NAGALAND UNIVERSITY

(A Central University Estd. By the Act of Parliament No. 35 of 1989)

Headquarters: Lumami – 798 627

M.Sc. (PHYSICS) PROGRAMME

COURSE STRUCTURE AND DETAILS

(Approved by the 39th Meeting of the Board of School of Sciences)

DEPARTMENT OF PHYSICS
SCHOOL OF SCIENCES

Program Learning Outcomes (PLO)

A student who has completed MSc physics programme creates a comprehensive scientific knowledge, and this knowledge will help to understand, explain, and to solve advanced scientific problems.

1. An adequate level of physics knowledge transmitted through courses in the basic curriculum covering the following topics: Classical Mechanics, Electromagnetic theory, Quantum mechanics, and Statistics

When a student has a solid grasp of the fundamental ideas and is equipped with critical thinking skills, they are able to understand mechanics and electronics.

2. Possess expertise in a variety of optical spectroscopy techniques, including the use of spectrometers and the interpretation of IR, Raman, electronic absorption, and fluorescence spectra.

3. By practicing problem-solving skills and improving the ability to understand breakthroughs in emerging physics research areas and through exploratory work, project work, research seminars, and other activities.

4. To use cutting-edge computer technology to forecast and model complex physics problems using current experimental and theoretical physics tools.

Program specific outcomes (PSO)

On completion of the course the students will be able to explain the wide range of physical phenomena:

1. Recognize and apply the fundamental physics concepts and interaction laws that control our universe.
2. Show the ability to solve physics related problems and demonstrate the physics phenomenon through experiments.
3. Well qualified to pass national and state-level qualifying exams for graduate and post graduate level research and teaching.
4. The information learned in the course will also enable the students to pursue their higher education and to use their knowledge to enter the R&D and industrial sectors.

Semester I **Total No. of Credits: 20**

Course No.	Name of the Course	Contact Hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
PHY401	Classical Mechanics	4	--	4
PHY402	Mathematical Methods – I	4	--	4
PHY403	Electromagnetic Theory – I	4	--	4
PHY404	Analog and Digital Electronics	4	--	4
PHY405	Computational Methods laboratory	2	4	4

Semester II **Total No. of Credits: 20**

Course No.	Name of the Course	Contact Hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
PHY451	Quantum Mechanics - I	4	--	4
PHY452	Mathematical Methods – II	4	--	4
PHY453	Electromagnetic Theory – II	4	--	4
PHY454	Statistical Mechanics	4	--	4
PHY455	Electronics Laboratory	2	4	4

Semester III **Total No. of Credits: 20**

Course No.	Name of the Course	Contact Hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
PHY501	Quantum Mechanics – II	4	--	4
PHY502	Solid State Physics - I	4	--	4
PHY503	Spectroscopy	4	--	4
PHY504	Nuclear and particle Physics	4	--	4
PHY505	General Physics Laboratory - I	2	4	4

Semester IV **Total No. of Credits: 20**

Course No.	Name of the Course	Contact Hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
PHY551(A) (or) PHY551(B)	Advanced Quantum Mechanics (or) Magnetism	4	--	4
PHY552(A) (or) PHY552(B)	Solid State Physics – II (or) Superconductivity	4	--	4
CBCP PHY553(A) (or) PHY553(B)	Modern Optics (or) Dielectric and Luminescence properties of Solids	4	--	4
PHY554	Project	4	--	4
PHY555	General Physics Laboratory - II	2	4	4

1. The minimum (or total) number of credits towards completion of M.Sc. (Physics) course is 80.
2. A student must have 75% attendance in each of the courses including practical, failing which the student is not allowed to attend the end-semester examination.
3. The student must secure 40% marks in both *sessional* and *end-semester* examinations in order to get passed in the paper.
4. For 4-credit papers, the sessional and end-semester examinations are for 40 and 60 marks respectively.
5. The paper *PHY553(A & B)* with title *Dielectric and Luminescence properties of Solids* or *Modern Optic*s with 4 credits each is also termed as **CHOICE BASED CREDIT PAPER (CBCP)**. The student may choose any one of these during the 4th semester.
6. A student may opt for earning additional credits by taking available elective papers from the department and/or SWAYAM platform.

Course Title: Classical Mechanics (Core)
Course Number: PHY401
Total Marks: 100
Total Credits: 4

Course Outcome:
At the end of the course PHY-401, the students will understand

- Basic knowledge of equation of motion of a single particle and a rigid body
- The Newtonian, Lagrangian and Hamiltonian formalism for the equation of motion
- Solving the equation(s) of motion for different physical systems through various formalism using generalized coordinates
- The features of central force experienced by a body

UNIT I: Conservation principles of a single and system of particles, Constraints, Degrees of freedom, Generalized coordinates, Hamilton's variational principle, D'Alembert's principle, Deduction of Lagrange's equation and Hamilton's principle, Rayleigh's dissipation function, Lagrange's equation of motion, Lagrangian for a charged particle in an electromagnetic field, and other applications, Superiority of Lagrangian approach over Newtonian mechanics.

UNIT II: Non-holonomic system and applications, Hamilton's equations of motion, Significance of Hamiltonian, Applications of Hamiltonian formulation, Charged particle in an Electromagnetic field, Ideal spring, Mass system, Cyclic coordinates.

UNIT III: Principle of Least action, Canonical transformations, Conditions for a transformation to be canonical, Hamilton-Jacobi method, Harmonic oscillator. Poisson brackets and properties – Invariance of Poisson's brackets under canonical transformation – Hamilton's equation in Poisson bracket notation.

UNIT IV: Motion under a Central force, General features, Motion under inverse square law – Kepler problem, Virial theorem, Unbound motion in Rutherford scattering, Transformation of scattering problem to laboratory co-ordinates.

Text Books & References:

1. Classical Mechanics – J.C.Upadhyaya, Himalaya Publishing House, India (2010).
2. Introduction to Classical Mechanics – R.G. Takwale & P.S. Puranik, Tata McGraw - Hill Education, New Delhi.
3. Classical Mechanics – H.Goldstein, 2nd Edition, Addison-Wesley Pub. Co.
4. Classical Mechanics of particles and Rigid bodies – Kiran C. Gupta, New Age International (p) Ltd (2008).
5. Classical Dynamics – J. B. Marion, Saunders College Publishing.
6. Classical Mechanics – A. K. Raichaudhuri Oxford University Press.

7. Classical Mechanics – S.L. Gupta, V. Kumar and H.V. Sharma, Pragati Prakashan Publishers, Meerut, India (2010).
8. Classical mechanics – P.S. Joag and N.C. Rana, Tata McGraw - Hill Education (2001).

Course Title: Mathematical Methods – I (Core)
Course Number: PHY402
Total Marks: 100
Total Credits: 4

Course Outcome:
At the end of the course, students will understand

- Basic and advanced mathematical tools required for Physics Problems
- Apply calculus, vectors, and vector calculus tools for problem solving various branches of Physics.
- Apply the methods of complex analysis to evaluate definite integrals and infinite series and they should be able to apply contour integrals and residue theorem to analyze simple problems in theoretical physics.
- Analyze theorems in Group theory and apply for solving physics problems.

UNIT I: Vector Analysis: Definitions, Dot and cross product, Scalar and vector triple product, Gradient, Divergence, Curl, Vector integration, Gauss and Stokes' theorem, Gauss's law, Poisson's equation, Delta function, Helmholtz's theorem.

UNIT II: Complex Variables: Geometrical representation of complex numbers, Functions of complex variables, Properties of elementary trigonometric and hyperbolic functions of a complex variable, Differentiation, Cauchy-Riemann equations, Properties of analytical functions, Contours in complex plane, Integration in complex plane, Cauchy theorem, Deformation of contours, Cauchy integral representation, Taylor series representation, Isolated and essential singular points, Laurent expansion theorem, Poles, Residues at an isolated singular point, Cauchy residue theorem, Applications of the residue theorem.

UNIT III: Group Theory: Definitions and examples of physically important finite groups. Point groups, multiplication table, Subgroups, Cyclic groups, Center, Classes, Cosets, Lagrange Theorem. Representations of finite groups, Irreducible representation characters, Great Orthogonality theorem and its consequences, Character table.

UNIT IV: Symmetry elements, Operations, Planes, Reflections, Inversion Center, Proper and Improper axes and rotations, Equivalence, Symmetry and Optical Isomerism, Symmetry point groups, Classes of Symmetry operations, Systematic procedure for symmetry classification of molecules and applications.

Text Books & References:

1. Applied Mathematics for Engineers and Physicists – Lious A Pipes and Lawrance R. Rarvill.
2. Mathematical Physics – By Ghatak, A K and Goyal, I
3. Mathematical Physics – By Satya Prakash
4. Mathematics for Physicists – Dennery & Kryzywicki
5. Complex Variables & Applications – R. V. Churchill
6. Mathematical Methods for Physics – G.Arfken
7. Mathematical Physics – B. D.Gupta. Vikas Publishing House, New Delhi
8. Complex Variables – Schaum Series
9. Vector and Tensor Analysis – Schaum Series
10. Chemical Applications of Group Theory – F.A. Cotton, John-Wiley and Sons.

Course Title: Electromagnetic Theory – I (Core)
Course Number: PHY403
Total Marks: 100
Total Credits: 4

Course Outcome:

- Basic and advanced understanding of electric and magnetic fields in vacuum and matter.
- Understanding the different approaches/techniques in finding the electric and magnetic fields.
- Finding the electric and magnetic potentials.

UNIT I: Electrostatics: Coulomb's law, Continuous charge distributions, Gauss's law and applications, Electric potential, Poisson and Laplace equations, Localized charge distribution, Boundary conditions, Energy of a point and continuous charge distributions, Comments. Conductors – Basic properties, Surface charge and the force on a conductor, Capacitors. 1D, 2D, 3D, spherical symmetric Laplace's equation, Boundary value problems and their solution by separation of variables. Method of images – Classic image problem, Induced surface charge, Force and energy and other image problems, Multipole expansion – Approximate potentials at large distances, Electric – monople, dipole and quadrupole moments.

UNIT II: Dielectric materials, Induced dipoles, Polarization, Bound charges and Physical interpretation, Gauss's law in the presence of dielectrics, Boundary conditions, Susceptibility, Permittivity, Dielectric constant, Boundary value problems with linear dielectrics. Maxwell's equations for electrostatics in differential and integral form. Introduction to vector and scalar potentials in electrostatics.

UNIT III: Magnetostatics: Magnetic field and Force, Biot-Savart Law, Magnetic field of a steady current, localized current distribution, magnetic moment, Ampere's law, Divergence and curl of B, Comparison of Magnetostatics and electrostatics, Magnetic vector potential, vector potential and magnetic induction for circular current loop, Boundary conditions, Multipole expansion.

UNIT IV: Dia, para and ferro-magnetic materials, Torque and forces on magnetic dipoles, Magnetic field on atomic orbits, Bound currents and Physical interpretation, Magnetic field inside matter, Ampere's law in magnetized materials, Boundary conditions, Magnetic Susceptibility and Permeability. Maxwell's equations for magnetostatics in differential and integral form.

Text Books & References:

1. Introduction to Electrodynamics – David J. Griffiths
2. Electrodynamics of continuous media – Landau & Lifshitz
3. Classical Fields – Landau & Lifshitz
4. Classical Electrodynamics – J. D. Jackson
5. Classical Electrodynamics – J. B. Marion

Course Title: Analog and Digital Electronics (Core)
Course Number: PHY404
Total Marks: 100
Total Credits: 4

Course Outcome:

At the end of the course, students will acquire knowledge of

- Skill in the design and development of electronic circuits to cater to the needs of electronic Industry.
- Understanding circuit components-diodes, transistor, FET.
- Design of amplifiers, Oscillators and OP-amp.
- Understand and execute the concepts of digital system design.
- Implement combinational and sequential logic circuits.

UNIT I: Analog Electronics

Network theorems. A. C. Equivalent Circuits of networks with active devices. Power Supplies: Half-Wave, Full-Wave and Bridge rectifiers. Transistor amplifiers: The CE, CB and CC configurations. The transistor hybrid model and the h-parameters for a transistor. Conversion formulae for the h-parameters of the different transistor configurations. Analysis of a transistor CE amplifier at low frequencies. The push-pull and the complementary–

symmetry power amplifiers. Transistor biasing, thermal stability. The BJT at high frequencies – the hybrid – model. Analysis of CE amplifier at high frequencies.

UNIT II:
The field effect transistor and its small signal model. The CS and CD amplifiers at low frequencies. Biasing the FET. The CS and CD amplifiers at high frequencies.

Feedback: The Gain of an amplifier with feedback. General characteristics of negative feedback amplifiers. The Barkhaussen Crieteria. Sinusoidal oscillators: RC oscillators – The Phase shift and the Wien's bridge oscillators. LC oscillators. Frequency stability and the crystal oscillators. Operational amplifiers: Characteristics of an ideal operational amplifier. Applications of operational amplifiers.

UNIT III: Digital Electronics
Digital computers, number systems, Arithmetic operations, decimal codes, Combinational logic circuits, binary logic and gates, Boolean algebra, Standard forms, Two-level circuit optimization, functions of two variables, exclusive-OR operator.

Combinational logic design: design concepts, Design procedure, Combinational functions and circuits, Binary adders (half and full adder), Binary subtraction (half and full subtraction), binary adder subtractors, Decoder, encoder, multiplexers, demultiplexer.

UNIT IV: Sequential circuits: latches, Flip-flops: R-S, J-K, Master slave J-K, D type and T type Flip Flop. Registers, Shift registers, Counters.

Data Converters: Analog to Digital data converters, Digital to analog data converters.

Text Books & References:

1. Integrated Electronics – Millman and Halkias
2. Electronic devices and circuit theory – Robert Boylested and Louis Nashlsky PHI 1991
3. Op-Amps & Linear integrated circuits – Ramakanth A.Gayakwad PHI 1991
4. Semi-Conductor Electronics – A.K.Sharma New Age International Publishers.
5. Electronics-anlog and digital – Nagarath PHI
6. Digital Logic and Computer Design – M. Morris Mano, Prentice-Hall India Pvt. Ltd.
7. Digital Electronics: Fundamental Concepts and Applications – C. E. Strangio, PHI.
8. Semi-Conductor Electronics – A.K.Sharma New Age International Publishers.
9. Fundamentals of Digital Circuits – A. Ananda Kumar, PHI, New Delhi.
10. Digital principles and applications – A.P. Malvino and Donald P. Leech TMH 1993.

Course Title: Computational Methods laboratory (Core)
Course Number: PHY405
Total Marks: 100
Total Credits: 4

Course Outcome:

At the end of the course, students will have understanding of

- Programming languages such as FORTRAN, C.
- Various numerical methods to solve algebraic and transcendental equations.
- Numerical integration and differentiation methods.
- Write and execute computer programs to solve numerical problems.

1. Roots of algebraic and transcendental equations: One point and two-point iterative methods, such as bisection method, inverse interpolation and Newton Raphson methods.

2. Matrix operations and simultaneous linear equations: Matrix addition, multiplication and inversion. Solution of simultaneous linear equations by matrix inversion methods.

3. Interpolation: Linear interpolation, Lagrangian interpolation, Newton's interpolation (different forms).

4. Integration: Newton-Cotes formulae, Gauss quadrature.

5. Ordinary Differential equations: Initial value problem Taylor's algorithm, Euler's methods, Runge-Kutta, and Predictor-corrector methods.

To execute the above-mentioned course, the course instructor may choose any one of the programming coding FORTRAN, C, MATLAB or MATHEMATICA, at his/ her discretion.

Text Books & References:

1. Introduction to Numerical Methods – T. R. McCalla,
2. Numerical Methods that work – F. S. Acton
3. An Introduction to Numerical Analysis – K. E. Atkinson
4. Numerical Recipes – W. H. Press

Course Title: Quantum Mechanics – I (Core)
Course Number: PHY 451
Total Marks: 100
Total Credits: 4

Course outcomes:
At the end of the course PHY-451, the students will understand

- Basic knowledge of wave function associated with a particle and the corresponding Schrödinger's wave equation
- The differential and operator method that describes the motion in the quantum regime
- Solving the Normalization constants, wave function and the total energy for a given system
- Differentiate the systems where quantum mechanics is to be applied.

UNIT I: Linear spaces and operators: Groups, fields, Vector spaces and subspaces, Linear dependence and independence, Basis and Dimensions, linear operators, Inverses, Inverse and rank of an operator, Matrix representation, Similarity transformations, Eigenvalues and eigenvectors, Norm and Inner product. Cauchy-Schwarz Inequality, Orthogonality,

UNIT II: Introduction only to Gramm-Schmidt orthogonalization procedure, Self-adjoint and unitary transformations, Eigenvalues & eigenvectors of Hermitian & Unitary transformations, Diagonalization. Review of linear algebra and introduction to Hilbert space. Dirac Bra-Ket notations,

UNIT III: Introduction to Quantum Mechanics: Black body radiation, Planck's hypothesis, Specific heat of solids, Heisenberg's uncertainty principle, Wave – Particle duality, Inadequacy of classical physics, the formulation of Quantum mechanics, The Schrödinger wave equation, Ehrenfest theorem, stationary states and their properties. Postulates of Quantum Mechanics, Wave function, Probabilistic interpretation, Expectation value.

UNIT IV: Particle in one dimension and three dimensions, potential well in one, two and three dimensions, Delta function potential, harmonic oscillator, hydrogen atom and rigid rotator, Problems

Text Books & References:

1. Quantum Mechanics – Leonard I. Schiff, 3rd Edition, Tata McGraw-Hill Education Private Limited, New Delhi. (2010).
2. Quantum Mechanics – Eugene Merzbacher, 3rd Edition, John Wiley & Sons, New York (1998).
3. Practical Quantum Mechanics – S. Flugge, 1st Edition, Springer-Verlag New York (1998)

4. A text book of Quantum Mechanics – Mathews and Venkatesan 2^{nd} Edition, McGraw-Hill Education Private Limited, New Delhi (2010).
5. Quantum Mechanics – M. P. Khanna, Har-Anand Publications Pvt. Limited
6. Principles of Quantum Mechanics – P. A. M. Dirac, 4^{th} Edition, Oxford University Press, London (1967).
7. Introduction to Quantum mechanics – David J. Griffiths, Prentice Hall, Inc. USA (1995).
8. Quantum mechanics – A.Ghatak and S.Lokanathan, McMillan publishers India Limited, New Delhi (2010)
9. Quantum physics of atoms, molecules, solids, nuclei, and particles – R. Eisberg and R.Resnick, 2^{nd} Edition, John Wiley & Sons, Inc. (1985)
10. Linear Vector Spaces – R. R. Halmos.

Course Title: Mathematical Methods – II (Core)
Course Number: PHY452
Total Marks: 100
Total Credits: 4

Course Outcome:

At the end of the course, students will have understanding of

- Mathematical tools for finding solutions of physics problems.
- Various types of special functions.
- Concept of Fourier and Laplace transform and their application in physics.
- Tensors and its importance in understanding as well as simplification of physical laws.

UNIT I: Differential equations & Special functions Power series solution for a differential equation, Legendre's differential Equation and its solution, Legendre's polynomials and Associated Polynomials Generating function, Rodrigue's formula – Orthogonal property, Recurrence Relations, Beta and Gamma functions, Properties-Relation between them, Bessel's differential equation and solution, Bessel's functions of 1^{st} and 2^{nd} kind, Generating function, Orthogonal property, Recurrence relations.

UNIT II: Hermite differential equation and solution, Hermite polynomials, Generating functions, Orthogonal property, Recurrence relations, Rodrigue formula, Hyper geometric equation and its solution, Laplace equation and its solution in Cartesian and spherical coordinates, Wave equation and its application to (i) Rectangular and (ii) Circular membranes.

UNIT III: Fourier and Laplace transforms: Fourier transforms and its properties, Fourier transform of a derivative, Finite Fourier transforms, Application of Fourier transform, Dirac delta function and its Fourier transform Auto correlation, Cross correlation and Convolution operations. Laplace transform and properties, Laplace transform of i) Derivative of a function (ii) Periodic function and (iii)Special functions like gamma, Bessel and error functions, Inverse Laplace transform and its properties, Convolution theorem and its use in evaluation of Inverse Laplace transform.

UNIT IV: Tensors: Transformation laws, Kronecker delta symbol, Contravariant and Covariant tensors, Rank of a Tensor, Tensors of higher rank, Pseudo and dual Tensor, Addition and subtraction of tensors, Outer product, Contraction of tensors, Inner product, Quotient Law, Extension of rank of a tensor, Symmetric and anti-symmetric tensors, Invariant tensors, Metric tensor, Christofell's symbols of first and second kind and transformation laws, Application of tensor to elasticity (simple stress and strain tensors only).

Text Books & References:

1. Mathematics for Physicists – Dennery & Kryzywicki
2. Mathematical Methods for Physics – G.Arfken
3. Laplace and Fourier Transforms – Goyal and Gupta. Pragati Prakashan Meerut
4. Matrices and Tensors for Physicists – A W.Joshi
5. Mathematical Physics – B.D.Gupta, Vikas Publishing House, New Delhi
6. Applied Mathematics for Engineers and Physicists – By Lious A Pipes and Lawrance R. Rarvill.
7. Mathematical Physics – A.K. Ghatak, and I. Goyal,
8. Mathematical Physics – Satya Prakash
9. Tensor Analysis –Schaum series
10. Ordinary differential equations – R. L. Rabenstein
11. Partial Differential Equation for Scientists – G. Stephenson

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Course Title: Electromagnetic Theory – II (Core)
Course Number: PHY453
Total Marks: 100
Total Credits: 4

Course Outcome:

- Basic and advanced understanding the dynamics of electric and magnetic fields.
- Understanding the behavior of electric and magnetic fields of the electromagnetic waves in dielectrics and conductors.
- Guided electromagnetic waves
- Understanding electrodynamics and relativity.

UNIT I: Ohm's law, Motional EMF, Time varying fields, Faraday's law of induction, Magnetic field energy. Self and mutual inductance, Continuity equation, Conservation: Poynting's theorem, Newton's third law in electrodynamics, Maxwell stress tensor, Momentum conservation.

UNIT II: Electromagnetic waves: Wave equation, Reflection, Transmission, Polarization, Plane waves, Energy and momentum in EM waves, EM waves in linear media, Normal and Oblique incidence, Fresnel formula, EM waves in conductors, Reflection at a conducting surface, Frequency dependence of permittivity, Skin effect, Wave guides, rectangular wave guide, Coaxial transmission line.

UNIT III: Gauge transformations, Retarded potentials, Jefimenko's equations, Liénard-Wiechert potentials. Electric and magnetic dipoles Radiation, Radiation from arbitrary source, Larmor formula, Radiation from a moving point charge and. Radiation reaction and Abraham-Lorentz formula and physical basis, Multipole expansion for radiation fields.

UNIT IV: Electrodynamics & Relativity: Introduction to special theory of relativity, Lorentz transformation, Transformations of electromagnetic fields under Lorentz transformations. Space-time, Relativistic kinematics and dynamics, Magnetism as a relativistic phenomenon, Field tensor.

Text Books & References:

1. Introduction to Electrodynamics – David J. Griffiths
2. Electrodynamics of continuous media – Landau & Lifshitz
3. Classical Fields – Landau & Lifshitz
4. Classical Electrodynamics – J. D. Jackson
5. Classical Electrodynamics – J. B. Marion

Course Title: Statistical Mechanics (Core)
Course Number: PHY 454
Total Marks: 100
Total Credits: 4

Course outcome:
The students will understand

- Different types of ensembles, relation between statistics and thermodynamics, quantum statistics and other related phenomena.
- To understand the relationship between macroscopic and microscopic physics using ideas of statistics.
- Apply the concept of phase space to the microcanonical and canonical ensemble approaches to study equilibrium systems.

UNIT 1: Basis of Classical and Quantum statistical mechanics, Phase space, Ensemble, Ensemble averages, Liouville theorem and Equation of motion, Equal a priori probability, Statistical equilibrium, Micro and macro states, Microcannonical ensemble in CSM and QSM.

UNIT II: Quantization of Phase space, Basic postulates of QSM, Symmetry of wave functions, Effect of symmetry on Counting, Various distributions using microcanonical ensemble, Ideal gas, Density matrix. Canonical partition function,

UNIT III: Molecular, Translational, Rotational, Vibrational, Electronic and Nuclear partition function, Application of Vibrational and rotational partition function, Homonuclear molecules, Chemical Equilibrium, Entropy of an Ideal gas using the Microcanonical, Canonical and Grand canonical ensemble, Gibbs paradox, Entropy and Information theory.

UNIT IV: Ideal Bose gas, Bose-Einstein distribution, BE condensation, Thermodynamic properties of an ideal BE gas, Liquid Helium, Ideal Fermi gas, Fermi-Dirac distribution, Degenaracy, Electrons in a metal, Magnetic susceptibility of free electrons, White Dwarfs, Superconductivity (Subjected to time constraints).

Text Books & References:

1. Fundamentals of Statistical and Thermal Physics – F.Reif, McGraw – Hill, International Edition (1985).
2. Fundamentals of Statistical Mechanics – B.B.Laud, New Age International Publication (2003).
3. Statistical Mechanics – R.K.Pathria, Bufferworgh Heinemann (2nd Edition).
4. Statistical Mechanics – K.Huang, John Willey & Sons (2nd Edition).
5. Statistical Mechanics – Satya Prakash, Kedar Nath Ram Nath Publication (2008).
6. Statistical Mechanics – Loknathan and Gambhir.
7. Thermal Physics – C. Kittel.
8. Statistical Physics – L. D. Landau and E. M. Lifshitz.
9. Problems in Thermodynamics and Statistical Physics – P. T. Landsberg (Ed.).
10. Introduction to Statistical Mechanics – F. Reif.
11. Statistical mechanics – Gupta, Kumar and Sharma
12. Statistical Mechanics – Eisner and Agarwal.

Course Title: Electronics Laboratory (Core)
Course Number: PHY455
Total Marks: 100
Total Credits: 4

Course Outcome:

At the end of the course, students will have understanding of

- Characteristics and applications of P-N junction diode, LED and Zener diodes.
- Characteristics of BJT and Field effect transistors.
- Determination of h-parameters in the CE transistor configuration.
- Operation and oscillating frequency determination of Colpitts and Hartley Oscillators.
- Design of simple logic circuits using basic logic gates.

1. Diode Applications – I: Power supplies – Bridge rectifiers with capacitive input filters. Shunt Voltage regulator using zener diode.
2. Diode Applications – II: Clipping and Clamping circuits.
3. BJT characteristics. Determination of h-parameters in the CE configuration using the measured input and output characteristics of a BJT (e.g.2N 2218)
4. Common Emitter Amplifier with and without feedback.
5. Common Source and Common Drain Amplifiers using JFET.
6. RC Oscillators: Phase shift oscillator using RC ladder network as the phase shifting network; Wien's Bridge Oscillator.
7. Emitter Coupled Differential Amplifier using BJT's.
8. Multivibrators – Bistable, Monostable and Free Running multivibrators using BJT's (e.g.2N 2218).
9. Op-Amp (741) characteristics: V_{io}, I_b, V_{ol}, CMRR, Slew Rate. Applications of Op-amps: inverting Amplifier, Unity Gain Buffer, Summing Amplifier.
10. 555 IC timer. Free Running and Monostable Multivibrators, Sawtooth wave generator.
11. Series Dissipative Voltage Regulator using 723 IC.
12. Series Switching Voltage Regulator using 494 IC.
13. Tuned High Frequency Amplifiers: RF and IF amplifiers.
14. High Frequency Oscillators: Colpitts and Hartley Oscillators.

Course Title: Quantum Mechanics – II (Core)
Course Number: PHY 501
Total Marks: 100
Total Credits: 4

Course outcomes

At the end of the course PHY-501, the students will understand

- Basic knowledge of approximation methods in quantum mechanics
- The application of the approximation methods to different physical systems
- Solving the normalization constants, wave function and the total energy for a given system using Dirac's Bra-Ket notation
- Basic understanding angular momentum and the Heisenberg's matrix notation
- Quantization of spin-angular momentum and the Pauli spin matrices.

UNIT I: Approximation methods: Time-independent Perturbation theory: Non degenerate and degenerate cases (upto second order). Applications: Zeeman effect, Stark effect, anharmonic oscillator. Time-dependent Perturbation theory, Transition amplitude 1st and 2nd order, selection rules, constant perturbation (1st order). Fermi's golden rule, Harmonic perturbation, Einstein coefficient for spontaneous emission.

UNIT II: Variational method, Basic principles and applications to particle in box, Harmonic oscillator, hydrogen atom, helium atom. (Qualitative approach)
WKB approximation, Qualitative development and condition for validity of this approx., Bohr's quantization condition, Einstein's coefficients

UNIT III: Angular momentum: Commutation relations, eigen-functions of the angular momentum operators, matrix representation of angular momentum operators.

UNIT IV: Spin: Stern Gerlach experiment, Pauli's two component equation, addition of angular momenta, Identical particles, Symmetrization postulate, Bose and Fermi-statistics, Pauli exclusion principle, Helium atom, Spin in a time dependent magnetic field, Hartree-Fock method, Spin-orbit coupling, j-j coupling.

Text Books & References:

1. Quantum Mechanics – Leonard I. Schiff, 3rd Edition, Tata McGraw-Hill Education Private Limited, New Delhi. (2010).
2. Quantum Mechanics – Eugene Merzbacher, 3rd Edition, John Wiley & Sons, New York (1998).
3. Practical Quantum Mechanics – S. Flugge, 1st Edition, Springer-Verlag New York (1998)
4. A text book of Quantum Mechanics – Mathews and Venkatesan 2nd Edition, McGraw-Hill Education Private Limited, New Delhi (2010).
5. Quantum Mechanics – M. P. Khanna, Har-Anand Publications Pvt. Limited
6. Principles of Quantum Mechanics – P. A. M. Dirac, 4th Edition, Oxford University Press, London (1967).
7. Introduction to Quantum mechanics – David J. Griffiths, Prentice Hall, Inc. USA (1995).
8. Quantum mechanics – A.Ghatak and S.Lokanathan, McMillan publishers India Limited, New Delhi (2010)
9. Quantum physics of atoms, molecules, solids, nuclei, and particles – R. Eisberg and R.Resnick, 2nd Edition, John Wiley & Sons, Inc. (1985).

Course Title: Solid State Physics – I (Core)

Course Number: PHY 502
Total Marks: 100
Total Credits: 4

Course outcome:
The students will understand
1. Structures of solids and their characterization using X-ray techniques
2. Concepts of energy bands and their origin,
3. Electrical and thermal properties of solids
4. Physics of semiconductors

UNIT I: Crystalline and amorphous solids, Classification of crystal structures, Miller indices, Reciprocal lattice, X-ray diffraction, Bragg's law, Experimental methods, atomic scattering factor, Structure factor, Electron and neutron diffraction. Classical picture of specific heat, Einstein's theory, Debye's approximation, Phonons, Lattice vibrational modes and specific heat of finite 1-D identical atoms and 3-D lattice, Diatomic linear lattice, Quasi crystals.

UNIT II: Free Electron model, Fermi-Dirac distribution, Electronic specific heat, Thermionic emission, Effective mass, Block theorem, Kronig-Penny model, 1-D and 3-D electron motion, Band theory of solids, Metals, Semiconductors and insulators, Concept of Hole, Brillouin zones, Density of states.

UNIT III: Electrical conductivity of metals, Boltzmann equation, Sommerfield theory, mean free path, Electron-phonon collisions, Electrical conductivity at low temperature, Thermal conductivity of metals and insulators.

UNIT IV: Physics of Semiconductors: Classification of Semiconductors, Intrinsic carrier densities, General Features of Extrinsic semiconductors, Extrinsic carrier densities, Temperature dependence of electrical conductivity, Hall Effect and Magnetoresistance, p-n junction, Examples of p-n junction based devices, Thermoelectric effects, Integral Quantum Hall Effect (IQHE).

Text Books & References:

1. Introduction to Solid State Physics – C. Kittel, 7th Edition, John-Wiley & Sons, New York.
2. Solid State Physics – N.W. Ashcroft and N.D. Mermin, Harcourt college publishers, New York.
3. Solid State Physics – A.J. Dekker, Prentice-Hall, Inc., New Jersey.
4. Solid State Physics – J. S. Blakemore, 2nd Edition, Cambridge University press, W.B. Saunders Company, Cambridge, United Kingdom (1998).
5. Principles of Solid-State Physics – R. A. Levy, Academic press, New York.

6. Principles of the Theory of Solids – J. Ziman, 2nd Edition, Cambridge University Press, Cambridge, United Kingdom (1995).
7. Solid State Electronics – S. Wang, McGraw-Hill Inc., USA (1996).

Course Title: Spectroscopy (Core)
Course Number: PHY503
Total Marks: 100
Total Credits: 4
Course Outcome:

- Acquaintance with the electronic transitions in the atoms.
- Understanding different types of molecular spectroscopy and finding the bond length, bond vibrations, etc.
- Understanding the nuclear level spectroscopic transitions.
- Understanding the basic principles on the working of different spectroscopic techniques.

Unit –I

Quantum states of one electron atoms, Atomic orbitals-Hydrogen spectrum-Pauli's principle; Spectra of alkali elements-Spin orbit interaction and fine structure in alkali Spectra-Equivalent and non-equivalent electrons-Normal and anomalous Zeeman effect- Paschen Back effect; Stark effect-Two electron systems-interaction energy in LS and *JJ* Coupling-Hyperfine structure (qualitative)-Line broadening mechanisms (general ideas)

Unit –II

Microwave spectrum of a diatomic molecule, Rigid and No-rigid rotator approximation, Moment of inertia and bond lengths of diatomic and linear triatomic molecule; vibrational spectra of Diatomic molecule, Harmonic and Anharmonic oscillator; Energy levels and spectrum-Morse potential energy curve-Molecules as vibrating rotator-Vibration spectrum of diatomic molecule-PQR branches IR spectrometer (qualitative).

Unit –III

Electronic spectroscopy; Classical and Quantum theory of Raman Effect (qualitative), Rotational Raman spectra; Rotational constants from Infrared and Raman vibration-rotation spectra.

Unit –IV

Basic Principle and theory of electron spin resonance, thermal equilibrium and Relaxation methods, characteristics of g and A values, Unpaired electron, fine structure and Hyperfine structure. Nuclear magnetic resonance: Basic Principle and theory, Nuclear spin and Magnetic moment, Relaxation mechanism, spin-lattice and spin-spin relaxation.

Text books and references:

1. Atomic Physics – CJ Foot (Oxford University Press)
2. Physics of quanta Photons – Derm Troder
3. Atomic and Molecular Spectroscopy – SN Thakur and DK Rai
4. Physics of Atoms and Molecules – BH Bransden and CJ Joachain
5. Fundamentals of Molecular spectroscopy – Colin N. Banwell and E.M. McCash
6. Elements of Spectroscopy, R.C. Sharma, S.I. Gupta, V. Kumar

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Course Title: Nuclear and Particle Physics
Course Number: PHY504
Total Marks: 100
Total Credits: 4

Course Outcome:

At the end of the course, students will understand

- Basic properties of nucleus and different models which explain nuclear properties and behavior.
- Different types of nuclear reactions and reaction mechanisms.
- Natural and artificial radioactivity, different types of radiations and their interactions with matter. Students will have knowledge of various radiation detection and measurement techniques.
- Students will also understand present day applications of nuclear radiations in medical treatment and diagnostics.
- Elementary particles and conservation laws governing their behavior. Quark model of particles.

UNIT I: Introduction: Objective of studying Nuclear Physics, Nomenclature, nuclear radius, mass & Binding energy, angular momentum, magnetic dipole moment, Electric quadrupole moment, parity and symmetry, domains of instability, Energy levels, mirror nuclei.

Nuclear Forces: Characteristics of Nuclear Forces- Ground state of deuteron, scattering cross-sections, qualitative discussion of neutron-proton and proton- proton scattering at low energies- charge independence, spin dependence and charge symmetry of nuclear forces - exchange forces and tensor forces- Meson theory of nuclear forces (Yukawa's Potential).

UNIT II: Nuclear Models: Weisazacker's semi-empirical mass formula- mass parabolas- Liquid drop model -Bohr –Wheeler theory of nuclear fission - Nuclear shell model: magic numbers, spin orbit interaction, prediction of angular momenta and parities for ground states, Collective model, and More-realistic models

Nuclear Decay: Alpha decay process, Energy release in Beta-decay, Fermi's theory of β -decay, selection rules, parity violation in β -decay, Detection and properties of neutrino, energetics of gamma decay, selection rules, angular correlation, Mössbauer effect.

UNIT III: Nuclear Reactions: Types of reactions and conservation laws, Nuclear kinematics - the Q – equation, threshold energy- Nuclear cross section, Nuclear fission-energy release in fission- Stability limit against spontaneous fission, Characteristics of fission, delayed neutrons, Nuclear fusion, prospects of continued fusion energy. Four factor formula for controlled fission (nuclear chain reaction)-nuclear reactor- types of reactors.

Applications of Nuclear Physics: Trace Element Analysis, Rutherford Back-scattering, Mass spectrometry with accelerators, Diagnostic Nuclear Medicine, Therapeutic Nuclear Medicine.

UNIT IV: Elementary Particle Physics: Classification, Particle interactions and families, symmetries and conservation laws for energy and momentum, angular momentum, parity, Baryon number, Lepton number, isospin, strangeness quantum number, Discovery of K-mesons and hyperons, Gellmann and Nishijima formula, and Charm, Elementary ideas of CP and CPT invariance, SU(2), SU(3) multiplets, Quark model.

Accelerators: Electrostatic accelerators, Cyclotron, Synchrotron, Linear accelerators, Colliding beam accelerators, Intersecting Storage rings and stochastic cooling, Detectors for photons, leptons and hadrons.

Text Books & References:

1. Nuclear Physics – D.C.Tayal, Himalaya publishing Co.,
2. Introduction to Nuclear Physics – Harald A.Enge
3. Concepts of Nuclear Physics – Bernard L.Cohen.
4. Introduction to High Energy physics – D.H. Perkins
5. Introduction to Elementary Particles – D. Griffiths
6. Nuclear Physics – S.B.Patel, Wiley Eastern Ltd.,
7. Introductory Nuclear Physics – Kenneth S. Krane, John Wiley (1988)
8. Physics of Nuclei and Particles – E. Segre
9. Elements of Nuclear Physics – W. E. Burcham, Longman (1986)
10. An Introduction to Nuclear Physics – W. N. Cottingham and D. A. Greenwood

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Course Title: General Physics Laboratory - I
Course Number: PHY505
Total Marks: 100
Total Credits: 4

- The General physics laboratory – I course aims at the experiments in Solid State Physics
- Each student is expected to do 6-8 Experiments from the following list.

1. Temperature measurement: thermistor, diode & Pt. Resistor.
2. Electrical resistivity of Cu & Fe.
3. Determination of unit cell symmetry and lattice parameter by powder and Laue methods.

a. Determination of carrier concentration and their sign in Ia Semiconductor at room temperature by Hall Effect and magnetoresistance measurements.

4. Determination of the defect activation energy in an alkali halide crystal by measuring its ionic conductivity as a function of temperature.
5. Dielectric constant and dielectric loss measurements as functions of temperature and frequency to study structural phase transitions.
6. Study of order-disorder transition in β-brass by heat capacity measurements.
7. Superconductivity in high Tc superconductors.
8. Electrical resistivity of metallic glasses: nonmagnetic & magnetic
9. Thermoelectric power of metallic glasses: nonmagnetic & magnetic.
10. Optical spectra of thick semiconducting films.

Course Title: Advanced Quantum Mechanics (Optional)
Course Number: PHY551A
Total Marks: 100
Total Credits: 4

Course outcomes:

At the end of the course PHY-551A, the students will understand

- Different equations of motion of a quantum particle/ system in the relativistic limits
- The negative energy states and creation and annihilation of quantum particles
- Different quantum theories to describe the scattering phenomenon
- Quantization of fields, First and second quantization.

UNIT I: Relativistic Quantum Mechanics: Klein-Gordon equation, Non-relativistic limit, Dirac equation, properties of Dirac Matrices, positive and negative energy states. Spin of the Dirac particle, Significance of negative energy states, Free Dirac particle in an external electro-magnetic field, relativistic electron in a central potential.

UNIT II: Theory of Scattering: Differential and total cross sections, scattering amplitudes using Green's function, scattering by symmetric potential, mutual scattering of two particles, Centre of Mass frame, Laboratory frame. Born approximation, Validity of Born Approx., Application to square well potential and Yukawa potential.

UNIT III: Partial wave analysis, phase shift, scattering amplitudes in terms of phase shift, optical theorem, scattering by square well potential and perfectly rigid sphere. Scattering Theory, Central force problem, partial wave analysis Born's approximation, optical theorem bound states and resonances. Schrodinger and Heisenberg pictures.

UNIT IV: Quantization of fields: Introduction, Concept of field Hamiltonian formulation of classical field, Real scalar field Schrodinger field, Dirac field, Maxwell's field, Quantum equation of the field, Quantization of real scalar field and second quantization, Quantization of complex scalar field, Quantization of Schrödinger field, Quantization of Dirac field.

Text Books & References:

1. Quantum Mechanics – Leonard I. Schiff, 3rd Edition, Tata McGraw-Hill Education Private Limited, New Delhi. (2010).
2. Practical Quantum Mechanics – S. Flugge, 1st Edition, Springer-Verlag New York (1998)
3. A text book of Quantum Mechanics – Mathews and Venkatesan 2nd Edition, McGraw-Hill Education Private Limited, New Delhi (2010).
4. Quantum Mechanics – M. P. Khanna, Har-Anand Publications Pvt. Limited
5. Introduction to Quantum mechanics – David J. Griffiths, Prentice Hall, Inc. USA (1995).
6. Quantum mechanics – A.Ghatak and S.Lokanathan, McMillan publishers India Limited, New Delhi (2010)
7. Advanced Quantum Mechanics – J. Sakurai
8. Relativistic Quantum Fields. Vols. I & II – Bjorken and Drell
9. Quantum Field Theory – Mandl
10. Particles and Fields – Lurie
11. Quantum Theory of Fields. Vols. I & II – Weinberg

Course Title: Magnetism (Optional)
Course Number: PHY551B
Total Marks: 100
Total Credits: 4

Course outcomes:

At the end of the course PHY-551B, the students will understand

- The classical and quantum description of spin angular momenta and the origin of magnetism in materials
- Different classical and quantum theories to describe the dia and par magnetism
- Curie and Curie-Weiss law in the paramagnetic regime for different magnetic materials

- The classical and quantum mechanical theories for ferromagnetic and antiferromagnetic phenomena
- Different types of exchange interactions in magnetic materials

UNIT-I Diamagnetism and paramagnetism: Review of elementary and quantum theories of diamagnetism and paramagnetism. Effect of crystalline field, Quenching of orbital angular momentum. Landau Diamagnetism and Pauli paramagnetism, Relaxation and resonance phenomena, NMR, ESR.

UNIT-II Ferromagnetiam: Molecular field theory, Heisenberg model, Mean field solution, the series expansion method, The Bethe-Peierls-Weiss method, Magnons, Spin Waves.

UNIT III: Itinerant ferromagnetism, Stoner model, Wohlfarth's modification; Crystalline anisotropy magnetoelastic effects, Magnetisation of ferromagnetic materials, BH loop, Domain wall, Domain structure, Barkhausen effect

UNIT-IV Antiferromagnetism: Molecular field theory, Superexchange. Double-exchange. Series - expansion method, Bethe-Peierls-weiss method, Spin waves, Crystalline anisotropy, Domains in antiferromagnetic materials, Canted antiferromagnetism

References:

1.	Introduction to Solid State Physics	C. Kittel
2.	Solid State Physics	J. S. Blakemore
3.	Principles of Solid State Physics	R. A. Levy
4.	Principles of the Theory of Solids	J. Ziman
5.	Physical Principles of Magnetism	A. H. Morrish
6.	Physics of Magnetism	S. Chikazumi
7.	Quantum Theory of Magnetism	R. M. White
8.	Relaxation Phenomena in condensed matter	S. Dattagupta

Course Title: Solid State Physics - II
Course Number: PHY552A
Total marks: 100
Total Credits: 4

Course Outcome

Expose students to many body interactions giving magnetically ordered states, superconductivity and other exotic phenomena such as dielectric, Hall effect, quantization of conductance etc. This is expected for students who seriously consider research in condensed matter physics.

UNIT I: Dielectric materials, Macroscopic description of static dielectric constant, static and ionic polarizabilities, Orientational polarization, Static dielectric constant of solids and gases, Complex dielectric constant, Dielectric losses, Relaxation time, Classical theory of electronic polarization. Ferroelectric materials, Classification, Dipole theory and limitations, Spontaneous polarization, Thermodynamics of ferroelectric transitions, Ferroelectric domains, Behaviour of $BaTiO_3$,

UNIT II: Magnetic materials, Dia-, para-, ferro-, antiferro and ferrimagnetism, origin of permanent magnetic dipoles, Larmor precession, Static paramagnetic susceptibility, Hamilton for an electron in magnetic field, Weiss theory of ferromagnetism and interpretation, Domains, Anisotropy energy, Heisenberg exchange interaction, Thickness and energy of the Bloch wall, Coercive force and Hystresis,

UNIT III: Two-sublattice model of antiferromagnetism, Superexchange interaction, Structure of ferrites, Elements of Néel's theory, Spin-lattice and Spin-spin relaxation.
Basic properties of superconductors, Experimental survey, Phenomenological thermodynamic treatment, Two fluid model, Magnetic behaviour of superconductors, intermediate state, London's equations and penetration depth, quantized flux.

UNIT IV: Highlights of Ginzburg-Landau theory, variation of the order parameter, energy gap with magnetic field, isotope effect, Cooper cooper pairs electron-phonon interaction, brief discussion of the B.C.S. theory and high lights of BCS theory results. Type I and II superconductors, magnetization of type-II superconductors, mixed state, surface energy, specific heat, critical currents of type-II superconductors flux lattice, flux flow (creep).

Text Books & References:

8. Introduction to Solid State Physics – C. Kittel, 7th Edition, John-Wiley & Sons, New York.
9. Solid State Physics – N.W. Ashcroft and N.D. Mermin, Harcourt college publishers, New York.
10. Solid State Physics – A.J. Dekker, Prentice-Hall, Inc., New Jersey.
11. Solid State Physics – J. S. Blakemore, 2nd Edition, Cambridge University press, W.B. Saunders Company, Cambridge, United Kingdom (1998).
12. Principles of Solid State Physics – R. A. Levy, Academic press, New York.
13. Principles of the Theory of Solids – J. Ziman, 2nd Edition, Cambridge University Press, Cambridge, United Kingdom (1995).
14. Introduction to Superconductivity – M. Tinkham, 2nd Edition, McGraw-Hill, New York (1996).
15. The Physical Principles of Magnetism – A. H. Morrish, 1st Edition, Wiley-IEEE Press, New York (2001).
16. Introduction to Magnetic materials – B.D. Cullity and C.D. Graham, 2nd Edition, Wiley-IEEE Press, New York (2009).

Course Title: Superconductivity (Elective)
Course Number: PHY552B
Total Marks: 100
Total Credits: 4

UNIT-I:
Basic properties of superconductors, Phenomenological thermodynamic treatment, isotope effect, Energy gap and its measurement, Meissner effect, Two fluid model, Magnetic behaviour of superconductors, intermediate state, Type I and II superconductors, London's equations and penetration depth, DC and AC Josephson effect.

UNIT-II
Ginzburg-Landau theory, coherence length, variation of the order parameter and the energy gap with magnetic field, magnetization, specific heat and thermal conductivity, electron-phonon interaction and cooper pairs, B.C.S. theory, Phase transition in fluid and other systems with special emphasis on superconducting normal phase transition, critical points, order parameters, critical exponents and equalities.

UNIT-III
Mean field theory, Type II superconductivity, magnetization of type-II superconductors, mixed state, surface energy, specific heat, critical currents of type-II superconductors, flux lattice, flux flow (creep), High Tc Superconductors.

Unit-IV
Phase transition in fluid and other systems with special emphasis on superconducting normal phase transition critical points, order parameters, critical exponents and equalities, Mean field theory, role of fluctuations, Ginzburg-Landau theory, fluctuations in Gaussian approximation, Scaling hypothesis.

Recommended books:

1. Introduction to Superconductivity - M. Tinkham
2. Superconductivity of Metals and Alloys - P. G. deGennes
3. Theory of Superconductivity - J. R. Shrieffer
4. Solid State Theory - Harrison
5. Solid State Physics - SO Pillai

Course number: PHY553A
Course title: Modern Optics *(CBCP)*
Total marks: 100
Total credit: 4

UNIT I: Quantum Optics: Quantum theory of Radiation, Second quantization, Quantum statistical description of the radiation fields, Coherent states, Photon correlations, Squeezed states and applications.

Nonlinear Optics: Basic Principles, Harmonic generation, Second harmonic generation, Phase matching, Third Harmonic generation, Optical mixing, Parametric generation of light, Parametric light oscillator, Frequency up conversion, Self-focusing of light.

UNIT II: Holography: Introduction, Basic theory of Holography, Recording and reconstruction of Hologram, Diffuse object illumination, Speckle pattern, Fourier transform Holography, Applications.

Lasers: Introduction, Directionality, Brightness, Monochromacity, Coherence, Relation between the coherence of the field and the size of the source, Absorption and emission processes, Einstein coefficients, Amplification in a medium, Laser pumping, Boltzmann's principle and the population of energy levels, Attainment of population inversion, Two level, three level and four level pumping.

UNIT III: Optical feedback: Optical resonator, Laser power and threshold condition, Confinement of beam within the resonator, Stability condition.

Laser output: Absorption and emission, Shape and width of broadening lines, Line broadening mechanisms, Natural, Collision and Doppler broadening, Ruby laser, He-Ne Laser, CO_2 laser, Semiconductor Ga-As laser, Applications.

UNIT IV: Fiber Optics: Introduction, Total internal refraction, Optical fiber modes and configurations, Fiber types, Rays and modes, Step index fiber structures, Ray optics representation, Wave representation, Mode theory for circular wave guides, Wave guide equations, Wave equations for step indexed fibers, Modal equation, Modes in step indexed fibers, Power flow in step indexed fibers, Graded indexed fiber structure, Numerical aperture and modes in graded index fibers, Signal degradation in optical fibers, Attenuation, Losses, Absorptive and radiative scattering, Core cladding, Signal distortion in optical wave guides, Information capacity determination, Group delay, Material dispersion, Wave guide dispersion, Inter modal dispersion, Pulse broadening, Preparation of different techniques of optical fibers.

Text Books & References:

1. Introduction to Electrodynamics – D.J.Griffiths, Prentice-Hall, India
2. Electromagnetics – B.B.Laud, Wiley –Eastern, New Delhi.
3. Modern Optics – Fowels
4. Laser and their applications – M.J.Beesly, Taylor and Francis, 1976.
5. Laser and Non-Linear Optics – B.B.Laud, Wiley Eastern Ltd., 1983.
6. Optics – E.Hecht, Addison Wiley, 1974.
7. Optical fibers communications – Gerel Keiser, McGraw Hill Book, 2000.
8. Introduction to Quantum Optics – Baldwin

Course Title: Dielectric and Luminescence Properties of solids *(CBCP)*
Course Number: PHY553B
Total Marks: 100
Total Credits: 4

Course Outcome:

- To study the properties of dielectric materials and Ferroelectric materials.
- Understanding different types of luminescent materials and basic fundamentals
- Understanding the mechanism of the luminescence and various applications

UNIT – I

Dielectric materials, Macroscopic description of static dielectric constant, static and ionic polarizabilities, Orientational polarization, Static dielectric constant of solids and gases, Complex dielectric constant, Dielectric losses, Relaxation time, Classical theory of electronic polarization. Ferroelectric materials, Classification, Dipole theory and limitations, Spontaneous polarization, Thermodynamics of ferroelectric transitions, Ferroelectric domains, Behaviour of BaTiO3.

UNIT – II

Fundamentals of luminescence: Absorption and emission of light, Beer Lambert's law. Electronic transition in an atom: Electric dipole transition probability, Oscillator strength, forbidden transitions, selection rule. Decay of luminescence.

UNIT – III

General Considerations: Fluorescent lamps, cathode ray tubes. Types of luminescence: Classification of luminescence on the basis of (i) time dependence of emission: phosphorescence and fluorescence, (ii) Nature of the exciting energy sources: Photoluminescence, cathode illuminating photo and thermoluminescence etc.: Atomic, band theory and configuration Co-ordinate models, Randall and Wilkins theory for the derivation of the phosphorescence.

UNIT – IV

Luminescence mechanisms, centre of luminescence, Radiative and non-radiative transitions charge transfer luminescence and donor acceptor luminescence. Excitation mechanisms: Optical excitation of luminescence and energy transfer, energy transfer mechanisms between optical centres. Mechanisms underlying energy transfer, energy transfer governed by electrostatic and exchange interactions. Cross relaxations and energy transfer. Photoluminescence of nanoparticles of rare earth phosphors.

References

1. Solid State Physics, A J Dekker
2. Dielectric phenomena in solids, Kwan Chi Kao
3. Luminescence from theory to applications, C. Ronda
4. Luminescent Materials, G. Blasse, B C Grabmaier
5. Fundamentals of Phosphors, W M Yen, S Shionoya, H Yamamoto

Course Title: General Physics Laboratory – II
Course Number: PHY555
Total Marks: 100
Total Credits: 4

- The General physics laboratory – II course aims at the experiments in Modern Physics and Nuclear Physics.
- Each student is expected to do 6-8 Experiments from the following list.

1. Interference (Fabry-Perot)
2. Fraunhoffer Diffraction and acousto-optic experiments
3. Polarisation (Brewster angle, QW plate, Half wave plate)
4. Photo electric effect
5. Specific heat of graphite
6. Band gap of a semiconductor
7. Magnetic susceptibility by Guoy method
8. Vacuum system-operation & thin film deposition
9. Geiger Muller Counter-Counting Curve. Verification of Inverse Square Law. Dead time of detector using Split Source Method. Counting Statistics and Error prediction. Half Life.
10. Gamma Spectroscopy using Single Channel Analyser-Differential and Integral Pulse Height Spectra of Cs-137. Detector Resolution.
11. Gamma Spectroscopy using Multichannel Analyser-Energy Calibration and Identification of unknown source. Resolution. Spectrum Analysis. Determination of Activity. Peak Integration. Stripping and Background Subtraction.
12. Mass Attenuation of Gamma Radiation in Al
13. Mass attenuation Coefficient of Beta Radiation of Different End-point Energies
14. Alpha Spectroscopy using Surface Barrier Detectors
15. Beta and Conversion Electron Study

Text Books & References:

1. Radiation Detection and Measurement — G. F. Knoll, John Wiley (1988)
2. Nuclear Electronics — P. W. Nicholson, Wiley, London (1974)