound, ultrasonic waves and their generation and applications, light as wave. [10L]

Unit 3: Heat & Thermodynamics

Kinetic theory of gases, viscosity, Brownian motion, Laws of thermodynamics. [4L]

Unit 4: Geometrical Optics

Laws of reflection, spherical mirrors, focal length, uses, laws of refraction, refraction through prism and lenses, microscope and telescope. [6L]

Unit 5: Electricity-Magnetism

Current electricity, Ohm's law, electrical resistance, heating effect of electric current, emf and internal resistance of an electric cell, Kirchoff’s law and its simple applications, principle of Wheatstone bridge, potentiometer and their uses. Electromagnetic induction, idea of DC, AC, transformer, electric power, power transmission,

Concept of magnetic field, Lorentz force. Electromagnetic waves and their characteristics (qualitative ideas only). [14L]

Unit 6: Quantum Physics

Black-body radiation, Plank hypothesis, concept of quantum radiation, photoelectric effect and application of photoelectric cell. [6L]

Books Suggested:

1. University Physics by J. C. Upadhyaya, Himalaya Publishing Home.
2. Heat and Thermodynamics by Brijlal and N. Subramanyam, S. Chand Publication.
3. Modern Optics by Brijlal and N. Subramanyam, S. Chand Publication.
4. Elements of Quantum Mechanics by Kamal Singh, S. Chand Publication.
5. Physics: Foundation and frontiers by George Gamow.

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Course Code: HVP-740
Human Values and Professional Ethics
[Non-Credit Compulsory Course]

Course Description: The purpose of this course is to examine various ethical issues that may arise in one's professional life, and how such a life intersects one's personal life and self-understanding with the core focus to enlighten the students regarding value based approaches within a variety of context. The concept of value is understood in two different contexts; one is People's judgments about what is important or meaningful in their lives and the other is principles or standards for behavior, supported by religion, constitution and norms.

Course Objectives:
CO 1. To critically understand ethical issues as they pertain to professional and personal identity.
CO 2. To learn to consider oneself and the world around from these basic ethical positions.
CO 3. To develop sharpened analytic powers and capacities for oral and written expression.

Unit-1: Ethics and Human Values **[8L]**
Definition, Importance and Relevance in present-day Society.
Indian Constitutional Values**:** Fundamental Rights and Duties; Freedom, Equality, Fraternity, Justice; Directive Principles of State Policy.
Religious and Cultural Values: Values embedded in different religions; Religious Tolerance.

Unit-2: Basic Human Virtues **[8 L]**
Concept of Honesty, Punctuality, Responsibility, Courtesy, Discipline, Courage, Compassion, Empathy and Restrain
Family responsibilities: Duties as a Member of the Society, Guidance to youngsters; Gender Equality.
Social Concerns: Evils of Dowry & Caste System, Racial Discrimination, Suicidal Tendencies, Substance Abuse and Addiction.

Unit-3: Introduction to Professional Ethics **[8 L]**
Need, Importance and Goals; Ethical Values in Different Professions: Dignity of Labour, Respect for Authority, Code of Conduct, Conflicts of Interest.
Occupational Crime; Sexual and Mental Harassment in work place.
Professional Rights: Employee Rights, Intellectual Property Rights (IPR).

Unit-4: Ethics in Professional and Global Space **[5 L]**
Cyber Ethics and Etiquette.
Correct and Judicious use of Mobile Phones/electronic gadgets, Social Networking in professional space.
Environmental Ethics; Ethics in Research.

Suggested Readings:

1) Jayashree Suresh and B S Raghavan- *Human Values and Professional Ethics: Values and Ethics of Profession*. S Chand, 2005.
2) Martin, Clancy, Wayne Vaught, and Robert Solomon (eds.)- *Ethics Across the Professions: A Reader for Professional Ethics*. Oxford: Oxford University Press, 2010.
3) R.R. Gaur, R. Sangal and G.P. Bagaria- *A Foundation Course in Human Values and Professional Ethics* (Paperback). Excel Books, 2010
4) Terrence M. Kelly- *Professional Ethics: A Trust-Based Approach.* Lexington Books, 2018.
5) R. S. Naagarazan- *Professional Ethics and Human Values.* New Age International (Second ed.), 2019.

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