मोहनलाल सुखाड़िया विश्वविद्यालय, उदयपुर

MOHANLAL SUKHADIA UNIVERSITY, UDAIPUR

Syllabus of Physics

for

Three -Year Undergraduate (B.Sc.) Program

As per the Choice Based Credit System (CBCS)

Designed in accordance with Learning Outcomes-Based Curriculum Framework (LOCF) of National Education Policy (NEP-2020)

The DCC, DSE and SEC courses of B.Sc. with Physics for Academic Year 2023-2026

(Effective from Academic Year 2023-24)

List of the Courses in Physics for the CBCS in 3 year B.Sc. Program as per NEP2020.

Semester wise Types, Codes, Titles, Delivery type, Workload, Credits of the courses, Marks of Examination, and Remarks if any.

Level	Semester	Course Type	Course Code	Course Title	Delivery type per week			Total hours	Credits	Total Credits	Internal marks	EoSE Marks	Max. Marks	Remarks
					L	T	P							
5	I	DCC	PHY5000T	Physics-I: Mechanics	L	T	-	60	4	6	20	80	100	
			PHY5000P	Physics Lab-I: Mechanics	-	-	P	60	2		20	80	100	
		AECC	AEC520XT	AECC-I	L	-	-	30	2	2	20	80	100	
	II	DCC	PHY5001T	Physics-II: Electricity and Magnetism	L	T	-	60	4	6	20	80	100	
			PHY5001P	Physics Lab-II: Electricity and Magnetism	-	-	P	60	2		20	80	100	
		AECC	AEC520XT	AECC-II	2	-		30	2	2	20	80	100	May be (1L+1T) or (1L+1P)
Exit with Certificate in Science (After 4 more exit credits in SEC)														
6	III	DCC	PHY6002T	Physics-III: Thermal Physics	L	T	-	60	4	6	20	80	100	
			PHY6002P	Physics Lab-III: Thermal Physics	-	-	P	60	2		20	80	100	
		SEC	SEA630XT	Communicative English	L	T		30	2	2	20	80	100	
	IV	DCC	PHY6003T	Physics-IV: Waves and Optics	L	T	-	60	4	6	20	80	100	
			PHE6003P	Physics Lab-IV: Waves and Optics	-	-	P	60	2		20	80	100	
		SEC	SES6370T	Fundamentals of Electrical Instruments	L	-		30	2	2	20	80	100	
Exit with Diploma in Science														
7	V	**Select anyone of the following Discipline Specific Elective (DSE) Courses in V and VI semester**												

		DSE	PHY710XT	0. Quantum Mechanics & Spectroscopy 1. Elements of Modern Physics 2. Mathematical Methods 3. 4.	L	T	-	90	6	6	20	80	100	In future 2 new electives can be inducted
		SEC	SES7371P	Basics of Instrumentation and Measurements	-	-	P	30	2	2	20	80	100	
	VI	DSE	PHY710YT	5. Analog and Digital Electronics 6. Nuclear and Solid State Physics 8. 9. 10.	L	T	-	60	4	6	20	80	100	In future 3 more electives with labs can be inducted
			PHY710YP	5. Physics Lab-V-Elec-A: Electronics Lab 6. Physics Lab-V-Elec-B: Materials Lab 7. Physics Lab-V-Elec-C: 8. Physics Lab-V-Elec-D : 9. Physics Lab-V-Elec-E :	-	-	P	60	2		20	80	100	
		SEC	SES7372T	Medical Physics	L	T		30	2	2	20	80	100	
Exit with Graduation Degree in Science (B.Sc.)														

DCC- Discipline Centric Compulsory Course (000 to 099); **DSE**- Discipline Specific Elective Course (100 to 199)

AECC- Ability Enhancement Compulsory Course (English/Modern Indian Languages/Hindi) (201 to 299); **SEC**- Skill Enhancement Courses from Physics (370 to 379)

The code has eight places. XYZ (subject name) Level (5/6/7) DCC/DSE/AEC/SEC (3 digits) T/P/S

If an SEC course is offered by commerce: SE**C**53XXT; Science: SE**S**63XXT; Arts/Humanities/…..: SE**A**53XXT; Management SE**M**73XXT

B.Sc. (Three Years Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY5000T
Title of the Course	Physics-I: Mechanics
Qualification Level of the Course	NHEQF Level 4.5
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Lecture, 40+20=60. The 40 lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Physics and Mathematics courses of XII standard
Co-requisites	None
Objectives of the course	This is the conceptual course in Physics after school level which lays foundation of the principles of Mechanics and fundamental characteristics of rudimentary mechanical systems.
Learning outcomes	The students would be able to understand: • Basic laws of motion, conservation of energy and momentum, Inertial & non inertial frames and transformation equations. Concept of fictious forces. • Motion under a central force, conservation of angular momentum, Kepler's laws. • Fields and potential under gravitational field. • Two body problem, scattering and scattering cross sections, dynamics of a system of particles, centre of mass and its evaluation for regular bodies. • Rigid body and angular momentum, concept of inertia under different configurations, System of variable mass, elastic and inelastic collisions, degrees of freedom, Euler's theorem. • Applications of rotational dynamics to di and tri atomic molecules.

	• Precession motion of top. • Concept of elasticity, elastics constants and its simple uses in design of structures . • Kinematics of moving fluid and associated laws, Viscosity of fluids.
Syllabus	
UNIT-I	Laws of motion, conservation of energy and momentum, inertial and non-inertial frames of reference, transformation equations for rotating frame, centripetal and Coriolis accelerations, Coriolis force, Coriolis force due to Earth's rotation – experimental demonstration by Foucault pendulum. (6+2=8)
	Motion under a central force, conservation of angular momentum, Kepler's laws (No derivation). (2+2=4)
UNIT -II	Field and potential, gravitational field and potential due to spherical bodies, gravitational self-energy. (3+1=4)
	Two body problem, reduced mass, scattering and scattering cross sections, illustrations, elastic and inelastic scattering and momentum transfer, centre of mass and laboratory reference frames.(5+3=8)
UNIT-III	System of particles, centre of mass, calculation of centre of mass of regular bodies, angular momentum, equations of motion, conservation theorems for angular momentum and torque, system of variable mass, rigid body, degrees of freedom, Euler's theorem, Moment of inertia, Moments of Inertia of simple objects, Perpendicular and parallel axis theorems . (8+4=12)
UNIT-IV	Molecular rotations (as rigid bodies), di and tri atomic molecules, intrinsic spin, precessional motion, motion of top, gyroscope. (4+2=6)
	Elasticity, Hook's law, Elastic constants of an isotropic solid and their inter-relations, torsion of a cylinder, bending of beam, applications to cantilever. (4+2=6)
UNIT-V	Kinematics of moving fluid, Equation of continuity, Euler's law for fluidity, Bernoulli theorem. (3+1=4)
	Viscous fluids, streamline and turbulent flow, flow through a capillary tube, Poiseuille's law, Reynold's number, Stoke's law, theory of rotation viscometer, effect of temperature and pressure on the viscosity of liquids. (5+3=8)
Text Books	1. Mechanics- J.C.Upadhyaya, Ram Prasad & Sons 2. Mechanics- D.S. Mathur S.Chand & Co. 3. Mechanics of Particles, Rigid Bodies and Continuous Media (In Hindi) by Kalra, Bhandari and Kakani
Reference Books	1. E.M. Purcell, Editor, Berkeley Physics Course, Vol. 1, Mechanics, McGraw Hill. 2. R.P. Feynmann, R.B. Lighton, M. Sands, The Feynmann Lectures in Physics, Vol. 1. B.I. Publications, Bombay, Delhi, Calcutta, Madras. 3. Mechanics of Particles, Rigid Bodies and Continuous Media (In Hindi) by Kalra, Bhandari and Kakani

	4. https://archive.org/details/BerkeleyPhysicsCourse/page/n19/mode/2up
Suggested E-resources	1. MIT open Course ware. Classical Mechanics - This resource provides lecture notes, problem sets, and solutions for a complete course on classical mechanics: https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/ 2. This online resource provides concise explanations and interactive simulations for various topics in mechanics: http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

B.Sc. (Three Years Degree Program)	
First Semester	
Subject-Physics	
Code of the Course	PHY5000P
Title of the Course	Physics Lab-I: Mechanics
Qualification Level of the Course	NHEQF Level 4.5
Credit of the course	2
Type of the course	Discipline Centric Compulsory (DCC) Course in Physics
Delivery type of the Course	Practical 60. The student will perform the experiments and submit the record of observations after getting the results.
Prerequisites	Physics and associated laboratory exposure of XII standard
Co-requisites	None
Objectives of the course	The objectives focus to acquire idea of the magnitude of various physical quantities and their measurements, as well as to train to minimize the errors due to performance and usage of measuring devices. The students can link principles of mechanics with observations and underlying principles. The course also aims to enable the students to examine, determine and explain systematic errors introduced due to problems or limitations in the measuring devices and other sources.
Learning outcomes	The students will be able to learn and measure elastic properties of rods, wire, rubber etc. They will get an idea of the order of the magnitude of the elastic properties and can relate that with the performance. The will also learn to measure physical properties employing techniques based on different principles and effect as well as advantages thereof. In the experiments related to oscillations students will get acquaint with real oscillatory systems and measurement of their characteristic parameters.

Syllabus	
	The students have to perform at least 8 experiments from the given list during the semester. Experiments closely connected with the theme of the course may be incorporated. 1. To determine the height of a building using Sextant. 2. To determine the moment of inertia of a Flywheel. 3. To determine the Young's modulus of a wire by optical lever method. 4. To determine the modulus of rigidity of a wire using Maxwell's needle. 5. To determine the elastic constants of a wire by Searle's method. 6. To determine Poisson ratio of a rubber tube. 7. To determine **g** by studying oscillations of a bar pendulum. 8. To determine the modulus of rigidity of a wire by Barton's method. 9. To determine the Young modulus of a rod with rectangular cross section by bending of beam. 10. To determine **g** and velocity for a freely falling body using Digital Timing Technique. 11. To study the motion of a spring and calculate (a) Spring constant (b) value of **g**. 12. To determine time period of a compound pendulum. 13. To determine g by Kater pendulum. 14. To study effect of air damping on the oscillatory motion of simple pendulum. 15. To study the effect of viscous damping on the oscillatory motion of a simple pendulum. 16. To study effect of air damping on the oscillatory motion of a compound pendulum. 17. To study the effect of viscous damping on the oscillatory compound pendulum.
Text and reference books	1. Advanced Practical Physics for Students, B.L. Flint & H.T.Worsnop, 1971, Asia Publishing House. 2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, 11th Ed, 2011, New Delhi. 3. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd. 4. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edn, 1985, Heinemann Educational Publishers 5. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, CBH Publications, Jaipur.
Suggested E-resources	1. Online virtual labs.

Scheme of EoSE	The duration of the examination shall be three hours wherein the student has to perform any one experiment. The marks distribution shall be the following: 1. One experiment : 45 (Formula(e)-7, Figure(s)- 6, Observations-12, Calculations-10, Result(s)-5, Precautions-5) 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester: 15

B.Sc. (Three Years Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY5001T
Title of the Course	Physics-II: Electricity and Magnetism
Qualification Level of the Course	NHEQF Level 4.5
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) course in Physics
Delivery type of the Course	Lecture, 40+20=60. The 40 lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Physics and Mathematics courses of XII standard
Co-requisites	None
Objectives of the course	This course develops understanding of the basic concepts of electricity and magnetism, alternating current based applications. This basic course will equip the student with required prerequisites to understand more advanced electrodynamics phenomena.
Learning outcomes	The students would be able to understand: • Electric field, Coulomb's law, Gauss law and its applications to find electric field due to point charge, line, surface, and volume charge distribution. • Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential. • Demonstrate working of capacitors, dielectrics. Energy in dielectric systems. Polarizability and susceptibility, frequency dependence of polarizability. • Describe the magnetic field produced by magnetic dipoles and electric currents. Biot Savart law Amperes law and their applications.

	• Distinction between H and B fields, magnetic permeability, susceptibility. Comparison of magnetostatics and electrostatics. • The dielectric properties, storage of charges and the capacitors. • Behaviour and usage of various types of AC/DC circuits and bridges and transformers • Construction, working and usage of Ballistic Galvanometer. • Measurement of resistances, inductances and capacitances.
Syllabus	
UNIT-I	**Electric Field:** Field due to different charge distributions, monopole, dipole, quadrupoles, line charge, sheet charge. Torque on a dipole in uniform field and non-uniform fields, flux of an electric field. Gauss's law and its applications to deduce E fields, force per unit area on the surface of a charged conductor. (4+2=6)
	Potential: Potential as line integral of electric field. Potential energy of a system of charges and its calculation in various configurations. Differential form of Gauss's law: Poisson's equation, Laplace's equation, boundary conditions and uniqueness theorems. (4+2=6)
	Method of electric images and applications: Electric field around conductors, induced charges, field and potential inside a conductor, field near the surface of a conductor. (2+1=3)
UNIT -II	**Electric fields in matter:** atomic and molecular dipoles, induced dipoles. Electrical field caused by polarized matter, **E** and **D** fields, permittivity, dielectric constant. Capacitor filled with dielectric, field equations in presence of dielectric. The field of a polarized sphere, dielectric sphere in a uniform field. Energy in dielectric systems. Polarizability and susceptibility, Claussius-Mossotti equation. (4+2=6)
	Magnetic field: Lorentz force on a moving charge, unit for B field, magnetic dipoles in atoms. Biot and Savart's law, Ampere's law. Fields due to a straight wire, magnetic dipole, circular current and solenoid. Magnetic field in matter. Magnetizing current, magnetization vector, H and B fields, magnetic permeability, susceptibility. Comparison of magnetostatics and electrostatics. (4+2=6)
UNIT-III	**Electrical current**: current density and current; non-steady current and continuity equations. Electrical conductivity, resistivity, conductance and its temperature dependence. Thermo electric current and dark current, non-Ohmic circuitry, thermistor. (3+1=4)
	Varying current: Rise and decay of current in LR and CR circuits, time constant, integrating and differentiating circuits, electrical shielding. Study of a discrete LC transmission line. (4+2=6)
UNIT-IV	**Alternating currents:** Impedance, reactance, impedance of LCR series and parallel circuits, resonance, Q factor, power dissipation and power factor. Alternating current and the Skin effect at high frequencies.

	AC bridges: Anderson's ,de Sauty's and Owen's bridges, Kelvin bridge, Self and mutual inductances. Measurement of mutual inductance by Carry Foster Method, Measurement of small resistance by Kelvin's double bridge, Coupled circuits and Transformers.(8+4=12)
UNIT-V	Ballistic Galvanometer (moving coil type), its distinction from beat type. B.G. differential equation and its solution under different conditions of damping. Critical damping, over damping. Logarithmic decrements, charge sensitivity, current sensitivity, Determination of B using search coil and B.G. Determination of high resistance using B.G. Factors for sensitivity. B.G. constant.(7+4=11)
Text Books	1. Electricity and Magnetism, A.S. Mahajan and A.A. Rangawala, Tata McGraw Hill. 2. Electricity and Magnetism, P. Chakrabarty and K.C. Gupta, New Age International. 3. Electricity and Magnetism (In Hindi) by K.C. Bhandari, M.L. Kalra and S.L. Kakani. 4. Electricity and Magnetism, K.K. Tiwari, S. Chand , New Delhi. 5. Electromagnetics (in Hindi), M.P. Saksena, P.R. Singh, S.S. Rawat, CBH Publications, Jaipur 6. Electricity, Magnetism and Electromagnetic Theory (in Hindi), J.C. Upadhyay, H.P. Sinha and S.C. Upadhyay, Ram Prasad & Sons, Agra.
Reference Books	1. E.M. Purcell, Berkely Physics Course, Vol. 1, Electricity and Magnetism McGraw Hill. 2. https://www.scribd.com/document/474459603/Berkeley-Physics-Course-Vol-2-Electricity-and-Magnetism-2nd-Ed-pdf# 3. D. Halliday and R. Resnick, Physics, vol. 2, Wiley Eastern, New Delhi. 4. B.B. Laud, Electromagnetics, New Age International, New Delhi (2017).
Suggested E-resources	1. https://ocw.mit.edu/courses/8-022-physics-ii-electricity-and-magnetism-fall-2004/ 2. https://ocw.mit.edu/courses/8-02t-electricity-and-magnetism-spring-2005/ 3. https://ocw.mit.edu/courses/8-02-physics-ii-electricity-and-magnetism-spring-2007/ 4. https://ocw.mit.edu/courses/8-02-physics-ii-electricity-and-magnetism-spring-2019/5.

B.Sc. (Three Years Degree Program)	
Second Semester	
Subject-Physics	
Code of the Course	PHY5001P
Title of the Course	Physics Lab-II: Electricity and Magnetism
Qualification Level of the Course	NHEQF Level 4.5
Credit of the course	2
Type of the course	Discipline Centric Compulsory (DCC) course in Physics
Delivery type of the Course	Practical 60. The student will perform the experiments and submit the record of observations after getting the results
Prerequisites	Physics of XII standard and associated exposure of labs and simple instruments
Co-requisites	None
Objectives of the course	The objectives focus to acquire idea of the magnitude of various physical quantities and their measurements, as well as to train to minimize the errors due to performance and usage of measuring devices. The students can link principles of electricity and magnetism with observations and underlying principles. The course also aims to enable the students to examine, determine and explain systematic errors introduced due to problems or limitations in the measuring devices and other sources.
Learning outcomes	The students will learn • Measuring inductance, resistance, capacitance and dielectric constant as well as understand the behavior of active and passive elements in the DC and AC circuits. • To study the phase relationship between voltage and current using rise and decay of currents in LR, RC and LCR circuits and to find the time constant. • Uses of AC bridges: Anderson's, de Sauty's and Kelvin's double bridge to find dielectric constant, self and mutual inductances and small resistance.

	• Ballistic Galvanometer (BG) experiments: to study the logarithmic decrements, charge and current sensitivity, Determination of B using search coil and BG and high resistance using BG.
Syllabus	
	1. Measurement of charge, current sensitivity and Ballistic constant of a Ballistic Galvanometer. 2. Determine high resistance by leakage method using Ballistic galvanometer. 3. To determine self -inductance of a coil by Rayleigh's Method. 4. To determine low resistance using Kelvin's double bridge. 5. To determine dielectric constant of a given liquid using LCR circuit. 6. To measure inductance of coil by Anderson's bridge. 7. To undertake unknown capacitances and compare using de Sauty's bridge. 8. Measurement of field strength B and verification of Bio Savart law using a circular coil. 9. To study electromagnetic induction and verify the Faraday's law of induction. 10. To study the characteristics of a series RC circuit. 11. To study the characteristics of a series LR circuit. 12. To study the characteristics of a series LC circuit. 13. To study a series LCR circuit and determine its resonance frequency and quality factor. 14. To study a parallel LCR circuit and find its anti-resonant frequency and quality factor. 15. To determine low resistance by Carey Foster's bridge. 16. To verify the Thevenin and Norton theorems. 17. To verify the superposition, and maximum power transfer theorems. 18. Determination of EMF of a cell using potentiometer. 19. Conversion of a galvanometer into ammeter. 20. Conversion of a galvanometer into voltmeter. Any other experiment could be set by the faculty within the scope of the objectives and learning outcomes.

Text and reference books	1. Advanced Practical Physics for Students , B. L. Worsnop & H.T. Flint,1971, Asia Publishing House. 2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, 11th Ed,2011, New Delhi. 3. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd. 4. Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th Ed.,1985, Heinemann Edu. Pub. 5. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, CBH Publications, Jaipur. 6. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, G.S. Ladiwala, CBH Publications, Jaipur.
Suggested E-resources	1. Advanced Practical Physics for Students , B. L. Worsnop & H.T. Flint,1971, Asia Publishing House. Ebook on scribd.com
Scheme of EoSE	The examination shall be of three hours wherein the students has to perform any one experiment. The marks distribution shall be the following: 1. One experiment : 45 (Formula(e)-7, Figure(s)- 6, Observations-12, Calculations-10, Result(s)-5, Precautions-5) 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester: 15

B.Sc. (Three Years Degree Program)	
Third Semester	
Subject-Physics	
Code of the Course	PHY6002T
Title of the Course	Physics-III: Thermal Physics
Qualification Level of the Course	NHEQF Level 5.0
Credit of the course	4
Type of the course	Discipline Centric Compulsory Course (DCC) in Physics
Delivery type of the Course	Lecture, 40+20=60. The 40 lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Foundation and courses of Physics and Mathematics
Co-requisites	None
Objectives of the course	This course develops fundamentals of Thermal Physics. It sets up need of Statistical Physics to explain microscopic thermodynamic behaviour, Physics and Chemistry of various phases of matter. The evolution of concepts of Thermal Physics and to explain the need of quantum mechanics which has extended its scope from monatomic gases to black holes.
Learning outcomes	The students would be able to understand: • Kinetic theory of gases, Ideal gas and its thermodynamic parameters, Equipartition theorem and the specific heat, Van der Waal gas equation, Critical constants and liquification gases, J-T effect and adiabatic demagnetization. Cooling of H_2 and He. • Mean free path calculation and measurement, transport of thermal energy, momentum and concentration in gases and the effect of pressure and temperature. • Maxwell's law of velocity distribution of molecules, RMS, mean and the most probable velocities. Experimental proof and application to find Doppler broadening of spectral lines.

	• Zeroth, first, second and the third law of thermodynamics. Idea of Carnot engine and concept of entropy. • Maxwell relations and the thermodynamic potentials. Simple applications. Clausius -Clapeyron equation. • Statistical basis of thermodynamics and the phase space, • Spectral distribution of BB radiation and associated laws given by Stefan-Boltzmann, Wien's, and Rayleigh-Jeans law. • Quantum oscillator of Planck and Planck's law. Origin of discreteness and quantized nature. • The connection between Statistical physics and thermodynamics. • Transition to quantum statistics: Bose-Einstein and Fermi-Dirac distribution functions and their simple examples.
Syllabus	
UNIT-I	**Ideal Gas:** Review of the kinetic model of an ideal gas, Brownian motion, Estimation of the Avogadro number, Equipartition of energy, specific heat of monatomic gas, extension to di and triatomic gases, Behaviour at low temperatures, Adiabatic expansion of an ideal gas. Application to atmospheric physics (derivation of barometric equation) (4+2 =6)
	Real Gas: Van der Waals model; equation of state, nature of Van der Waals forces, comparison with experimental P-V curves. The critical constants, gas and vapour. Joule-Thomson expansion of an Ideal gas and Van der Waals gas, Estimation of J-T cooling coefficient, adiabatic expansion of an ideal gas.. (3+1=4)
	Liquification of gases: Joule Expansion, Joule-Thomson and adiabatic cooling, Boyle temperature and inversion temperature, principles of regenerative cooling and cascade cooling, Liquification of Hydrogen and Helium, efficiency. (3+2=5)
UNIT -II	**Transport phenomena in gases:** Molecular collisions, mean free path and collision cross-sections, Estimation of molecular diameter and mean free path, Experimental determination of mean free path. Transport of mass, momentum and energy and interrelationship, dependence on temperature and pressure. (3+2=5)
	Maxwell's distribution function of speed in gas: Derivation of distribution of speeds and velocities, experimental verification, distinction between mean, rms and the most probable speed values. Doppler broadening of spectral lines. (3+1=4)
UNIT-III	**The laws of thermodynamics:** The Zeroth law, Various indicator diagrams and the work done, First law of thermodynamics, internal energy as a state function. Carnot cycle and its efficiency, Carnot theorem and the second law of thermodynamics, Different versions of the second law, Reversible and irreversible changes. Entropy, principle of increase of entropy. Thermodynamic scale of temperature; its

	identity with the perfect gas scale. Impossibility of attaining absolute zero temperature; third law of thermodynamics (3+2=5)
	Thermodynamic relationships: Thermodynamic variables; extensive and intensive, Maxwell's general relationships; applications to J-T cooling and adiabatic cooling in a general system, Van der Waals gas, and the Clausius-Clapeyron heat equation**..** (3+1=4)
	Thermodynamic potentials: Relation to the thermodynamic variables, Equilibrium of thermodynamic systems, Cooling due to adiabatic demagnetization (2+1=3)
UNIT-IV	**Statistical basis of the thermodynamics:** Probability and thermodynamic probability, principle of equal a *priori* probabilities, probability distribution and its narrowing with the increasing **n**, average properties, Accessible and inaccessible states, distribution of particles with a given total energy into a discrete set of energy states. (3+1=4)
	Phase space representation: The mu space; its division into sheets of energy, phase cells of arbitrary size, one-dimensional oscillator, free particles, the functions Φ(E) and φ(E), definition of probability**.** (2+1=3)
	Black Body radiation: Spectral distribution of BB radiation; pure temperature dependence, Stefan-Boltzmann law, Wien's displacement law, Rayleigh-Jeans law (no derivation) and the ultraviolet catastrophe, Pressure of radiation, Planck's hypothesis, mean energy of an oscillator and the Planck's law, complete fit with the experiment. Interpretation of specific heats of gases at low temperature. (3+2=5)
UNIT-V	**The connection of Statistical Physics with thermodynamics:** Thermal equilibrium between two sub-systems, beta parameter and its identity with $(kT)^{-1}$**,** probability and entropy, Boltzmann entropy relation, statistical interpretation of the second law of thermodynamics. Boltzmann canonical distribution law; rigorous form of equipartition of energy. (4+2=6)
	Transition to quantum statistics: '*h*' as a natural constant and its implications, Setting phase-cell size as nature's constant (Planck's constant *h*); quantization of energy. Indistinguishability of particles and its consequences. Bose-Einstein and Fermi-Dirac conditions, applications to liquid Helium, free electrons in a metal, and photons in blackbody chamber, Fermi level and Fermi energy. (4+2=6)
Text Books	1. Heat, Thermodynamics and Statistical Mechanics by S.S. Singhal, J. P. Agarwal and Satyaprakash, Pragati Prakashan (In Hindi and English) 2. Thermal and Statistical Physics, B.S. Agarwal, Kedar nath Ram Nath, Meerut 3. Heat and Thermodynamics by D.S. Mathur Sultan Chand & Sons 4. Kinetic Theory, Thermodynamics and Statistical Physics (in Hindi), Kalra,Kakani and Bhandari 5. Thermal Physics & Semiconducting Devices, P.S. Hemne and C.L. Arora, S. Chand LPS Edn, 2022.

Reference Books	1. Introduction to Statistical Mechanics by B.B. Laud, Macmillan 1981. 2. Thermodynamics, Kinetic Theory and Statistical Thermodynamics by F.W.Sears and G.L. Salinger, Narosa Publishing House, New Delhi, 1990. 3. Thermal Physics by S.C Garg, R. M. Bansal and C. K. Ghosh, McGraw-Hill, 2012 4. Thermal Physics by A. B. Gupta, H. P. Roy, Books & Allied Ltd, 2010 5. Heat and Thermodynamics by M.W. Zemansky, R. Dittman, McGraw-Hill, 1981 6. Concepts of Thermal Physics, S. J. Blundell and K. M. Blundell, Oxford university press, 2010.
Suggested E-resources	1. https://www.academia.edu/19609677/Berkelley_Physics_Course_5_Statistical_Physics 2. https://ocw.mit.edu/courses/8-21-the-physics-of-energy-fall-2009/resources/mit8_21s09_lec04/

B.Sc. (Three Years Degree Program)	
Third Semester	
Subject-Physics	
Code of the Course	PHY6002P
Title of the Course	Physics Lab-III : Thermal Physics
Qualification Level of the Course	NHEQF Level 5
Credit of the course	2
Type of the course	Discipline Centric Compulsory (DCC) course in Physics
Delivery type of the Course	Practical 60. The student will perform the experiments and submit the record of observations after getting the results
Prerequisites	Exposure of basic instruments of fundamental nature in thermal physics
Co-requisites	None
Objectives of the course	The objectives focus to acquire idea of the magnitude of various physical quantities and their measurements, as well as to train to minimize the errors due to performance and usage of measuring devices. The students can link principles of thermal physics with observations. The students will learn to examine, determine and explain systematic errors introduced due to problems or limitations in the measuring device etc. The course will enable students to deploy temperature measurement techniques under various conditions.
Learning outcomes	The students will learn to measure temperature, pressure, thermal conductivity and will get an idea of the magnitude these quantities under changing thermodynamic conditions. The students will understand the importance of the constants and the measurement techniques used more often in thermal physics.

Syllabus	
	1. To measure the volume of different solid objects, calculate density of the objects and find the standard deviation and percent error. 2. To determine the Boltzmann constant k by measuring the barrier height of a PN junction diode. 3. To study variation of surface tension of water with temperature using Jeager's method. 4. To determine the specific heat of a liquid by the method of cooling. 5. To determine the thermal conductivity of a bad conductor by Lee and Charlton's method. 6. To determine of Specific Heat of Solid with Radiation Correction. 7. To determine of coefficient of thermal conductivity of a metal using Searle's apparatus. 8. To determine of Latent heat of fusion of ice with radiation correction. 9. To calibrate a thermocouple and determine unknown temperature. 10. To determine of the ratio of the specific heats of a gas by Clement and Desorme's apparatus. 11. To determine the mechanical equivalent of heat (J) by electrical method with radiation correction. 12. To determine the mechanical equivalent of heat (J) by Callendar and Barne's apparatus (with radiation correction) 13. To determine temperature co-efficient of resistance of the material of a given wire. 14. To measure the coefficient of linear expansion of a given material. 15. To measure temperature of a given object using Platinum resistance thermometer. Any other experiment related to the thermodynamic concepts, properties and thermodynamic behaviour of materials can also be included.
Text and reference books	1. Advanced Practical Physics for Students, B.L. Worsnop & H .T. Flint, 1971, Asia Publishing House. 2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, 11th Ed,2011, New Delhi. 3. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd. 4. Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th Ed.,1985, Heinemann Edu. Pub. 5. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, CBH Publications, Jaipur. 6.. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, G.S. Ladiwala, CBH Pub., Jaipur.

Suggested E-resources	1. https://physics.howard.edu/sites/physics.coas.howard.edu/files/2020-08/2-measurements.pdf 2. rashid-phy.github.io/me/pdf/notes/Heat_PHY2104_lab_manual_2020.pdf 3. https://physics.howard.edu/sites/physics.coas.howard.edu/files/2019-07/11-thermal_expansion.pdf 4. Advanced Practical Physics for students, B.L. Worsnop & H .T. Flint, 1971, Asia Publishing House, Ebook on scribd.com.
Scheme of EoSE	The examination shall be of three hours wherein the students has to perform any one experiment. The marks distribution shall be the following: 1. One experiment : 45 (Formula(e)-7, Figure(s)- 6, Observations-12, Calculations-10, Result(s)-5, Precautions-5) 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester: 15

B.Sc. (Three Years Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY6003T
Title of the Course	Physics IV: Waves and Optics
Qualification Level of the Course	NHEQF Level 5
Credit of the course	4
Type of the course	Discipline Centric Compulsory (DCC) course in Physics
Delivery type of the Course	Lecture, 40+20=60. The 40 lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Fundamental level courses of Physics and Mathematics
Co-requisites	None
Objectives of the course	This course on basics of waves and optics will enable the student to understand various wave and the optical phenomena and principles. The objective is to able to characterize a wave generated from a disturbance as longitudinal, transverse or the progressive/ stationary wave. The optics part focusses on the construction, science at work and applications of optical instruments. This course is mandatory to understand design of instruments in optical spectroscopy in experimental solid state physics, medical sciences and astronomy.
Learning outcomes	The students would be able to understand: • The physics underlying various phenomena in waves and optics. • Physics of the various natural phenomena (like interference and diffraction) in our surroundings. • Longitudinal, transverse waves, characteristics and their applications.

	• Aberration in images and various types of lenses and mirrors, • Function of Optical instruments: Common type eye pieces, microscopes and telescopes. • Application of diffraction in resolution of images, Origin of lasers, simple laser beams and their applications.
Syllabus	
UNIT-I	**Wave equation and motion:** 1-D and 3-D wave equation, Transverse waves in stretched string, Longitudinal waves in fluid, Elastic waves in solids, Pressure waves in Gas Column- Newton's hypothesis and Laplace correction, Spherical waves, classical wave equation, energy density, and transmission in waves, wave velocity, phase velocity, group velocity and the dispersion relations. (5+2=7) **Fourier analysis:** Fourier series and Fourier coefficients, the sine, cosine and exponential representations, determination of Fourier coefficients. Examples of Square wave, saw-tooth wave, half and full wave rectifier waves, triangular waves. (3+2=5)
UNIT-II	**Free vibrations and coupled oscillations:** Equilibrium concept, small oscillations, basic mass spring system, pendulums, torsional oscillations Free oscillation of systems with two degrees of freedom, 2-D oscillator, normal modes, longitudinal and transverse oscillations of coupled masses, energy transfer between modes, coupled pendulum. (5+2=7) **Superposition of waves:** Linear homogeneous equations and superposition principle, interference in space and energy distribution, beats and combination tones. (3+2=5)
UNIT-III	**Fermat's principle**: Principle of experiments path, the aplantic points of a sphere and other applications. **Aberration in images**: Basics of image formation, Chromatic aberration; achromatic combination of lenses in contact and separated lenses. Monochromatic aberrations and their reduction; spherical mirrors and Schmidt corrector plates; oil immersion objective, meniscus lenses. (3+2=5)
	Optical instruments: Entrance and exit pupils, need for a multiple lens eye pieces. Common type eye pieces. Huygens and Ramsden eyepieces, Compound microscope, Reflecting telescope, Constant deviation spectrometer. (3+2=5)
UNIT -IV	**Interference of light**: The principle of superposition ; two slit interference pattern and fringe width, Fresnel biprism, coherence requirement for the sources, localized fringes in thin films, conversion of fringes of equal thickness to those of equal inclination, Newton's rings, Michelson interferometer and its use in determination of wavelength, wavelength difference and standardization of unit of length-Meter, Intensity distribution in multiple beam interference, Febry-Perot interferometer and etalon. Lummer Gehrke plate, Lloyd's mirror. (5+2=7)

	Diffraction: Fresnel diffraction- Half period zones, circular aperture and obstacles; straight edge, explanation of rectilinear propagation, Zone plate with multi foci Fraunhofer diffraction-Diffraction from a slit, a circular aperture and a circular disc, resolution of images ; Rayleigh criterion, Resolving power of a telescope and microscope, outline of phase contrast microscopy. **Diffraction grating:** Diffraction from multiple parallel slits, plane diffraction grating, resolving power of grating and prisms. (5+2=7)
UNIT-V	**Polarization of light**: Polarized light, Polarizer and analyser, Anisotropic crystals, Calcite crystal, positive and negative crystals. Nicol Prism and uniaxial crystals, explanation in terms of electromagnetic theory of double diffraction, Malus Law, phase retardation plates, rotation of plane of polarization, origin of optical rotation in liquids and crystals. Babinet compensator, Polarimeters and their applications in measurement of specific rotation . (4+2=6)
	Laser: Purity of spectral lines; Coherence length and coherence time, spatial coherence of a source; Einstein's A and B coefficients; Coherence of induced emissions, conditions for laser action, existence of a metastable state , population inversion, optical pumping and cavity. He-Ne and Ruby Laser. **Applications of lasers:** Spatial coherence and directionality, Holography-construction and reconstruction, non-linear applications. (4+2=6)
Text Books	1. Waves by Frank S. Crawford Jr. , Berkeley Physics Course, Vol. 3, 2007, McGraw-Hill. 2. Vibrations and Waves by A.P. French, W.W. Norton & Company, New York. 3. Waves & Oscillations by Satyaprakash, Pragati Prakashan. 4.The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill. 5. Fundamentals of Optics, A. Kumar, H.R. Gulati, and D.R. Khanna, 2011, R. Chand Publications. 6. Principle of Optics: B. K. Mathur (III edition) 7. Text book of Optics by Subrahmanyam and Brijlal, S. Chand and Co. 8. Optics (in Hindi) Bhandari, Kalra and Kakani
Reference Books	1. Optics by Jenkins and White, Tata McGraw Hill 2. Text book of Optics : D. P. Khandelwal 3. Universities Optics Vol. I & II by Whittkar and Yarwood 4. Optics by Ajoy Ghatak, Tata McGraw Hill
Suggested E-resources	1. https://ocw.mit.edu/courses/res-8-009-introduction-to-oscillations-and-waves-summer-2017/pages/lecture-notes/ 2. https://ocw.mit.edu/courses/8-03sc-physics-iii-vibrations-and-waves-fall-2016/pages/part-iii-optics/ 3. https://ocw.mit.edu/courses/8-03sc-physics-iii-vibrations-and-waves-fall-2016/download/ 4. https://ocw.mit.edu/search/?d=Physics&s=department_course_numbers.sort_coursenum

B.Sc. (Three Years Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	PHY6003P
Title of the Course	Physics Lab-IV : Optics
Qualification Level of the Course	NHEQF Level 5
Credit of the course	2
Type of the course	Discipline Centric Compulsory (DCC) course in Physics
Delivery type of the Course	Practical 60. The student will perform the experiments and submit the record of observations after getting the results
Prerequisites	Exposure of optical instruments of foundation level courses of optics and waves phenomenon
Co-requisites	None
Objectives of the course	The objectives focus to acquire idea of the magnitude of various physical quantities and their measurements, as well as to train to minimize the errors due to performance and usage of measuring devices. The students can link wave and optical phenomenon with observations. The students will learn to examine, determine and explain systematic errors introduced due to problems or limitations in the measuring device etc. The course will enable students to analyze the functioning of various types light sources.
Learning outcomes	The students will be able to learn the level of accuracy offered by the optical phenomenon and the instruments. The students will understand the importance of the constants and the measurement techniques used more often in waves optics.
Syllabus	

	1. To measure dispersive power of prism material. 2. To measure wavelength of Sodium light using Fresnel's biprism. 3. To determine wavelength of Sodium light using method of Newton's rings. 4. To determine the refractive index of a given liquid using method of Newton's rings. 5. To determine wavelength of major spectral lines of Hg light by plane diffraction grating. 6. To determine the resolving power of plane transmission grating. 7. To determine of the resolving power of a telescope. 8. To verify Brewster's law. 9. To determine the specific rotation of sugar solution using polarimeter. 10. To determine size of the granules of lycopodium powder using the method of Cornu's spiral. 11. To analyze elliptically polarized light. 12. To calibrate the Babinet compensator and find the path difference produced by a half/quarter wave plate. 13. To measure wavelength of Sodium light by Michelson interferometer. 14. To study interference pattern from a given object using laser beam. 15. To study diffraction pattern from a given object using laser beam. Any other experiment can be designed to demonstrate the concepts and phenomenon of wave optics.
Text and reference books	1. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, 1971, Asia Publishing House. 2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, 11th Ed,2011, New Delhi. 3. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Ltd. 4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Ed.,1985, Heinemann Educational Publishers 5. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, CBH Pub., Jaipur. 6. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, G.S. Ladiwala, CBH Pub., Jaipur.
Suggested E-resources	1. Advanced Practical Physics for Students, B.L. Flint & H.T.Worsnop, 1971, Asia Publishing House. Ebook on scribd.com
Scheme of EoSE	The examination shall be of three hours wherein the students has to perform any one experiment. The marks distribution shall be the following: 1. One experiment : 45 (Formula(e)-7, Figure(s)- 6, Observations-12, Calculations-10, Result(s)-5, Precautions-5) 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester: 15

B.Sc. (Three Years Degree Program)	
Fourth Semester	
Subject-Physics	
Code of the Course	SES6370T
Title of the Course	Fundamentals of Electrical Instruments
Qualification Level of the Course	NHEQF Level 5
Credit of the course	2
Type of the course	Skill Enhancement Course (SEC) in Physics
Delivery type of the Course	Lecture, 20+10=30. The 20 lectures for content delivery and 10 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Physics of XII standard
Co-requisites	None
Objectives of the course	This is the conceptual course on the working and technological aspects of electrical instruments. This also covers the sensors and actuators used in electrical instruments and devices.
Learning outcomes	The students would be skilled in the fundamental aspects of the applied part of the curriculum undertaken which are desirable in industries. They will also understand the basic principles of working, functionalities, specifications with underlying meanings and applications of the simple instruments such as; motors and drives, generators and AC machines, power devices and circuits, transducers, piezo electric devices, various types of Camera, loudspeakers and microphones.
Syllabus	

UNIT-I	**Types of motors and Motor drives:** Construction, principle and working of DC and AC motors, Induction motors, Single and three phase motors, Synchronous motors, Stepper motors, and Servo motors. Motor driving and speed control circuits and their applications, motor starters.
UNIT-II	**Generators and AC machines:** AC and DC generators, comparison between generator and motor action (excluding constructional comparison). AC Machines: Types of transformers, Transformer construction, Electromotive force and related equations, Transformer losses, Condition for maximum efficiency, all day efficiency, Auto transformers.
UNIT-III	**Basic power devices and circuits:** SCR, Diacs and Triacs, Two transistor model of SCR, Resistive and RC triggering circuits. Applications of SCR: Basic series inverter circuit, Chopper circuit – Basic concept, step up and step down choppers. **Supplies:** Regulated power supply, Uninterrupted power supply (UPS) and Switched mode power supply (SMPS).
UNIT-IV	**Transducers** – Classification as Active, Passive, Mechanical, Electrical, their comparison. Selection of Transducers, Principle and working of: Displacement transducers - Resistive (Potentiometric, Strain Gauges – Types, Gauge Factor, bridge circuits, Semi-conductor strain gauge) Capacitive (diaphragm), Inductive (LVDT-Principle and characteristics, Hall effect sensors, magneto-strictive transducers).
UNIT-V	**Piezoelectric** t**ransducers**: Basic elements and allied properties, Piezoelectric coefficients. Equivalent circuit and frequency response of piezoelectric transducers., **Optical transducers:** Photo-conductive, photo emissive, photo voltaic, semiconductor, and LDR. **Temperature**: Electrical and non-electrical. **Pressure:** Force summing devices, load cell **Photography:** Optical, CCD and other camera **Sound** Microphones and loud speakers.
Text and Reference Books	1. Power Electronics, 2nd Ed. by M. D. Singh, K. B.Khanchandani, 2006, Tata McGraw Hill. 2. Electrical Technology, 23rd Ed. by B. L. Thareja and A. K. Thareja, 2005, S. Chand & Sons. 3. Electronic Principles, 7th Ed. by A. Malvino, D. J. Bates, 2007, Tata McGraw Hill. 4. Power Electronics, 4th Ed. by P. S. Bimbhra, 2002, Khanna Publishers. 5. Electrical Machines, 2nd Ed. by I. J. Nagrath and D. P. Kothari, 1997, Tata McGraw Hill. 6. Electronic Instrumentation, 4th Ed. by H.S.Kalsi, McGraw Hill. 7. Measurement & Instrumentation by DVS Murthy, PHI Pub. 8. Sensors and Transducers, 2nd Ed. by D. Patranabis, PHI Pub. 9. Introduction to Measurements and Instrumentation, PHI, 4th Ed. by A.K. Ghosh, PHI Pub. 10. Comprehensive Basic Physics by Vimal Saraswat, Himanshu Publications, Udaipur.

B.Sc. (Three Years Degree Program)	
Fifth Semester	
Subject-Physics	
Code of the Course	PHY7100T
Title of the Course	Quantum Mechanics & Spectroscopy
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	(5+1=6)
Type of the course	Discipline Specific Elective (DSE) course in Physics
Delivery type of the Course	Lecture, 75+15=90. The 60 lectures for content delivery, 15 for the tutorial and 15 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Physics and Mathematics of the level of foundation and intermediate courses.
Co-requisites	None
Objectives of the course	Objectives of the contents of quantum mechanics are to get the students familiar with the language and formulation of quantum mechanics. Applications to simple problems will enable to appreciate the strength of quantum Physics. The objectives of the spectroscopic part is to give exposure of the atomic and molecular spectra of simple systems. To understand the language of spectroscopy and its relation to the quantum mechanical description of atomic and molecular systems. The aim is also to get the students acquaint with the quantum mechanical explanation of the atomic and molecular spectra as well as a few measurement techniques of atomic and molecular spectra.
Learning outcomes	The students will understand the inadequacies of classical mechanics and the need of wave mechanical approach. The students would be able to apply quantum mechanical formulation such as Schrodinger method to simple problems and analyze the results to arrive on new concepts offered by the quantum mechanics on those problems. They will grasp the basic ingredients of the quantum mechanics and there interpretation by solving simple problems and realize how new physics will coming out using this

	subject. Moreover, the objectives are to; apply quantum mechanics to explain the electronic, vibrational and rotational spectra of atoms and molecules, expose to the the measurement techniques to find electronic, vibrational and rotational bands, origin of bands spectra in many electron atoms, L-S and J-J couplings.
Syllabus	
UNIT-I	**Need of quantum mechanics:** Rise and fall of Planck-Bohr quantum theory Duality of radiation and matter, de-Broglie's hypothesis, justification for the relation, experimental confirmation. (3+3=6)
	Wave mechanics: Phase and group velocities, formation of a wave packet, illustrations. Uncertainty principle and the x-p and E-t uncertainty relations, application complementarity principle, photon interpretation of two slit interference, Einstein-de-Broglie relations as a link between particle and wave properties, general equation of wave propagation, propagation of matter waves, time dependent and time independent Schrodinger equations, physical meaning of ψ, conditions to be satisfied by Schrodinger equation as an operator equation. Postulates of Quantum mechanics. (5+1=6)
	Algebra of operators: Operators, observables and measurement, eigen values and eigen functions; linear operators, product of two operators, commuting and non-commuting operators, simultaneous eigen functions, orthogonal functions. Hermitian operators, their eigen values, Hermitian adjoint operators, expectation values of an operator. (4+2=6)
UNIT -II	**Schrodinger equation and 1-D problems:** Particle in a box with rigid walls. Concept of a potential well. Wave functions and energies for the ground and excited states; quantization of energy qualitative discussion of the solutions for a shallow potential well. (3+2=5)
	Simple harmonic oscillator: Application of Operator methods-step-up and step-down operators, eigen functions and eigen values of the ground state and excited state, zero point energy, probability density and its variations with order of excitation; orthogonality of wave functions .(4+2=6)
	Other one dimensional problems: Potential step, penetration through rectangular barrier. Transmission coefficients, barriers of special shapes, quantum mechanical tunnelling, particle in a 3-D cubical box, degeneracy. (5+2=7)
UNIT-III	**Angular momentum and spin:** Central force; orbital angular momentum, operators for its Cartesian components, commutation relations- mutual as well as with L^2 , operators L^+ and L^-, their interpretation as step operators eigen values of L^2 , half integral values for L_z . Angular momentum operators in spherical polar coordinates; deduction of their eigen functions. (5+2=7) **Atoms in external fields**-Normal and Anomalous Zeeman Effect, Paschen back and Stark Effect (qualitative Discussion only) (3+1=4) **Hydrogen atom:** Schrodinger equation for Hydrogen atom in spherical polar coordinates; separations into radial and angular variables, qualitative discussion of spherical harmonics. The eigen functions of the hydrogen atom and their characteristics. (4+3=7)
UNIT-IV	**Monovalent and divalent atoms:** Background from quantum theory: The four quantum numbers; spectral terms arising from L-S coupling, s,p,d,f, notation, selection rules. Half-life of excited states, width of a spectral line. (4+2=6)

	Spectra of mono and divalent atoms: Doublet fine structures of Hydrogen lines; screening constant for monovalent atoms, series limits, doublet structure for alkali spectrum. Spectra of Helium and alkaline earth atoms, singlet and triplet series. Effect of magnetic field on energy levels: Gyromagnetic ratio for orbital and spin motions; vector model, Lande **g** factor, strong and weak field effects, illustrative cases of H, Na, Ca and Hg. (6+2=8)
	X-ray spectra: The continuous X-ray spectrum, Duane and Hunt limit. Characteristic X-rays: Mosley's law, doublet fine structure, X-ray absorption spectra, absorption edges. (3+1=4)
UNIT-V	**Sharing of electrons:** Formation of molecular orbitals, H_2^+ ions, H^-_2 molecule, electronic levels, singlet and triplet characters. Rotational energy levels, internuclear distance. (3+1=4)
	Vibrational and rotational spectra: Vibrational energy levels, force constants, anharmonicity dissociation energy, isotope effects on rotational and vibrational energies. Raman effect and spectrometer. Spectra of diatomic molecules: Pure rotation spectra; selection rules, vibration-rotation spectra, selection rules, vibration-rotation spectra; selection rules, P, Q and R branches, Microwave and IR spectrometers. (7+4=11)
	Electronic band systems, sequences and progressions, Frank-Condon principle. (No derivation) (2+1=3)
Text Books	1. Quantum Mechanics by S.P. Singh, M.K. Bagde and Kamal Singh, S. Chand and Co. 2. Quantum Mechanics by G.R. Chatwal and S.K. Anand, 1988, Himalaya Publishing House. 3. Spectroscopy- Atomic and Molecular by G.R. Chatwal and S.K. Anand, 2016, Himalaya Publishing House. 4. Quantum Mechanics and Modern Physics by Mahipal Singh, Ram Prasad and Sons, Agra. 5. Molecular Structure and Spectroscopy by G. Aruldhas, 2008, PHI Learning Pvt. Ltd., New Delhi. 6. Quantum Mechanics by G. Aruldhas, 2011, PHI Learning Pvt. Ltd. , New Delhi.
Reference Books	1. Quantum Mechanics by , Alistair I M Rac. ELBS (Low Drice edition) 2. Quantum Mechanics by S. N. Biswas, Books and Allied, Calcutta (P) Ltd. 3. Atomic and Nuclear Physics by A.B. Gupta, New central book agency Pvt. Ltd. 4. Introduction to Modern Physics by H S Mans and G K Mehta
Suggested E-resources	1. https://onlinecourses.nptel.ac.in/noc22_ph06/preview 2. https://www.coursera.org/lecture/understanding-modern-physics-2-quantum-mechanics-and-atoms/schrodinger-equation-pFUbv 3. https://archive.nptel.ac.in/courses/115/101/115101107/ 4. https://onlinecourses.nptel.ac.in/noc23_ph16/preview 5. https://ocw.mit.edu/courses/8-04-quantum-physics-i-spring-2013/ 6. https://ocw.mit.edu/courses/8-04-quantum-physics-i-spring-2016/ 7. https://ocw.mit.edu/search/?d=Physics&s=department_course_numbers.sort_coursenum

B.Sc. (Three Years Degree Program)	
Fifth Semester	
Subject-Physics	
Code of the Course	PHY7101T
Title of the Course	Elements of Modern Physics
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	(5+1=6)
Type of the course	Discipline Specific Elective (DSE) course in Physics
Delivery type of the Course	Lecture, 75+15=90. The 60 lectures for content delivery, 15 for the tutorial and 15 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Physics and Mathematics of the level of foundation and intermediate courses
Co-requisites	None
Objectives of the course	This course is an introduction to a broad range of topics in Modern Physics. It is meant to introduce the basic concepts of a range of topics, with the full details left to upper-level Physics classes. The course covers basic understanding and rudiments of Relativity, Wave mechanics, Quantum Mechanics to simple problems, Atomic Physics, and Nuclear Physics.
Learning outcomes	By the end of the course students should be able to do the following: • Understand and explain the basis for quantum mechanics and be able to solve Schrodinger's equation for simple potentials • Understand the formalism to solve a problem using quantum mechanical principles. • Understand the working principle, function and usage of popular lasers. • Know the fundamental particles in the Standard Model • Be able to understand properties of nucleus, radioactivity, fusion and fission processes.

Syllabus	
UNIT-I	**Inadequacy of classical physics:** Review of Classical Physics- Mechanics, Velocity addition, Electricity and magnetism, Kinetic theory; Classical concepts of space, time and particle statistics, **(1+2=3).** **Special theory of relativity:** Classical Relativity, The Michelson-Morley Experiment, Einstein's Postulates and its Consequences, The Lorentz Transformation, Time dilation, Length contraction, Velocity addition, The Twin Paradox, Relativistic Dynamics, Conservation Laws in Relativistic Decays and Collisions, Momentum conservation, Doppler effect, Experimental Tests of Special Relativity **(5+2=7)** **Experiments on wave and particle nature of light:** Review of EM waves, X-ray and electron diffraction, Experiments-Black body radiation, Photoelectric effect, Compton effect **(3+1=4)** **The wavelike properties of particles:** De Broglie's Hypothesis, Experimental Evidence for De Broglie Waves, Uncertainty Relationships for Classical Waves , Heisenberg Uncertainty Relationships, Wave Packets, The Motion of a Wave Packet, Probability and Randomness. **(3+1=4)**
UNIT-II	**The Rutherford-Bohr model of the atom:** Basic Properties of Atoms, Scattering Experiments and the Thomson Model, The Rutherford Nuclear Atom, Line Spectra , The Bohr Model, The Franck-Hertz Experiment, The Correspondence Principle, Deficiencies of the Bohr Model. **(5+3=8)** **Many electron atoms:** Pauli Exclusion principle, X-ray transitions, LS and JJ coupling in addition of angular momenta. **(2+1=3)** **Lasers:** Spontaneous and stimulated emission, Einstein's A and B coefficients, Metastable states, Population inversion, Lasing action, Properties and applications of lasers, He-Ne, Ruby and Semiconductor lasers. **(5+2=7)**
UNIT-III	**Algebra of operators:** Operators, observables and measurement, eigen values and eigen functions; orthonormality and linear dependence of eigenfunctions, linear operators, product of two operators, commuting and non-commuting operators, Hermitian operators and their properties, Adjoint operators. Energy, momentum parity and angular momentum operators. **(2+1=3)** **The Schrodinger equation:** Behavior of a Wave at a Boundary, Confining a Particle, The Schrodinger Equation, Applications of the Schrodinger Equation, The Simple Harmonic Oscillator, Steps and Barriers **(5+2=7)** **The Hydrogen atom in wave mechanics:** A One-Dimensional Atom, Angular Momentum in the Hydrogen Atom, The Hydrogen Atom Wave Functions, Radial Probability Densities, Angular Probability Densities, Intrinsic Spin, Energy Levels and Spectroscopic Notation, The Zeeman Effect-Normal and Anomalous, Stark and Paschen back effects, Fine Structure **(5+3=8)**
UNIT-IV	**Structures and properties of crystals:** Crystal structures, The Heat Capacity of Solids, Electrons in Metals, Band Theory of Solids, Superconductivity, Intrinsic and Impurity Semiconductors, Semiconductor Devices, Magnetic Materials **(7+3=10)** **The nucleus:** Nuclear Structure and Constituents, Nuclear Sizes and Shapes, Nuclear Masses and Binding Energies, The Nuclear Force, The Four Basic Forces **(5+3=8)**

UNIT-V	**Radioactivity:** Radioactive Decay and laws, Alpha Decay, Beta Decay, Gamma Decay and Nuclear Excited States, Natural Radioactivity **(3+2=5)** **Introductory cosmology:** The Expansion of the Universe, The Cosmic Microwave Background Radiation, Dark Matter, The General Theory of Relativity, Tests of General Relativity, Stellar Evolution and Black Holes, Cosmology and General Relativity, The Big Bang Cosmology, The Formation of Nuclei and Atoms, Experimental Cosmology **(9+4=13).**
Text Books	1. Modern Physics, 3rd Edn by K. S. Krane, 2012, John Wiley & Sons. 2. Concepts of Modern Physics by, Aurthur Beiser, 2016, Tata McGraw Hill.
Reference Books	1. Perspectives of Modern Physics by Aurthur Beiser, 2014, Tata McGraw Hill. 2. University Physics with Modern Physics, 15th Ed., Raul Caldwell 3. Modern Physics by R. Murugeshan and K. Sivaprasath, 2017, S. Chand & Co., New Delhi.
Suggested E-resources	1. https://www.academia.edu/43188426/University_Physics_with_Modern_Physics_15th_Edition

B.Sc. (Three Years Degree Program)	
Fifth Semester	
Subject-Physics	
Code of the Course	PHY7102T
Title of the Course	Mathematical Methods
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	(5+1=6)
Type of the course	Discipline Specific Elective (DSE) course in Physics
Delivery type of the Course	Lecture, 75+15=90. The 60 lectures for content delivery, 15 for the tutorial and 15 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Physics or Mathematics of the level of foundation and intermediate courses
Co-requisites	None
Objectives of the course	This course is an introduction to concepts of advanced Mathematical methods. This can be opted by the students wish to opt mathematics in PG and willing to deal with the problems of theoretical physics. It is meant to introduce the basic concepts of (i) Vector, Vector spaces, Function space and Hilbert space (ii) The Fourier, Laplace transforms and properties of Dirac delta function (iii) Complex numbers, and their differentiation and integration (iv) Rudiments of special functions namely- Hermite, Legendre, Bessel, Neumann and Laguerre polynomials (v). Partial differential equations and Green functions.
Learning outcomes	By the end of the course students would be able to understand and use the following mathematical techniques: • The function and Hilbert spaces and their properties • The concept and properties of the Fourier and Laplace transforms and the Dirac-delta function. • The differentiation and integral of functions of Complex numbers. • The properties of the important special functions useful in physics.

	• Green function technique and solution of partial differential equation. These contents lay foundation of theoretical physics in general.
Syllabus	
UNIT-I	**Vectors:** Differentiation of a vector function of a real variable, smooth curves, Frenet-Serret formulae, Gradient of a scalar field, line integrals, surfaces, Surface and volume integrals, Divergence of a vector field, Curl of a vector field, Integral theorems- Green's theorem, Stokes's theorem, Curvilinear coordinates-Spherical and cylindrical coordinates. **(6+3=9)** **Vector spaces:** Basic concepts and examples, Scalar product, Orthonormality, Schmidt's orthogonalization process, Dirac dual space-Bra and Ket notations, Basis and dimensions ,Change of basis, Isomorphism of vector spaces **Operators:** Linear, Adjoint, Hermitian, Unitary, Projection, Eigenvalues and eigenvectors, Link with matrix algebra, Diagonalization, Caley-Hamilton theorem **(6+3=9)**
UNIT-II	**Function spaces:** Metric spaces-definition and examples, Vector spaces of functions-Function spaces, Hilbert spaces, L^2 (a,b) space and Riesz-Fischer theorem, Orthogonal expansions, Fourier series-Definition and concept, Convergence of Fourier series, Gibbs phenomenon, Linear, Adjoint and Unitary operators in infinite dimensional Hilbert space , Eigenfunctions and eigenvalues of linear differential operators **(6+4=10)** **Integral transforms:** Fourier transform-Definition and properties, Convolution theorem, Laplace transforms-Definition and properties, Faltung theorem, Dirac-delta function- Definition, various forms and properties, Uncertainty relation for square integrable functions. **(6+2=8)**
UNIT-III	**Algebra of Complex numbers**: Complex numbers- addition, multiplication, division, conjugate, commutation, distributive, associative properties and inequalities, Stereographic projection. **Differentiation**-Cauchy-Riemann conditions, Multi-valued functions, Branch points. **(3+2=5)** **Integration**-Contour integrals, Cauchy's theorem and various proofs, Cauchy's integral formula, Cauchy's formulae for derivatives, Applications of Cauchy's integral formulae- Derivative, Gauss mean values theorem, Poisson's integral formula, Cauchy-Liouville theorem, Morera theorem, Cauchy integral formula for multiply connected domain, Taylor and Laurent series, Residues and Cauchy Residue theorem, Jordan's lemma and its proof, Evaluation of integrals using Cauchy's theorems **(9+4=13)**

UNIT-IV	**Ordinary differential equations:** Linear differential equations, second order differential equations, power series method. **(2+1=3)** **Special functions: Hermite polynomials-** Definition and concept, Generating functions, Recurrence formulae, Orthogonality relations, Completeness, Hermite functions, connection with simple harmonic oscillator. **Legendre polynomials and Associated Legendre functions**-Definition and concepts, Generating functions, Recurrence formulae, Rodrigue's formula Orthogonality relations, Completeness, Hermite functions, **Spherical Harmonics-** Definitions and properties, multipole expansions. **Bessel functions**-Definition and concepts, Generating functions, Recurrence formulae, Orthogonality relations, Completeness, Neumann and Hankel functions, Asymptotic behaviour of Bessel and related functions, Spherical Bessel and Neumann and Hankel functions, Expansion of a plane wave. **Laguerre polynomials-** Definition and concept, Generating functions, Recurrence formulae, Orthogonality relations, Completeness, Associated Laguerre functions, link with hydrogen atom. **(10+5=15)**
UNIT-V	**Partial differential equations:** Definition and concept, Equation of continuity, equation of heat low, Wave equation for sound waves in fluids, Wave equation for transverse vibrations in strings and membranes, Poisson and Laplace equation for electrostatic potential. Solution by separation of variables-Laplace equation in cartesian, spherical polar and cylindrical coordinates, the vibrating string and circular membranes. Classification of second order partial differential equations and boundary conditions.**(7+4=11)** **Green functions:** Notations, definitions and physical significance of Green functions, Adjoint Green function and reciprocity relation, translational invariance, expansion of Green Functions. Green functions for ordinary differential operators- First and second order differential operators, Laplace operator, operator for heat equation and their self-adjoint ness, Solutions of Laplace and Poisson equations using Green functions. **(5+2=7)**
Text Books	1. Mathematical Methods in Classical and Quantum Physics by Tulsi Dass and S.K. Sharma, 1998, University Press, Hyderabad.
Reference Books	1. Problems and Exercises in Integral Equations by M. L Krasnov, 1971, MIR publisher. 2. Introduction to Integral Equations with Application 2nd Ed. by A.J. Jerry, 1999, Wiley Pub. 3. Integral Equations: A Short Course by L. G. Chambers, 1976, International Text Book Company Ltd. 4.Integral Equations by H. Hochstad, 1989 John Wiley & Sons.
Suggested E-resources	1. https://onlinecourses.nptel.ac.in/

B.Sc. (Three Years Degree Program)	
Fifth Semester	
Subject-Physics	
Code of the Course	SES7371P
Title of the Course	Basics of Instrumentation and Measurements
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	2
Type of the course	Skill Enhancement Course (SEC) in Physics
Delivery type of the Course	Lecture, 20+10=30. The 20 lectures for content delivery and 10 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Science student of XII
Co-requisites	None
Objectives of the course	This is the conceptual course in measurements and instrumentation. The specifications and basics of the electrical, mechanical and optical instruments of daily usage are delivered. The students are exposed to the basics of simple instruments based on the principles of mechanics, electricity, electronics and optics. The ideal of instrumental error is also to be given.
Learning outcomes	The students would be able to understand: • The basic physics and specifications of UPS, power Supply, SMPS, inverter, batteries. • Measurement of current, voltage, frequency etc. of a given DC or AC signal. • Dimensional measurements using Vernier calipers, Screw gauge, Spherometer, travelling microscopes, and spectrometers. • Basics and specifications of optical instruments and sources. • The least count and instrumental errors.

Syllabus	
Section -A	1. To study characteristics and specifications of a UPS and its performance. 2. To study characteristics and specifications of a regulated Power supply and its performance. 3. To study characteristics and specifications of an inverter and its performance. 4. To study characteristics and performance of SMPS. 5. To perform AC signal analysis using CRO. 6. To compare two AC signals using CRO and find the frequency difference. 7. To study characteristics of DC and AC motors, motor starters operating under the single and three phases. 8. To study specifications of stabilisers and variac. 9. To study characteristics, functioning and specifications of a generator. 10. To study characteristics, functioning and specifications of various types of transformers. 11. To study characteristics, functioning and specifications of various types of cells and batteries. 12. Usage of multimeter, VTVM, digital multimeter, oscillators and signal generators. Any other experiment could be designed within the scope of the objectives and learning outcomes.
Section-B	1. To study inside depth, height and length of given object using Vernier Calipers. 2. To study diameter of a wire using the Screw gauge. 3. To study the angular characteristics such as rpm offered by a motor. 4. To calibrate temperature using a thermocouple and spot galvanometer. 5. To find value of a resistance by color code and verify using a multimeter. 6. To identify type of a capacitor and find capacitance using multimeter. 7. To identify active and passive devices and report the specifications. 8. To study measurement of temperature and pressure using various scales, units and interrelation. 9. To identify loudspeakers, microphones and give their specifications. 10. To find height of building using sextant. 11. To study angular displacement using a spectrometer. 12. To study characteristics and performances of various displaying devices such as TV monitor, Computer monitors, smart boards etc. Any other experiment could be designed within the scope of the objectives and learning outcomes.
Section-C	1. To find focal length of a lens using spherometer. 2. To study nature and power of given lens and its relation with myopia, hyper myopia. 3. To study characteristics of parabolic and mixed type of mirrors and lenses. 4. To study basic elements of a various types of microscopes and their specifications. 5. To study basic elements of a various types of telescopes and their specifications. 6. To study characteristics of various light sources, bulb, tube light, candle, Sodium and Mercury lamps. 7. To study characteristics of gas, solid state and semiconductor lasers, . 8. To study components and specifications of a simple camera.

	9. To study components and specifications of a digital camera. 10. To study components and specifications of a CCD camera. 11. To study characteristics and specifications of an optical fibre. Any other experiment may be included within the scope of the objectives and learning outcomes.
Text Books	1. Comprehensive Basic Physics by Vimal Saraswat, Himanshu Publications, Udaipur.
Reference Books	1. Measurement Systems, 4th Ed. by Doeblin and MAnek, 1992, Tata McGraw Hill, New York. 2. Instrumentation Measurements and Analysis, 2nd Ed. by Nakra and Choudhary, Tata McGraw-Hill. 3. Electrical & Electronic Measurements & Instrumentation, 19th Ed. by A.K. Sawhney. 4. Instrumentation- Devices and Systems, 2nd Ed., by Rangan, Sarma and Mani, Tata-McGraw Hill. 5. Electronic Instrumentation, 4th Ed., by H.S. Kalsi, McGraw Hill. 6. Measurement & Instrumentation by D.V.S. Murthy, PHI 7. Sensors and Transducers, 2nd Ed., D. Patranabis, PHI. 8. Introduction to Measurements and Instrumentation, 4th Ed. by A.K. Ghosh, PHI. 9. Engineering metrology by R.K.Jain 1973, Khanna Publishers, New Delhi.
Scheme of EoSE	The examination shall be of three hours wherein the students has to perform three exercises, one from each section. The marks distribution shall be the following: 1. Three exercises one from each section 20x3=60 Formula(e)-3, Figure/Block diagram(s)- 3, Observations-7, Calculations-3, Result(s)-2, Precautions-2 Depending upon the problem the subdivisions may be merged. 2. Viva Voce : 10 3. Evaluation of the exercises performed during the semester and reported in a record book which required to be frequently signed by the lecturer : 10

B.Sc. (Three Years Degree Program)	
Sixth Semester	
Subject-Physics	
Code of the Course	PHY7105T
Title of the Course	Analog and Digital Electronics
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Lecture, 40+20=60. The 40 lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	The foundation and intermediate level courses of Physics and Mathematics
Co-requisites	None
Objectives of the course	The objectives are to focus on the explanation of the underlying principles of Physics and functionality of some semiconductor devices. The students will learn about different types of semiconductors, their use in making transistors and amplifiers and will study their characteristics. They will also be introduced to different types of operational amplifiers and oscillators and use them in laboratory experiments to explain their functioning and properties.
Learning outcomes	The students will learn • The basic elements of circuit analysis. • Working principles, operation and construction of the p-n junction diodes, Zener, Varactor diode as well as their applications, Optoelectronic diodes: LED and Photodiodes. • Basic construction and biasing concepts of pnp and npn transistors using load line concept, the I//O characteristics of CB, CE and CC configurations and various regions.

	• Basic constructions of JFET and MOSFET, Drain characteristics of JFET, biasing of JFET, operating regions, pinch-off voltage. • Small signal amplifiers: Two port analysis of a transistor using h-parameters and analysis of CB, CE and CC amplifiers. • Basics of Negative feedback, Merits, demerits and types of negative feedback and its applications, Positive feedback, Barkhausen criterion and working of a few oscillators. • Fundamental and characteristics of OP-Amp, Inverting and noninverting OP-Amps, Applications as an adder, subtractor, inverter, scale changer, phase shifter, differentiator and integrator. • Number systems and Boolean Algebra: Binary, Octal, decimal and hexadecimal numbers, 1's and 2's compliments, addition and subtraction of binary numbers. • The fundamental logic gates, DeMorgan's theorem, sum of minterms and product of maxterms forms of Boolean functions, simplifications using Karnaugh's map (up to 4-variables). Conceptualization of Boolean Algebra. • Basics of modulation and demodulation, amplitude and frequency modulation, power of amplitude modulation and spectrum, idea of AM and FM transmitters. Demodulation of AM and FM waves, Heterodyne and super-heterodyne receiver. • Cathode Ray Oscilloscope: Cathode ray tube- theory and construction, Cathode Ray Oscilloscope (Block diagram and operation), Application of CRO, wave form display, frequency, phase and amplitude determination, Lissajous figures.
Syllabus	
UNIT-I	**Basic circuit analysis:** Voltage and current sources, Open and Short Circuits, Kirchoff's laws, Voltage and current divider rules, Mesh and node analysis, Principle of superposition, Thevenin's and Norton's theorem, Maximum Power transfer theorem.**(6+2=8)**
	Semiconductor diodes: p-n junction diodes, I-V characteristics, diode as a rectifier, half wave, full wave and bridge rectifiers, clippers and clampers, Zener, varactor diode and their applications, Optoelctronic diodes: LED and Photodiodes. **(2+2=4)**
UNIT -II	**Bipolar junction transistors (BJT):** Basic construction of pnp and npn transistors and their operation, Input and output characteristics of CB, CE and CC configurations, Biasing methods, active, saturation and cutoff regions, load line concepts, Graphical analysis of CE configuration and phase relationship. **(3+1=4)**
	Field effect transistors: Basic constructions of JFET and MOSFET, Drain characteristics of JFET, biasing of JFET, operating regions, pinch-off voltage. **(2+1=3)**
	Small signal amplifiers: General amplifier characteristics, Two port analysis of a transistor, definition of h-parameters, current gain, voltage gain and power gain of an amplifier, Input and output resistances,

	Analysis of CB, CE and CC amplifiers for current gain, voltage gain, input and output impedences using h – parameters, **(3+2=5)**
UNIT-III	**Feedback amplifiers:** Basics of Negative feedback, Merits and demerits of negative feedback and its applications, Voltage series amplifier (Emitter follower) and Current series amplifier (CE amplifier with and without bypass capacitor). **(3+1=4)**
	Oscillators: Positive feedback, Barkhausen criterion, Phase shift oscillator, Colpitt's and Hartley oscillators, and Crystal oscillator. **(2+1=3)**
	Operational amplifiers: Characteristics of Operational amplifiers, circuit symbols, ideal and practical op-amp, Inverting and noninverting configurations, Applications of OP-AMP as an adder, subtractor, inverter, scale changer, phase shifter, differentiator and integrator. **(3+2=5)**
UNIT-IV	**Digital electronics:** Binary, Octal, decimal and hexadecimal numbers and their inter conversions, 1's and 2's compliments of binary numbers, addition and subtraction of binary numbers, OR, AND, NOT, NAND, NOR and XOR gates and their symbols and truth tables, Boolean algebra, DeMorgan's theorem, minterms and maxterms, sum of minterms and product of maxterms, forms of Boolean functions, simplifications of Boolean function using Karnaugh's map (up to 4-variables). **(8+4=12)**
UNIT-V	**Modulation:** Basics of modulation, amplitude and frequency modulation, sidebands, Comparison between AM and FM, power of amplitude modulation and spectrum, AM and FM transmitters (Block diagram and principle of operation only).**(3+1=4)**
	Demodulation: Demodulation of AM and FM waves, linear envelope detector, Hetrodyne and superhetrodyne receiver (Block diagram and principle of operation only). **(2+1=3)**
	Cathode Ray Oscilloscope: Cathode ray tube- theory and construction, Cathode Ray Oscilloscope (Block diagram and operation), Applications of CRO, wave form display, frequency, phase and amplitude determination, Lissajous figures. **(3+2=5)**
Text Books	1. Foundations of Electronics by D. Chattopadhyaya, P.C. Rakshit, B. Saha and N.N. Purkait (New Age International (P) Limited Publishers). 2. Electronic Devices and Circuit theory by R. Boylestead and L. Nashelsky (Prentice Hall of India). 3. Electronics (in Hindi) by Bhandari and Kakani
Reference Books	1. Electronic Devices by Allan Mottershed (Prentice Hall of India). 2. Digital fundamentals by Thomas L Floyd (Unuited Book Stall, New Delhi). 3. Electronic fundamentals and applications by John D. Ryder (Prentice Hall of India). 4. Electricity and Magnetism by K.K. Tewari (S. Chand &Company Limited).
Suggested E-resources	. 1. https://onlinecourses.nptel.ac.in/

B.Sc. (Three Years Degree Program)	
Sixth Semester	
Subject-Physics	
Code of the Course	PHY7105P
Title of the Course	Physics Lab-VA -Electronics
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	2
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Practical 60. The student will perform the experiments and submit the record of observations after getting the results
Prerequisites	Rudiments of the Semiconducting devices and measurement techniques using CRO, multimeter, digital multimeters etc.
Co-requisites	None
Objectives of the course	The objectives are to get an idea of the magnitude of operational currents and voltages of various semiconducting devices and circuits based on diodes, BJP and FET. The aim is also to know the specifications, construction, shapes, and identification of common semiconducting devices. Students will understand the performance of various type of amplifiers, wave shaping and the properties. The students also learn to examine, determine and explain systematic errors introduced due to problems or limitations in the measuring device etc.
Learning outcomes	The students will learn to use CRO, multimeter, VTVM, signal generators and the digital multimeter in electrical measurements. They will also learn the behavior and performance of various wave shaping circuits, characteristics of the BJT and FET, performance of different kinds of amplifier and oscillators, modulation and demodulation using various semiconducting devices.
Syllabus	

	1. To study characteristic of an FET. 2. To study frequency response of a negative feedback amplifier. 3. To study frequency response of an inverting and non-inverting operational amplifier. 4. To study waveshape of an astable and a bistable multivibrator. 5. To study clipping and clamping of wave forms using diodes and capacitors. 6. To study amplitude modulation and percentage variation on frequency and amplitude. 7. To draw characteristics of a CE amplifier. 8. To study demodulation using diode. 9. To draw characteristic curve of a Zener diode and study voltage regulation. 10. To draw characteristic curve of a Varactor diode and study variation of capacitance on biasing voltage. 11. To verify the truth tables of basic logic gates and the De Morgan's law. 12. To study RS flip flop. 13. To study T and D flip flops. 14. To study a half-wave rectifier and performance of the filter circuits. 15. To study a full-wave rectifier and performance of the filter circuits. Any other experiment could be included within the scope of the objectives and learning outcomes.
Text and reference books	1. Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing House. 2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, 11th Ed,2011, New Delhi. 3. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd. 4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Ed.,1985, Heinemann Educational Publishers 5. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, CBH Publications, Jaipur. 6. Comprehensive Basic Physics by Vimal Saraswat, Himanshu Publications, Udaipur (2023).
Suggested E-resources	1. Online virtual labs.
Scheme of EoSE	The examination shall be of three hours wherein the students has to perform any one experiment. The marks distribution shall be the following: 1. One experiment : 45 (Formula(e)-7, Figure(s)- 6, Observations-12, Calculations-10, Result(s)-5, Precautions-5) 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester: 15

B.Sc. (Three Years Degree Program)	
Sixth Semester	
Subject-Physics	
Code of the Course	PHY7106T
Title of the Course	Nuclear and Solid State Physics
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	4
Type of the course	Discipline Specific Elective (DSE) course in Physics
Delivery type of the Course	Lecture, 40+20=60. The 40 lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	The foundation and intermediate level courses of Physics and Mathematics
Co-requisites	None
Objectives of the course	This course exposes students to the two important branches of Physics. It introduces the modern concepts of materials Physics and a few experimental techniques to characterize materials. It also exposes the students to the structure and properties of the nucleus and introduction of a number of nuclear techniques.
Learning outcomes	The students would be able to understand: • Crystal geometry, symmetry and basic elements of typical crystal structures, crystal classes, space groups. Crystal structure determination by Diffraction of crystals by X-rays. • Definition, length scales and importance of nanoscale and nanoparticles. • Types of binding in solids and conducting properties of metals. • Conduction and transport in semiconductor on the basis of band theory, effective mass, electrons and holes, donor and acceptor impurities, donor impurity levels. Thermal excitation of carriers, electrical conductivity. Elementary ideas of Hall effect in metals and semiconductors and magne-toresistance. Impurity induced conducting properties of semiconductors.

	• Structure and properties of nucleus, binding energy, binding energy per nucleon, Semi-empirical mass formula and explanation of the binding energy curve. Liquid drop model of the nucleus. • Nuclear forces-properties and various type of potential and forces, results of p-p and n-p scattering experiments, meson theory of nuclear forces. • Radioactivity: Properties and characteristics of various decay processes. • Detectors for charged particles: Ion chamber, Geiger counter, cloud chamber. • Accelerators: Various type of reactors, their construction and utilities. Brief introduction to Accelerator facilities in India. • Artificial radioactivity and reactors: Nuclear fission, neutron reactions, Fermi and transuranic elements, chain reaction, criticality, moderators. • Elementary particles: Discovery and properties, Standard model Strangeness and conservation laws, sub-structure of elementary particles.
Syllabus	
UNIT-I	**Crystal geometry:** crystal lattice, crystal planes and Miller indices, unit cells. Typical crystal structures, coordination number, packing fraction, symmetry elements, rotation, inversion and reflection, point groups and crystal classes, space groups. **(3+2=5)**
	Crystallography: Bloch functions, Bloch's theorem, diffraction of X-rays by a crystal lattice. Laue's formulation of X-ray diffraction, reciprocal lattice, Brillouin zones, Laue spots, rotating crystal and Debye-Scherrer methods. **(4+1=5)**
	Nanoparticles and crystals: Definition, length scales, Importance of nanoscale and Technology.**(1+1=2)**
UNIT -II	**Types of binding in solids**: covalent binding and its origin, ionic binding, energy of binding, transition between covalent and ionic binding, metallic binding, Van der Waal's binding, Hydrogen bond. **(4+2=6)**
	Conduction in metals : Drude's theory, DC conductivity, AC conductivity, plasma frequency, thermal conductivity of metals, Fermi-Dirac distribution, thermal properties of free-electron gas, Sommerfeld's theory of conduction in metals. **(4+2=6)**
UNIT-III	**Conduction in semiconductor:** Bands in solids, metals, insulators and semiconductors. Motion of electrons, effective mass, electrons and holes, donor and acceptor impurities, donor impurity levels. Thermal excitation of carriers, electrical conductivity. Elementary idea of Hall effect in metals and semiconductors and magnetoresistance. **(4+2=6)**
	Charge transport in semi-conductors: Ionization energy of impurity atoms, carrier concentration in doped semiconductors at high and low temperatures, control on conductivity of semiconductors by impurities, and current flow in semi-conductors. **(4+2=6)**
UNIT-IV	**Structure of nucleus:** discovery of the nucleus, composition. Basic properties: charge, mass, size, spin, magnetic moment, electric quadrupole moment, binding energy, binding energy per nucleon and its observed variation with mass number of the nucleus. Coulomb energy, volume energy, surface energy, other corrections, explanation of the binding energy curve. Liquid drop model of the nucleus. **(3+1=4)**

	Nuclear forces: two-nucleon system, deuteron problem, binding energy, nuclear potential well, results of p-p and n-p scattering experiments, exchange nature of nuclear forces **(3+2=5)**
	Radioactivity: decay constant and half-life, spectra of emitters, Geiger-Nuttal law, Gamow‟s explanation. Beta decay: elementary Fermi's theory (No derivations). Antineutrino. Nuclear radiation, energy levels. **(1+2=3)**
UNIT-V	**Detectors for charged particles:** Ion chamber, Geiger counter, resolving time, cloud chamber. Accelerators: Need for accelerators; cyclic accelerators, cyclotron, betatron, synchrocyclotron, variable energy cyclotron, phase stability, brief introduction to accelerator facilities in India. **(3+2=5)**
	Artificial radioactivity: Nuclear fission, neutron reactions, Fermi and transuranic elements, chain reaction, criticality, moderators. Brief discussion on Reactor facilities in India, endothermic and exothermic nuclear reactions **(2+1=3)**
	Elementary particles: Discovery and important properties, Standard Model, Strangeness, conservation of strangeness in particle interactions, quark hypothesis, high energy electron scattering from protons, basic interactions of quarks and leptons, interrelation between Particle Physics and cosmology. Big Bang theory (Brief study. No derivations) Brief introduction to Larger Hadron Collider "Big Bang" experiments at CERN **(2+2=4)**
Text Books	1. Nuclear Physics by Brijlal & Subramanniam 2. Solid State Physics by Charles Kittel 3. Solid State Physics by R.J. Singh, 2012, Pearson Education India, New Delhi. 4. Basic Nuclear Physics and Cosmic rays by B.N. Srivastava, 2020, Anu Books, Meerut. 5. Solid State Physics, Nuclear Physics and Particle Physics (In Hindi) Kalra, Kakani and Mandot 6. Structure and Properties of Solids by B.A, Mattoo, Pragati Prakashan. 7. Modern Physics, 3rd Edn by K. S. Krane, 2012, John Wiley & Sons.
Reference Books	1. Concepts of Modern Physics, Aurthur Beiser, 2016, Tata McGraw Hill. 2. Nuclear Physics by D.C. Tayal, 2009, Himalay Publishing House. 3. Solid State Physics by R.K. Puri and V.K. Babbar, 2007, S. Chand & Com., New Delhi.
Suggested E-resources	1. https://ocw.mit.edu/courses/8-701-introduction-to-nuclear-and-particle-physics-fall-2020/ 2. https://onlinecourses.nptel.ac.in/noc21_ph21/preview 3. https://onlinecourses.nptel.ac.in/noc21_ph30/preview

B.Sc. (Three Years Degree Program)	
Sixth Semester	
Subject-Physics	
Code of the Course	PHY7106P
Title of the Course	Physics Lab-VB -Materials Lab
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	2
Type of the course	Discipline Specific Elective (DSE) Course in Physics
Delivery type of the Course	Practical 60. The student will perform the experiments and submit the record of observations after getting the results
Prerequisites	An intermediate level course of nuclear physics and solid state physics
Co-requisites	None
Objectives of the course	The objectives are to get an idea of the magnitude of electronic, optical and magnetic properties of materials. Students will understand the illustration of some phenomenon and the physics underlying. The students also learn to examine, determine and explain systematic errors introduced due to problems or limitations in the measuring device etc.
Learning outcomes	The students will learn to measure some important properties of materials and relate with the phenomenon underlying the physical behavior. Students will also learn techniques of measurements of the mechanical, magnetic and electrical of requisite precision. The students will be able to understand the random events, working and operation of radioactive detectors.
Syllabus	

	1. To study Faraday's law of electromagnetic induction. 2. To draw B-H curve using a CRO and study hysteresis loss with number of plates. 3. To find thickness of thin films using interferometry. 4. To study characteristics of a solar panel. 5. To determine **e/m** of electron using helical method. 6. To study photoelectric effect using a photocell. 7. To verify Bio-Savart law. 8. To determine Young's modulus of a given material using Searl's method. 9. To find barrier height of a PN junction diode. 10. To find specific heat of a material. 11. To find conductivity of a semiconductor using two probe method. 12. To draw plateau of a GM counter and determine the operating voltage of a GM tube. 13. To study random events and draw the distribution curve. Any other experiment may be incorporated within the scope of the objectives and learning outcomes.
Text and reference books	1. Advanced Practical Physics for Students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House. 2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, 11th Ed, 2011, New Delhi. 3. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd. 4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Ed.,1985, Heinemann Educational Publishers 5. Practical Physics by M.P. Saksena, P.R. Singh, S.S. Rawat, CBH Publications, Jaipur. 6. Comprehensive Basic Physics by Vimal Saraswat, 2023, Himanshu Publications, Udaipur.
Suggested E-resources	1. online virtual labs.
Scheme of EoSE	The examination shall be of three hours wherein the students has to perform any one experiment. The marks distribution shall be the following: 1. One experiment : 45 (Formula(e)-7, Figure(s)- 6, Observations-12, Calculations-10, Result(s)-5, Precautions-5) 2. Viva Voce : 20 3. Evaluation of the record book of experiments performed in the semester: 15

B.Sc. (Three Years Degree Program)	
Sixth Semester	
Subject-Physics	
Code of the Course	SES7372T
Title of the Course	Medical Physics
Qualification Level of the Course	NHEQF Level 5.5
Credit of the course	2
Type of the course	Skill Enhancement Course (SEC) in Physics
Delivery type of the Course	Lecture, 20+10=30. The 20 lectures for content delivery and 10 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Physics, Biology or Mathematics courses of XII standard
Co-requisites	None
Objectives of the course	This course is aimed to expose the working principles of physics and functions of the instruments used in the medical sciences. The course lays foundation of the principles underlying the measurement and standardization of physiological parameters and indices deployed in diagnose.
Learning outcomes	The students would be able to understand: • Basic physics underlying the working of a medical instrument and radiography. • The functionality and salient features of the general medical instruments and diagnostic tools. • Constructions, working and specification of some diagnostic tools and instruments.
Syllabus	

UNIT-I	**Ultrasonography:** Introduction, wave parameters, nature and propagation, generation and detection of ultrasound, Interaction of ultrasound with matter-reflection, refraction, scattering, absorption. Attenuation of ultrasound in tissues, Intensity, Characteristics of beam-shape, size, focusing, resolution. **Ultrasound Image:** Basic principles, electronic processing, Echo ranging, display modes, Transducers in real time imaging (4+2=6)
UNIT-II	**Image characteristics in ultrasound:** Spatial resolution-axial and lateral, Contrast and temporal resolution, Optimization of image, sensitivity, artefact and quality control of ultrasounds images. **Medical Imaging system:** Thermal imaging system, working, IR detectors, applications. Radiography conventional X-ray, properties, generation of X-ray and Radiation dosage and various units. (4+2=6)
UNIT -III	**Cardiac vascular system & measurements**: ECG: origin, Instrumentation, bipolar system lead system I, II, III, Einthovan's triangle, Augmented lead system, unipolar chest lead system, types of display. Blood pressure measurements: direct, indirect. Defibrillators: AC, DC. Pacemakers- Internal, External. Blood Flow meters: Electromagnetic blood flow meter, ultrasonic blood flow meter. Oximeters: Different types of oximetry systems, pulse oximeter. (6+1=7)
UNIT-IV	**Respiratory measurement Systems:** Types of volume, types of measurements, Instrumentation of respiratory system, principle & types of pneumographs, Spirometer, pneumotachometers, nitrogen wash out technique. Ventilators: Basic principles of ventilators, different generators, inspiratory phase and expiratory phase, types of ventilators. (3+3=6)
UNIT-V	**Nervous system:** Action potential of brain, brain wave, Instrumentation of Electroencephalography (EEG), electrodes used for recording EEG analysis. (3+2=5)
Text and Reference books	1. Basic principles of ultrasonographic imaging by by Nimrod M. Tole. WHO Press, World Health Organization, Geneva, Switzerland, 2005. 2. Biomedical Instrumentation and Measurements by L. Cromwell, F.J. Wiebell, E.A. Pfeiffer, 2nd Edn., PHI learning pvt. Ltd., New Delhi, 2010. 3. . Introduction to Biomedical Equipment Technology by J.J. Carr, J. M. Brown, 4th Edn., Pearson Education Inc. 2010. 4. Handbook of Biomedical Instrumentation by R.S. Khandpur, 2nd Edn., Tata McGraw-Hill, 2009. 5. The Biomedical Engineering Handbook by Joseph D. Bronzino, Vol. I, 2nd Edn., IEEE Press, 2000. 6. Principles of Biomedical Instrumentation & Measurement by Richard Aston, Merrill Publishing Company, 1990. 7. Introduction to Biomedical Instrumentation by Mandeep Singh, PHI learning Pvt. Ltd., 2010.
Suggested E-resources	