NAAC Grade A++ Accredited (CGPA-3.78)

भौतिकी विभाग, दीनदयाल उपाध्याय गोरखपुर विश्वविद्यालय,गोरखपुर

Syllabus

as per

Ordinance, Four Years B.Sc. Programme 2024

Department of Physics

Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur

SESSION: 2024-2025

The Ordinance, 4-year B.Sc. program 2024 of Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur laid down the following guidelines:

Types of Courses:

Student has to choose two Major disciplines (subjects) from their Faculty and study them for three years (six semesters).

Additionally, they will choose a minor discipline (subject) either from their Faculty or from other Faculties and study it for the first two years (four semesters).

Additional Course Requirements:[1]

Every student must opt for the following courses:

- One Skill Enhancement/Vocational course per semester from a pool of courses offered by the University in the first three semesters (Semesters I, II, III).
- One Ability Enhancement/Co-curricular Course per semester from a pool of courses offered by the University in the first four semesters (Semesters I, II, III, IV).
- Undertake a Research Project/Dissertation/Internship/Fieldwork/Survey in one of their major disciplines (subjects) in the semester IV.

Special Requirements for B.Sc. (Honours with Research):[2]

Students opting for the four-year B.Sc. Degree (Honours with Research) must prepare a Major Research Project or Dissertation in the semester VIII.

Exit Options:[3]

In the 4-year B.Sc. Program, students have an exit option at different levels, including Certificate, Diploma, B.Sc. Degree, B.Sc. Honors Degree, and B.Sc. Honors with Research Degree.

Year Completed	Total Credits	Degree	Options
1	46	Certificate	EXIT
2	92	Diploma	EXIT
3	132	B.Sc. Degree	EXIT
4	172	B.Sc. Honors	EXIT

Or

4	172	B.Sc. Honors with Research	EXIT

These guidelines provide a structured framework for students pursuing the 4-year B.Sc. program at Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur ensuring a comprehensive academic experience with opportunities for specialization and skill development.

Reference:

[1]From Article 3 subsection- 3.3,3.4 & 3.5 of 4 Year UG Ordinance of DDUGU

[2]From Article 3 subsection- 3.6 of 4 Year UG Ordinance of DDUGU

[3]From Appendix - Aof 4 Year UG Ordinance of DDUGU

Course Structure for Four Years B.Sc. Programme

SEMESTER-WISE TITLES OF COURSES ALONGWITH CREDITS			
YEAR	**COURSE CODE**	**PAPER TITLE**	**CREDIT**
1st Year	**Semester-I**		
	PHY- 101F	Mathematical Physics & Newtonian Mechanics	4 + 0
	PHY- 102F	Practical (Mechanical Properties of Matter)	0 + 2
	SEC-PHY-1	--	3
	AEC-PHY-1	--	2
	Semester-II		
	PHY- 103F	Thermal Physics & Semiconductor Devices	4 + 0
	PHY- 104F	Practical (Thermal Properties of Matter & Electronic Circuits)	0 + 2
	SEC-PHY-2	--	3
	AEC-PHY-2	--	2
2nd Year	**Semester-III**		
	PHY- 201F	Electromagnetic Theory & Optics	4 + 0
	PHY- 202F	Practical (Demonstrative Aspects of Electricity & Magnetism)	0 + 2
	SEC-PHY-3	--	3
	AEC-PHY-3	--	2
	Semester-IV		
	PHY- 203F	Modern Physics & Electronics	4 + 0
	PHY- 204F	Practical (Basic Electronics Instrumentation)	0 + 2
	AEC-PHY-4	--	2
	PHY- 205F	Research Project / Dissertation / Internship / Fieldwork / Survey	3
3rd Year	**Semester-V**		
	PHY- 301F	Classical Mechanics & Statistical Mechanics	4 + 0
	PHY- 302F	Quantum Mechanics & Spectroscopy	4 + 0
	PHY- 303F	Practical (Demonstrative Aspects of Optics & Lasers)	0 + 2
	Semester-VI		
	PHY- 304F	Solid State Physics & Nuclear Physics	4 + 0
	PHY- 305F	Analog & Digital - Principles & Applications	4 + 0
	PHY- 306F	Practical (Analog & Digital Circuits)	0 + 2

YEAR	COURSE CODE	PAPER TITLE	CREDIT
4th Year	**Semester-VII**		
	PHY- 401F	Mathematical Physics	4 + 0
	PHY- 402F	Classical Mechanics	4 + 0
	PHY- 403F	Quantum Mechanics	4 + 0
	PHY- 404F	Electronics	4 + 0
	PHY- 405F OR PHY- 406F	Physics Practical – Electronics Physics Practical - Optics	0 + 4
	Semester-VIII		
	PHY- 407F	Thermodynamics and Statistical Physics	4 + 0
	PHY- 408F	Electromagnetic Theory and Plasma Physics	4 + 0
	PHY- 409F	Solid State Physics	4 + 0
	PHY- 410F	Group Theory and Molecular Spectra	4 + 0
	PHY- 405F OR PHY- 406F	Physics Practical – Electronics Physics Practical - Optics	0 + 4

For students who secured 75% marks in First Six Semesters

YEAR	COURSE CODE	PAPER TITLE	CREDIT
4th Year	**Semester-VII**		
	PHY- 401F	Mathematical Physics	4 + 0
	PHY- 402F	Classical Mechanics	4 + 0
	PHY- 403F	Quantum Mechanics	4 + 0
	PHY- 404F	Electronics	4 + 0
	PHY- 405F OR PHY- 406F	Physics Practical – Electronics Physics Practical - Optics	0 + 4
	Semester-VIII		
	PHY- 407F	Thermodynamics and Statistical Physics	4 + 0
	PHY- 408F	Electromagnetic Theory and Plasma Physics	4 + 0
	PHY- 411F	Major Research Project/Dissertation	12

Semester I

PHY - 101F: Mathematical Physics & Newtonian Mechanics **Credits 4+0**

Course Outcomes (COs):

CO1 Recognize the difference between scalars, vectors, pseudo-scalars and pseudo-vectors.
CO2 Understand the physical interpretation of gradient, divergence and curl.
CO3 Comprehend the difference and connection between Cartesian, spherical and cylindrical coordinate systems.
CO4 Know the meaning of 4-vectors, Kronecker delta and Epsilon (Levi Civita) tensors.
CO5 Study the origin of pseudo forces in rotating frame.
CO6 Study the response of the classical systems to external forces and their elastic deformation.
CO7 Understand the dynamics of planetary motion and the working of Global Positioning System (GPS).
CO8 Comprehend the different features of Simple Harmonic Motion (SHM) and wave propagation.

Part A

Unit 1 Vector Algebra
Coordinate rotation, reflection and inversion as the basis for defining scalars, vectors, pseudo-scalars and pseudo-vectors (include physical examples). Component form in 2D and 3D. Geometrical and physical interpretation of addition, substraction, dot product, wedge product, cross product and triple product of vectors. Position, separation and displacement vectors.

Unit 2 Vector Calculus
Geometrical and physical interpretation of vector differentiation, Gradient, Divergence and Curl and their significance. Vector integration, Line, Surface (flux) and Volume integrals of vector fields. Gradient theorem, Gauss-divergence theorem, Stoke-curl theorem, Greens theorem and Helmholtz theorem (statement only). Introduction to Dirac delta function.

Unit 3 Coordinate Systems
2D & 3D Cartesian, Spherical and Cylindrical coordinate systems, basis vectors, transformation equations. Expressions for displacement vector, arc length, area element, volume element, gradient, divergence and curl in different coordinate systems. Components of velocity and acceleration in different coordinate systems. Examples of non-inertial coordinate system and pseudo-acceleration.

Unit 4 Introduction to Tensors
Principle of invariance of physical laws w.r.t. different coordinate systems as the basis for defining tensors. Coordinate transformations for general spaces of nD, contravariant, covariant & mixed tensors and their ranks, 4-vectors. Index notation and summation convention. Symmetric and skew-symmetric tensors. Invariant tensors, Kronecker delta and Epsilon (Levi Civita) tensors. Examples of tensors in physics.

Part B

Unit 1 Dynamics of a System of Particles

Review of historical development of mechanics up to Newton. Background, statement and critical analysis of Newton's axioms of motion. Dynamics of a system of particles, centre of mass motion, and conservation laws & their deductions. Rotating frames of reference, general derivation of origin of pseudo forces (Euler, Coriolis & centrifugal) in rotating frame, and effects of Coriolis force.

Unit 2 Dynamics of a Rigid Body

Angular momentum, Torque, Rotational energy and the inertia tensor. Rotational inertia for simple bodies (ring, disk, rod, solid and hollow sphere, solid and hollow cylinder, rectangular lamina). The combined translational and rotational motion of a rigid body on horizontal and inclined planes. Elasticity, relations between elastic constants, bending of beam and torsion of cylinder.

Unit 3 Motion of Planets & Satellites

Two particle central force problem, reduced mass, relative and centre of mass motion. Newton's law of gravitation, gravitational field and gravitational potential. Kepler's laws of planetary motion and their deductions. Motions of geo-synchronous & geo-stationary satellites and basic idea of Global Positioning System (GPS).

Unit 4 Wave Motion

Differential equation of simple harmonic motion and its solution, use of complex notation. Damped and forced oscillations, Quality factor. Composition of simple harmonic motion, Lissajous figures. Differential equation of wave motion. Plain progressive waves. Principle of superposition of waves, stationary waves, phase and group velocity. Fourier series and Fourier coefficients (simple examples)

Suggested Readings

PART A

1. Murray Spiegel, Seymour Lipschutz, Dennis Spellman, "Schaum's Outline Series: Vector Analysis", McGraw Hill, 2017, 2e
2. A.W. Joshi, "Matrices and Tensors in Physics", New Age International Private Limited, 1995, 3e
3. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

PART B

1. Charles Kittel, Walter D. Knight, Malvin A. Ruderman, Carl A. Helmholz, Burton J. Moyer, "Mechanics (In SI Units): Berkeley Physics Course Vol 1", McGraw Hill, 2017, 2e
2. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 1", Pearson Education Limited, 2012
3. Hugh D. Young and Roger A. Freedman, "Sears & Zemansky's University Physics with Modern Physics", Pearson Education Limited, 2017, 14e
4. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

PHY - 102F: Practical (Mechanical Properties of Matter) **Credits 0+2**

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the mechanical properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Moment of inertia of fly wheel.
2. Compound pendulum; Acceleration due to gravity and radius of gyration.
3. Modulus of rigidity by Maxwell’s needle.
4. Young’s modulus of rectangular bar by cathetometer or optical lever method
5. To determine the force constant of a spiral spring by statical and dynamical methods
6. To determine height of building and draw zero-error graph of sextant.
7. Elastic constants by Searle’s apparatus.
8. Surface tension of water by Jaeger’s method.
9. Coefficient of viscosity of water by Poiseuille’s method.
10. Frequency of electrically maintained tuning fork.
11. Frequency of A.C. mains using sonometer.

Semester II

PHY – 103F: Thermal Physics & Semiconductor Devices **Credits 4+0**

Course Outcomes (COs):

CO1 Recognize the difference between reversible and irreversible processes.
CO2 Understand the physical significance of thermodynamical potentials.
CO3 Comprehend the kinetic model of gases w.r.t. various gas laws.
CO4 Study the implementations and limitations of fundamental radiation laws.
CO5 Utility of AC bridges.
CO6 Recognize the basic components of electronic devices.
CO7 Design simple electronic circuits.
CO8 Understand the applications of various electronic instruments.

PART A

Unit 1 Zeroth & First Law of Thermodynamics

State functions and terminology of thermodynamics. Zeroth law and temperature. First law, internal energy, heat and work done. Work done in various thermodynamical processes. Enthalpy, relation between C P and C V . Carnot's engine, efficiency and Carnot's theorem. Efficiency of internal combustion engines (Otto and diesel).

Unit 2 Second & Third Law of Thermodynamics

Different statements of second law, Clausius inequality, entropy and its physical significance. Entropy changes in various thermodynamical processes. Third law of thermodynamics and unattainability of absolute zero. Thermodynamical potentials, Maxwell's relations, conditions for feasibility of a process and equilibrium of a system. Clausius- Clapeyron equation, Joule-Thompson effect.

Unit 3 Kinetic Theory of Gases

Kinetic model and deduction of gas laws. Derivation of Maxwell's law of distribution of velocities and its experimental verification. Degrees of freedom, law of equipartition of energy (no derivation) and its application to specific heat of gases (mono, di and poly atomic).

Unit 4 Theory of Radiation

Blackbody radiation, spectral distribution, concept of energy density and pressure of radiation. Derivation of Planck's law, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law.

PART B

Unit 1 DC & AC Circuits

Growth and decay of currents in RL circuit. Charging and discharging of capacitor in RC, LC and V RCL circuits. Network Analysis. Thevenin's and Norton's theorems. AC Bridges - measurement of inductance (Maxwell's and Anderson's bridges) and measurement of capacitance (Schering's and de Sauty's bridges).

Unit 2 Semiconductors & Diodes

P and N type semiconductors, qualitative idea of Fermi level. Formation of depletion layer in PN junction diode, field & potential at the depletion layer. Qualitative idea of current flow mechanism in forward & reverse biased diode. Diode fabrication. PN junction diode and its characteristics, static and dynamic resistance. Principle, structure, characteristics and applications of Zener, Tunnel, Light Emitting, Point Contact and Photo diodes. Half and Full wave rectifiers, calculation of ripple factor, rectification efficiency and voltage regulation. Basic idea about filter circuits and voltage regulated power supply.

Unit 3 Transistors

Bipolar Junction PNP and NPN transistors. Study of CB, CE & CC configurations w.r.t. active, cutoff & saturation regions; characteristics; current, voltage & power gains; transistor currents & relations between them. Idea of base width modulation, base spreading resistance & transition time. DC Load Line analysis and Q-point stabilisation. Voltage Divider Bias circuit for CE amplifier. Qualitative discussion of RC coupled amplifier (frequency response not included).

Unit 4 Electronic Instrumentation

Multimeter: Principles of measurement of dc voltage, dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. Cathode Ray Oscilloscope: Block diagram of basic CRO. Applications of CRO to study the waveform and measurement of voltage, current, frequency & phase difference.

Suggested Readings

PART A

1. M.W. Zemansky, R. Dittman, “Heat and Thermodynamics”, McGraw Hill, 1997, 7e
2. F.W. Sears, G.L. Salinger, “Thermodynamics, Kinetic theory & Statistical thermodynamics”, Narosa Publishing House, 1998
3. Enrico Fermi, “Thermodynamics”, Dover Publications, 1956
4. S. Garg, R. Bansal, C. Ghosh, “Thermal Physics”, McGraw Hill, 2012, 2e
5. Meghnad Saha, B.N. Srivastava, “A Treatise on Heat”, Indian Press, 1973, 5e

PART B

1. R.L. Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”, Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, “Electronic Devices and Circuits”, McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, “Solid State Electronic Devices”, Pearson Education India, 2015, 7e
4. J.D. Ryder, “Electronic Fundamentals and Applications”, Prentice-Hall of India Private Limited, 1975, 5e
5. A. Sudhakar, S.S. Palli, “Circuits and Networks: Analysis and Synthesis”, McGraw Hill, 2015, 5e
6. S.L. Gupta, V. Kumar, “Hand Book of Electronics”, Pragati Prakashan, Meerut, 2016, 43e

PHY – 104F: Practical (Thermal Properties of Matter & Electronic Circuits) Credits 0+2

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the thermal and electronic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Mechanical Equivalent of Heat by Callender and Barne's method
2. Value of Stefan's constant
3. Verification of Stefan's law
4. Characteristics of P-N junction.
5. Characteristics of Zener diode.
6. Measurement of inductance of a coil using Anderson's bridge.
7. Measurement of capacity and power factor of a capacitor using Schering's Bridge.
8. Study the behaviour of LCR circuit.
9. Characteristics of p-n-p transistor in common-emitter configuration.
10. Characteristics of p-n-p transistor in common-base configuration.
11. Study of resonance of digital display (LCR) in series and parallel circuit to find its resonance frequency.

Semester III

PHY – 201F: Electromagnetic Theory & Optics **Credits 4+0**

Course Outcomes (COs):

CO1 Better understanding of electrical and magnetic phenomenon in daily life.
CO2 To troubleshoot simple problems related to electrical devices.
CO3 Comprehend the powerful applications of ballistic galvanometer.
CO4 Study the fundamental physics behind reflection and refraction of light (electromagnetic waves).
CO5 Study the working and applications of Michelson and Fabry-Perot interferometers.
CO6 Recognize the difference between Fresnel's and Fraunhofer's class of diffraction.
CO7 Comprehend the use of polarimeters.
CO8 Study the characteristics and uses of lasers.

PART A

Unit 1 Electrostatics

Electric force between two charges. General expression for Electric field in terms of volume charge density (divergence & curl of Electric field), general expression for Electric potential in terms of volume charge density and Gauss law (applications included). Study of electric dipole. Electric fields in matter, polarization, auxiliary field D (Electric displacement), electric susceptibility and permittivity.

Unit 2 Magnetostatics

Magnetic force between two current elements. General expression for Magnetic field in terms of volume current density (divergence and curl of Magnetic field), General expression for Magnetic potential in terms of volume current density and Ampere's circuital law (applications included). Magnetic fields in matter, magnetisation, auxiliary field H, magnetic susceptibility and permeability.

Unit 3 Time Varying Electromagnetic Fields

Faraday's laws of electromagnetic induction and Lenz's law. Displacement current, equation of continuity and Maxwell-Ampere's circuital law. Self and mutual induction (applications included). Maxwell's equations and their physical significance.

Unit 4 Electromagnetic Waves

Electromagnetic energy density and Poynting vector. Plane electromagnetic waves in linear infinite dielectrics, dispersive & non- dispersive media. Reflection and refraction of homogeneous plane electromagnetic waves, law of reflection, Snell's law, Fresnel's formulae (Reflection and transmission coefficient for normal incidence).

PART B

Unit 1 Interference

Conditions for interference and spatial & temporal coherence. Division of Wavefront - Fresnel's Biprism and Lloyd's Mirror. Division of Amplitude - Parallel thin film, wedge shaped film and Newton's Ring experiment. Interferometer - Michelson and Fabry-Perot.

Unit 2 Diffraction

Fresnel's and Fraunhofer's class of diffraction. Fresnel's Half Period Zones and Zone plate. Fraunhofer diffraction at a single slit, N-slits and Diffracting Grating. Resolving Power of Optical Instruments - Rayleigh's criterion and resolving power of telescope.

Unit 3 Polarisation

Polarisation by dichronic crystals, birefringence, Nicol prism, retardation plates. Analysis of polarized light. Optical Rotation - Fresnel's explanation of optical rotation and Half Shade & Biquartz polarimeters.

Unit 4 Lasers

Characteristics and uses of Lasers. Qualitative analysis of Spatial and Temporal coherence. Conditions for Laser action and Einstein's coefficients. Ruby and He-Ne Lasers (qualitative discussion)

Suggested Readings

PART A

1. D.J. Griffiths, "Introduction to Electrodynamics", Prentice-Hall of India Private Limited, 2002, 3e
2. E.M. Purcell, "Electricity and Magnetism (In SI Units): Berkeley Physics Course Vol 2", McGraw Hill, 2017,2e
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 2", Pearson Education Limited, 2012
4. D.C. Tayal, "Electricity and Magnetism", Himalaya Publishing House Pvt. Ltd., 2019, 4e

PART B

1. Francis A. Jenkins, Harvey E. White, "Fundamentals of Optics", McGraw Hill, 2017, 4e
2. Samuel Tolansky, "An Introduction to Interferometry", John Wiley & Sons Inc., 1973, 2e
3. A. Ghatak, "Optics", McGraw Hill, 2017, 6e

PHY – 202F: Practical (Demonstrative Aspects of Electricity & Magnetism) Credits 0+2

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the electric and magnetic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Determine unknown resistance using Carey Foster's bridge.
2. Determination of high resistance by method of leakage.
3. Reduction factor of Helmholtz galvanometer.
4. Variation of magnetic field along the axis of Helmholtz coil
5. Verification of Child's law.
6. Current sensitivity of a dead-beat moving coil galvanometer.
7. Charge sensitivity of a ballistic galvanometer by capacity discharge method.
8. Calibration of energy meter using ammeter and voltmeter.
9. Time constant using charging discharging of capacitor.
10. Earth Inductor: Horizontal component of earth's magnetic field

Semester IV

PHY – 203F: Modern Physics & Electronics **Credits 4+0**

Course Outcomes (COs):

CO1 Recognize the difference between the structure of space & time in Newtonian & Relativistic mechanics.
CO2 Understand the physical significance of consequences of Lorentz transformation equations.
CO3 Comprehend the wave-particle duality.
CO4 Develop an understanding of the foundational aspects of Quantum Mechanics.
CO5 Study the comparison between various biasing techniques.
CO6 Study the classification of amplifiers.
CO7 Comprehend the use of feedback and oscillators.
CO8 Comprehend the theory and working of optical fibers along with its applications.

PART A

Unit 1 Relativity-Experimental Background

Michelson-Morley experiment and significance of the null result. Einstein's postulates of special theory of relativity. Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations (4-vector formulation included). Consequences of Lorentz Transformation Equations (derivations & examples included)

Unit 2 Relativity-Relativistic Kinematics

Concept of Simultaneity (Relativity of simultaneity); Transformation of Length (Length contraction); Transformation of Time (Time dilation); Transformation of Velocity (Relativistic velocity addition); Transformation of Acceleration; Transformation of Mass (Variation of mass with velocity). Relation between Energy & Mass (Einstein's mass & energy relation) and Energy & Momentum.

Unit 3 Inadequacies of Classical Mechanics

Particle Properties of Waves: Spectrum of Black Body radiation, Photoelectric effect, Compton effect and their explanations based on Max Planck's Quantum hypothesis. Wave Properties of Particles: Louis de Broglie's hypothesis of matter waves and their experimental verification by Davisson-Germer's experiment and Thomson's experiment.

Unit 4 Introduction to Quantum Mechanics

Matter Waves: Mathematical representation, Wavelength, Concept of Wave group, Group (particle) velocity, Phase (wave) velocity and relation between Group & Phase velocities. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function based on Born Rule.

PART B

Unit 1 Transistor Biasing
Faithful amplification & need for biasing. Stability Factors and its calculation for transistor biasing V circuits for CE configuration: Fixed Bias (Base Resistor Method), Emitter Bias (Fixed Bias with Emitter Resistor), Collector to Base Bias (Base Bias with Collector Feedback) &, Voltage Divider Bias. Discussion of Emitter-Follower configuration.

Unit 2 Amplifiers
Classification of amplifiers based on Mode of operation (Class A, B, AB, C & D), Stages (single & multi stage, cascade & cascode connections), Coupling methods (RC, Transformer, Direct & LC couplings), Nature of amplification (Voltage & Power amplification) and Frequency capabilities (AF, IF, RF & VF). Theory & working of RC coupled voltage amplifier (Uses of various resistors & capacitors, and Frequency response) and Transformer coupled power amplifier (calculation of Power, Effect of temperature, Use of heat sink & Power dissipation). Calculation of Amplifier Efficiency (power efficiency) for Class A Series-Fed, Class A Transformer Coupled, Class B Series-Fed and Class B Transformer Coupled amplifiers.

Unit 3 Feedback & Oscillator Circuits
Feedback Circuits: Effects of positive and negative feedback. Voltage Series, Voltage Shunt, Current Series and Current Shunt feedback connection types and their uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion, Noise and Band Width for Voltage Series negative feedback and their comparison between different negative feedback connection types. Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for self-sustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators (Tuned oscillator circuits): Hartley & Colpitt oscillators.

Unit 4 Introduction to Fiber Optics
Basics of Fiber Optics, step index fiber, graded index fiber, light propagation through an optical fiber, acceptance angle & numerical aperture, qualitative discussion of fiber losses and applications of optical fibers.

Suggested Readings

PART A

1. A. Beiser, Shobhit Mahajan, “Concepts of Modern Physics: Special Indian Edition”, McGraw Hill, 2009, 6e
2. John R. Taylor, Chris D. Zafiratos, Michael A.Dubson, “Modern Physics for Scientists and Engineers”, Prentice-Hall of India Private Limited, 2003, 2e
3. R.A. Serway, C.J. Moses, and C.A. Moyer, “Modern Physics”, Cengage Learning India Pvt. Ltd, 2004, 3e
4. R. Resnick, “Introduction to Special Relativity”, Wiley India Private Limited, 2007
5. R. Murugeshan, Kiruthiga Sivaprasath, “Modern Physics”, S. Chand Publishing, 2019, 18e

PART B

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e

2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e

3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e

4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e

5. John M. Senior, "Optical Fiber Communications: Principles and Practice", Pearson Education Limited, 2010, 3e

6. John Wilson, John Hawkes, "Optoelectronics: Principles and Practice", Pearson Education Limited, 2018, 3e

7. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

PHY – 204F: Practical (Basic Electronics Instrumentation) **Credits 0+2**

Course Outcomes (COs):

Basic Electronics instrumentation has the most striking impact on the industry wherever the components / instruments are used to study and determine the electronic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Measurement of dc and ac voltages and frequency using cathod ray oscilloscope.
2. To study the characteristics of R-C network.
3. To study the characteristics of a rectifier circuit.
4. To study the characteristics of an unregulated power supply.
5. To study the characteristics of low/high pass filter.
6. To study the characteristics of interstage audio transformer.
7. To determine the dispersive power of the material of prism by spectrometer
8. Specific rotation of cane sugar using Polarimeter.
9. Resolving power of telescope
10. Resolving power of plane transmission grating
11. To determine the wavelength of sodium light by grating.

Semester V

PHY – 301F: Classical Mechanics and Statistical Mechanics **Credits 4+0**

Course Outcomes (COs):

CO1 Understand the concepts of generalized coordinates and D'Alembert's principle.
CO2 Understand the Lagrangian dynamics and the importance of cyclic coordinates.
CO3 Comprehend the difference between Lagrangian and Hamiltonian dynamics.
CO4 Study the important features of central force and its application in Kepler's problem.
CO5 Recognize the difference between macrostate and microstate.
CO6 Comprehend the concept of ensembles.
CO7 Understand the classical and quantum statistical distribution laws.
CO8 Study the applications of statistical distribution laws.

PART A

Unit 1 Constrained Motion
Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D'Alembert's principle.

Unit 2 Lagrangian Formalism
Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation.

Unit 3 Hamiltonian Formalism
Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton's equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation.

Unit 4 Central Force
Definition and properties (with prove) of central force. Equation of motion and differential equation of orbit. Bound & unbound orbits, stable & non-stable orbits, closed & open orbits and Bertrand's theorem. Motion under inverse square law of force and derivation of Kepler's laws. Laplace-Runge- Lenz vector (Runge-Lenz vector) and its applications.

PART B

Unit 1 Macrostate & Microstate

Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D.

Unit 2 Concept of Ensemble

Problem with time average, concept of ensemble, postulate of ensemble average and Liouville's theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.

Unit 3 Distribution Laws

Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in ith state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi-Dirac statistics. Comparison of statistical distribution laws and their physical significance. Canonical Distribution Law: Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials.

Unit 4 Applications of Statistical Distribution Laws

Application of Bose-Einstein Distribution Law: Photons in a black body cavity and derivation of Planck's Distribution Law. Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Definition of Fermi energy, Determination of Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).

Suggested Readings

PART A

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
3. R.G. Takwale, P.S. Puranik, "Introduction to Classical Mechanics", McGraw Hill, 2017

PART B

1. F. Reif, "Statistical Physics (In SI Units): Berkeley Physics Course Vol 5", McGraw Hill, 2017, 1e
2. B.B. Laud, "Fundamentals of Statistical Mechanics", New Age International Private Limited, 2020, 2e
3. B.K. Agarwal, M. Eisner, "Statistical Mechanics", New Age International Private Limited, 2007, 2e

PHY – 302F: Quantum Mechanics & Spectroscopy **Credits 4+0**

Course Outcomes (COs):

CO1 Understand the significance of operator formalism in Quantum mechanics.
CO2 Study the eigen and expectation value methods.
CO3 Understand the basis and interpretation of Uncertainty principle.
CO4 Develop the technique of solving Schrodinger equation for 1D and 3D problems.
CO5 Comprehend the success of Vector atomic model in the theory of Atomic spectra.
CO6 Study the different aspects of spectra of Group I & II elements.
CO7 Study the production and applications of X-rays.
CO8 Develop an understanding of the fundamental aspects of Molecular spectra.

PART A

Unit 1 Operator Formalism

Operators: Review of matrix algebra, definition of an operator, special operators, operator algebra and operators corresponding to various physical-dynamical variables. Commutators: Definition, commutator algebra and commutation relations among position, linear momentum & angular momentum and energy & time. Simple problems based on commutation relations.

Unit 2 Eigen & Expectation Values

Eigen & Expectation Values: Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate & Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation. Hermitian Operators: Definition, properties and applications. Prove of the hermitian nature of various physical-dynamical operators.

Unit 3 Uncertainty Principle & Schrodinger Equation

Uncertainty Principle: Commutativity & simultaneity (theorems with proofs). Non commutativity of operators as the basis for uncertainty principle and derivation of general form of uncertainty principle through Schwarz inequality. Uncertainty principle for various conjugate pairs of physical- dynamical parameters and its applications.
Schrodinger Equation: Derivation of time independent & time dependent forms, Schrodinger equation as an eigen equation, Deviation & interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation.

Unit 4 Applications of Schrodinger Equation

Application to 1D Problems: Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. Application to 3D Problems: Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom (radial distribution function and radial probability included). (Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted).

PART B

Unit 1 Vector Atomic Model

Inadequacies of Bohr and Bohr-Sommerfeld atomic models w.r.t. spectrum of Hydrogen atom (fine structure of H-alpha line). Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model (Stern-Gerlach experiment included) and physical & geometrical interpretations of various quantum numbers for single & many valence electron systems. LS & jj couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model.

Unit 2 Spectra of Alkali & Alkaline Elements

Spectra of alkali elements: Screening constants for s, p, d & f orbitals; sharp, principle, diffuse & fundamental series; doublet structure of spectra and fine structure of Sodium D line.

Unit 3 X-Rays & X-Ray Spectra

Nature & production, Continuous X-ray spectrum & Duane-Hunt's law, Characteristic X-ray spectrum & Mosley's law, Fine structure of Characteristic X-ray spectrum.

Unit 4 Molecular Spectra

Discrete set of energies of a molecule, electronic, vibrational and rotational energies. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Rotational-Vibrational spectra; transition rules; fundamental band. P,Q, R

Suggested Readings

PART A

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Pearson Education, India, 2004, 2e
2. E. Wichmann, "Quantum Physics (In SI Units): Berkeley Physics Course Vol 4", McGraw Hill, 2017
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 3", Pearson Education Limited, 2012
4. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e

PART B

1. H.E. White, "Introduction to Atomic Spectra", McGraw Hill, 1934
2. C.N. Banwell, E.M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw Hill, 2017, 4e
3. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e
4. S.L. Gupta, V. Kumar, R.C. Sharma, "Elements of Spectroscopy", Pragati Prakashan, Meerut, 2015, 27e

PHY – 303F: Practical (Demonstrative Aspects of Optics & Lasers) **Credits 0+2**

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the optical properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Focal length of thin lenses and their combination by Nodal slide.
2. Wavelength of light using bi-prism.
3. Wavelength of light by Newton’s rings method.
4. Breadth of single slit by diffraction of light using spectrometer.
5. Wavelength of light using double slit experiment (using spectrometer)
6. Refractive index using Brewster’s law.
7. To determine the wavelength and separation between D1 and D2 line with the help of Michelson Interferometer.
8. To determine the Young’s modulus by Cornue’s Fringes or Newton’s rings.
9. To determine the velocity of ultrasonic wave by diffraction method.
10. To determine the diameter of a thin wire by interference in a wedge shape air film.
11. To determine the wavelength of sodium light by interference due to three/ four slits.

Semester VI

PHY – 304F: Solid State Physics & Nuclear Physics **Credits 4+0**

Course Outcomes (COs):

CO1 Understand the crystal geometry w.r.t. symmetry operations.
CO2 Comprehend the power of X-ray diffraction and the concept of reciprocal lattice.
CO3 Study various properties based on crystal bindings.
CO4 Recognize the importance of Free Electron & Band theories in understanding the crystal properties.
CO5 Study the salient features of nuclear forces & radioactive decays.
CO6 Understand the importance of nuclear models & nuclear reactions.
CO7 Comprehend the working and applications of nuclear accelerators and detectors.
CO8 Understand the classification and properties of basic building blocks of nature.

PART A

Unit 1 Crystal Structure

Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP & FCC, Diamond, Cubic Zinc Sulphide, Sodium Chloride, Cesium Chloride.

Unit 2 Crystal Diffraction

X-ray diffraction and Bragg's law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct & Reciprocal lattice. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to SC, BCC & FCC lattices.

Unit 3 Crystal Bindings

Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals- London) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant.

Unit 4 Lattice Vibrations

Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit's law and Einstein's theory of lattice heat capacity.
Free Electron Theory: Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals.
Band Theory: Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Effectice mass of an electron & Concept of Holes & Classification of solids on the basis of band theory.

PART B

Unit 1 Nuclear Forces & Radioactive Decays

General Properties of Nucleus: Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector and electric quadrupole moment tensor. Nuclear Forces: General characteristic of nuclear force and Deuteron ground state properties. Radioactive Decays: Nuclear stability, basic ideas about beta minus decay, beta plus decay, alpha decay, gamma decay & electron capture, fundamental laws of radioactive disintegration and radioactive series.

Unit 2 Nuclear Models & Nuclear Reactions

Nuclear Models: Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model (the level scheme in the context of reproduction of magic numbers included).

Nuclear Reactions: Bethe's notation, types of nuclear reaction, Conservation laws, Cross-section of nuclear reaction, nuclear fission and fusion(qualitative), Nuclear reactors.

Unit 3 Accelerators & Detectors

Accelerators: Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. Detectors: Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber.

Unit 4 Elementary Particles

Fundamental interactions & their mediating quanta. Concept of antiparticles. Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime.

Suggested Readings

PART A

1. Charles Kittel, "Introduction to Solid State Physics", Wiley India Private Limited, 2012, 8e
2. A.J. Dekker, "Solid State Physics", Macmillan India Limited, 1993
3. R.K. Puri, V.K. Babbar, "Solid State Physics", S. Chand Publishing, 2015

PART B

1. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley India Private Limited, 2008
2. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, 2017
3. S.N. Ghoshal, "Nuclear Physics", S. Chand Publishing, 2019

PHY – 305F: Analog & Digital- Principles & Applications **Credits 4+0**

Course Outcomes (COs):

CO1 Study the drift and diffusion of charge carriers in a semiconductor.
CO2 Understand the Two-Port model of a transistor.
CO3 Study the working, properties and uses of FETs.
CO4 Comprehend the design and operations of SCRs and UJTs.
CO5 Understand various number systems and binary codes.
CO6 Familiarize with binary arithmetic.
CO7 Study the working and properties of various logic gates.
CO8 Comprehend the design of combinational and sequential circuits.

PART A

Unit 1 Semiconductor Junction
Expressions for Fermi energy, Electron density in conduction band, Hole density in valence band, Drift of charge carriers (mobility & conductivity), Diffusion of charge carries and Life time of charge carries in a semiconductor. Work function in metals and semiconductors. Expressions for Barrier potential, Barrier width and Junction capacitance (diffusion & transition) for depletion layer in a PN junction. Expressions for Current (diode equation) and Dynamic resistance for PN junction.

Unit 2 Transistor Modeling
Transistor as Two-Port Network. Notation for dc & ac components of voltage & current. Quantitative discussion of Z, Y & h parameters and their equivalent two-generator model circuits. h-parameters for CB, CE & CC configurations. Analysis of transistor amplifier using the hybrid equivalent model and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power).

Unit 3 Field Effect Transistors
JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions (Ohmic or Linear, Saturated or Active or Pinch off & Break down); Important Terms (Shorted Gate Drain Current, Pinch Off Voltage & Gate Source Cut-Off Voltage); Expression for Drain Current (Shockley equation); Characteristics (Drain & Transfer); Parameters (Drain III Resistance, Mutual Conductance or Transconductance & Amplification Factor); Biasing w.r.t. CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs).

Unit 4 MOSFET: Construction and Working of DE-MOSFET (N channel & P channel) and E- MOSFET (N channel & P channel); Characteristics (Drain & Transfer) of DE-MOSFET and E- MOSFET; Comparison of JFFET and MOSFET.

PART B

Unit 1 Number System

Number Systems: Binary, Octal, Decimal & Hexadecimal number systems and their inter conversion. Binary Codes: BCD, Excess-3 (XS3), Parity, Gray, ASCII & EBCDIC Codes and their advantages & disadvantages. Data representation.

Unit 2 Binary Arithmetic

Binary Addition, Decimal Subtraction using 9's & 10's complement, Binary Subtraction using 1's & 2's compliment, Multiplication and Division.

Unit 3 Logic Gates

Truth Table, Symbolic Representation and Properties of OR, AND, NOT, NOR, NAND, EX-OR & EX-NOR Gates. Implementation of OR, AND & NOT gates (realization using diodes & transistor). De Morgan's theorems. NOR & NAND gates as Universal Gates. Application of EX-OR & EX- NOR gates as pairty checker. Boolean Algebra. Karnaugh Map.

Unit 4 Combinational & Sequential Circuits

Combinational Circuits: Half Adder, Full Adder, Parallel Adder, Half Substractor, Full Substractor. Data Processing Circuits: Multiplexer, Demultiplexer, Decoders & Encoders. Sequential Circuits: SR, JK & D Flip-Flops, Shift Register (transfer operation of Flip-Flops), and Asynchronous & Synchronous counters.

Suggested Readings

PART A

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

PART B

1. D. Leach, A. Malvino, Goutam Saha, "Digital Principles and Applications", McGraw Hill, 2010, 7e
2. William H. Gothmann, "Digital Electronics: An Introduction to Theory and Practice", Prentice-Hall of India Private Limited, 1982, 2e
3. R.P. Jain, "Modern Digital Electronics", McGraw Hill, 2009, 4e

PHY – 306F: Practical (Analog & Digital Circuits) **Credits 0+2**

Course Outcomes (COs):

Analog & digital circuits have the most striking impact on the industry wherever the electronics instruments are used to study and determine the electronic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Verification of Richardson-Dushman equation and evaluation of work function of cathode material.
2. To draw the characteristics and to determine the parameters of a field effect transistor (FET).
3. Characteristics of MOSFET
4. Verification of truth table of OR, AND and NOT gates.
5. Study and Verification of AND gate using TTL IC 7408
6. Study and Verification of OR gate using TTL IC 7432
7. Study and Verification of NAND gate and use as Universal gate using TTL IC 7400
8. Study and Verification of NOR gate and use as Universal gate using TTL IC 7402
9. Study and Verification of NOT gate using TTL IC 7404
10. Study and Verification of Ex-OR gate using TTL IC 7486

Semester VII

PHY – 401F: Mathematical Physics **Credits 4+0**

Course Objectives: Understanding mathematical functions and solution methods useful in various branches of Physics.

Course Outcomes:

CO1. The students will understand various functions and solutions to differential equations.
CO2. The foundation for understanding of Classical and Quantum Mechanics will be laid.
CO3. The techniques learnt will be useful in different branches of Physics.

Unit – I

Special Functions: Second order linear differential equations; Solution by series expansion; Legendre, Bessel, Hermite and Laguerre differential equations, their solutions and properties, Spherical Harmonics**.**

Unit – II

Fourier Transform: Dirac Delta function, Fourier Transform, Sine and Cosine transform, Linearity, Change of Scale, Translation, Modulation, simple applications.

Green Function: Green's function as a technique to solve linear ordinary differential equations, Homogeneous and Inhomogeneous boundary conditions, Solution of Poisson equation using Green's function technique, Symmetry property.

Unit – III

Complex Variables I: General function of complex variable, Cauchy-Riemann differential equation and analyticity, conformal mapping (translation, rotation, inversion), Cauchy's integral formula, Taylor's and Laurent's series, singularity poles.

Unit – IV

Complex Variables II: Residue theorem. Evaluation of definite integrals, around (i) unit circle and (ii) infinite semi-circle; using Jordan's lemma with poles lying on real axis, and of integrals involving multiple valued function-branch point.

References:

1. Mathematical Methods for Physicists by G. Arfken, H. Weber and F.E. Harris (Elsevier)
2. Mathematics for Physicist by P. Dennery and A. Krzynicki (Dover Publication)
3. Special Functions and their Applications by N.N. Lebedev (Dover Publication)
4. Mathematical Methods for Physics and Engineering by K.F. Riley, M.P. Hobson and S.J.Bence (Cambridge University Press)
5. Mathematical Physics by B. S. Rajput (Pagati Prakashan)
6. Complex Variables and Applications by J.W. Brown and R. V. Churchill (McGraw-Hill)

PHY – 402F: Classical Mechanics **Credits 4+0**

Course Objectives: Understanding basic methods of mechanics and use of Lagrangian and Hamiltonian approach.

Course Outcomes:

CO1. The students will understand dynamics of particles and conservation laws.

CO2. The understanding of different mechanical problems and their solutions will be developed.

Unit - I

Vectors: Curvilinear Coordinates, Gradient, Divergence and Curl, Laplace equation in spherical polar and cylindrical polar coordinates and their solution, Green's theorem, Gauss and Stokes Theorems.

Tensors: Covariant and Contravariant vectors, Tensors – Addition, Multiplication, Contraction, Symmetry properties; Tensor density, Pseudo-tensors.

Unit-II

Mechanics of a system of particles: Generalized coordinates and Constraints, Generalized coordinates, D' Alembert's principle, Lagrange's Equation, symmetry and cyclic coordinates. Hamilton's principle, Least action principle, Langrange's equations, symmetry properties and Noether's theorem, Lagrangian formulation for elementary mechanical systems - free particle, simple and double pendulum.

Unit-III

Two Body Problem: Reduction to one-body problem, reduced mass, Virial Theorem, planetary orbits.

Scattering: Collision between particles, disintegration of particles, elastic collisions, scattering, Rutherford's formula.

Small oscillations: Damped and Forced oscillations, coupled vibrations.

Unit-IV

Hamiltonian Formulation: Hamilton equations, canonical transformations, Poisson's bracket, Symplectic approach to canonical transformations; Hamilton Principle function, Hamilton-Jacobi equation, conservation theorem in Poisson brackets. Harmonic Oscillator Problem, Hamilton characteristic Function, separation of Action angle variables, Central Force problem.

References:

1. Vector Analysis and Introductory Tensor Analysis by M.R. Spiegel (Schaum Series)
2. Matrices and Tensors in Physics by A.W. Joshi (New Age)
3. Classical Mechanics by H. Goldstein (Narosa, New Delhi)
4. Classical Mechanics by K.C. Gupta (Wiley Eastern)
5. Classical Mechanics by L.D. Landau (Elsevier)
6. Classical Mechanics by N.C. Rana and P.S. Joag (Tata-McGraw-Hill)

PHY – 403F: Quantum Mechanics **Credits 4+0**

Course Objectives: Understanding concepts of quantum mechanics and solving operator equations for different quantum problems.

Course Outcomes:

CO1. The students will understand wave mechanical formulation of quantum particles and various rules arising out of it.
CO2. The understanding of different formulations of quantum mechanics laying foundations for the study of molecules, atoms and fundamental particles

Unit-I
Wave Mechanical formulation: Schrodinger wave equation, Hermitian operators and observables, Discreet and continuous spectrum, Dirac delta function, Commuting observables and related algebra, Pure and mixture states; Simple applications: potential well, barrier potential, tunnel effect, unbound states: reflection and transmission of waves.

Unit - II
Identity of Particles: Distinguishability of identical particles, exchange degeneracy and operator, construction of symmetric and antisymmetric wave functions, Pauli's exclusion principle and Slater's determinant, Electron spin hypothesis, spin matrices and eigen value equations, symmetric and antisymmetric wave functions for hydrogen molecule.

Unit - III
Matrix formulation: Dirac's bra and ket notations, Hilbert Space, Orthonormality and completeness relations (discrete and continuous), linear and real operators, eigen value equations and related theorems, degeneracy, projection operators and measurement, application to Harmonic Oscillator, Equivalence of wave and matrix mechanics.

Unit - IV
Theory of Angular momentum: Orbital, spin and total angular momentum operators: eigen value equations and matrix representations, Ladder operators, commutation relations, Addition of angular momenta, Clebsch-Gordon coefficients.

References:
1. Quantum Mechanics, Vol. I & II by Albert Messiah (Dover Publication)
2. The Principles of Quantum Mechanics by P.A.M. Dirac (Oxford University Press)
3. Quantum Mechanics by L.I. Schiff (Tata-McGraw-Hill)
4. Modern Quantum Mechanics by J.J. Sakurai (Addison Wesley)
5. Introduction to Quantum Mechanics by D.J. Griffths (Pearson Education)
6. Quantum Mechanics by C. Cohen-Tannoudji, B. Diu and F. Laloe (Wiley VCH)
7. Quantum Mechanics by B. K. Agarwal and Hari Prakash (Prentice-Hall, India)

PHY – 404F: Electronics **Credits 4+0**

Course Objectives: Understanding functions of electronic devices and circuit logic.

Course Outcomes:

CO1. The students will understand electronic circuits and control using various devices.
CO2. The students will understand simple logic and control via logic circuits.

Unit - I
Power Electronics: SCR: Basic structure, I-V characteristics and two- transistor model of SCR, SCR controlled half and full wave rectifier circuit and their analysis. UJT, equivalent circuit, I-V characteristics, Saw tooth wave generation. Elements of SMPS.

Unit - II
Operational Amplifier: IC-741 -Block diagram, operation, Characteristics of op-amp; inverting and non-inverting inputs: Input offset current and Input offset voltage, differential amplifier, CMRR, Slew rate and power band width, op-amp as an amplifier. Application of Op-amp: summer, integrator and differentiator. Timer: IC-555 -Block diagram, Astable and Monostable operations, applications of IC-555 as VCO.

Unit - III
Boolean Algebra and Gates: Boolean algebra, composite function and their algebraic simplification, De-Morgan's theorem ,duality in Boolean algebra, Universality of NAND and NOR gates. SOP and POS forms, karnaugh map, design of logic circuits, X-OR gate and its applications, half adder and full adder, parallel adder, look ahead carry.

Unit - IV
Elements of Logic Families: Transistor as a switch, FAN IN , FAN OUT, Noise Immunity, propagation delay, RTL, DTL, TTL logic, Sourcing and Sinking logic, TTL loading and Fan out, ECL logic.

References:
1. Switch Mode Power Conversion by K. Kit Sum (Marcel Dekker).
2. Power Electronics by P.C. Sen (Tata Mc Graw-Hill)
3. Pulse, Digital and Switching Wave Forms by J. Milman and H. Taub (McGraw-Hill)
4. Op-amp and Linear Integrated Circuits by R.A. Gayakwad (Prentice-Hall India)
5. Integrated Circuits by J. Millman and C.C. Halkias (Tata-McGraw-Hill)
6. Digital Principle and Application by A.P. Malvino and D.P. Leach (McGraw-Hill)
7. Modern Digital Electronics by R.P. Jain (Tata McGraw-Hill)

*** The following two courses PHY-405 and PHY-406 are mandatory. One course will be allotted in the VII semester and the other in VIII semester.**

PHY – 405F: Physics Practical-Electronics **Credits 0+4**

Course Objectives: The student will handle instruments, take readings and analyze the results, to understand various concepts and applications.

Course Outcomes:

CO1. Learning circuit fundamentals and making connections to study properties of electronic devices.
CO2. Learn to present observations, results and analysis in suitable and presentable form.

LIST OF EXPERIMENTS

Students will be required to perform at least five experiments from each course. They will have to maintain record books of experiments done.

1. Study of regulator circuits
2. Study of switch mode power supply (SMPS)
3. Study of characteristic of SCR and controlled rectification by SCR.
4. Study of RC coupled amplifier
5. Study of emitter follower
6. Study of phase shift oscillator
7. Study of multivibrator: Use of 555
8. Study of saw tooth wave generation by UJT
9. Study of characteristics of operational amplifier
10. Study of TTL gates
11. Study of combinational logic circuits
12. Study of super heterodyne receiver
13. Study of linear and square wave detector
14. Microwave measurement: Mode analysis and standing wave ratio

PHY – 406F: Physics Practical- Optics **Credits 0+4**

Course Objectives: The student will handle instruments, take readings and analyze the results, to understand various concepts and applications.

Course Outcomes:

CO1. Hands on experience with optical instruments and understanding concepts of physical optics.
CO2. Learn to present observations, results and analysis in suitable and presentable form.

LIST OF EXPERIMENTS

Students will be required to perform at least five experiments from each course. They will have to maintain record books of experiments done.

1. Use of constant deviation spectrograph
2. Use of Fabry-Perot interferometer
3. Use of concave grating
4. He-Ne Laser
5. e/m by Zeeman effect
6. EPR of free radicals
7. Programming on PC
8. Velocity of ultrasonic wave
9. Hall effect
10. Magnetic Susceptibility
11. Measurement of dipole moment
12. Use of scintillation counter
13. Determination of Dielectric Constant
14. Double slit/Triple slit/ Four slit Wedge shape

Semester VIII

PHY – 407F: Thermodynamics and Statistical Physics **Credit 4+0**

Course Objectives: Understanding laws of thermodynamics and microscopic statistical description.

Course Outcomes:

CO1. The students will understand laws of thermodynamics and relation between macroscopic and microscopic properties.

CO2. The students will be able to apply the concepts in different states of matter.

Unit – I

Second law of thermodynamics, Entropy and Probability, Thermodynamic Potentials, Thermodynamic Equilibrium, Third law of thermodynamics, First and Second order phase transistions: Clausius - Clapeyron and Ehrenfest's equations; Chemical potential and phase equilibria, Gibb's phase rule.

Unit – II

Thermodynamic properties of liquid Helium II, The lambda - transition, London's explanation, Quantum liquid, Tisza two fluid model, Landau spectrum, concept of second sound.
Conditions for Equilibrium, Entropy of an Ideal Boltzmann gas, Gibb's paradox, Sackur - Tetrode equation.

Unit – III

Canonical and Grand Canonical Ensembles, Entropy of a system in contact with heat reservoir, Ideal gas in canonical ensemble, Maxwell velocity distribution, Grand canonical ensemble, Thermodynamics of photons, Translational, Rotational and Vibrational partition functions of a molecule and their applications.

Unit – IV

Thermodynamical properties, Black body radiation, Bose - Einstein Condensation, Ideal Fermi - Diarc gas, Fermi temperature, applications of degeneracy to free electrons in metals, Magnetic susceptibility, White dwarfs and Chandrashekhar limit.

References:

1. A Treatise on Heat by M.N. Saha and B.N. Srivastava (Indian Press Limited, Allahabad)
2. Heat and Thermodynamics by M.W. Zemansky and R.H. Dittman (McGraw Hill)
3. Fundamentals of Statistical and Thermal Physics by F. Reif (McGraw-Hill)
4. Statistical Mechanics by K. Huang (John Wiley & Sons)
5. Statistical Mechanics by R.K. Pathria (Elsevier)
6. Statistical Mechanics and Properties of Matter by E.S.R. Gopal (Macmillan Ltd., Delhi)
7. Statistical Mechanics by B. K. Agarwal and M. Eisner (Wiley Eastern)

PHY – 408F: Electromagnetic Theory and Plasma Physics **Credit 4+0**

Course Objectives: Understanding Physics of Electromagnetic waves and plasma state.

Course Outcomes:

CO1. The students will understand nature of Electric and Magnetic fields, Electromagnetic waves and plasma state.
CO2. The students will be able to apply the concepts in various branches of Physics.

Unit – I
Maxwell Equations: Microscopic and Macroscopic fields, Macroscopic Maxwell equations, Fields **D** and **H**, Dielectric tensor, Principal dielectric axes.
Potential and Gauges: Scalar and vector potentials, Gauge transformation, Lorentz guage and Transverse gauge, Maxwell equations in terms of electromagnetic potentials.

Unit - II
Propagation of Electromagnetic Waves: Propagation of electromagnetic waves in free space, conducting and non-conducting medium, skin depth, Boundary conditions on EM Fields, Reflection and refraction at a plane interface between dielectrics.
Polarisation of EM Waves: Fresnel's Formula, Normal- and anomalous- Dispersion, metallic reflection. EM Wave in bound media: rectangular and circular wave guides, TE, TM and TEM Modes, Cut-off frequency and Wavelength.

Unit – III
Plasma State: Plasma state of matter, Motion of charge particles in uniform E & B fields, non-uniform fields, drifting motion, electrostatic and magnetostatic lenses; Time varying E & B fields, Adiabatic invariants, Plasma confinements(Pinch effect, Mirror confinement,Van Allen Belts), Elementary idea of fusion technology.

Unit – IV
Hydrodynamics of Plasma: Hydrodynamical description, Equation of magneto hydrodynamics, High frequency plasma oscillations, Short wavelength limit and Debye-screening distance.
Wave Phenomenon in Magneto-Plasma: Electromagnetic waves perpendicular to B_0, phase velocity, Polarization, Cut-off and resonances, Electromagnetic waves parallel to B_0, Alfven waves.

References:
1. Introduction to Electrodynamics by D.J. Griffiths (Prentice - Hall, New Delhi)
2. The Classical theory of Fields by L.D. Landau and E.M. Lifshitz (Elsevier)
3. Classical Electrodynamics by J.D. Jackson (Wiley Eastern)
4. Introduction to Plasma Physics by F.F. Chen (Plenum Press, New York)
5. Plasma Physics by S.N. Sen (Pragati Prakashan)

PHY – 409F: Solid State Physics **Credit 4+0**

Course Objectives: Understanding the physics related to matter in solid state.

Course Outcomes:

CO1. The students will understand crystal structure and energy concepts.

CO2. Learn different properties of solids and their relation to crystal structure and defects.

Unit - I

Crystal Structure: Ionic, covalent, metallic and hydrogen bonding, space lattice and basis ; Types of lattice, Miller indices, crystal structures of NaCl, CsCl, ZnS, graphite and diamond; Reciprocal lattice and Brillouin Zones; Basic idea of crystal defects and dislocations.

Unit – II

Band Theory of Solids: Sommerfield model, Density of states, Fermi and mean energies at zero and finite temperatures; Origin of energy bands; Bloch Theorem; Kronig Penny model, Electron dynamics in crystalline lattice.

Unit - III

Thermal Properties: Lattice vibrations of mono and diatomic chains, Quantization of lattice vibration, Phonon; Infrared absorption; Einstein and Debye theories of specific heat; Thermal conductivity; Anharmonicity and Thermal expansion.

Unit - IV

Optical Properties: Optical reflectance, Kramers-Kronig relations; Conductivity and dielectric function of electron gas; Basic theory of luminescence, phosphorescence, thermoluminescence, electroluminescence and photo-conductivity; Excitons in ionic and molecular crystals, Electron-hole drops (EHD) and colour centres.

References:

1. Solid state Physics by A.J. Dekkar (McMillan Publishers)
2. Introduction to Solid State Physics by C. Kittel (Wiley Eastern)
3. Elementary Solid State Physics by M. Ali Omar (Pearson Education)
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, (Harcourt Asia Limited)
5. Principles of the Theory of Solids by J.M. Ziman (Cambridge University Press)
6. Solid State Physics by S.O. Pillai (New Age Publishers)

PHY – 410F: Group Theory and Molecular Spectra **Credit 4+0**

Course Objectives: Understanding radiations due to transitions in molecules and symmetry considerations for them.

Course Outcomes:

CO1. The students will understand various electromagnetic transitions in molecules.
CO2. Finding selection rules using symmetry and group considerations.
CO3. The students will be able to apply the concepts in various branches of Physics.

Unit – I
Rotation and Vibration Spectra: IR and Raman spectra of rigid rotator and harmonic oscillator, IR and Raman spectra of non-rigid rotator, anharmonic oscillator and vibrating rotator, Intensities in rotation - vibration spectra, Isotope effects in rotation and vibration spectra.

Unit – II
Electronic Spectra: Electronic energy and total energy, vibration structure of electronic transitions, progressions and sequences, rotational structure of electronic bands, band head formation and band origin. Intensity distribution in vibrational structure, Frank-Condon principle and its quantum mechanical formulation, intensity alternation in rotational lines.

Units – III
Group Theory: Symmetry elements and symmetry operations, Point group and their representation, Mathematical group, Matrix representation, Orthogonality theorem (statements and interpretation only), Reducible and irreducible representations, Direct product group.

Unit – IV
Vibrational and Raman Spectra: Normal modes, symmetry characterization of electronic states and vibrational modes of polyatomic molecules, character tables (C_{2v}, D_{3h} and D_{6h}) and their applications to selection rules of IR and Raman spectra, application to H_2O and CO_2 molecules.

References:
1. Molecular Spectra and Molecular Structure by G. Herzberg (Dover Publication).
2. Fundamentals of Spectroscopy by C.N. Banwell and E.M. McCash (Tata-McGraw-Hill)
3. Introduction to Molecular Spectroscopy by G.M. Barrow (McGraw-Hill)
4. Modern Spectroscopy by M.J. Hollas (Wiley Inter Science)
5. Elements of Group theory for Physicists by A.W. Joshi (Wiley Eastern)
6. Chemical Applications of Group Theory by F.A. Cotton (Wiley Eastern)

PHY – 411F: Major Research Project/Dissertation **Credit 12**

Course Objective: The primary goal of this course is to open the students to visualize and learn new techniques. The assigned project work could be related to the experiments available, theoretical concepts and development. The candidate shall submit a brief report and present seminar.

Course Outcomes: Student will learn presentation skills including making power point presentations etc.