School of Physics (Autonomous) and Affiliated Colleges, Sambalpur University
M.Sc. Physics Course Structure
Effective from 2022 -23 Batch

I Semester

Course No	Course Title	Credit
PHY – 411	Classical and Relativistic Mechanics	4 CH
PHY – 412	Quantum Mechanics (I)	4 CH
PHY – 413	Mathematical Methods for Physics	4 CH
PHY – 414	Computer Programming	4 CH
PHY – 415	Computer Practical (I)	2 CH
PHY – 416	Optics Practical	2 CH
ESDMS -419	Environmental Studies & Disaster Management	2 CH
Total of I Semester		**22 CH**

Students have to enroll for a course on Environmental Studies & Disaster Management to be offered by the Environmental Science department of the University.

II Semester

Course No	Course Title	Credit
PHY – 421	Electrodynamics	4 CH
PHY – 422	Quantum Mechanics (II)	4 CH
PHY – 423	Basic Electronics	4 CH
PHY – 424	Statistical Mechanics	4 CH
PHY – 425	Computer Practical (II)	2 CH
PHY – 426	Electricity and Magnetism Practical	2 CH
IDC – 429	IDC or Open Elective	3 CH
Total of II Semester		**23 CH**

The students will enroll for a course on Open Elective to be offered by other departments of the University.

III Semester

Course No	Course Title	Credit
PHY – 511	Solid State Physics	4 CH
PHY – 512	Elective Paper (I)	4 CH
PHY – 513	X-ray and Laser Spectroscopy	4 CH
PHY – 514	Research Methodology	4 CH
PHY – 515	Modern Physics Practical (I)	2 CH
PHY – 516	Elective Paper Practical (I)	2 CH
PHY – 517	MOOC course	3 CH
EDPS – 439	Entrepreneurship Development	2 CH
Total of III Semester		**25 CH**

The students will enroll for one MOOC course being offered which will be of 3 credits and the credit will be incorporated. Further students also have to enroll for a course on Entrepreneurship Development.

IV Semester

Course No	Course Title	Credit
PHY – 521	Nuclear Physics	4 CH
PHY – 522	Particle Physics	4 CH
PHY – 523	Elective Paper (II)	4 CH
PHY – 524	Modern Physics Practical (II)	2 CH
PHY – 525	Elective Paper Practical (II)	2 CH
PHY – 526	Research Project cum Grand Viva	4 CH
Total of IV Semester		**20 CH**

The students have to enroll compulsorily for two non-credit course like: (a) Yuvasanskara, (b) NCC/NSS/Sports/Yoga/ Performing Arts (in first semester).

Grand Total Semester I to IV – 90 CH

List of Elective Papers:

1. Nuclear Physics
2. High Energy Physics
3. Condensed Matter Physics
4. Electronics

Subject: M.Sc. Physics
Academic Session: 2022 -24

I Semester - December, 2022

Course No	Course Title	Credit	Mark Distribution	Maximum Marks
PHY – 411	Classical and Relativistic Mechanics	4 CH	80+20	100
PHY – 412	Quantum Mechanics (I)	4 CH	80+20	100
PHY – 413	Mathematical Methods for Physics	4 CH	80+20	100
PHY – 414	Computer Programming	4 CH	80+20	100
PHY – 415	Computer Practical (I)	2 CH	100	100
PHY – 416	Optics Practical	2 CH	100	100
ESDMS 419	Environmental Studies & Disaster Management	2 CH	30+20	50
Total of I Semester		**22 CH**		

Students have to enroll for a course on Environmental Studies & Disaster Management to be offered by the Environmental Science department of the University.

II Semester – June, 2023

Course No	Course Title	Credit	Mark Distribution	Maximum Marks
PHY – 421	Electrodynamics	4 CH	80+20	100
PHY – 422	Quantum Mechanics (II)	4 CH	80+20	100
PHY – 423	Basic Electronics	4 CH	80+20	100
PHY – 424	Statistical Mechanics	4 CH	80+20	100
PHY – 425	Computer Practical (II)	2 CH	100	100
PHY – 426	Electricity and Magnetism Practical	2 CH	100	100
IDC 429	IDC or Open Elective	3 CH	60+40	100
Total of II Semester		**23 CH**		

The students will enroll for a course on Open Elective to be offered by other departments of the University.

III Semester – December, 2023

Course No	Course Title	Credit	Mark Distribution	Maximum Marks
PHY – 511	Solid State Physics	4 CH	80+20	100
PHY – 512	Elective Paper (I)	4 CH	80+20	100
PHY – 513	X-ray and Laser Spectroscopy	4 CH	80+20	100
PHY – 514	Research Methodology	4 CH	80+20	100
PHY – 515	Modern Physics Practical (I)	2 CH	100	100
PHY – 516	Elective Paper Practical (I)	2 CH	100	100
PHY – 517	MOOC course	3 CH	60+40	100
EDPS 439	Entrepreneurship Development	2 CH	30+20	50
Total of III Semester		**25 CH**		

The students will enroll for one MOOC course being offered which will be of 3 credit and the credit will be incorporated. Further students also have to enroll for a course on Entrepreneurship Development.

<u>IV Semester – April, 2024</u>

Course No	**Course Title**	**Credit**	**Mark Distribution**	**Maximum Marks**
PHY – 521	Nuclear Physics	4 CH	80+20	100
PHY – 522	Particle Physics	4 CH	80+20	100
PHY – 523	Elective Paper (II)	4 CH	80+20	100
PHY – 524	Modern Physics Practical (II)	2 CH	100	100
PHY – 525	Elective Paper Practical (II)	2 CH	100	100
PHY – 526	Research Project cum Grand Viva	4 CH	20+50+30	100
Total of IV Semester		**20 CH**		

The students have to enroll compulsorily for two non-credit course like:
(a) Yuvasanskara, (b) NCC/NSS/Sports/Yoga/ Performing Arts (in first semester).

Grand Total Semester I to IV – 90 CH

List of Elective Papers:

1. Nuclear Physics
2. High Energy Physics
3. Condensed Matter Physics
4. Electronics

SEMESTER-I COURSE-I 4CH

PHY- 411: Classical and Relativistic Mechanics

OBJECTIVE: To make the students understand the basic concepts of Classical and Relativistic Mechanics and its application in various field of Physics to bring them to a level where they can face the competitive examinations.

1. **Theory of small oscillations and Rigid body kinematics and dynamics:** Principal axis transformation, normal co-ordinates & normal modes, vibration of linear symmetric molecules, Generalized co-ordinates for rotation, rotation as orthogonal transformation, general motion of a rigid body, Euler- angles, angular momentum and kinetic energy of rotation in terms of the Euler-angles, rate of change of a vector, inertia tensor and moments of inertia, Euler's equations of motions, motion of a heavy symmetrical top, motion in a non-inertia frame of reference, Coriolis force.
2. **Hamiltonian Formulation and Canonical transformations:** Derivation of Hamilton's equations from Lagrange's equations, and from the variational principle, Hamiltonian of simple systems and in different co-ordinate systems, solution of equations of motion for Simple Harmonic Oscillator and other simple systems, Legendre transformation generating functions and classifications of canonical transformations, Poisson's brackets, Equations of motion in Poisson- bracket form, canonical invariants, Liouville's theorem.
3. **Hamilton-Jacobi Theory and Action angle variables:** The Hamilton-Jacobi equation, separation of variables, the Harmonic Oscillator problem, Action angle variables, formulation of periodic systems.
4. **Elements of Relativistic Mechanics:** Interpretation of Lorentz transformations as orthogonal transformation in 4-dimensional Minkowski space, Lorentz scalars, 4-vectors and 4-tensors in Minkowski space, Laws of mechanics in covariant form and the proper time interval, 4-vector position, 4-vector velocity and 4-vector momentum, Generalisation of Newton's force equation to covariant form, energy-momentum relation in relativistic mechanics.

OUTCOME: The students will be able to remember and derive various formulas of Hamiltonian mechanics, small oscillations, canonical transformations, rigid body dynamics and relativistic mechanics in four vector notation. They will be able to analyse the various concepts and solve problems relating to the knowledge gained. Apply the mechanical formulations learned, to practical physics/science problems in different topics and gain understandings about its limitations and their implication in quantum mechanics.

Text Books:

[1] Mechanics: L.D. Landau and E.M. Liftshitz , Pergamon Press

[2] Classical Mechanics : Herbert Goldstein , Pearson

[3] Introduction to classical Mechanics: David Morin, Cambridge University Press.

[4] Classical Mechanics: Tom Kibble, Imperial college press.

References:

[1] Classical Mechanics by J.C. Upadhaya, Himalaya Publishing House.

[2] Classical Mechanics by N. C. Rana and P.S. Joag, Tata McGraw-Hill, New Delhi

SEMESTER-I **COURSE-II** **4CH**

PHY- 412 : Quantum Mechanics (I)

OBJECTIVE: Course introduces the methods to do the mechanics of atomic and subatomic particles.

1. **Review and Postulates of quantum mechanics: I**nadequacy of classical mechanics, Wave-particle duality, wave-packets, Uncertainty principle, Schrodinger equation, wave function and its significance, Basic postulates, Representation of states, Representation of dynamical variables, expectation values, observables, Eigenvalue problem, degeneracy, Eigen function, ortho-normality, Dirac-delta function and its properties, completeness, closure property, Application to the momentum space, general derivation of Uncertainty principle, states with minimum uncertainty product, commuting observables and removal of degeneracy, evaluation of system with time and constant of motion.
2. **The central Force Problem:** Separation of the wave equation, theory of orbital angular momentum, eigen values and eigen functions, rigid rotator, the radial equation, spectrum of Hydrogen and Hydrogen-like atoms, three dimensional square well potential, bound states and energy levels, case of infinite depths, the three dimensional isotropic Harmonic oscillator.
3. **Matrix Formulation of Quantum Theory:** Matrix representation of operators, transformation theory-change of basis of representation, Quantum dynamics in schrodinger and Heisenberg pictures, interaction picture, Dirac Bra and Ket notation, harmonic oscillator problem-creation and annihilation operators, energy spectrum and the eigen functions.
4. **Symmetries and conservation laws, and Theory of angular momentum:** Space and time translation symmetries, generators and the conservation of energy-momentum, symmetries under rotation, generators, Algebra of the generators, diagonalisation, matrix representation of generators J=1/2 and 1 cases, addition of angular momenta, Clebsch- Gorden coefficients, calculation of C.G. coefficients for angular momenta 1/2 and 1/2 and 1/2 and 1 cases.

OUTCOME: Familiarizing students with the theoretical framework of non-relativistic quantum mechanics and its applications to simple problems. The students will gain knowledge about general formalism of Quantum Mechanics, wave packets, uncertainty relation, representation in quantum mechanics, picture of quantum mechanics, Eigenvalue problem, matrix mechanics, angular momentum, Clebsch-Gordon coefficients. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply the quantum mechanical techniques and laws learned to practical physics/science problems in different topics including chemistry and biology.

Text books:

[1] Quantum Mechanics, Leonard I Schiff, Mc Graw-Hill 1968

[2] A Textbook of quantum mechanics / P. M. Mathews, K. Venkatesan, New York: McGraw-Hill Book Co., 1978.

[3] Quantum Mechanics 2nd Ed; Bransden and Joachain; Pearson; 2000;

References:

[1] Quantum Mechanics, Eugen Merzabacher, JOHN WILEY & SONS, INC.

[2] Quantum Mechanics, Franz Schewabl, Springer, Berlin, Heidelberg.

[3] Quantum Mechanics, John L. Powell and Bernd Crasemann, The Amazon Book.

[4] Quantum Mechanics, AjoyGhatak, S. Lokanathan, Springer Netherlands.

SEMESTER-I COURSE-III 4CH

PHY- 413 : Mathematical Methods for Physics

OBJECTIVE: This course will help the students to solve the mathematical problems in Physics.

1. **Function of a complex variable, Linear vector space and Matrices:** Residue theorem, evaluation of integrals by the method of residues, multi-valued function-branch point and branch cut, contour integration involving branch point, Definition, linear independence, basis and dimension, scalar product, dual vector, Cauchy-Schwarz inequality, orthonormal basis, Schmidt orthogonalisation process, Inverse of a matrix, orthogonal matrix, rotation, similarity transformation, Eigenvalues and Eigenvectors, secular equation, Cayley- Hamilton theorem, matrix diagonalisation.
2. **Partial differential equations and Group theory:** First and second Order Differential Equations, Separation of Variables, Ordinary Differential Equations, Singular Points, Series Solutions – Frobenius' Method, Special functions (Hermite, Bessel, Laguerre and Legendre functions as an assignment), A second Solution, Non-homogenous Equation – Green's Function, Basic concepts of groups, group representation, relevance to quantum mechanics, Lie group and Lie algebra, SU (2) groups and their representation, SO (3) groups and their representation.
3. **Tensors in physics:** Cartesian tensor, covariant, contravariant and mixed tensors, tensor algebra, the Kronecker delta and Levi-Civita symbol, tensors in Minkowski space, tensor calculus, tensors in general relativity, the Reimann-Christoffel symbol, Ricci and Curvature tensor.
4. **Integral Transforms:** Development of Fourier Integral, Fourier Transforms – Inversion Theorem & Derivatives, Convolution Theorem, Momentum Representation, Transfer Functions, Laplace Transform - Derivatives, Properties, Inverse Laplace Transform and applications to solution of differential equations.

OUTCOME: The students will be able remember and derive various theorems of complex variables, linear algebra , differential equations with special functions, tensors and group theory and integral transforms. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply the mathematical techniques and laws learned, to practical physics/science problems in different topics.

Text Books:

[1] G.B. Arfken, H.J. Weber and F. Harris: Mathematical Methods for Physicist: A Comprehensive Guide (Elsevier Science and Technology)

[2] T.L. Chow: Mathematical methods for Physicist: A concise introduction (Cambridge University Press)

References:

[1] P. Dennery and A. Krzywicki: Mathematics for Physicists (Harper and Row)

[2] A. W. Joshi: Matrices and Tensors in Physics (Wiley – Eastern)

[3] P. K. Chattopadhyay: Mathematical physics (Wiley- Eastern)

[4] M. C. Potter and J. Goldberg: Methods of Mathematical physics (Prentice Hall)

SEMESTER-I **COURSE-IV** **4CH**

PHY- 414: Computer Programming

OBJECTIVE: To gain basic knowledge on computer programming.

1. **Introduction to Program** (General)**:** Introduction to programming language, Introduction to using a computer system

   Introduction to C: Programming discipline, Constants, variables and data type, Operators and expressions.

2. **Programming with C:** Input and output operations, Decision-making and branching, Decision making and looping, array and strings. User defined functions.

3. **Pointer & File managements:** Pointers, Structures and Unions and its uses, Dynamic memory allocation, File managements in C.

4. **MATLAB:** Introduction to MATLAB, Some useful Function and Data Type, Arrays, Input Output statements, Conditional Statements, Loop, Graphing.

OUTCOME: The students will be able write computer programmes in C and MATLAB to solve algebraic transcendental, polynomial equations, linear simultaneous equations, Eigenvalue problem, Ordinary differential equations, Numerical integration, Interpolation, Curve fittings, Random number generation. They will be able to analyse and debug programmes for scientific computing and solve problems relating to the expertise gained. Apply the programming skill developed to practical physics/science problems in different topics.

Texts Books:

[1] Byron Gottfried: Programming with C , Schaum outline series
[2] Y. Kanetkar: Let Us C , BPB Publications
[3] Stormy Attaway : MATLAB: A Pratical Introduction to Programming and Problem Solving, 3Rd Ed., Elsevier 2013

References:

[1] E. Balaguruswami: Programming in ANSI C , Tata McGraw-Hill
[2] Rudra Pratap: Getting started with MATLAB- A quick introduction for scientist and engineers.

SEMESTER-I **COURSE-V** **2CH**

PHY- 415: Computer Practical (I)

OBJECTIVE: Learning of basic OS commands under Linux and Windows, Learning to use word processor under Windows and Linux, Learning of editor commands under Linux

Programming: (using C/MATLAB)

1. Solution of quadratic equation
2. Sorting of a set of numbers in a desired way
3. Series summation like Sin(x), Cos(x), e^x, Log(x) etc.
4. Interpolation – linear, quadratic, cubic spline, Newton and Starlin Interpolation methods.
5. Solution of transcendental equations
6. Matrix multiplication, Transpose of a matrix,
7. Evaluate determinant of a matrix
8. Matrix inversions and solutions of simultaneous linear algebraic equations
9. Solutions of simultaneous linear algebraic equations by Gauss elimination
10. Solutions of simultaneous linear algebraic equations by LU decomposition
11. Least square fitting of a set of points to a straight line

(Any Other Experiments Suggested by Course Teacher)

OUTCOME: The students will learn basic OS commands under Linux and Windows use word processor under Windows and Linux, editor commands under Linux. They will use the editing command to write and execute computer programming in C and MATLAB. They will be able sort numbers, sum various series, matrix inversion and solution to linear and quadratic equations and curve fitting. Apply the programming techniques learned, to practical physics/science problems in different topics.

SEMESTER-I **COURSE-VI** **2CH**

PHY- 416: Optics Practical

1. Experiment with Biprism.
2. Experiment with Narrow wire.
3. Experiment with Single slit.
4. Experiment with Plane diffraction grating.
5. Experiment with Double slit.
6. Experiment with Babinet compensator.
7. Determination of Resolving Power of Telescope.
8. Determination of the Resolving Power of Grating.
9. Experiment with Constant Deviation Spectrograph.

(Any Other Experiments Suggested by Course Teacher)

OUTCOME: The students will experiment with biprism, single slit, double slit, plain diffraction grating, Babinet compensator, resolving power of telescope, Interferometers etc. They will be able to handle sophisticated equipment and learn its use in diverse field in science and technology. Apply the skill developed to pursue experimental research in advanced topics.

SEMESTER-I COURSE-VII 2CH

ESDMS- 419: Environmental Studies & Disaster Management

Section A: Environment

Unit - I : Concept of Environment, Ecosystem, Biogeochemical Cycling and Pollution

The Environment: The Atmosphere, Lithosphere, Hydrosphere, Biosphere. Anthroposphere Ecosystem: Structure of Ecosystem, Function of Ecosystem, Energy flow in ecosystem Biogeochemical cycle: The concept of Elemental Cycling: Carbon, Hydrogen. Nitrogen Oxygen. Phosphorous, Sulphur cycle

Pollution: Pollution, Pollutant and Thresholds; Ambient State and Polluted State: Water, Air, Soil, Radiation, Industrial, Noise. Social Pollution

Unit -II : Climate Change & Sustainable Development

Drivers of Climate Change: Natural, Human Population Growth. Urbanization, Industrialization

Planetary Scale Changes: Causes, effects, Global Warming. Ozone Depletion, Carbon footprint and Environmental Protection

Sustainable Development: Sustainable development concept, sustainable Development Goal (SDGs). Agenda 21 of Rio Earth Summit, Sustainable Montréal 2016-2020, COP 26

Measures for sustainable Development: Recycle, Reuse, Efficiency enhancement, Policy Development. Performance and Management.

Section B: Disaster management

Unit- I11 : Disaster Management

Concept of Disaster: Definition, Types of disasters. Classification of Disasters

Vulnerability Assessment and Risk Analysis: Risk assessment and analysis with respect to various disasters (Flood. Cyclone, Earthquake. Tsunami., Heat waves and Lightning)

Institutional Framework: National Disaster Management Authority (NDMA). State Disaster Management Authority (SDMA). District Disaster Management authority (DDMA). National Disaster Response Force (NDRF) and Odisha Disaster Rapid Action Force (ODRAF)

Preparedness Measures: Disaster Management Models: Warning System. Management strategies, Corporate Social Responsibility (CSR)

Unit-IV: Public Health Management

Brief idea on Epidemics and Pandemics

Non-communicable diseases with special reference to cardiovascular diseases, Cancer. Diabetes, Hypertension and Obesity and their prevention

Communicable diseases with special reference to Covid-19, Dengue, Hepatitis and AlDS, their transmission

Prevention of Epidemic/Pandemic Diseases: prevention Measures (Quarantine. Sanitization, Personal Protective measures such as Hand washing and use of protective devices, Vaccination); Control Measures (Surveillance, Isolation. Cotact Tracing)

Life Style management: Diet, Physical Exercise. Yoga and sleeping habit

Role of different Sectors in Managing Health Disaster: Role of CGiovernment and Non Covernment agencies in health management.

Suggested Books

1. Botkin, D. B. and E. A. Keller. Environmental Studies: The Earth as a Living Planet. Charles E. Merrill Publishing Co., Columbus, Ohio, 506 p.
2. Cunningham, W. and Cumnningham, M. (2017). Principles of Environmental Science: Inquiry and Applications. McGraw Hill Education; 4th edition., 410 p.
3. Dash, M.C. and Dash, S.P. (2009). Fundamentals of Ecology. (2009). McGraw-Hill Education (India) Pvt. Limited. 370 p.
4. Miller G.T. (1992). Living in the Environment: An Introduction to Environmental Science. International Thomson Publishing; 7th Ed edition, 768 p.
5. NIDM (2022). Handbook of Disaster Management for Nodal officers, Ministry of Home Affairs, Government of India, New Delhi, 176p.
6. Smith, K. and Petley, D.N. (2013). Environmental Hazards: Assessing risk and reducing hazards. Routledge (Taylor and Francis Group). London. 478 p.
7. Strahler, A.N. and Strahler, A.H. (1973). Environmental Geoscience: interaction between Natural Systems and Man. Hamilton Publishing Company, California. 511 p.
8. Sunder Lal Vikash (2022). Public Health Management Principles and Practice, CBS Publishers &Distributors, New Delhi, 348 p.

SEMESTER-II COURSE-I 4CH

PHY-421 : Electrodynamics

OBJECTIVE: The course content covers the propagation of electromagnetic waves in linear media (vacuum, dielectric, and conductor).

1. **Maxwell's equations, Conservation laws and Electromagnetic potentials:** Maxwell's equations (No derivation), Equation of continuity and conservation of charge, Lorentz force law, Poynting's theorem and conservation of energy, Maxwell's stress tensor and conservation of momentum, Electromagnetic potentials, Gauge transformation, Lorentz and Coulomb gauge, Lorentz force law in the potential formulation, Inhomogeneous wave equation for the potentials and its solution by Green function method, Retarded potentials.
2. **Propagation of plane Electromagnetic waves, polarization and dispersion, Radiation and Scattering:** Propagation of plane electromagnetic waves in free space, dielectrics and conductors, Reflection and refraction, polarization, Fresnel's law, The oscillator model and dispersion in dielectrics, conductors and plasma, anomalous dispersion and resonant absorption, casual and non-local connection between D and E, Kramers- Kroning dispersion relations. Retarded potentials, fields and radiation due to an arbitrary system of charges and currents in the electric dipole approximation, Multipole expansion of retarded potentials and fields in the radiation zone, emission of radiation in the electric dipole, magnetic dipole, and electric quadrupole approximations, simple radiating system, Linear centerfed antenna, scattering of plane electromagnetic waves by a bound charge in the electric dipole approximation, resonance scattering, Raleigh scattering and Thomson scattering.
3. **Electromagnetic potentials, fields and Radiation due to a moving point charge:** Leinard-Weichart potentials and fields due to a moving point charge, Radiation by an accelerated point charge, Larmor formula and its generalization to Leinard formula, Angular distribution of emitted radiation, Radiation reaction and damping, Abraham-Lorentz formula.
4. **Relativistic Electrodynamics: The 4-vector covariant formulation-** 4-vector gradient and the D'Alembertian operator, the charge-current 4-vector and covariant formulation of charge conservation law, the 4-vector electromagnetic potential, covariant formulation of the wave equation for the electromagnetic potentials in the Lorentz gauge and the Lorentz condition, Maxwell's electromagnetic field tensor in Minkowski space and transformation equations for the electromagnetic field components, covariant formulation of Maxwell's equations and the Lorentz force law, the four dimensional wave vector and invariance of the phase of plane electromagnetic wave under Lorentz transformation, relativistic Doppler effect, the electromagnetic stress-energy-momentum tensor in the 4- dimensional, Minkowski space and covariant formulation of energy and momentum conservation law for a system of charge particles and electromagnetic fields. Covariant formulation of equation of motion of a charge particle under electromagnetic force.

OUTCOME: It familiarizes students with different principles and phenomena when electromagnetic wave propagates in different media. Solve problems relating to electromagnetic stress-energy-momentum tensor in the 4-dimensional, Minkowski space and covariant formulation of energy and momentum conservation law for a system of charge particles and electromagnetic. Apply the techniques and laws learned to the problems of energy momentum conservation in relativistic collision between two particles, dynamics of a charge particle under electromagnetic force, relativistic generalization of Larmour formula.

Text Books:

[1] J.D.Jackson: Classical Electrodynamics, John Wiley & Sons Publisher.
[2] E.C.Jordan and K.G.Balman: Electromagnetic waves & Radiating Systems
[3] Electrodynamics; Gupta, Kumar and Sharma; Pragati Prakashan; 2010
[4] David J Griffith: Introduction to Electrodynamics, PHI publishing.
[5] H. Goldstein: Classical Mechanics.
[6] B Podolsky and K S Kunz: Fundamental of Electrodynamics
[7] Feynman Lectures on Physics, R.P. Feynman, Addison-Wesley publishing.

References:

[1] B.G.Levich: Theoretical Physics, North-Holland Publishing Company.
[2] P. Lorrain and D. Corson: Electromagnetic Fields and Waves, WH Freeman & Co. publisher

SEMESTER-II **COURSE-II** **4CH**

PHY-422 : Quantum Mechanics (II)

OBJECTIVE: To utilize the principles of quantum mechanics to solve different problems at atomic level.

1. **Spin Angular Momentum and Identical Particles:** Expt. Evidence, Pauli theory, spin wave functions, properties of Pauli matrices, System of two spin1/2 particles, Symmetry and anti-symmetry of wave functions as conserved quantities, spin-statistics relation, Pauli exclusion principle, Simple manifestation of Pauli principle, Fermi level.
2. **Approximation Methods:** Time independent perturbation theory, energy levels and eigen functions up to 2^{nd} order, Anharmonic oscillator, non-degenerate and degenerate case-removal of degeneracy, stark effect, He–atom, W.K.B approximation, turning points, applications to bound states and tunneling, Bohr-Sommerfeld quantisation formula, The variational principle, estimation of ground state and excited state energy levels. Time Dependent Perturbation Theory: The Dirac-Picture, transition Probability, density of states, Fermi Golden rule, harmonic perturbation. Semi-classical theory of Radiation.
3. **Scattering Theory:** The scattering integral equation, scattering amplitude and differential equation, Born approximation, Rutherford scattering, validity of Born approximation, Partial wave analysis, phase shifts, differential and total cross-section for elastic scattering, Optical theorem, low energy scattering (l=0) case, scattering length, effective range.
4. **Relativistic Quantum Mechanics:** Klein-Gordon equation, drawback, Dirac equation – derivation, Properties of Dirac matrices, plane wave solution of Dirac equation.

OUTCOME: Students will learn about spin angular momentum, identical particles, scattering Theory, differential and total scattering cross-section laws, partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and simple applications, Approximation Methods, Dirac equation and its solutions. They will be able to analyse the above concepts and solve quantum mechanical like approximation methods and exact solutions of Schrödinger equation problems relating to the knowledge gained. Apply the scattering and approximation methods to solve problems like tunnelling through barriers and use of scattering theory for understanding interaction between elementary particles.

Text Books:

[1] Quantum Mechanics, Leonard I Schiff, McGraw-Hill 1968

[2] A Textbook of quantum mechanics / P. M. Mathews, K. Venkatesan, New York : McGraw-Hill Book Co., c1978.

References:

[1] Quantum Mechanics, EugenMerzabacher, JohnWiley& Sons, INC.

[2] Quantum Mechanics, Franz Schewabl, Springer, Berlin, Heidelberg.

[3] Quantum Mechanics, John L. Powell and Bernd Crasemann, The Amazon Book

[4] Quantum Mechanics, AjoyGhatak, S. Lokanathan, Springer Netherlands.

[5] Relativistic Quantum Mechanics, Bjorken Drell, McGraw-Hill.

SEMESTER-II COURSE-III 4CH

PHY-423: Basic Electronics

OBJECTIVE: To educate the students with the basics and intricacies of the given subject area and enable them to use the knowledge for meaningful applications.

1. **Network Theory:** T and PI network, their inter conversations, Foster's reactance theorem, Thevenin's theorem and Norton's theorem, Reciprocity theorem, superposition and compensation theorem, maximum power transfer theorem.
2. **Amplifiers and Oscillators:** Transistor parameters and equivalent circuit, amplifier characteristics of transistor in CE, CB and CC configurations, small signal low and high frequency transistor circuits and analysis, the Miller effect, gain band width product, effect of cascading, Feedback in amplifiers, effect of negative feedback on gain, distortion, input and output resistances, different feedback circuits, Feedback and circuit requirement for oscillators, analysis of Hartley, Colpitt, RC (phase shift) and Wein-bridge oscillator, circuit analysis of astable, monostable and bistable multivibrators.
3. **Operational amplifiers:** Basic OP-AMP-differential amplifier, inverting and non-inverting type, common mode rejection ratio, use of OP-AMP in scale changing, phase shifting, summing, voltage to current (and vice-versa) conversion, multiplying, differentiating and integrating circuits, solution of linear and differential equation using OP-AMP, analog computation.
4. **Digital Electronics:** NAND and NOR as universal gates, Logic functions and their simplifications using K-map, Combinational logic design: multiplexer, half ladder and full ladder, use of adder as substractor, Sequential logic design: Different type of Flip-Flops and their characteristics, advantage of master-slave configuration.

Outcome: Knowledge gained in areas like (i) Feedback in amplifiers, (ii) Audio power amplifiers, (iii) Oscillators, (iv) Power supplies and Electronic regulators, (v) Some special application of OP AMP, (vi) Digital electronics and (vii) Networks and lines. Students should be competent enough to design different electronic circuits which are very useful in the application point of view.

Text Books:

[1] P C Rakshit and D Chattopadhyay: Foundations of Electronics, New Age.
[2] P C Rakshit and D Chattopadhyay: Fundamentals and Applications, New Age.
[3] John D Ryder: Electronic Fundamentals and Applications , Prentice-Hall Inc.
[4] Robert L Boylestad and Louis Nashelsky: Electronic devices and circuit theory, Pearson
[5] Ramakant A. Gayakwad: Op-Amps and Linear Integrated Circuits , Pearson
[6] David A. Bell: Op-Amps and Linear Integrated Circuits , Prentice-Hall Inc

References:

[1] Jacob Millman and C C. Halkias: Electronic Devices and Circuits , Tata Mc-Hill
[2] Allen Mottershead: Electronics Devices and Circuits, PHI.
[3] R.P.Jain: Modern Digital Electronics.
[4] S.L. Gupta and V. Kumar: Handbook of Electronics , Pragati Prakashan
[5] D. Roy Choudhary: Networks and Systems, New Age

SEMESTER-II COURSE-IV 4 CH

PHY-424 : Statistical Mechanics

OBJECTIVE: To make the students understand the basic concepts of Statistical Mechanics and its application in various field of Physics to bring them to a level where they can face the competitive examinations.

1. **Kinetic Theory:** Kinetic theory, binary collisions, Boltzmann transport equation, H-theorem, Maxwell Boltzmann Distribution law, Mean free path.
2. **Classical Statistical Mechanics:** Elements of ensemble theory, phase space, ergodic hypothesis, Liouville's theorem, micro-canonical, canonical and grand canonical ensembles, thermodynamic functions, classical ideal gas, equipartition theorem, Gibb's paradox, energy fluctuations in canonical ensemble, density fluctuations in grand-canonical ensemble.
3. **Quantum Statistical Mechanics:** Density matrix, Quantum Liouville's theorem, ensembles in quantum mechanics, equilibrium average of observables, thermodynamic function, partition function, Ideal mono atomic gas.
4. **Application of Quantum Statistical Mechanics:** Statistics of indistinguishable particles, Derivations of Fermi- Dirac, Bose-Einstein and Maxwell-Boltzmann distribution law, ideal Fermi and Bose gas, theory of white dwarfs and Chandrasekhar limit, Plank's radiation formula, Bose Einstein condensation.

OUTCOME: Students will learn basic postulates of classical and quantum statistical mechanics; concepts of microstates, phase-space, partition function and density function; micro-canonical, canonical and grand canonical ensembles; various distribution functions and their application to degenerate Fermi gas, White dwarf system and Bose-Einstein condensation. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply the statistical laws to study any thermodynamic system under equilibrium in solid state physics, nuclear physics and cosmology.

Text Book:

[1] Statiatical Mechanics by K.Huang, Wiley publisher

[2] Statistical Mechanics by S L Gupta, Kumar V, Pragati Pakashan

References:

[1] J.D. Walecka: Fundamentals of Statistical Mechanics (World Scientific)

[2] Pathria: Statiatical Physics, Elsevier India Pvt. Ltd.

[3] Charles Kittel: Elementary Statistical Physics, Dover Publications

SEMESTER-II **COURSE-V** **2 CH**

PHY-425 : Computer Practical (II)

Basic: Learning to plot graphs under windows and Linux OS, Learning to use Internet/E-mail, Learning to design web-pages - Learning the basic of HTML

Programming: (using C/MATLAB)

1. Evaluation of integrals using Trapezoidal method and testing the accuracy of the method

2. Evaluation of integrals using Simpson's $1/3^{rd}$ method

3. Evaluation of integrals using Weddle's methods

4. Evaluation of integrals using Gauss quadrature formula

5. Numerical differentiation- calculation of first and second order derivatives at any point in the range of a tabular data

6. Solution of first order differential equations using Euler's method and testing the accuracy of the method

7. Solution of first and second order differential equations using Runge-Kutta method

8. Solution of first and second order differential equations using finite difference method

9. Solution of Eigen value equation – Schrodinger equation for a given potential

10. Generation of random numbers

(Any other experiments suggested by the Course Teacher)

Outcome: The students will learn to plot graphs under windows and Linux OS, to design web-pages and the basics of HTML. They will be able to execute numerical integration by various methods, differentiation and solution to differential equation of first and second order. Apply the programming techniques learned, to practical physics/science problems in different topics.

SEMESTER-II COURSE-VI 2CH

PHY-426: Electricity and Magnetism Practical

1. Static characteristics of a triode, tetrode, and pentode and determination of tube Parameters.
2. Static characteristics of BJT.
3. Determination of the tube constants of a triode by Miller's method.
4. Setting up, calibration and experiments with VTVM.
5. Measurement of current, voltage and frequency with CRO.
6. Setting up and study of unregulated power- supply with various filters and determination of ripple factor.
7. Determination of power factor of a fan.
8. Measurement of the ballistic constant using the Hilbert's magnetic standard.
9. Measurement of ballistic constant by standard solenoid.
10. Measure of a magnetic field by using a search coil and Bismuth spiral.
11. Experiments to obtain B.H. curve.

(Any other experiments suggested by the Course Teacher)

Outcome: The students will experiment to determine characteristic triode, tetrode, pentode and BJT; use of CRO, Power efficiency of solar panels, Rectifiers, etc. They will be able to handle sophisticated equipment and learn its use in diverse field in science and technology. Apply the skill developed to pursue experimental research in advanced topics.

SEMESTER-II COURSE-VII 3CH

IDC- 429: IDC or Open elective course

Students have to choose from a list of courses floated by other different departments of the university based on their preference.

SEMESTER - III COURSE - I 4CH

PHY- 511 : Solid-State Physics

OBJECTIVE: This course will help the students to understand the concepts of solid state Physics and its application.

1. **Lattice Vibration and Thermal properties of solids:** Review of crystal structures and bonding in solids, Normal modes of mono and diatomic lattice, salient features of dispersions curves, phonon density of states, quantum theory of heat capacity.
2. **Free electron theory, Band Theory of Solids and Semiconductor Physics:** Sommerfeld theory of free electron gas, density of states, Fermi-Dirac (FD) distribution function and its temperature dependence, electronic heat capacity, cyclotron resonance and Hall effect, The AC conductivity and optical properties, Thermionic emission. Bloch Theorem, Nearly free electron model (NFEM), Tight binding models, Approximate solution near a Zone boundary, Kronig-Penny model, effective mass. Intrinsic and extrinsic semiconductors, band model, carrier concentration and electrical conductivity, law of mass action, Magnetic field effects.
3. **Magnetism, Dielectric and Optical Properties of solids:** Review of basic formulae, quantum theories of dia, para and ferromagnetism, Elementary idea of antiferromanetism, Ferrimagnetism, Paramagnetic resonance, Nuclear magnetic resonance, Spin waves. Review of basic formulas, The local field, Clausius-Mossotti relation, Sources of polarizability, Dipolar dispersion, Piezoelectricity, Ferroelectricity.
4. **Superconductivity:** Experimental study, Meissner effect, Type-I and Type-II superconductors, Critical field, Thermodynamics properties, Isotope effect, The two fluid model, London’s equation, Elementary discussion of the BCS theory, Tunneling and the Josephson effect, High T_C superconductors.

OUTCOME: The students will gain knowledge about the quantization of lattice vibrations, phonon momentum, thermal properties of solids, dielectric properties solids and its properties, band theory of solids, Semiconductor Physics**,** Magnetic properties of solids like Diamagnetism, paramagnetic, ferromagnetism, anti-ferromagnetism and ferrimagnetism and Superconductivity. Students will be able to: correlate the X-ray diffraction pattern for a given crystal structure based on the corresponding reciprocal lattice, explain how the predicted electronic properties of solids differ in the classical free electron theory, quantum free electron theory and the nearly free electron model, and explain various magnetic phenomena in solids.

Text Books:

[1] M. Ali Omar**:** Elementary Solid State Physics, Pearson Edition

[2] S.O. Pillai: Solid-state Physics, New Age International Pvt. Ltd

[3] R.K. Puri and V.K. Babbar: Solid State Physics , S. Chand and Company Ltd.

References:

[1] A.J. Dekker: Solid-state Physics , Macmillan India Publisher

[2] C. Kittel: Introduction to Solid-state Physics , Wiley Edition

[3] N.W. Ashcroft and N.D. Mermin: Solid-state Physics , Thomson Press (India) Ltd.

[4] C.M. Kachhava: Solid-state Physics, Solid State Devices and Electronics, New Age International Pvt. Ltd.

SEMESTER - III COURSE – II 4CH

PHY- 512 : ELECTIVE PAPER – I

(The student shall choose any one of the following elective paper)

1) Nuclear Physics (I)

OBJECTIVE: To educate the students with useful applications of Nuclear force and structure, and to enable them to recognize the applications.

1. **Nuclear forces and two nucleon systems:** Spin, parity and iso-spin of two nucleon states, symmetry and nuclear forces.

2. **The Deuteron problem and Meson theory of nuclear force:** Ground state of Deuteron with central force and tensor force, magnetic dipole moment and eletric-quadrupole moment of the deuteron, Low energy Neutron- Proton scattering and phase shift, effective range theory and low energy neutron proton scattering parameters and charge independence of nuclear force. Scalar and pseudo-scalar meson theory, exchange character of nuclear force, elementary idea about three body and many body forces in nuclei.

3. **Shell Model and Unified Collective Model of the Nucleus:** Motion of nucleon in a mean field of force and extreme single particle shell model, Magic numbers in infinite square-well and harmonic oscillator potential well, spin-orbit interaction and prediction of correct magic numbers, Angular momentum, magnetic dipole moment and electric quadrupole moment of odd-A nuclei, elementary ideas about single particle shell model.

4. **Collective motion in nuclei:** Rotational and Vibrational motions, Rotational spectra of even-even and odd-A nuclei, collective surface vibration of deformed nuclei in the liquid drop model.

OUTCOME: The students gather advanced knowledge in models of the nucleus , nuclear force, the Compound model of the nucleus, the inelastic scattering, The Briet-Wigner formula to know that unstable particles. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. So that it will help to pursue research career in respective fields.

Text Books:

[1] Nuclear Physics, R. R. Roy and B. P. Nigam, Wiley Eastern Limited.
[2] Introductory Nuclear Theory, L. R. B. Elton, Published by Saunders, Philadelphia.
[3] Introductory Nuclear Physics, Samuel S.M. Wong, Wiley-VCH Verlag GmbH & Co.
[4] Introductory Nuclear Physics, Kenneth S. Krane, JOHN WlLEY& SONS.

References:

[1] Nuclear Physics, S. N. Ghoshal, S. Chand Publishing.
[2] Structure of the Nucleus, M. A. Preston and R. K. Bhaduri, CRC Press; 1 edition (December 21, 1993)
.
[3] Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, K. Heyde, by CRC Press.
[4] Nuclear Structure, Vol-I & II, Aage Bohr and Ben. R. Mottelson, World Scientific Publishing Co. Pte. Ltd..
[5] NuclearModels: Basic Conceptsin NuclearTheory, Joachim A. Maruhn, Springer London, Limited, 1997.

2) Condensed Matter Physics (I)

OBJECTIVE: To educate the students with useful applications of Condensed Matter Physics and to enable them to recognize the applications.

1. Lattice Dynamics and Energy Band Theory

Harmonic and Anharmonic approximation, Born-Openheimer approximation, Hamiltonian for lattice vibration in the harmonic approximation to normal modes, quantization, phonons. Wave equation of an electron in a periodic potential, Bloch Floquet theorem, Brillouin Zones, Ellective mass of an electron, tight binding approximation.

2. Fermi Surfaces

Characteristics of the Fermi surfaces, construction of the Fermi surfaces, case of metals, experimental studies of Fermi surfaces, De Hass Van Alphen effect, Cyclotron resonances in metals.

3. Beyond the Independent Electron Approximation

Hartree and Hartree-Fock equation, correlation, Screening, Thomas Fermi Theory of di-electric function.

4. Wannier Representation

Wannier function, Equation of motion in the Wannier representation, The equivalent Hamiltonian-Impurity levels, Excitons: Weakly bound excitons and Tight bound excitons

OUTCOME: A more elaborate view on lattice dynamics leading to plotting determining phonon dispersion curves, detailed discussion of Band theory of solids leading to finding a real life electron band structure, Characteristics and experimental studies of the fermi surfaces, beyond the independent electron approximation used in complex systems and Wannier representation. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. So that it will help to pursue research career in respective fields.

Text Books:

1. Introduction to Solid State Physics by C. Kittel, Wiley Publication
2. Quantum Theory of Solids by C. Kittel, Wiley Publication
3. Solid State Physics by H. Ibach, H. Luth, Springer Publication
4. Solid State Physics by C. M. Kachhava, TATA McGraw- Hill Publication

References:

1. Solid State Physics by Neil W. Aschroft, N. David Mermin Cengage Learning Pub
2. Principles of Theory of Solids by J. M. Ziman, Cambridge University Press
3. Elementary Solid State Physics by M. Ali Omar, Pearson Publication

3) High-Energy Physics (I)

OBJECTIVES: This course is intended to introduce the basics of quantum field theory (QFT). QFT is essential to understand nature at smallest scales hence it plays important roles in understanding particle physics, advanced nuclear physics, condensed matter physics and cosmology. Application of fundamental concepts QFT to Quantum Electrodynamics(QED) has been rigorously pursued in this course.

1. **Basic Field Theory, Symmetries and Conservation Laws:** Natural Units, Review of four vectors, tensors and Lorenz Invariance, Motivation for Local field theory, Elementary particles and fields, Lagrangian Density and Euler-Lagrange equations for Scalar, Complex scalar, Dirac and Vector fields. Noether's theorem, Space-Time translations and the Energy-Momentum Tensor, Lorentz Transformations and Angular Momentum Tensor, Internal Symmetries, Global transformations, U(1) Local transformation and gauge fields. Coupling to Fermions, Coupling to Scalars, The Hamiltonian Formalism.

2. **Free Fields Quantization:** Canonical quantization procedure, Quantization of free hermitain scalar field and Complex Scalar fields. Vacuum, Cosmological Constant, Normal ordering, Relativistic Normalization. Dirac field. Spinors and its Lorentz Transformations, Bi-bilinear Covariants, Quantization of Dirac fields, Commutation and anti-commutation relations and spin statistics theorem, Electromagnetic field quantization, Gupta-Bleuler formalism. Propagators as vacuum expectation values, Green's Functions, time ordering and Wick's Theorem.
3. **Greens' Function and Fields in Interaction:** Propagators as vacuum expectation values, Green's Functions, time ordering and Wick's Theorem. Construction of interaction Lagrangians, Yukawa interaction, φ^4 interaction, The Heisenberg Picture, Interaction picture and S matrix, Dyson's Formula,.
4. **QED and Elementary process**: QED Lagrangian and Perturbative expansion of S Matrix. 1st and 2nd order diagrams. Elementary process and Feynman rules in co-ordinate space, Feynman rules in momentum space. Lowest order calculation of Compton scattering, Klein-Nishina formula. Elementary discussion of mass and charge renormalisation.

Outcome: Students learn Electromagnetic field quantization; Propagators of scalar, spinor and electromagnetic fields; Quantum Electrodynamics (QED) and interacting fields, examples of some basic QED Process. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. So that it will help to pursue research career in respective fields.

Text Books:

1 Quantum Field Theory: C Itzykson and J B Zuber: McGRAW-HILL International Editons 1985

2 Quantum Field Theory : Franz Mandl and Graham Shaw: John Wiley and Sons Ltd, 2010

References:

1. Quantum Field Theory: Lewis H. Ryder : Cambridge University Press: 1996 2nd Edition.
2. Donald H. Perkins: Introduction to High-energy Physics, Cambridge University Press
3. D. C. Cheng and G. K. O'neill: Elementary particle Physics, Addison-Wesley.

4) Electronics (I)

OBJECTIVE: The Electronics topics covered here deals with the fundamentals of charge carrier motion, basics and working of pn junction, different types of junctions and their properties and working, fundamentals of bipolar junction transistor and its working, and different types of special devices. This will help students to gain knowledge on the basics and working of different electronic devices.

1. **Fundamentals:**

   Semiconductors: Formation of energy bands, band gap, elemental and compound semiconductors, E-k diagram, direct and indirect semiconductors, electrons and holes, effective mass, intrinsic semiconductors, extrinsic semiconductors – donor and acceptor levels, Fermi level and Fermi-Dirac distribution function, density of states, thermal equilibrium electron and hole concentrations in C-band and V-band respectively, Intrinsic carrier concentration and Fermi level, extrinsic carrier concentration and Fermi level, degenerate and non-degenerate semiconductors.

   Carrier transport: Drift current density, mobility and conductivity, velocity saturation, diffusion and total current density.

   Excess carriers: Generation and recombination, continuity equation, time dependent diffusion, steady state carrier injection, diffusion length

2. **Junctions:**

   p-n junction: basic structure, contact potential, electric field, space charge width, effect of reverse biasing, junction capacitance, linearly graded junction, hyper abrupt junction and the varactor, forward bias and current flow in p-n junction, carrier injection, minority carrier distribution, ideal current-voltage relation, junction breakdown – Zener and avalanche, transients and switching diodes.

Metal-semiconductor junction: Ohmic and rectifying contacts, Schottky diode – ideal junction properties, non-ideal effects on barrier height, current-voltage characteristics, comparison with p-n junction.

Heterojunctions: Materials and band diagram, 2-D electron gas, electric field, potential, space charge, junction capacitance, isotype and anisotype heterojunction, current-voltage relation.

3. **Transistors:**

   BJT: Fundamentals of BJT operation, current gain relations, amplification with BJT, minority carrier distribution, evaluation of terminal currents and current gains and approximations for them, biasing modes and Ebers-Moll model, BJT switching, non-ideal effects – base width modulation, high injection, emitter band gap narrowing, non-uniform base doping, avalanche breakdown.

   JFET: basic operation, pinch off and saturation, ideal dc current voltage relation, transconductance, the MESFET

   MOSFET: Properties of the two terminal MOS structure, the MOSFET structure, current-voltage relation, transconductance

   HEMT and MODFET: Quantum well structure, Transistor performance, current-voltage relation.

4. **Special Devices:** Basic structure, principle, mechanism of operation, Current voltage relation/characteristics and applications of SCR, UJT, Diac, Triac; photodiode, photo transistor, solar cell, LED, Laser diode, Tunnel diode, Gunn diode and IMPATT diode.

OUTCOME: The course will enable the student to get an idea about basics of movement of charge carriers in semiconductors along with their behaviour in different energy bands. Students will also learn fundamental principles of pn junction and BJT along with their working under various conditions. They will further learn about some special electronic devices which work on similar principles.

Text Books:

[1] Physics of Semiconductor Devices by Donald A. Naemen, TMH
[2] Solid State Electronic Devices 4th Edition by Ben G. Streetman, PHI
[3] Electronics devices and circuits: Robert L Boylestad and Louis Nashelsky, Pearson

References:

[1] Physics of semiconductor devices: S. M. Sze
[2] Physics of semiconductor devices by D. K. Roy, University press
[3] Electronics devices and circuit theory: Allen Mottershead, PHI.

SEMESTER - III COURSE- III 4 CH

PHY- 513: X-ray and Laser Spectroscopy

OBJECTIVE: Laser spectroscopy topics covered here deals with the observation and interpretation of radiation absorbed or emitted by atoms or molecules. This information can lead into the knowledge of structure and properties of the atom/ molecule and help students to apply coherent light to solve various problems in areas such as scientific, industrial, healthcare etc.

1. **X-rays and Atomic Spectra:** Production and properties of X-rays, Augur transitions, Thomson and Compton scattering, X-ray spectra, Mosley diagram, Regular and irregular doublets. Sommerfeld's extension of the Bohr theory, Vector atom model, Quantum states of one electron atoms, Atomic orbitals, Hydrogen spectrum-Pauli's principle. Spin orbit interaction and fine structure in alkali Spectra, intensity rules – Equivalent and non-equivalent electrons. Interaction energy in LS and jj Coupling – Hyperfine structure
   Zeeman effect – Splitting of spectral lines in presence of weak and strong magnetic field, Stark effect, Two electron systems
2. **Molecular spectra:** Molecular spectra, Rotational spectra of diatomic molecules as a rigid rotator using Schrodinger wave equation and nonrigid rotator, intensity of rotational lines, Frank-Condon principle. Vibrational-rotational spectra, vibrational energy of diatomic molecule-Diatomic molecule as a simple harmonic oscillator, Effect of anharmonicity, Energy levels and spectrum-Morse potential, Raman spectroscopy
3. **Laser Fundamentals:** Einstein's quantum theory of radiation; Population inversion, Rate equations, Stability conditions, Three level and four level lasers;
4. **Types of Laser:** Issues in designing a laser; Pumping mechanisms; Stable and unstable resonators, Laser Cavity, Longitudinal and Transverse Modes, Mode Selection, Gain in a Regenerative Laser Cavity; Q-switching, Mode locking, Laser amplification, Ruby laser, He-Ne laser, Semiconductor lasers.

OUTCOME: The course will enable the student to get an idea about atomic and molecular spectra, spin orbit interaction, Zeeman and Stark effects, Raman spectra. Students will also learn fundamental principles of stimulated emission and how to convert it into coherent light emission, applications of various lasers in various fields including scientific research to common use.

Text Books:

[1] Atomic & Molecular Spectra; Raj Kumar, KedarNath Ram Nath, New Delhi, 1997
[2] Physics of Atoms and Molecules: Bransden and Joachain; Pearson; 2006.
[3] Lasers – Theory and Applications, by K. Thyagarajan and A. K. Ghatak; Macmillan.
[4] Harvey E. White: Introduction to Atomic spectra, McGraw-Hill Inc.
[5] Gerhard Hertzberg: Spectra of diatomic molecule, Krieger Pub. Company
[6] G. W. King: Spectroscopy and molecular Structure , Holt, Rinehart, New York
[7] S. Bhagavantam: Scattering of light and Raman Effect, Chemical Publishing Company, New York

References:

[1] Introduction to Atomic and Molecular Spectroscopy by Vimal Kumar Jain, Narosa Publishing House.
[2] Lasers and Non-Linear Optics, B. B. Laud; New Age International, New Delhi

SEMESTER –III COURSE - IV 4 CH

PHY- 514: RESEARCH METHODOLOGY

Unit - I

Application of statistical concept / procedures, data, diagrammatic, representation of data, probability, Measure of central tendency, Measures of dispersion, Skewness and kurtosis. Normal distribution: Simple correlation, multiple correlation, regression analysis.

Unit - II

Sampling simple random sampling, stratified random sampling, Systematic sampling. Testing of Hypothesis tests. χ (Chi-square), t and F-tests; Analysis of Variance; Covariance; Principal component analysis, Experimental design: Completely randomized block design, Randomized block design, Latin square design.

Unit – III

One-way analysis of variance, two way analysis of variance, Follow up tests; Non parametric procedure; Plotting graph; Preparing paper/report using Latex. Writing of research reports.

Unit - IV

Integration: Trapezoidal, Simpson, Weddle's and Gaussian Quadrature methods; Differentiation: Numerical derivative; Root Finding: Bisection and Newton-Raphson Method; Differential Equation: (1^{st} and 2^{nd} order): Euler's method, Runge-Kutta Method (4^{th} order algorithm), Least square fitting of a set of points to a straight line, Quadratic equation.

Texts and References:

1) D.K. Bhattacharyya, Research Methodology, Excel Books, New Delhi, II Edition
2) C.R. Kothari, Research Methodology.
3) S.C. Gupta, and V.K. Kapoor, Fundamental of Mathematical Statistics, S. Chand, New Delhi.
4) P. Richard, Linux: The complete Reference, Mc GrawHill.
5) J.B. Scarborough, Numerical Mathematical Analysis, Oxford and I.B.H.
6) S. S. Sastry: Introductory methods of Numerical Analysis, Prentice-Hall India Pvt. Ltd. Publisher

SEMESTER –III COURSE - V 2 CH

PHY- 515: Modern Physics Practical (I)

1. Experiments with the ESR Spectrometer, determination of the Lande’s g-factor.
2. Resistivity of semiconductor at different temperatures by Four-probe Method.
3. Determination of Hall Coefficient by Hall effect apparatus.
4. Determination of e/m by Braun tube method.
5. Determination of e/m by Hellical method.
6. Determination of e/m by Magnetron Valve.
7. Determination of Plank’s constant by using an optical pyrometer.
8. Determination of Planck’s constant by using photo-cell and a ballistic Galvanometer.

OUTCOME: The students will do experiment determe the Lande’s g-factor using ESR method, resistivity of semiconductor at different temperatures by Four-probe Method, Hall Coefficient by Hall effect apparatus, specific charge of electron by helical method, Planck's constant Planck's constant using pyrometer and photocell and Frank-Hertz experiment. They will be able to handle sophisticated equipment and learn its use in diverse field in science and technology. Apply the skill developed to pursue experimental research in advanced topics.

(Any other experiment suggested by the course teacher)

SEMISTER – III **COURSE - VI** **2 CH**

PHY – 516: Elective Paper Practical (I)

The student shall choose the corresponding special paper practical as for Course No. PHY – 512.

1) Nuclear Physics Practical (I)

Experiments with GM counter**:**

1. Determination of the operating plateau and its percentage slope.

2. Determination of the dead time of the instrument using Beta source.

3. Determination of the linear mass absorption co-efficient of aluminium for beta source.

4. Determination of the end point energy of beta rays by finding its range in aluminium.

5. Verification of the inverse square law.

6. Determination of half-life of given beta-source.

7. Experiments with the Gamma Ray Spectrometer:

8. Calibration and determination of resolution of the spectrometer.

9. Spectrum analysis of given Gamma-sources (Cs^{137}, Co^{60}, Co^{57},N^{22} etc) with the photo peak, back scatter peak, Compton peak etc.

10. Determination of energy and relative intensity of Gamma rays of the supplied source.

11. Determination of the resonance frequencies of different samples using Nuclear Magnetic Resonance technique.

12. Determination of Lande's "g" factor using Nuclear Magnetic Resonance technique.

(Any other experiment suggested by the course teacher)

OUTCOME: Students will do experiment on determination of the operating plateau and its percentage slope for G.M. Counter, determination of the dead time of the instrument using Beta source, determination of the linear mass absorption co-efficient of aluminium foil for beta source, determination of the end point energy of beta rays by finding its range in aluminium, Verification of the inverse square law and Experiments with the Gamma Ray Spectrometer.

2) Condensed Matter Physics Practical (I)

1. Measurement of magnetic susceptibility (X_m) by Quincke's method

2. Measurement of X_m of solid by magnetic balance

3. Measurements with the Ultrasonic-interferometer: determination of velocity of ultrasonic waves in the given liquid.

4. Measurements of the di-electric constant of the given liquid by the ultrasonic interferometer.

5. Determination of heat capacity of a given sample.

6. Measurements of di-electric constant of wax (and other materials) using the Lecher wire.

7. To study the hybrid parameters of a junction transistor.

8. Experiments with the Lattice dynamics Kit: (i) Study of dispersion relation of Mono and di-atomic linear chain, (ii) to determine the band-gap frequency.

9. Study of LED, Zener diode and Phototransistor characteristics.

10. Determination of energy gap of a given semiconductor

(Any other experiment suggested by the course teacher)

OUTCOME: Students will do experiment on measurement of magnetic susceptibility (χ_m) of a paramagnetic substance by Quincke's method, determine the velocity of wave in a liquid medium, measurements of di-electric constant of wax using the Lecher wire, determination of heat capacity of a given sample, and experiments with the Lattice dynamics kit to study of dispersion relation of mono and di-atomic linear chain and to determine the band-gap frequency.

3) High-Energy Physics Practical (I)

Experiments with GM counter**:**

1. Determination of the operating plateau and its percentage slope.

2. Determination of the dead time for Beta rays.

3. Determination of the linear mass absorption co-efficient of aluminium for beta source.

4. Determination of the end point energy of beta rays by finding its range in aluminium.

5. Verification of the inverse square law.

6. Determination of half-life of given beta-source.

7. Experiments with the Gamma Ray Spectrometer:

8. Calibration and determination of resolution of the spectrometer.

9. Spectrum analysis of given Gamma-sources (Cs^{137}, Co^{60}, Co^{57},N^{22} etc) with the photo peak, back scatter peak, Compton peak etc.

10. Determination of energy and relative intensity of Gamma rays of the supplied source.

(Any other experiment suggested by the course teacher)

OUTCOME: Students will do experiment on determination of the operating plateau and its percentage slope for G.M. Counter, determination of the dead time of the instrument using Beta source, determination of the linear mass absorption co-efficient of aluminium foil for beta source, determination of the end point energy of beta rays by finding its range in aluminium, Verification of the inverse square law and Experiments with the Gamma Ray Spectrometer

4) Electronics (I)

1. Characteristics of OP-Amp IC741, Inverting and Non-Inverting type, Mathematical Operations using Op-Amp - Adder, Substractor, Differentiator and Integrator.

2. Feedback amplifier using Op-Amp.

3. Relaxation Oscillator using Op-Amp

4. High and low frequency compensation of RC amplifier.

5. Effect of circuit elements on RC amplifier frequency response.

6. Negative feedback effects on RC amplifier.

7. Characteristics of RF amplifier.

8. Characteristics of power amplifier.

9. Hartely oscillator.

10. Colpitt Oscillator

11. Phase shift Oscillator

12. Astable Multivibrator

13. Characteristics of a regulated power supply

14. Characteristics of an FET Amplifier

(Any other experiment suggested by the course teacher)

OUTCOME: Students will do experiment on different functionalities of OPAMP, different oscillators and amplifiers and thereby understand the basic working principles and the applicability of such devices.

SEMISTER - III **COURSE - VII** **3 CH**

PHY – 517 : MOOC Course

Students have to choose from a list of related courses floated by different online platforms like SWAYAM and NEPTL during that given semester.

SEMISTER - III **COURSE - VIII** **2 CH**

EDPS-439 : Entrepreneurship Development

(Syllabus as prescribed by P. G. Council, S. U.)

SEMESTER - IV **COURSE - I** **4 CH**

PHY- 521 : Nuclear Physics

OBJECTIVE: To gain the knowledge of basic concept of nucleus, nuclear force, nuclear structure, nuclear reaction and nuclear transformation.

1. **Basic facts about Nuclei, The two Nucleon problem and Nuclear Force:** Composition, mass, charge, density, radii, spin parity, I-spin and statistics, Nuclear size: Nuclear and E.M. methods, electron scattering. Ground state of deuteron with central force, low energy neutron-proton scattering, concept of scattering length and spin dependence of nuclear force, Elementary idea about proton-proton and neutron-neutron scattering.

2. **Symmetries, Nuclear Force and Nuclear Structure:** Exchange nature of nuclear force, phenomenological nucleon-nucleon potentials, elementary idea about Meson theory of nuclear force. Binding energy, semi-empirical mass formula, extreme single particle shell model, magic numbers, magnetic moments.

3. **Nuclear Reaction:** Elastic and reaction cross-sections, compound nucleus, resonances, Breit-Wigner formula.

4. **Radioactivity:** Laws of radioactivity, Gamow theory of alpha decay, Fermi theory of beta decay, selection rules.

OUTCOME: The students will learn about elementary nuclear physics, Meson theory of nuclear force, two nucleon system, nuclear structure and reactions and radioactivity. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply basic concepts to advanced topics in nuclear physics and technology.

Text Books:

[1] Lewis R. Elton: Introductory Nuclear Physics, publisher, Pitman, 1995
[2] Nuclear Physics, R. R. Roy and B. P. Nigam, Wiley Eastern Limited.
[3] S. N. Ghosal: Nuclear Physics , S. Chand Publisher.

References:

[1] Structure of the Nucleus, M. A. Preston and R. K. Bhaduri, CRC Press; 1 edition
[2] Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, K. Heyde, by CRC Press

SEMESTER - IV **COURSE - II** **4 CH**

PHY- 522 : Particle Physics

OBJECTIVE: This course is aimed to introduce elementary particle physics from phenomenological and experimental prospective. The treatment is non-mathematical and it is geared to expose students to the exciting discovery of new particles and the necessity of new ideas for theoretical explanations of observed phenomena.

1. **Particle and their classification:** Basic interactions and their characteristics, Classification of elementary particles, their properties and history of their discovery, leptons, baryons, mesons and gauge fields.

2. **Symmetries and conservation laws:** Energy, momentum, angular momentum, electric charge, lepton and baryon number, parity, charge conjugation and time reversal, iso-spin, strangeness and hypercharge quantum numbers, Eight Fold Way, the Gellman Nishijima scheme.

3. **Elementary discussion of the quark model:** SU(3), Colour and flavour, quark model of hadrons, basic characteristics of weak interaction, parity non-conservation in weak interaction, CP violation.

4. **Detection of particles, radiation and Accelerators:** Passage of radiation through matter, classical derivation of stopping power (dE/dx) of heavy charged particles, G.M. counter, semi-conductor detectors, bubble chamber and cloud chamber, spark counter. Cherenkov Detectors. The Van-de Graff generator, cyclotron, synchrotron, linear and circular accelerators, colliders.

OUTCOME: The students will gain knowledge about history of discovery of elementary particle and the nature of fundamental forces, baryon number, lepton number, Eightfold way, quark model of baryons and mesons, CP violation, accelerators and detectors. Apply the mind-set developed in the process to look into any issues relating science or society in a fundamental and logical way challenging conventional wisdoms.

Text Books:

1. Introduction to Elementary Particles: David Griffiths: WILEY-VCH: 2008
2. Techniques for Nuclear and Particle Physics Experiments: How-to Approach: Leo, William R: Springer-Verlag: 1994

References:

[1] Melvin Leon: Particle physics: an introduction, Academic Press

[2] Donald H. Perkins: Introduction to High-energy physics, Cambridge University Press
[3] David C. Cheng and K. O'neil: Elementary particle physics, Addison Wesley.
[4] M P Khanna: Particle Physics an Introduction , Prentice hall of India Pvt. Ltd.

SEMESTER - IV **COURSE - III** **4 CH**

PHY – 523 : ELECTIVE PAPER-II

The student shall choose second part of the corresponding elective paper as in PHY – 512.

1) Nuclear Physics (II)

OBJECTIVE: This paper provides a broad knowledge on Nuclear reaction, beta decay and nuclear energy production.

1. **Nuclear Reactions and Compound Nuclear Model:** Partial wave analysis, Scattering and reaction cross-section, Resonances, The one level Breit- Weigner formula for S-wave neutrons, Kapur-Pierl's many level dispersion formula for S-wave neutrons. Formation cross-section of compound nucleus and its various modes of decay. The continuum model of nuclear reaction, Statistical theory of nuclear reactions.

2. **The Optical Model:** The complex potential and mean free path of a nucleon in a nucleus, averaging of scattering and reaction cross section Phenomenological optical potentials. General features of direct nuclear reactions, stripping and pick-up reaction cross-sections in Plane wave Born approximation, Qualitative features of distorted wave Born approximation.

3. **Nuclear beta decay and weak interaction:** Observed beta decay spectrum, neutrino hypothesis and Fermi theory of beta decay, Kurie plot, Fermi and Gamow –Teller transitions, Nuclear transition matrix elements, weak interaction in beta decay and parity violation.

4. **Nuclear fission and Nuclear Astro-Physics:** Spontaneous and induced fission, fission cross section, mass and energy distribution of fission fragments, description of fission in the liquid drop model, nuclear fission as a barrier penetration phenomena, chain reaction. Nucleo-synthesis in star matter, CNO cycle, elementary idea on s-process and r-process.

OUTCOME: Meson theory of nuclear force, two nucleon system, nuclear structure and reactions and radioactivity. They will be able to analyse the above concepts and solve problems relating to the knowledge gained for the future endeavour.

Text Books:

[1] Nuclear Physics, R. R. Roy and B. P. Nigam, Wiley Eastern Limited.
[2] Introductory Nuclear Theory, L. R. B. Elton, Published by Saunders, Philadelphia.
[3] Introductory Nuclear Physics, Samuel S.M. Wong, Wiley-VCH Verlag GmbH & Co.

[4] Cauldrons in the cosmos: Nuclear Astrophysics, Nuclear Astrophysics,Claus E. Rolfs and William S. Rodney, University of Chicago Press: 1427 E. 60th Street Chicago, IL 60637 USA.

[5] Compact stars : nuclear physics, particle physics, and general relativity, Norman K. Glendenning, New York ; Springer-Verlag.

References:

[1] Nuclear Physics, S. N. Ghoshal, S. Chand Publishing.

[2] Structure of the Nucleus, M. A. Preston and R. K. Bhaduri, CRC Press; 1 edition (December 21, 1993)

[3] Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, K. Heyde, by CRC Press.

[4] Nuclear Structure, Vol-I & II, Aage Bohr and Ben. R. Mottelson, World Scientific Publishing Co. Pte. Ltd..

[5] Nuclear Models: Basic Concepts in NuclearTheory, Joachim A. Maruhn, Springer London, Limited, 1997.

[6] Theoretical Nuclear Physics, J. M. Blatt and V. F. Weisskof, Springer-Verlag New York.

[7] Theory of Nuclear Structure, M. K. Pal,Published by Scientific and Academic Editions (1983).

[8] Elementary Nuclear Theory, Hans Bethe and Philip Morrison, Dover Publications.

[9] Introductory Nuclear Physics, Kenneth S. Krane, JOHN WlLEY& SONS.

[10] Black Holes, White Dwarfs and Neutron Stars : the physics of compact objects, S. L. Shapiro & S. A. Teukolsky, WILEY-VCH Verlag GmbH & Co. KGaA.

2) Condensed Matter Physics (II)

OBJECTIVE: This paper provides a broad knowledge on Condensed Matter Physics and their use in basic and applied research.

1. **Magnetism:** Dia and Para magnetism, Langevin’s equation, diamagnetic and Para magnetic susceptibility, the Curie law, Quantum theory of paramagnetism, Pauli paramagnetism, Landau levels, Ferro, anti-ferro and ferrimagnetism, The nature and origin of the Weiss molecular field: exchange interaction, Temperature dependence, the ferromagnetic phase transition, Spin waves and magnons, Bloch $T^{3/2}$ law, anti ferromagenatic order, Neel temperature, Simple description of magnetic resonances: NMR, ESR and Some applications, the Bloch equation.

2. **Superconductivity:** Fundamental Characterization of Superconductors, Flux exclusion: Meissner effect, London’s equation, Instability of the Fermi see and Copper pairs, The BCS theory, BCS Ground state, Comparision with experimental results, super current, the coherence length

3. **Types of superconductors:** Type-I and Type-II super conductors, Elementary discussion of high temperature superconductors, Heavy Fermions superconductor and Fullerene superconductor.

4. **Nanostructured Materials:** Brief introduction to different nanostructuredmaterials, Discussion of the size dependent properties related to Mechanical, Magnetic and Optical properties of these nano particles, Quantum mechanical solution and the derivation for the energy spectrum and density of states for Quantum wells, Quantum wires and Quantum dots.

OUTCOME: At the end of the course students will learn Crystallography, band structure of semiconductors, dielectric and optical properties insulators, phase transitions and critical phenomena, nanomaterials and liquid crystals. They will be able to analyse the above concepts and solve problems relating to the knowledge gained for the future endeavour.

Text Books:

1. Introduction to Solid State Physics by C. Kittel, Wiley Publication
2. Quantum Theory of Solids by C. Kittel, Wiley Publication
3. Solid State Physics by H. Ibach, H. Luth, Springer Publication
4. Solid State Physics by C. M. Kachhava, TATA McGraw- Hill Publication
5. Solid State Physics by Neil W. Aschroft, N. David Mermin Cengage Learning Pub

References:

1. Nanomaterial synthesis, Properties and Applications Ed. by A.S. Edelstauin and R.C. Cammarata, IOP Publications
2. Physics and Chemistry of finite systems: From clusters to crystals by P. Jena, S.N. Khana and B.K. Rao, Deventer: Kluwer, 1992.
3. Quantum Heterostructures by Vladmir V. Mitin, V.A. Kochelap, Michael A. Stroscio.
4. Principles of Theory of Solids by Ziman, Vikas Publishing House Pvt. Ltd.
5. Elementary Solid State Physics by M. Ali Omar, Pearson Publication

3) High-Energy Physics (II)

OBJECTIVE: This course is aimed to introduce the standard model of particle physics and neutrino physics to advanced undergraduate students. The course is taught from the experimental perspectives; covering details of the underlying theory along with mathematical details.

1. **Symmetries and quarks:** Basic facts about Lie Algebras, SU (2), SU(3), quarks and leptons, strangeness, isospin and color quantum numbers, Eight fold way, Gellman-Nishijima formula, evidence for colour, hadrons as color singlets, Gellman-Okubo mass formula, Charge Conjugation, Parity and Time reversal symmetry.
2. **Gauge Theory and Spontaneous Symmetry Breaking:** Abelian and Non Abelian gauge theory. Geometry of Gauge Invariance, Yang-Mills Lagrangian, Spontaneous Symmetry Breaking in global and local gauge theory, Goldstone Theorem and Higgs Mechanism.

3. **Standard Model:** Helicity, Chirality, V-A structure of weak interaction, $SU(2)_L X U(1)_Y$, Glashow - Salam-Weinberg model and electro weak unification, masses of W and Z bosons, fermion masses and mixing, CP violation, Feynman Rules of Standard Model, production and detection of Higgs.

4. **Neutrino Physics and Parton Model:** neutrino mass, Solar and Atmospheric neutrinos, Detection of neutrinos, Standard Solar Model and neutrino puzzles, neutrino oscillation in vacuum and in matter, MSW resonance, neutrinos in cosmology.Deep inelastic scattering, scaling of structure functions, the quark-parton model, Scaling violations and elementary discussion on QCD.

OUTCOME: At the end the course students should be able to describe the basic ingredients of the Standard Model of particle physics and recent developments in neutrino physics. Explain how experimental results are interpreted in terms of fundamental properties of quarks, leptons and force mediators. Understand and calculate physical process of various extensions of Standard Model and beyond it.

Text Books:

1 An Introduction to Quantum Field Theory: Michael E Peskin and Daniel V Schroeder: Westview Press, 1995, Levant Books 2005.

2 Massive Neutrinos in Physics and Astrophysics:): Rabindra N Mohapatra and Palash B Pal : World Scientific Lecture Notes in Physics: Volume 72, 3rd Edition, 2004

3 Gauge Theories of the Strong, Weak, and Electromagnetic Interactions: Chris Quigg : Princeton University Press: Second Edition 2013.

References:

[1] D. H. Perkins: Introduction to High Energy Physics, Cambridge University Press
[2] T.D. Lee: Particle Physics and Introduction to Field Theory, Harwood Academic Publisher
[3] L.H. Ryder: Quantum Field Theory, Cambridge University Press
[4] M. Leon: Particle Physics: An introduction, Academic Press

4) Electronics (II)

OBJECTIVE: This course is aimed to introduce the students to the fundamentals of analog and digital modulation, noise in communication systems, information theory and coding, and ionosphere communication. The course is taught from the experimental perspectives; covering details of the underlying theory along with mathematical details.

1. **Fundamentals, Analog and Digital Modulation:** Transmission through Linear System; Ideal and Practical Filters; Distortion over a channel; Energy and Energy Spectral Density; Power and Power Spectral Density, Principle of Modulation, Generation, and Detection of DSB, DSB-SC, AM, and SSB, Elementary idea on Superheterodyne AM Receiver; Exponential Modulation, Concept of Instantaneous Frequency, Bandwidth of Angle Modulated Wave, Indirect (Armstrong) and Direct

Generation of FM, FM Demodulation, Interference in Angle Modulation. Sampling approximations, Quantization, PCM, DPCM, Delta Modulation, Adaptive Delta Modulation, ASK, PSK, DPSK, and FSK.

2. **Noise in Communication Systems:** AM receiver SNR, Noise in DSB-SC & SSB using coherent receiver, Noise in AM using envelop detection, Noise in FM system, FM threshold effects, Pre-emphasis and De-emphasis in FM, BW requirements for CW Modulation.

3. **Information Theory and Coding:** Discrete message, Concept of Information amount, Entropy, Information Rate, Coding to increase Average Information per Bit, Shannon's Theorem, Channel capacity, Gaussian Channel Capacity, BW-S/N Tradeoff, Orthogonal Signals for Shannon's Limit, Orthogonal Signal Transmission efficiency.

4. **Ionosphere Communication:** Stratification of ionosphere, propagation of electromagnetic waves through the ionosphere, Effective ϵ and σ of an ionized gas, reflection and refraction of e-m waves by the Ionosphere, Attenuation factor for Ionosphere propagation, Effect of collision and Earth's magnetic field. Skip distance and Maximum usable frequency.

OUTCOME: At the end the course students should be able to describe the basics of analogue and digital modulation covering the working of various parts and demodulation. Further the students will learn about the cause and remedy of noise in communication systems, information theory and coding and the details of the communication in ionosphere.

Text Books:

[1] R. L. Boylestad & L. Nashelsky : Electronic Devices and Circuit Theory, Pearson edition

[2] Physics of Semiconductor Devices by Donald A. Naemen, TMH

[3] Solid State Electronic Devices 4th Edition by Ben G. Streetman, PHI

References:

[1] Principles of Communication Systems: Taub & Scheiling, TMH – 2nd Edition.

[2] Modern Digital and Analog Communication Systems: B. P. Lathi, Oxford University Press, 3rd Edition

[3] Electromagnetic waves & Radiating Systems: E.C. Jordan, K.G. Balman, PHI 2nd edition

[4] Communication Systems: Symon Hykins, New Age International.

[5] Electronic Communication System: George A Kennedy, TMH Publication.

SEMESTER - IV **COURSE - IV** **2 CH**

PHY – 524 : Modern Physics Practical (II)

1. Characteristics of an astable multi vibrator.

2. Experiments with a Lecher wire.

3. Spectral sensitivity of a photocell.

4. Experiments with an Ultrasonic interferometer.

5. Experiments with CD-spectrograph.

6. Magnetic susceptibility of solid by magnetic balance.

7. Determination of e by Millikan's Oil-drop method.

8. Experiment with NMR

(Any other experiment suggested by the course teacher)

OUTCOME: The students will do experiment to measure dielectric constant of a wax using Lecher wire, determine the velocity of ultrasonic wave in a liquid medium, measure the electric charge of a single electron**,** spectral sensitivity of photo cell and multi-vibrators, determine the Lande's "g" factor using Nuclear Magnetic Resonance technique. Apply the skill developed to pursue experimental research in advanced topics.

SEMESTER - IV **COURSE - V** **2 CH**

PHY – 525: Elective Paper Practical (II)

The student shall choose the corresponding elective paper practical as for Course No. PHY – 512.

1) Nuclear Physics Practical (II)

1. Determination of energy resolution of given Gamma sources.
2. Activity of the Gamma source (Relative Method).
3. Activity of the Gamma source (Absolute Method).
4. Photo-peak efficiency of Na-I crystals.
5. Experiments with the Beta-Ray Spectrometer:
6. Plot of momentum distribution of beta-rays.
7. Calibration by a pulser.
8. Determination of the end point energy of beta rays.
9. The Fermi **plot** and Curie **plot**.
10. Measurement of energy spectrum of emitted beta rays.
11. Experiments with the radiation detection inerfacing instrument: Spectrum analysis of given Gamma-sources (Cs^{137}, Co^{60}, Co^{57},N^{22} etc) with the photo peak, back scatter peak, Compton peak etc. by obtaining the spectrum on the computer screen with the radiation detection interfacing instrument.
12. Calibration of the gamma spectrum and determination of the energy of unknown source

(Any other experiment suggested by the course teacher)

OUTCOME: The students perform experiments by using Gamma ray spectrometer, Alpha spectrometer, Scintillators and Nuclear emulsion. They acquire a hands on experience of handling these particle detectors, collect and analyze data and verify some results that they learn in theory.

2) Condensed Matter Physics Practical (II)

1. Measurement of electrical resistivity of germanium crystal by Four-Probe method, at different temperature.
2. Measurement of electrical resistivity of GaAs at different temperature by the Four-Probe method.

3. To set up and study the Hall-effect and measurement of carrier concentration in Ge, Si and GaAs semiconductor.
4. Determination of carrier mobility and Hall coefficient for Ge, Si, and GaAs.
5. Experiment with the electron spin resonance spectrometer.
6. Determination of dielectric constant of a given sample.
7. Determination of longitudinal velocity of Ultrasonic wave.
8. Study of characteristics of transistors (common base and common emitter configurations).
9. Study of characteristics of FET.
10. Determination of band gap in a semiconductor using p-n junction diode.
11. Determination of transistor parameters in CE, CB and CC using BJT. Configurations.
12. Determination of Young's modulus using Piezo electric oscillator.
13. Determination of Curie temperature of a given ferroelectrics sample.
14. Determination of loss factor and natural frequency of a sample.

(Any other experiment suggested by the course teacher)

OUTCOME: Students perform experiment to measure resistivity of a material using four probe method, carrier concentration of semiconducting material using Hall effect, dielectric constants of solids and Curie temperature of a ferroelectric material.

3) High-Energy Physics Practical (II)

1. Determination of energy resolution of given Gamma sources.
2. Activity of the Gamma source (Relative Method).
3. Activity of the Gamma source (Absolute Method).
4. Photo-peak efficiency of Na-I crystals.
5. Experiments with the Beta-Ray Spectrometer:
6. Plot of momentum distribution of beta-d\rays.
7. Calibration by a pulser.
8. Determination of the end point energy of beta rays.
9. The Fermi-Curie point.
10. Measurement of energy spectrum of emitted beta rays.

(Any other experiment suggested by the course teacher)

OUTCOME: The students perform experiments by using Gamma ray spectrometer, Alpha spectrometer, Scintillators and Nuclear emulsion. They acquire a hands on experience of handling these particle detectors, collect and analyze data and verify some results that they learn in theory.

4) Electronics Practical (II)

1. Design and study of AM and SSB systems (Generation and Detection).
2. Design and Study of FM systems (Generation and Detection).
3. Design and Study of PCM, PAM and PDM (PWM) systems.
4. Study of truth tables of different logic gates.
5. Study of NAND and NOR gates as Universal building block.
6. Study of various arithmetic circuits, Half adder, full adder, half substractor, full substractor,
7. Study of various Flip-flops.
8. Study of 7-segment display.
9. Study of Multiplexer and Demultiplexer.
10. Design and study of TDM Units.
11. Design and study of FDM Units.
12. Study of ADC and DAC.
13. Measurement of microwave frequency, wavelength, power, and SWR.
14. Study of satellite communication.

(Any other experiment suggested by the course teacher)

OUTCOME: The students perform experiments on different electronics gates, logic gates, functions of OPAMP, flip-flops, multiplexer and TDM units, ADC and DAC. They acquire a hands on experience of handling these instruments and verify some results that they learn in theory.

SEMESTER - IV **COURSE - VI** **4 CH**

PHY - 526 : Research Project cum Grand Viva

Every student will have to work under the supervision of a faculty for a project and deliver a seminar talk on the findings. Further, a Grand Viva for all subjects taught in the entire course will be conducted.

SEMESTER-II COURSE-VII 3CH

IDC- 429: IDC or Open elective course (PHYSICS)

Inter Disciplinary Course offered by School / Department of Physics, SU

Title of the Course: General Concepts of Physics.
Nature of Course: Open elective paper for students of other departments including students from humanities and social science.
Prerequisites: This course will be at popular level with school level mathematical/science knowledge. What is needed is curiosity to learn how physical world works.
Course Credit: 3 CH
Duration: 3 Hrs lecture/week, total 10 to 12 weeks duration in 2nd Semester.
Intake Capacity: 40
Evaluation: Two quizzes of 5 marks each, 15 marks mid semester and 25 marks end semester examination.
Course Objectives: Learning about concepts of physics in their scientific, historical and current technological context.

Unit-1 6 Hr

History of Modern Physics from Galileo, Newton up to Einstein, Introduction of solar system, galaxy, various astrophysical objects and big bang cosmology, Introduction of molecules, atoms, nucleus, elementary particles and their observation at various laboratories.

Unit-2 8 Hr

Nuclear Physics, Binding Energy, Nuclear Fusion and fission, Nuclear reactors, Nuclear Medicines, X-ray, MRI, PET/CT Scan.

Unit-3 8 Hr

Solid, Liquid and Gaseous state of matter. Metal, Insulator and semiconductor, Photoelectric Effect and its uses, Superconductivity and novel materials, Light and lasers, working of heat engines.

Unit-4 8 Hr

Basics of electronics, working of microphones, speakers and amplifiers, Power generation and transmission, Basics of Computers.