NATIONAL EDUCATION POLICY
(NEP – 2020)

FOUR-YEARS UNDERGRADUATE PROGRAMME
WITH HONOUR/RESEARCH
(Eight Semester Course)

Syllabus for B.Sc. (Physics)

(Effective from the Academic Year 2022-2023)

HEMVATI NANDAN BAHUGUNA GARHWAL UNIVERSITY
Srinagar (Garhwal) 246 174, Uttarakhand

COURSE STRUCTURE WITH CREDIT DISTRIBUTION

B.Sc. (Physics)

Semester - I

Core Physics-I (6 Credits)	Core Subject-II (6 Credits)	Additional-Multidisciplinary/ Interdisciplinary Physics M.D-I/I.D-I (4 Credits)	SEC Skill of Physics (2 Credits)	Extra-curricular Courses/CC (EC) (2 Credits)	Total Credits
Mechanics and Properties of Matter Theory – 4 Credits Practical – 2 Credits	Other Subject (6 Credits)	Mechanics Theory – 2 credits Practical – 2 Credits	Basic Electronics (2 Credits)	Understanding and connecting with Environment (2 Credits)	20

Semester - II

Core Physics-I (6 Credits)	Core Subject-II (6 Credits)	Additional-Multidisciplinary/ Interdisciplinary Physics M.D-I/I.D-I (4 Credits)	SEC Skill of Physics (2 Credits)	Extra-curricular Courses/CC (EC) (2 Credits)	Total Credits
Electricity and Magnetism Theory – 4 Credits Practical – 2 Credits	Other Subject (6 Credits)	Basic Electromagnetism Theory – 2 credits Practical – 2 Credits	Waves and Oscillations (2 Credits)	Life Skill and Personality Development (2 Credits)	20

Note: Students will opt skill course of Physics either in first year (I & II Semesters) or second year (III & IV Semester)

Student on exit after successfully completing first year (i.e., securing minimum required 40 credits) will be awarded "Undergraduate Certificate" of one year, in related field/discipline/subject.

Semester - III

Core Physics-I (6 Credits)	Core Subject-II (6 Credits)	Additional-Multidisciplinary/ Interdisciplinary Physics (M.D-I/I.D-I (4 Credits)	SEC Skill of Physics (2 Credits)	Extra-curricular Courses/CC (EC) (2 Credits)	Total Credits
Heat and Thermodynamics Theory – 4 Credits Practical – 2 Credits	Other Subject (6 Credits)	Thermodynamics Theory – 2 credits Practical – 2 Credits	Basic Electronics (2 Credits)	Indian Knowledge System (IKS)/ (AMSC)* (2 Credits)	20

Semester - IV

Core Physics-I (6 Credits)	Core Subject-II (6 Credits)	Additional-Multidisciplinary/ Interdisciplinary Physics M.D-I/I.D-I (4 Credits)	SEC Skill of Physics (2 Credits)	Extra-curricular Courses/CC (EC) (2 Credits)	Total Credits
Waves and Optics Theory – 4 Credits Practical – 2 Credits	Other Subject (6 Credits)	Elementary Optics Theory – 2 credits Practical – 2 Credits	Waves and Oscillations (2 Credits)	Indian Knowledge System (IKS)/ (AMSC)* (2 Credits)	20

Note: Students will opt skill course of Physics either in first year (I & II Semesters) or second year (III & IV Semester)

***Student has to opt either** Indian Knowledge System (IKS) or Additional Multidisciplinary Skill Course (AMSC) in III or IV Semester*

Student on exit after successfully completing two years (i.e., securing minimum required 80 credits) will be awarded "Undergraduate Diploma" of two years, in related field/discipline/subject.

Semester - V

Core Physics-I (6 Credits)	Core Subject-II (6 Credits)	Vocational course*/ Field Visit/Lab Work/ Entrepreneurship Skills (4 Credits)	Extra-curricular Courses/CC (EC) (2 Credits)	Language - I (2 Credits)	Total Credits
Modern Physics Theory – 4 Credits Practical – 2 Credits	Other Subject (6 Credits)	Lab Testing of Electronics Components (4 credits)	Culture, Traditions and Moral Values (2 Credits)	Indian, Modern, Regional Language-I (2 Credits)	20

**Evaluation Process: 30% Internal Test + 70% Design and Study of an Electronic Device*
Note: Students will opt vocational course of Physics either in fifth of sixth semester
Note: Student will have the option to study any two languages one each in V & VI Semester.

Semester - VI

Core Physics-I (6 Credits)	Core Subject-II (6 Credits)	Vocational course*/ Field Visit/Lab Work/ Entrepreneurship Skills (4 Credits)	Communication Skills/CC (2 Credits)	Language - II (2 Credits)	Total Credits
Quantum Mechanics Theory – 4 Credits Practical – 2 Credits	Other Subject (6 Credits)	Lab Testing of Electronics Components (4 credits)	Based on soft skill Development (2 Credits)	Indian, Modern, Regional Language-II (2 Credits)	20

**Evaluation Process: 30% Internal Test + 70% Design and Study of an Electronic Device*
Note: Students will opt vocational course of Physics either in fifth of sixth semester
Note: Student will have the option to study any two languages one each in V & VI Semester.
Student on exit after successfully completing three years (i.e., securing minimum required 120 credits along with securing additional 2 credits under SSD course work) will be awarded "Bachelor's Degree" of three year, in related field/discipline/subject.

Four-Year Undergraduate Program (FYUP)

U.G. Fourth Year (U.G. with Honours)

B.Sc. (Physics) Fourth Year - Seventh Semester

Entry requirement	After completing the requirements of a 3-year bachelor's degree (120 credits and 2 additional credits under SSD, will be allowed to continue studies in the fourth year of the undergraduate program leading to the four year bachelor's degree (with Honours)				
Course Type	**Semester - VII**				
	Subject/Title	**Number of Papers**	**Credits**		**Total Credit**
			T	**P**	
Major Subject (One)	**Core Major-I: Classical Mechanics**	**1**	5	-	**5**
	Core Major-II: Mathematical Physics	**1**	5		**5**
	Core Major-III: Electrodynamics	**1**	5	-	**5**
	Core Major Elective – I: **1. Electronics – A** **2. Laser Physics – A** **3. Digital Circuits (SWAYAM Course)**	**1**	4	-	**4**
	Major Practical	**1**		5	**5**
Minor (One)	**Minor-I: Optical Fibers**	**1**	2	2	**4**
Total		**6**	21	7	**28**

B.Sc. (Physics) Fourth Year - Eighth Semester

Course Type	**Semester - VIII**				
	Subject/Title	**Number of Papers**	**Credits**		**Total Credit**
			T	**P**	
Major Subject (One)	**Core Major-I: Atomic and Molecular Physics**	**1**	5	-	**5**
	Core Major-II: Solid State Physics	**1**	5		**5**
	Core Major-III: Astrophysics	**1**	5	-	**5**
	Core Major Elective – II: **1. Electronics – B** **2. Laser Physics – B** **3. Principles of Communication Systems (SWAYAM Course)**	**1**	4	-	**4**
	Major Practical	**1**		5	**5**
Minor (One)	**Minor-II: Computational Physics**	**1**	2	2	**4**
Total		**6**	21	7	**28**
NHEQF Level- 6	***Students on exit after successfully completing four years (i.e., securing a minimum required 176 credits along with securing an additional 2 credits under SSD coursework) will be awarded "Four years Bachelor's Degree (Honours)", in the related field/discipline***				

Four-Year Undergraduate Program (FYUP)

U.G. Fourth Year (U.G. Honours with Research)

B.Sc. (Physics) Fourth Year - Seventh Semester

Entry requirement	After completing the requirements of a 3-year bachelor's degree (120 credits and 2 additional credits under SSD, will be allowed to continue studies in the fourth year of the undergraduate program leading to the four year bachelor's degree (with Honours)				
Course Type	Semester - VII				
	Subject/Title	Number of Papers	Credits		Total Credit
			T	P	
Major Subject (One)	Core Major-I: Classical Mechanics	1	5	-	5
	Core Major-I: Mathematical Physics	1	5		5
	Core Major Elective – I: 1. Electronics – A 2. Laser Physics – A 3. Digital circuits (SWAYAM Course)	1	4	-	4
	Major Practical	1		5	5
	Research Methodology	1	5		5
Minor (One)	Minor-I: Optical Fibers	1	2	2	4
Total		6	21	7	28

B.Sc. (Physics) Fourth Year - Eighth Semester

Course Type	Semester - VIII				
	Subject/Title	Number of Papers	Credits		Total Credit
			T	P	
Major Subject (One)	Core Major-I: Atomic and Molecular Physics	1	5	-	5
	Core Major Elective – I: 1. Electronics – B 2. Laser Physics – B 3. Principles of Communication Systems (SWAYAM Course)	1	4	-	4
	Major Practical	1		3	3
	Dissertation	1		12	12
Minor (One)	Minor-II: Computational Physics	1	2	2	4
Total		5	11	17	28
NHEQF Level- 6	*Students on exit after successfully completing four years (i.e., securing a minimum required 176 credits along with securing an additional 2 credits under SSD coursework) will be awarded "Four years Bachelor's Degree (Honours with Research)", in the related field/discipline*				

CORE PHYSICS
(Theory: 4 Credits; Practical: 2 Credits)

ADDITIONAL INTERDISCIPLINARY PHYSICS
(Theory: 2 Credits; Practical: 2 Credits)
[For students with Core Subjects other than Physics]

B.Sc. (Physics) Semester I

Core Physics-I: Mechanics and Properties of Matter	**4 Credits [60 hours]**

Laws of Motion and conservation laws: Frames of reference, Newton's Laws of motion, Work and energy, uniform circular motion, Conservation of energy and momentum. Conservative and non-conservative forces, Motion of rocket, Motion of a particle in a central force field, Kepler's laws of planetary motion, Newton's Law of Gravitation, Gravitational field, potential and potential energy, Gravitational potential and field intensity for spherical shell. Satellite, Basic idea of global positioning system (GPS).
Rotational Motion: Dynamics of a system of particles, Centre of mass, Angular velocity and momentum, Torque, Conservation of angular momentum, Equation of motion, Moment of inertia, theorem of parallel and perpendicular axis, moment of inertia of rod, rectangular lamina, disc, solid sphere, spherical shell, kinetic energy of rotation, rolling along a slope.
Fluids: Surface Tension and surface energy, Excess pressure across surface: application to spherical drops and bubbles, variation of surface tension with temperature - Jaeger's method. Viscosity: Flow of liquid, equation of continuity, energy of fluid, Bernoulli's theorem, Poiseuille's equation and method to determine coefficient of viscosity, Variations of viscosity of a liquid with temperature
Elasticity: Hooke's law, Stress –strain, Elastic potential energy, Elastic moduli: Young's, Bulk and shear modulus of rigidity, Poisson's ratio, relation between elastic constants Work done in stretching and in twisting a wire, Twisting couple on a cylinder, Strain energy in twisted cylinder, Determination of Rigidity modulus by statical and dynamical method (Barton's and Maxwell's needle), Torsional pendulum, Young's modulus by bending of beam, Determination of Y, η and σ and moment of inertia by Searle's method.

Additional Interdisciplinary Physics: Mechanics	**2 Credits [30 Hours]**

Laws of Motion: Frames of reference, system of particle, Centre of Mass.
Momentum and Energy: Conservation of momentum, Work and energy, Conservation of energy , and Motion of rockets.
Rotational Motion: Angular velocity and angular momentum. Torque, Conservation of angular momentum.
Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant).Kepler's Laws (statement only).

Reference Books:

1. Mechanics Berkeley Physics course, vol.1: Charles Kittel et al. 2007, Tata McGraw- Hill
2. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
3. Mechanics: Mathur and Hemne, S Chand Publications.
4. Fundamentals of Mechanics: J. C. Upadyaya, Himalyan Publication.
5. Mechanics and General Properties of Matter: P. K. Chakraborty, Books and Allied Pvt. Ltd.
6. Elements of mechanics, Prakash & Agrawal, Pragati Prakashan Meerut.
7. University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison-Wesley
8. Mechanics Berkeley Physics course, v.1: Charles Kittle, et. Al. 2007, Tata McGraw-Hill.
9. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
10. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Core Physics-I: Mechanics and Properties of Matter (Practical)	**2 Credits**
Additional Interdisciplinary Physics: Mechanics (Practical)	**2 Credits**

List of Experiments:

1. To determine the Modulus of Rigidity by static method
2. To determine the Moment of Inertia of a Flywheel.
3. To determine the Moment of Inertia of an irregular body by Inertia Table
4. To determine the Young's Modulus by Bending of Beam Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine g by Bar Pendulum.
7. To determine the Elastic Constants of a Wire by Searle's method.
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine g by Kater's Pendulum.
10. To study the Motion of a spring and to determine (a) Spring Constant (b) Value of g

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

B.Sc. (Physics) Semester I or III

Skill Course Physics: Basic Electronics	**2 Credits [30 Hours]**

Diode, valve, triode Valve, Tetrode Valve, their characteristics, P-N Junction, Transistors, PNP, and NPN, their characteristics, common emitter, common base, and common base configurations.

Rectifier half wave and Full wave, Filter L-section and π-section, principles of CRO, Principle of operational amplifier.

Boolean algebra, logic Gates, Binary hexadecimal, octal decimal systems, LED, Photodiode. Tunnel diode, Point contact diode, Schotkey diode, SCR.

Reference Books

1. Electricity and electronics – Saxena, Arora and Prakash (Pragrati Prakashan Meerut).
2. Principles of electrical engineering and electronics, V K Metha and Rohit Mehta (S Chand Publication Delhi).

B.Sc. (Physics) Semester II

Core Physics-I: Electricity and Magnetism **4 Credits [60 hours]**

Vector Analysis: Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (Statements only)
Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics, Parallel plate capacitor completely filled with dielectric.
Magnetism: Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current, Divergence and curl of magnetic field, Magnetic vector potential, Ampere's circuital law.
Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.
Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.
Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.

Additional Interdisciplinary Physics: Basic Electromagnetism **2 Credits [30 Hours]**

Electrostatics:

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, Uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculationof electric field from potential, Capacitance of an isolated spherical conductor, Parallel plate, spherical and cylindrical condenser, Energy per unit volume in electrostatic field, Dielectric medium, Polarization, Displacement vector, Gauss's theorem in dielectrics Parallel plate capacitor completely filled with dielectric.

Magnetism:

Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.
Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin.

Core Physics-I: Electricity and Magnetism (Practical)	**2 Credits**
Additional Interdisciplinary Physics: Basic Electromagnetism (Practical)	**2 Credits**

List of Experiments:

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) Dc current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   (i) Measuring of charge and current sensitivity
   (ii) Measurement of CDR
   (iii) Determine a high resistance by Leakage Method
   (iv) To determine Self Inductance of a Coil by Rayleigh's Method
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality factor
7. To study parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge
9. To verify the Thevenin and Norton Theorem
10. To verify the Superposition and Maximum Power Transfer Theorem

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, 11th Edition, 2011, Kitab Mahal, New Delhi.
3. Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

B.Sc. (Physics) Semester II or IV

Skill Course Physics: Waves and Oscillation	**2 Credits [30 Hours]**

HAMONIC OSCILLATION

Solution of equation of harmonic motion, simple pendulum, compound pendulum, motion of a vertically loaded spring, LC circuit, energy in simple harmonic motion, addition of simple harmonic motion, damped vibrations, relaxation time, forced harmonic oscillator, sharpness of resonance.

WAVES

Nature, production, and propagation, equation of progressive wave, forms of wave equation, longitudinal waves, superposition of waves, stationary waves, their characteristics, and their analytical treatment, phenomenon of beats, Fourier analysis, Fourier theorem, evaluation of constants, A_0, A_n and B_n, applications of Fourier analysis, square wave, saw tooth wave, vibration of a stretched strings, velocity, vibrations of a rectangular membrane, velocity, Doppler's shift, ultrasonic waves-definition, production and applications.

Reference Books:

1. A textbook of waves and oscillations, Ashok K Ganguli (S Chand).
2. Oscillations and waves, Satya Prakash (Pragrati Prakashan, Meerut).

B.Sc. (Physics) Semester III

Core Physics-I: Heat and Thermodynamics **4 Credits [60 hours]**

Thermodynamic Description of system and laws of thermodynamics: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law, Reversible & irreversible processes.

Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Clausius Clapeyron Equation, Joules Law, Joule Thomson effect.

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications. Clausius- Clapeyron Equation, Expression for $(C_P - C_V)$, C_P/C_V, TdS equations.

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases, mono-atomic and diatomic gases.

Theory of radiation: Black body radiation, Spectral distribution, Concept of energy density, Derivation of Planck's law, Deduction of Wein's distribution law, Rayleigh Jeans law, Stefan Boltzmann law and Wein's displacement law from Plank's law.

Maxwell Boltzmann law- distribution of velocity- Quantum statistics, Phase space, Fermi- Dirac distribution law, electron gas, Bose-Einstein distribution law, photon gas, comparison of three statistics.

Additional Interdisciplinary Physics: Thermodynamics **2 Credits [30 Hours]**

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P & C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes.

Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W. Sears &G. L. Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Core Physics-I: Heat and Thermodynamics (Practical)	**2 Credits**
Additional Interdisciplinary Physics: Thermodynamics (Practical)	**2 Credits**

List of Experiments:

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint & H. T. Workshop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, Kitab Mahal, New Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal,1985, Vani Publication.

B.Sc. (Physics) Semester I or III

Skill Course Physics: Basic Electronics	**2 Credits [30 Hours]**

Diode, valve, triode Valve, Tetrode Valve, their characteristics, P-N Junction, Transistors, PNP, and NPN, their characteristics, common emitter, common base, and common base configurations.

Rectifier half wave and Full wave, Filter L-section and π-section, principles of CRO, Principle of operational amplifier.

Boolean algebra, logic Gates, Binary hexadecimal, octal decimal systems, LED, Photodiode. Tunnel diode, Point contact diode, Schotkey diode, SCR.

Reference Books

1. Electricity and electronics – Saxena, Arora and Prakash (Pragrati Prakashan Meerut).
2. Principles of electrical engineering and electronics, v K Metha and Rohit Mehta (S Chand Publication Delhi).

B.Sc. (Physics) Semester IV

Core Physics-I: Waves and Optics	4 Credits [60 hours]

Superposition of Two Collinear Harmonic oscillations: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).
Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.
Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves, Spherical waves, Wave intensity.
Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions, Kinetic and Potential Energy, Total Energy and their time averages, Damped oscillations.
Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem, Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings:Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditorium.
Wave Optics: Electromagnetic nature of light, Definition and Properties of wave front, Huygens Principle.
Interference: Interference: Division of amplitude and division of wavefront, Young's Double Slit experiment, Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes, Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.
Michelson's Interferometer: (1) Idea of form of fringes (no theory needed), (2) Determination of wavelength, (3) Wavelength difference, (4) Refractive index, (5) Visibility of fringes.
Diffraction: Fraunhofer diffraction: Single slit; double Slit. Multiple slits & Diffraction grating, Fresnel Diffraction: Half-period zones. Zone plate, Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.
Polarization: Transverse nature of light waves. Plane polarized light – production and analysis, Circular and elliptical polarization.

Additional Interdisciplinary Physics: Elementary Optics	2 Credits [30 Hours]

Electromagnetic nature of light, Definition and Properties of wave front, Huygens Principle. Aberration in lenses, Eyepieces. Resolving power of Telescope and Microscope.
Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment
Diffraction: Fraunhofer diffraction: Single slit . Diffraction grating. Fresnel Diffraction. Fresnel Diffraction pattern of a straight edge,
Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

Reference Books:

1. Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill.
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, S. ChandPublication.
4. University Physics, F W Sears, M. W. Zemanskyand, H. D. Young.

Core Physics-I: Waves and Optica (Practical)	**2 Credits**
Additional Interdisciplinary Physics: Elementary Optics (Practical)	**2 Credits**

List of Experiments:

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ2 – T Law.
3. To study Lissajous Figures.
4. Familiarization with Schuster`s focusing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a given Prism using MercuryLight.
8. To determine the value of Cauchy Constants of a material of a prism.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium & (2) Mercury light using planediffraction Grating. To determine the Resolving Power of a Plane Diffraction Grating.
14. To measure the intensity using photosensor and laser in diffraction patterns ofsingle and double slits.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint & H. T. Workshop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

B.Sc. (Physics) Semester II or IV

Skill Course Physics: Waves and Oscillation	**2 Credits [30 Hours]**

HAMONIC OSCILLATION

Solution of equation of harmonic motion, simple pendulum, compound pendulum, motion of a vertically loaded spring, LC circuit, energy in simple harmonic motion, addition of simple harmonic motion, damped vibrations, relaxation time, forced harmonic oscillator, sharpness of resonance.

WAVES

Nature, production, and propagation, equation of progressive wave, forms of wave equation, longitudinal waves, superposition of waves, stationary waves, their characteristics, and their analytical treatment, phenomenon of beats, Fourier analysis, Fourier theorem, evaluation of constants, A_0, A_n and B_n, applications of Fourier analysis, square wave, saw tooth wave, vibration of a stretched strings, velocity, vibrations of a rectangular membrane, velocity, Doppler's shift, ultrasonic waves-definition, production and applications.

Reference Books:

1. A textbook of waves and oscillations, Ashok K Ganguli (S. Chand).
2. Oscillations and waves, Satya Prakash (Pragrati Prakashan, Meerut).

B.Sc. (Physics) Semester V

Core Physics-I: Modern Physics **4 Credits [60 hours]**

Wave–Particle Duality: Planck's quantum theory, photo-electric effect, Compton scattering, pair production, De Broglie hypothesis and matter waves, phase and group velocities, Davisson-Germer experiment, Heisenberg uncertainty principle, energy-time uncertainty.

Atomic Structure: Rutherford and Bohr's models, atomic spectra, Bohr's quantization rule and atomic stability, energy level and spectra, atomic excitation, electron spin, Pauli's exclusion principle, fine structure, spin orbit coupling, L-S and J-J couplings, total angular momentum.

Atoms in Electric and Magnetic Fields: Electron Angular Momentum, Space Quantization, electron Spin and Spin Angular Momentum, Larmor's Theorem, Spin Magnetic Moment, Stem-Gerlach Experiment, Normal and Anomalous Zeeman Effect, Stark effect, Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

Nuclear Properties and Transformation: Size and structure of nucleus, non-existence of electron in the nucleus, atomic weight, binding energy, semi-empirical mass formula, nature of nuclear force. Radioactivity: stability of nucleus, law of radioactive decay, half-life and Mean lifetime, α-Decay, β-decay, energy released, γ-ray emission, fission and fusion, mass deficit and generation of energy, elementary idea of nuclear reactors, thermonuclear reactions.

Reference Books

1. Concepts of Modern Physics. Arthur Beiger, 4th Edition. 2019, Tata McGraw Hill
2. Modern Physics for Scientists and Engineers. John R. Taylor, Chris D. Zafiratos, Michael A. Dubson, 2nd Edition, 2015, University Science Books, U.S.
3. Six Ideas that Shaped Physics: Particles Behave like Waves. Thomas A. Moore, 3rd Edition, 2016. Tata McGraw Hill
4. Quantum Physics, Berkeley Physics Course Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill
5. Modern Physics. R.A. Serway. C.J. Moses, and C.A. Moyer. 3rd Edition, 2012. Cengage Learning
6. Modern Physics. R Murugeshan, Kiruthiga Sivaprasath, 18th Edition, 2016, S. Chand & Company Pvt Ltd.
7. Modern Physics. Kenneth S. Krane, 4th Edition, 2019, Wiley

Core Physics-I: Modern Physics (Practical)	2 Credits

List of Experiments:

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine value of Planck's constant using LEDs of at least 4 different colours.
4. To determine the ionization potential of mercury.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source - Na light.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by magnetic focusing.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

Reference Books

1. Advanced Practical Physics for students. B.L. Worsnop & H.T. Flint,1971, Asia Publishing House.
2. Advanced level Practical Physics. Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985. Heinemann Educational Publishers
3. A Text Book of Practical Physics. Indu Prakash, Ramakrishna, A.K. Jha, 11th Edition, 2012, Kitab Mahal, New Delhi.

B.Sc. (Physics) Semester V or VI

Vocational Course Physics: Lab Testing of Electronic Components	4 Credits

Identification of various electronic components, understanding galvanometer, voltmeter, ammeter and Multimeter for their use in measurements, resistor, capacitor, and inductors testing and measurements and understanding their fundamentals.

AC and DC voltage and current, testing, measurements and understanding their fundamentals, testing of battery, fuse, and circuit continuity, tube light and heaters, switches and relays, testing of diodes, LED, transistors and ICs and their fundamentals.

Introduction to soldering and desoldering practices, fault finding and repair of electronic instruments, design and demonstration of an electronic circuit.

Reference Books

1. Testing of Electronic Components. E. A. Fernandez, P. J. Sarkar, 2021, Shroff Publishers
2. Principles of Testing Electronic Systems. S. Mourad, Y. Zorian, 2000, John Wiley & Sons, Inc.
3. Mastering Electronics Repair: A Practical Handbook for Beginners and Experts. V T Sreekumar (Author & Publisher)
4. Practical Electronics - A Self-Teaching Guide. R. Morrison 2003, Wiley Self-Teaching Guides
5. Basic Electronics. Mitchel E. Schultz, McGraw Hill, Special Indian Edition

B.Sc. (Physics) Semester VI

Core Physics-I: Quantum Mechanics **4 Credits [60 hours]**

Time Dependent Schrodinger Equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; properties of wave function, interpretation of wave function, probability and probability current densities in three dimensions, physical significance of wave functions, normalization, linearity and superposition principles, eigenvalues and eigenfunctions, position, momentum and energy operators, commutator of position and momentum operators, expectation values of position and momentum, wave function of a free particle.

Time Independent Schrodinger Equation: Hamiltonian, stationary states and energy eigenvalues, expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions, time independent Schrodinger equation and stationary states, wave packets, application to the spread of Gaussian wave-packet for a free particle in one dimension, Fourier transforms and momentum space wavefunction, uncertainty principle: example and applications.

General Discussion of Bound States in an Arbitrary Potential: continuity of wave function, quantization of momentum and energy, boundary condition and emergence of discrete energy levels, application to one-dimensional problem, particle in a box, potential barrier, square well potential, one dimensional harmonic oscillator, energy levels and energy eigenfunctions.

Quantum Theory of Hydrogen-Like Atoms: Time independent Schrodinger equation in spherical polar coordinates, separation of variables for the second order partial differential equation, spherical harmonics, angular momentum operator, radial wavefunctions, orbital angular momentum, quantum numbers and their significance.

Reference Books:

1. Quantum Mechanics, M.C. Jain, Tata McGraw Hills
2. Quantum Physics, H C Verma, 2nd Ed, TBS Publication
3. Quantum Mechanics: Concepts and Applications, Zettili N., 2nd Ed, John Wiley
4. Advanced Quantum Mechanics, Satya Prakash, 5th Ed, Kedarnat-Ramnath Publication
5. Quantum Mechanics, E. Merzbacher, John Wiley and Sons
6. Quantum Mechanics, V. K. Thankappan, Wiley Eastern
7. Quantum Mechanics, Satya Prakash, Pragati Prakashan, Meerut
8. A Textbook of Quantum Mechanics, P.M. Mathews, K.Venkatesan, Tata McGraw Hills
9. Modern Quantum Mechanics, J.J. Sakurai, Addison-Wesley
10. Quantum Mechanics, A. K. Ghatak and S. Lokanathan, 3rd Ed, MacMillan
11. Quantum Mechanics, Bransden and Joachain, Pearson Education publications
12. Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed 2005, Pearson Education

Core Physics-I: Quantum Mechanics (Practical)	2 Credits

Problem Solving Software

1. C/C++/Scilab for solving the problems based on Quantum Mechanics

Laboratory Based Experiments

2. Use C/C++/Scilab for solving the problems based on Quantum Mechanics
3. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
4. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
5. To study the quantum tunnelling effect with solid state device, e.g. tunnelling current in backward diode or tunnel diode.

Reference Books

1. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Publications.
2. Numerical Recipes in C: The Art of Scientific Computing, W. H. Press et al., 3rd Edn. 2007, Cambridge University Press.
3. Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn, 2 0 0 7, Wiley India Edition.
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer ISBN: 978-3319067896
5. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
6. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S.Chand and Company, New Delhi, ISBN: 978-8121939706
7. Scilab Image Processing: Lambert M. Surhone, 2010, Betascript Publishing, ISBN: 978-6133459274A
8. Quantum Mechanics, Leonard I. Schiff, 3rd Ed. 2010, Tata McGraw Hill.
9. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

B.Sc. (Physics) Semester V or VI

Vocational Course Physics: Lab Testing of Electronic Components	4 Credits

Identification of various electronic components, understanding galvanometer, voltmeter, ammeter and Multimeter for their use in measurements, resistor, capacitor, and inductors testing and measurements and understanding their fundamentals.

AC and DC voltage and current, testing, measurements and understanding their fundamentals, testing of battery, fuse, and circuit continuity, tube light and heaters, switches and relays, testing of diodes, LED, transistors and ICs and their fundamentals.

Introduction to soldering and desoldering practices, fault finding and repair of electronic instruments, design and demonstration of an electronic circuit.

Reference Books

1. Testing of Electronic Components. E.A. Fernandez, P.J. Sarkar, 2021, Shroff Publishers
2. Principles of Testing Electronic Systems. S. Mourad, Y. Zorian, 2000, John Wiley & Sons, Inc.
3. Mastering Electronics Repair: A Practical Handbook for Beginners and Experts. V.T. Sreekumar (Author & Publisher)
4. Practical Electronics - A Self-Teaching Guide. R Morrison 2003, Wiley Self-Teaching Guides
5. Basic Electronics. Mitchel E. Schultz, McGraw Hill, Special Indian Edition

B.Sc. (Physics) Honours

Semester - VII

Core Major - I

Classical Mechanics

(Credits: Theory – 05)

Lagrangian Formulation: Mechanics of system of particles, conservation theorems for a system of particles, generalized coordinates, degree of freedom, constraints, principle of virtual work, D'Alembert's principle, Lagrange's equations of motion, Lagrange's equations in polar and cylindrical co-ordinates, applications of Lagrange's equations.

Hamiltonian Formulation and Variational Principle: Hamiltonian function and its physical significance, cyclic coordinates, Hamilton's equations of motion, Hamilton's equations in different co-ordinates, applications of Hamilton's equations, Hamilton's principle, Euler-Lagrange's equations, modified Hamilton's principle, derivation of Lagrange's equations from Hamilton's principle, derivation of Hamiton's equations of motion from Hamilton's principle (Variational Principle), principle of least action.

Canonical Transformations and Brackets: Legendre transformation, Canonical transformations, generating functions, conditions for the transformations to be canonical, use of canonical transformations, Poisson and Legendre Brackets, properties of Poisson brackets, invariance of Poisson and Legendre brackets under canonical transformations, angular momentum and Poisson bracket, applications of Poisson bracket.

Dynamics of Rigid bodies and Small oscillations: Generalized coordinates of a rigid body, Euler's angles, angular velocity, angular momentum and inertia tensor, principal axes and principle moment of inertia, rotational kinetic energy, Euler's equation of motion of a rigid body, torque-free motion, Force-free motion of symmetrical top, one -dimensional harmonic oscillator, normal coordinates and normal modes, small oscillations, secular equation and eigen value equation, two coupled oscillations, double pendulum, vibration of linear triatomic molecule.

Reference Books:

1. S Leonard: Classical Mechanics (Penguin UK)
2. N C Rama and P S Joag: Classical Mechanics (Tata McGraw Hill)
3. H Goldstein: Classical Mechanics (Addition Wesley)
4. J C Upadhyay: Classical Mechanics (Himalaya Publishing House)
5. S L Gupta, V Kumar & H V Sharma: Classical mechanics (Pragati Prakashan)

B.Sc. (Physics) Honours

Semester - VII

Core Major - II

Mathematical Physics

(Credits: Theory – 05)

Special Functions and Partial Differential Equations in Physics: Series Solution of Legendre's, Bessel's, Hermite's and Laguerre's Differential equation; Legendre's, Bessel's, Hermite's and Laguerre's Polynomials; Generating function, Orthogonality condition, Rodrigue's formula, Recurrence relations for Legendre's, Bessel's, Hermite's and Laguerre's Polynomials; Dirac delta and Green's function; Laplace's equation and it's solution in Cartesian, Cylindrical and Spherical Coordinates; Circular, Cylindrical and Spherical Harmonics; Heat flow in two and three Dimensions; Heat flow in Circular Plate; Potential of a ring and spherical surface; Wave equation in two and three dimensions; Vibration of Rectangular and Circular membrane.

Group Theory: Definition; Classification of groups; Subgroup; Cyclic group; Multiplication table, The group of symmetry of an Equilateral Triangle and a Square; Isomorphism and Homomorphism; Classes; Product of classes; Representation theory of finite groups; Reducible and Ir-reducible representations; Schur's Lemma; Orthogonality theorem; Characters of representations; The Unitary groups.

Complex Variables: Function of complex variable; Analytic functions; Cauchy's Riemann equations; Taylor and Laurent's series; Cauchy's integral formula; Singularities of an analytical function; Residues and their evaluation; Cauchy's integral theorem; Contour integration; Evaluation of definite integrals; Integration round the unit circle; Improper real integral; Evaluation of integrals when integrand has poles on real axis; Jordan Lemma and evaluation of integrals by Jordan Lemma.

Matrices and Tensors: Inverse and Trace of a Matrix; Hermitian, Orthogonal and Unitary Matrices; Similarity transformations; Solutions of linear differential equations; Eigen values-Eigen vectors; Cayley-Hamilton theorem; Diagonalisation of matrices; Tensors; Coordinate transformations; Covariant and contravariant Tensors; Raising and lowering of indices; Addition, Multiplication and Contraction of tensors; Metric tensors; Christoffel symbols; Transformation laws of Christoffel symbols; Geodesic.

Reference Books:

1. G B Arfken: Mathematical Methods for Physicist, Elsevier (Academic Press)
2. L A Pipes and L R Harvil: Mathematical Methods for Engineers and Physicists, McGraw-Hill
3. C Harper: Introduction to Mathematical Physics, Prentice Hall of India
4. B D Gupta, Mathematical Physics, S Chand & Company Ltd.
5. H K Das and Rama Verma, Mathematical Physics, S Chand & Company Ltd.
6. A W Joshi: Element of Group Theory for Physicists, Wiley Eastern Ltd.

B.Sc. (Physics) Honours

Semester - VII

Core Major - III

Electrodynamics

(Credits: Theory – 05)

Maxwell's Equations and Special Relativity: Maxwell's equations and their physical significance; Equation of continuity; Four-vectors; Vector and scalar potentials; Lorentz Transformations; Lorentz and Coulomb gauge: Gauge transformations; Gauge invariance; Electromagnetic energy; Poynting vector; Poynting's theorem.

Electromagnetic Waves: Electromagnetic waves and the wave equation; Electromagnetic waves in vacuum; Electromagnetic in matter; Absorption and dispersion; Guided Electromagnetic waves; Plane wave solutions of Electromagnetic wave; Fourier Solution.

Electromagnetic Field and Potentials: Fields from the random distribution of charges; Fields from a charged particle at random motion; Multipole expansion of electromagnetic fields; Hertz Potential; Retarded potential; Lienard-Wiechert potential; Electromagnetic field tensor; Covariance of electromagnetic fields;

Electromagnetic Radiations from Moving Charges: Fields produced by moving charges; Radiations from an accelerated charged particle at low velocities; Radiations from charged particles with co-linear velocity and acceleration; Radiations from an accelerated charged particle at low velocities in circular orbits-Larmor formula; Radiations from an accelerated charged particle at relativistic velocities in circular orbits; Relativistic generalization of Larmor's Formula; Bremsstrahlung; Cerenkov radiation.

Reference Books:

1. D J Griffiths: Introduction to Electrodynamics, Prentice Hall
2. J R Reitz, F J Milford & R W Christy: Foundation of E.M. Theory, Pearson
3. J D Jackson: Classical Electrodynamics, Wiley Eastern
4. S P Puri: Classical Electrodynamics, Tata McGraw Hill Publishing Co Ltd.
5. M A Heald & J B Marion: Classical Electromagnetic Radiation, Dover Publications Inc.
6. L D Landau & E M Lifshitz: The Classical Theory of Fields, Pergamon Press
7. W K H Panofsky & M Philips: Classical Electricity and Magnetism, Dover Publications
8. R N Singh: Electromagnetic Waves and Fields, Tata McGraw Hill
9. E C Jordan & K G Balman: Electromagnetic Waves and Radiating Systems, Pearson Education

B.Sc. (Physics) Honours

Semester - VII

Core Major Elective – I

Electronics – A

(Credits: Theory – 04)

Amplifiers and Oscillators: Power Amplifiers, Class A, B, AB, C and D amplifiers, Push Pull Circuits, Principles of feedback amplifiers, General characteristics of negative feedback amplifier, Effect of Feedback on Gain, Stability, Nonlinear Distortion, Bandwidth, Input, and Output Impedance, Different Types of Feedback, Criteria for Oscillation, Phase Shift, Wein Bridge, Crystal oscillator, Astable, Monostable and Bistable Multivibrators, Schmitt Trigger, Bootstrap-sweep Circuits. Differential amplifiers. Operational amplifiers, Mathematical Operations, Active Filters, Analog Computations, Comparators, S and H Circuits.

Number Systems and Logic Gates: Binary, Octal, Decimal & Hexadecimal Numbers and their interconversions, AND, OR, NOT, NAND, NOR, XOR, Universal Gates, DTL, TTL, and CMOS Logic Families, comparison of various logic families, Adders, Subtractors, Comparators, Multiplexers, Demultiplexers, Encoders, Decoders.

Sequential Circuits and Memory Devices: Basic Architectural Distinctions between Combinational and Sequential circuits, SR Latch, SR, JK, JK Master Slave, D and T Type Flip Flops, Excitation Table of all Flip Flops, Timing and Triggering Consideration, Shift Registers, Universal shift register, Applications of Shift Registers, Asynchronous/ Ripple counters, Synchronous counters, Modulo–n Counters, Shift counters, Ring counters. Classification of memories, ROM, PROM, EPROM, EEPROM, RAM, Write operation, Read operation, Static RAM, Programmable Logic Array (PLA), Programmable Array Logic, Implementation of Combinational Logic circuits using ROM, PLA, PAL.

Optoelectronics: Light propagation through optical fiber, Total Internal Reflection (Critical angle and its expression), step index and Graded index fibres, Attenuation, absorption, scattering losses, bending loss, dispersion, point-to-point communication using Optical Fibers. Light Emitting Diodes (LED), Injection Laser Diode (ILD), comparison of LED and ILD. PIN Photodetector, Avalanche Photodiodes, Detector response time, Temperature effect on Avalanche gain, Comparison of Photo detectors.

Reference Books:

1. Robert L. Boylestad and Louis Nashelsky: Electronic Devices and Circuit Theory, Pearson Education India.
2. Ashish Bagwari and G.S. Tomar: Fundamentals of Electronic Devices and Circuits, Springer Verlag, Singapore.
3. S.M. Sze: Semiconductor Devices - Physics and Technology, Wiley, New York
4. A.P. Melvino & D.P. Leach: Digital Principles and Applications, McGraw-Hill
5. Morris Mano: Digital Design, Pearson Education
6. J. Millman & C.C. Halkias: Integrated Electronics, McGraw-Hill
7. Pallab Bhattacharya: Semiconductor Optoelectronic Devices, Prentice-Hall
8. Gerd Keiser: Optical Fiber Communications, Tata McGraw-Hill

B.Sc. (Physics) Honours

Semester - VII

Core Major Elective – I

Laser Physics – A

(Credits: Theory – 04)

Basic principles: Basic principles and theory of absorption and emission of radiation, Einstein's coefficients, line-broadening mechanisms, rate equations for three and four level laser systems, population inversion, theory of optical resonators, laser modes, spatial and temporal coherence,

Types of lasers: Gas lasers, He-Ne, argon ion, N2, CO2 lasers; dye lasers, solid state, Semiconductor lasers: Ruby, Nd:YAG and Nd:glass lasers, Fabrication technology of lasers, diode lasers, colour centre and spin flip lasers, laser spikes, mode locking Q-switching, CW and pulsed lasers.

Nonlinear optics: Theory of nonlinear phenomena, second and third harmonic generation, phase matching, parametric generation, self-focusing,

Laser spectroscopy: Laser fluorescence spectroscopy using CW and pulsed lasers, Single photon counting, Laser Raman spectroscopy, multiphoton processes, photo acoustic and photon electron spectroscopy, stimulated Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy.

Reference Books:

1. A. Ghatak and K. Thyagarajan: Lasers: Fundamentals and Applications, Laxmi Publications
2. O. Svelto: Principles of Lasers, Kluwer Academic
3. W.T. Silfvast: Lasers Fundamentals, Cambridge University Press
4. B.B. Laud: Lasers and Non-Linear Optics, New Age International Pvt Ltd.

B.Sc. (Physics) Honours

Semester - VII

Core Major Elective – I

Digital Circuits (Swayam Course)

(Credits: Theory – 04)

Link for the course: https://onlinecourses.nptel.ac.in/noc25_ee125/preview

B.Sc. (Physics) Honours

Semester - VII

Major Practical

(Credits: 05)

List of experiments:

At least ten experiments are to be performed

1. Determine the Expansion of periodic functions in a series of sine by Fourier coefficients.
2. Verification of Fresnel Law
3. Determine the velocity of ultrasonic waves
4. Measurement of the wavelength of He-Ne laser using interference and diffraction pattern
5. Measurement of thickness of thin wire using laser
6. Determination of absorption coefficient of iodine vapour
7. Design and study of FET amplifier
8. Design and study of MOSFET amplifier
9. Frequency response curve of R-C coupled amplifier
10. Frequency response curve of transformer coupled amplifier
11. Design and study of Hartley oscillator
12. Design and study of phase shift oscillator
13. Design and study of the Wien-Bridge oscillator
14. Astable/Monostable/Bistable Multivibrators
15. Study of pin connection and biasing of various linear IC's and their timers 555

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, Asia Publishing House.
2. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, New Delhi.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers

B.Sc. (Physics) Honours

Semester - VII

Minor - I

Optical Fibers

(Credits: Theory – 02)

Optical fibers and fabrication: Fiber materials, Fiber fabrication, step-index and graded-index, Mechanical properties of fibers, Attenuation, Signal distortion in optical waveguides, Pulse broadening in graded index waveguides, Mode coupling, Design optimization of single mode fibers.,

Power launching and coupling: Source-to-fiber launching, fiber-to-fiber joints, LED coupling to single-mode fibers, Fiber splicing, Optical fiber connectors.

Photodetectors: The pin photodetector, Avalanche photodiodes, Photodetector noise, Detector response time, Structures for In GaAs APDs, Temperature effect on avalanche gain,

Optical amplifiers and Optical Receivers: Fundamental receiver operation, Pre-amplifier types, Optical amplifiers, Semiconductor optical amplifiers, Erbium-doped fiber amplifiers, Amplifier noise, System applications.

Reference Books:

1. Cherin, A.H., An Introduction to Optical Fibers for Engineers and Physicists, McGraw-Hill Inc.
2. Agarwal G.P., Nonlinear fibre optics, Academic Press, Elsevier.
3. Senior, J.M., Optical Fiber Communications – Principles and Practice, Pearson Education, India.
4. Keiser, G., Optical Fiber Communications, McGraw-Hill Education.
5. Yariv, A., Quantum Electronics, John Wiley & Sons Inc.

B.Sc. (Physics) Honours

Semester - VII

Minor Practical

(Credits: 02)

List of experiments:

At least five experiments are to be performed

4. Study of IC- Based Power supply
5. Study of operational amplifier
6. Study of photovoltaic cell
7. Study of Light Emitting Diode
8. Study of Light Depended Resistor
9. Study of De-morgans theorem
10. Study of logic gates
11. Fiber Optics communication
12. Transmission of Light between two fibers
13. Study of losses in optical fibers

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, Asia Publishing House.
2. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, New Delhi.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers

B.Sc. (Physics) Honours

Semester - VIII

Core Major - I

Atomic and Molecular Physics

(Credits: Theory – 05)

Atomic Spectroscopy:

Fine structure of Hydrogen lines, alkali atom Spectra, penetrating and non-penetrating orbits, Hunde's rule Spectra of two valence electron atoms (Helium, Magnesium), selection rules for atomic transitions, multielectron spectra, Central field approximation Hartree self-consistent field theory, Thomas Fermi statistical model.

Pauli's exclusion principle and determination of ground state, electron spin-orbit interaction, L-S and J-J coupling schemes, Zeeman Effect, Paschen Back Effect, Hyperfine structure, Stark effect, width of spectral lines, lamb shift.

Molecular Spectroscopy:

Rotational spectra of diatomic molecules, nonrigid rotator, vibrational spectra enharmonic oscillator explanation of rotational, vibrational spectra in infrared, molecular dissociation and calculation of dissociation energy, Raman effect and intensity alternation of the rotational bands, Applications of infrared and Raman spectroscopy.

Born Oppenheimer approximation, Molecular orbital theory, Heitler-Loudon treatment of Hydrogen molecule ion and Hydrogen molecule, Electronic spectra of molecules, Fortrat Parabola, Deslandres table, vibrational structure of electronic bands, Intensities of electronic transitions, Franek Condon principle, Condon parabola.

Reference Books:

1. Atomic Spectra: H.E. white, Cambridge University Press, New York
2. Principle of Atomic Spectra: B.W. Shore and H.D. Menzel, John Wiley & Sons
3. Spectra of Diatomic Molecules: G. Herzberg, Krieger Publishing Company
4. Fundamentals of Molecular Spectroscopy: C.N. Banwell and E.M. McCash, Tata McGraw Hill, New Delhi
5. Molecular Structure and Spectroscopy: G. Aruldhas, Prentice Hall India

B.Sc. (Physics) Honours

Semester - VIII

Core Major - II

Solid State Physics

(Credits: Theory – 05)

Crystal Structure: Crystal translational vectors, unit cell, two and three-dimensional Bravais lattice, lattice planes and miller indices, symmetry operations and point groups, simple crystal structures, examples of **fcc**, **bcc** and **hcp** structures, atomic packing fraction, wave diffraction in crystal lattice, Bragg's law, Laue equations, reciprocal lattice, Bragg's diffraction condition in terms of reciprocal lattice, Brillouin zones, atomic scattering factor, structure factor and atomic form factor

Crystal Binding and Elastic Constants: Ionic Crystal, Covalent Crystal, Metallic and Hydrogen bonds, analysis of elastic springs, elastic stress and strain, work done by elastic forces, elastic energy density, stress–strain relations, elastic compliance and stiffness constants, elastic waves and velocity in cubic crystals, Waves in **(100)**, **(110)** and **(111)** symmetry directions, experimental determination of elastic constants,

Phonons and Lattice Vibrations: Quantization of elastic waves, Normal modes of vibration, Concept of phonon, Phonon momentum, Phonon-phonon inelastic scattering, Vibrations of one-dimensional monatomic lattice, First Brillouin Zone, Group Velocity, Long wavelength limit, Vibrations of one-dimensional diatomic lattice, Infrared absorption and optical properties.

Thermal Properties of Solids: Specific heat of solids, Einstein Model of lattice specific heat, Density of states, Debye theory of lattice specific heat, Debye approximation, Thermal expansion, lattice thermal conductivity, electronic heat conduction.

Reference Books:

1. Introduction to Solid State Physics: C Kittel, Wiley India
2. Principles of the Theory of Solids: J M Ziman, Cambridge University Press
3. Solid State Physics: A J Dekker, Laxmi Publications
4. Solid State Physics: N W Ashcroft & N David Mermin, CENGAGE Brooks/Cole
5. Solid State Physics: R K Puri & V K Babbar, S Chand Publishing
6. Solid State Physics: Ajay Kumar Saxena, Laxmi Publications
7. Solid State Physics: B S Saxena, R C Gupta, P N Saxena, J N Mandal, Pragati Prakashan
8. Solid State Physics: R L Singhal, Kedar Nath Ram Nath
9. Solid state physics: S O Pillai, NEW AGE International Pvt Ltd

B.Sc. (Physics) Honours

Semester - VIII

Core Major - III

Astrophysics

(Credits: Theory – 05)

The Solar System: Aspects of the sky: Concept of Celestial Coordinates and spherical astronomy. Astronomical telescopes. The early years of solar system, the solar system today. Study of Planets: Classification of the Planets, Orbits, Laws of planetary motion, Physical features, surface features, Internal Structure, Atmosphere, Satellites and Rings.

Minor Bodies in Solar System: Asteroids, Meteors and Meteorites**,** Discovery of minor planets (Asteroids), their orbits and physical nature, Origin of the minor planets, Meteors and Meteorites, Observation of meteor showers and sporadic meteors, Orbits of sporadic meteoroids and meteor showers, Meteorites, its types and composition, Meteorite craters, Comets- Discovery and designation, Periodic comets, Physical nature, Spectra, Brightness variation, Gas production rates, dust and ion tails, Nature of dust particles and origin of comets.

Stellar System: Sun as a Star, History of Sun, Sun's interior, the photosphere, the solar atmosphere (chromosphere & corona). Salient features of sunspots, sun's rotation & solar magnetic field, explanation for observed features of sunspots, Distances of stars from the trigonometric, Secular and moving cluster parallaxes, Stellar motions. Magnitude scale and magnitude systems, Atmospheric extinction, Absolute magnitudes and distance modulus, Colour index, The Hertzberg- Russell Diagram, The colour, Brightness or luminosity, the population of star, Elementary idea of Binary & Variable Stars, Nuclear fission, Nuclear fusion, condition for nuclear reaction in stars.

Galaxy & Cosmology: Basic structure and properties of different types of Galaxies, Structure and features of the Milky Way Galaxy, Rotation curve of the Galaxy and the dark matter, Virial theorem Standard Candles (Cepheids and SNe Type1a), Cosmic distance ladder, Expansion of the Universe, Cosmological Principle, Newtonian Cosmology and Friedmann Models, Cosmic distance ladder.

Reference Books:

1. Marc L. Kutner: Astronomy: A Physical Perspective (Cambridge Univ Press)
2. Shu, F.H.: The Physical Universe An Introduction to Astronomy
3. Robert H. Baker: Astronomy
4. L Motz. & A. Duveen: The Essentials of Astronomy (Colombia Univ Press)
5. Willian K. Hartmann: Moons & Planets
6. I Morison: Introduction to Astronomy and Cosmology
7. A.W. Joshi & N. Rana: Our solar system
8. Jayant Naralikar: The Structure of Universe
9. K.D. Abhyankar: Astrophysics (Stars & Galaxies)
10. K.S. Krishnaswamy: Physics of Comets
11. McCusky: Introduction to Celestial Mechanics

B.Sc. (Physics) Honours

Semester - VIII

Core Major Elective – II

Electronics – B

(Credits: Theory – 04)

Modulation and Demodulation: Amplitude Modulation - Theory, Plate Modulated Class C Amplifier, Balanced Modulator, Single Side Band Modulation (Phase Shift Method). Frequency Modulation - Theory, Reactance Tube Modulator, Transistor Reactance Modulator, FET Reactance Modulator. Demodulation - Envelope Diode Detector, Super Regenerative Detection, Foster-Seely Phase Discriminator, Ratio Detector, A.M. Transmitter, F.M. Transmitter, TRF Receiver, Super Heterodyne Receiver, Amplitude Limiting.

Transmission Lines and Antennas: TL Equations and Their Solutions, Characteristic Impedance, Lossless Open and Short-Circuited Lines, Standing Wave Ratio and Reflection Coefficient, Stub Matching, Quarter and Half Wavelength Lines. Antenna - Radioactive Field Strength, Power & Radiation Patterns of an Elementary Electric Doublet and Linear Antenna, Effects of Ground Reflection. Hertz Antenna, Marconi Antenna, Yagi Antenna, Loop Antenna, Direction Finding, Resonant & Non-Resonant Antenna, Antenna array (Broadside & End fire arrays), T.V. aerials. Horn Antenna, Parabolic reflectors, Lens Antenna.

Propagation of Radio Waves: Eccles-Larmor Theory, Appleton–Hartree Theory of Sky Wave Propagation, Skip Distance and Maximum Usable Frequency, Chapman's Theory of Layer Formation. Pulse Method for Measuring the Height of the Ionospheric Region.

Television and Radar Systems: General Principles of Image Transmission and Reception of Signals, pick-up Instruments (Iconoscope, Image Orthicon, and Videocon), Image Scanning Sequence, Scanning Synchronization, Composite Video Signal, Colour Television. Radar Systems - Principle of Radar, Basic Arrangement of Radar System, Azimuth and Range Measurement, Operating Characteristics of Systems, Radar Transmitters and Receivers, Duplexers, Indicator Unit, Maximum Range of a Radar Set.

References Books:

1. F.E. Terman: Electronics and Radio Engineering, McGraw-Hill
2. G. Kennedy: B. Davis & SRM Prasanna, Electronic Communication Systems, McGraw-Hill
3. G.K. Mithal: Radio Engineering Vol. II, Khanna Publishers
4. S.L. Gupta & V. Kumar: Handbook of Electronics, Pragati Prakashan
5. Frenzel, Communication Electronics: Principles and Applications, McGraw-Hill
6. D. Rody & J. Coolen: Electronics Communication Systems, Pearson India
7. W. Tomasi: Electronic Communications System, Pearson Education

B.Sc. (Physics) Honours

Semester - VIII

Core Major Elective – II

Laser Physics – B

(Credits: Theory – 04)

Optical Modulation Techniques: Electro-optic effect, longitudinal and transverse phase modulation, consideration of modulator designs and circuit aspects, acousto-optic effect, Raman-Nath and Bragg regimes, acousto-optic modulators, magneto-optic effect, integrated optics, optical directional couplers and optical switches, phase modulators.

Optical sources and detectors: Laser devices, radiation pattern and modulation, LED structures, light source materials, liquid crystal diodes, photoelectric, photovoltaic and photconductive methods of detection of light, photodiodes: structure, materials and working, PIN photodiodes, avalanche photodiodes, microchannel plates, photodetector noise responsivity and efficiency, photomultipliers, image intensifier tubes, Videocon and CCD.

Fibre optics: Basic characteristics of optical fibres, fibre structure and fundamentals of waveguides, step and graded index fibres, signal degradation in optical fibres, absorption scattering, radiation and core cladding losses, Design considerations of a fibre optical communication system, analogue and digital modulation, optical fibre amplifiers.

Holography: Basic principles, construction and reconstruction of holograms, applications of holography, laser interferometry, laser applications in industry and medicine

Reference Books:

1. A. Ghatak and K. Thyagarajan: Optical Electronics, Cambridge India
2. J. Wilson and J. Hawkes: Optoelectronics, Pearson Education
3. G. Keiser: Optical Fibre Communications, McGraw-Hill Education
4. A. Ghatak and K. Thyagarajan: Introduction to fibre optics, Cambridge University Press
5. I.P. Csorba: Image tubes, Longman Higher Education
6. Eds. L.M. Biberman and S. Nudelman: Photoelectronic Imaging Devices, Kluwer Academic/Plenum Publishers

B.Sc. (Physics) Honours

Semester - VIII

Core Major Elective – II

Principles of Communication Systems (Swayam Course)

(Credits: Theory – 04)

Prof. Aditya K. Jagannatham, IIT Kanpur

B.Sc. (Physics) Honours

Semester - VIII

Major Practical

(Credits: 05)

List of experiments:

At least ten experiments are to be performed

1. Absorption spectroscopy by spectrophotometer
2. e/m by Zeeman Effect
3. Michelson Interferometer
4. Fabry Perot Interferometer
5. Measurement of resistivity by using four probe technique
6. To plot magnetic hysteresis loop of ferromagnetic rod
7. Measurement of Dielectric constant
8. Determination of magnetic susceptibility
9. Determination of Planks constant
10. Lecher wire experiment
11. Determine the magnetic susceptibility of a solution of paramagnetic salt
12. Determination of elastic constant of crystals by optical methods
13. Study of fluorescence spectra of a given compound
14. Determination of the Hall coefficient using the Hall effect
15. Determination of Energy gap of a semiconductor by four probe method

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, Asia Publishing House.
2. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, New Delhi.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers

B.Sc. (Physics) Honours

Semester - VIII

Minor - II

Computational Physics

(Credits: Theory – 02)

Numerical Methods: Roots of non-linear equations, Newton-Raphson Method, Interpolation-equal and unequal intervals, central and inverse interpolation, Numerical integration, Numerical solution of ordinary differential equations: Euler's method, Runge-Kutta Method, least square curve fitting method, power and Jacobi method, solution of simultaneous linear equations Gauss- elimination, Pivoting, Jacobi iterative method, matrix inversion, Eigen value and eigen vector.

Programming Languages: Basic Structure of **Compiled programming languages C++ and Fortran 90/95**- constants and variables, arithmetic and logical expressions, input-output statements, control statements, loops, arrays, format statements, function and subprograms, character string, pointers.

Interpreted Programming Languages and Application Software: Basic Knowledge of Python and JavaScript, Application software- MAPLE, MATLAB, MATHEMATICA and LaTeX.

Reference Books:

1. B D Hahn: Fortran 90 for Scientists and Engineers.
2. V Rajaraman: Computer Programming in C.
3. V Rajaraman: Computer Programming in FORTRAN 90/95.
4. V Rajaraman: Computer Oriented numerical methods.
5. Samuel S M Wong: Computational methods in Physics and engineering.
6. S Balachandra Rao: Numerical Methods.
7. Stephen J Chapman: Fortran 90/95 for Scientists and Engineers.
8. E Balagurusamy: Numerical methods
9. G Shanker Rao: Numerical analysis
10. Walter Gander J R: Solving Problems in Scientific Computing using **Maple**

B.Sc. (Physics) Honours

Semester - VIII

Minor Practical

(Credits: 02)

List of experiments:

At least five experiments are to be performed

1. Solution of simultaneous non-linear equations using Newton Raphson method
2. Calculating Eulers number using exp(x) series evaluated at x=1.
3. To printout natural even/odd numbers between given limits
4. Find the area of the Triangle, Rectangle, etc.
5. To find the sum of two matrices.
6. Motion of a projectile using simulation and plot the output for visualization.
7. Write a C++ program to convert a binary number to a decimal number.
8. Write a JavaScript code display the browser specifications.
9. Write a Python program to demonstrate Local and Global variables.

Reference Books:

1. Numerical Methods in Engineering & Science with Programs in C, C++ & MATLAB, B.S. Grewal, Khanna Publishers
2. Object Oriented Programming with C++, E. Balagurusamy, McGraw Hill
3. A Textbook of Java Programming, Surbhi Kakar, Dreamtech Press
4. Python: The Complete Reference, Martin C Brown, McGraw Hill

B.Sc. (Physics) Honours with Research

Semester - VII

Core Major - I

Classical Mechanics

(Credits: Theory – 05)

Lagrangian Formulation: Mechanics of system of particles, conservation theorems for a system of particles, generalized coordinates, degree of freedom, constraints, principle of virtual work, D'Alembert's principle, Lagrange's equations of motion, Lagrange's equations in polar and cylindrical co-ordinates, applications of Lagrange's equations.

Hamiltonian Formulation and Variational Principle: Hamiltonian function and its physical significance, cyclic coordinates, Hamilton's equations of motion, Hamilton's equations in different co-ordinates, applications of Hamilton's equations, Hamilton's principle, Euler-Lagrange's equations, modified Hamilton's principle, derivation of Lagrange's equations from Hamilton's principle, derivation of Hamiton's equations of motion from Hamilton's principle (Variational Principle), principle of least action.

Canonical Transformations and Brackets: Legendre transformation, Canonical transformations, generating functions, conditions for the transformations to be canonical, use of canonical transformations, Poisson and Legendre Brackets, properties of Poisson brackets, invariance of Poisson and Legendre brackets under canonical transformations, angular momentum and Poisson bracket, applications of Poisson bracket.

Dynamics of Rigid bodies and Small oscillations: Generalized coordinates of a rigid body, Euler's angles, angular velocity, angular momentum and inertia tensor, principal axes and principle moment of inertia, rotational kinetic energy, Euler's equation of motion of a rigid body, torque-free motion, Force-free motion of symmetrical top, one -dimensional harmonic oscillator, normal coordinates and normal modes, small oscillations, secular equation and eigen value equation, two coupled oscillations, double pendulum, vibration of linear triatomic molecule.

Reference Books:

1. S Leonard: Classical Mechanics (Penguin UK)
2. N C Rama and P S Joag: Classical Mechanics (Tata McGraw Hill)
3. H Goldstein: Classical Mechanics (Addition Wesley)
4. J C Upadhyay: Classical Mechanics (Himalaya Publishing House)
5. S L Gupta, V Kumar & H V Sharma: Classical mechanics (Pragati Prakashan)

B.Sc. (Physics) Honours with Research

Semester - VII

Core Major - II

Mathematical Physics

(Credits: Theory – 05)

Special Functions and Partial Differential Equations in Physics: Series Solution of Legendre's, Bessel's, Hermite's and Laguerre's Differential equation; Legendre's, Bessel's, Hermite's and Laguerre's Polynomials; Generating function, Orthogonality condition, Rodrigue's formula, Recurrence relations for Legendre's, Bessel's, Hermite's and Laguerre's Polynomials; Dirac delta and Green's function; Laplace's equation and it's solution in Cartesian, Cylindrical and Spherical Coordinates; Circular, Cylindrical and Spherical Harmonics; Heat flow in two and three Dimensions; Heat flow in Circular Plate; Potential of a ring and spherical surface; Wave equation in two and three dimensions; Vibration of Rectangular and Circular membrane.

Group Theory: Definition; Classification of groups; Subgroup; Cyclic group; Multiplication table, The group of symmetry of an Equilateral Triangle and a Square; Isomorphism and Homomorphism; Classes; Product of classes; Representation theory of finite groups; Reducible and Ir-reducible representations; Schur's Lemma; Orthogonality theorem; Characters of representations; The Unitary groups.

Complex Variables: Function of complex variable; Analytic functions; Cauchy's Riemann equations; Taylor and Laurent's series; Cauchy's integral formula; Singularities of an analytical function; Residues and their evaluation; Cauchy's integral theorem; Contour integration; Evaluation of definite integrals; Integration round the unit circle; Improper real integral; Evaluation of integrals when integrand has poles on real axis; Jordan Lemma and evaluation of integrals by Jordan Lemma.

Matrices and Tensors: Inverse and Trace of a Matrix; Hermitian, Orthogonal and Unitary Matrices; Similarity transformations; Solutions of linear differential equations; Eigen values-Eigen vectors; Cayley-Hamilton theorem; Diagonalisation of matrices; Tensors; Coordinate transformations; Covariant and contravariant Tensors; Raising and lowering of indices; Addition, Multiplication and Contraction of tensors; Metric tensors; Christoffel symbols; Transformation laws of Christoffel symbols; Geodesic.

Reference Books:

1. G B Arfken: Mathematical Methods for Physicist, Elsevier (Academic Press)
2. L A Pipes and L R Harvil: Mathematical Methods for Engineers and Physicists, McGraw-Hill
3. C Harper: Introduction to Mathematical Physics, Prentice Hall of India
4. B D Gupta, Mathematical Physics, S Chand & Company Ltd.
5. H K Das and Rama Verma, Mathematical Physics, S Chand & Company Ltd.
6. A W Joshi: Element of Group Theory for Physicists, Wiley Eastern Ltd.

B.Sc. (Physics) Honours with Research

Semester - VII

Core Major Elective – I

Electronics – A

(Credits: Theory – 04)

Amplifiers and Oscillators: Power Amplifiers, Class A, B, AB, C and D amplifiers, Push Pull Circuits, Principles of feedback amplifiers, General characteristics of negative feedback amplifier, Effect of Feedback on Gain, Stability, Nonlinear Distortion, Bandwidth, Input, and Output Impedance, Different Types of Feedback, Criteria for Oscillation, Phase Shift, Wein Bridge, Crystal oscillator, Astable, Monostable and Bistable Multivibrators, Schmitt Trigger, Bootstrap-sweep Circuits. Differential amplifiers. Operational amplifiers, Mathematical Operations, Active Filters, Analog Computations, Comparators, S and H Circuits.

Number Systems and Logic Gates: Binary, Octal, Decimal & Hexadecimal Numbers and their interconversions, AND, OR, NOT, NAND, NOR, XOR, Universal Gates, DTL, TTL, and CMOS Logic Families, comparison of various logic families, Adders, Subtractors, Comparators, Multiplexers, Demultiplexers, Encoders, Decoders.

Sequential Circuits and Memory Devices: Basic Architectural Distinctions between Combinational and Sequential circuits, SR Latch, SR, JK, JK Master Slave, D and T Type Flip Flops, Excitation Table of all Flip Flops, Timing and Triggering Consideration, Shift Registers, Universal shift register, Applications of Shift Registers, Asynchronous/ Ripple counters, Synchronous counters, Modulo–n Counters, Shift counters, Ring counters. Classification of memories, ROM, PROM, EPROM, EEPROM, RAM, Write operation, Read operation, Static RAM, Programmable Logic Array (PLA), Programmable Array Logic, Implementation of Combinational Logic circuits using ROM, PLA, PAL.

Optoelectronics: Light propagation through optical fiber, Total Internal Reflection (Critical angle and its expression), step index and Graded index fibres, Attenuation, absorption, scattering losses, bending loss, dispersion, point-to-point communication using Optical Fibers. Light Emitting Diodes (LED), Injection Laser Diode (ILD), comparison of LED and ILD. PIN Photodetector, Avalanche Photodiodes, Detector response time, Temperature effect on Avalanche gain, Comparison of Photo detectors.

Reference Books:

1. Robert L. Boylestad and Louis Nashelsky: Electronic Devices and Circuit Theory, Pearson Education India.
2. Ashish Bagwari and G.S. Tomar: Fundamentals of Electronic Devices and Circuits, Springer Verlag, Singapore.
3. S.M. Sze: Semiconductor Devices - Physics and Technology, Wiley, New York
4. A.P. Melvino & D.P. Leach: Digital Principles and Applications, McGraw-Hill
5. Morris Mano: Digital Design, Pearson Education
6. J. Millman & C.C. Halkias: Integrated Electronics, McGraw-Hill
7. Pallab Bhattacharya: Semiconductor Optoelectronic Devices, Prentice-Hall
8. Gerd Keiser: Optical Fiber Communications, Tata McGraw-Hill

B.Sc. (Physics) Honours with Research

Semester - VII

Core Major Elective – I

Laser Physics – A

(Credits: Theory – 04)

Basic principles: Basic principles and theory of absorption and emission of radiation, Einstein's coefficients, line-broadening mechanisms, rate equations for three and four level laser systems, population inversion, theory of optical resonators, laser modes, spatial and temporal coherence,

Types of lasers: Gas lasers, He-Ne, argon ion, N2, CO2 lasers; dye lasers, solid state, Semiconductor lasers: Ruby, Nd:YAG and Nd:glass lasers, Fabrication technology of lasers, diode lasers, colour centre and spin flip lasers, laser spikes, mode locking Q-switching, CW and pulsed lasers.

Nonlinear optics: Theory of nonlinear phenomena, second and third harmonic generation, phase matching, parametric generation, self-focusing,

Laser spectroscopy: Laser fluorescence spectroscopy using CW and pulsed lasers, Single photon counting, Laser Raman spectroscopy, multiphoton processes, photo acoustic and photon electron spectroscopy, stimulated Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy.

Reference Books:

1. A. Ghatak and K. Thyagarajan: Lasers: Fundamentals and Applications, Laxmi Publications
2. O. Svelto: Principles of Lasers, Kluwer Academic
3. W.T. Silfvast: Lasers Fundamentals, Cambridge University Press
4. B.B. Laud: Lasers and Non-Linear Optics, New Age International Pvt Ltd.

B.Sc. (Physics) Honours with Research

Semester - VII

Core Major Elective – I

Digital Circuits (Swayam Course)

(Credits: Theory – 04)

Link for the course: https://onlinecourses.nptel.ac.in/noc25_ee125/preview

B.Sc. (Physics) Honours with Research

Semester - VII

Major Practical

(Credits: 05)

List of experiments:

At least ten experiments are to be performed

1. Determine the Expansion of periodic functions in a series of sine by Fourier coefficients.
2. e/m by Zeeman effect
3. Study of IC- Based Power supply
4. Absorption spectroscopy by spectrophotometer
5. Study of optoelectronic devices
6. Determination of absorption coefficient of iodine vapour
7. Design and study of FET amplifier
8. Design and study of MOSFET amplifier
9. Measurement of the wavelength of He-Ne laser using interference and diffraction pattern
10. Measurement of thickness of thin wire using laser
11. Logicom AND/or/NAND/NOR/NOT gates
12. Study of pin connection and biasing of various linear IC's and timers 555
13. Design and study of phase shift oscillator
14. Study of operational amplifier

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, Asia Publishing House.
2. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, New Delhi.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers

B.Sc. (Physics) Honours with Research

Semester - VII

Research Methodology

(Credits: Theory – 05)

Meaning of Research: Function of Research, Research Characteristics, Steps involved in Research, Significance of Research, Types of Research, Criteria of Good Research, Research in Pure and Applied Sciences, Areas of Science, Philosophy of Science, Interdisciplinary Research, Review of Literature.

Identification of Research Problem: Selecting the Research Problem, Defining the Problem, Goals and Criteria for Identifying problems for research, Techniques Involved in Defining the Problem, Source of Problems, Personal Consideration.

Research Design: Concept and Importance in Research, Need for Research Design, Formulation of Research Design, Exploratory Research Design, Descriptive Research Designs, Experimental Design, Basic principles of experimental designs, Computer and Internet in designs.

Qualitative and Quantitative Research: Qualitative research, Quantitative research, Concept of measurement, causality, generalization, replication, Merging the two approaches.

Sampling and Data Analysis: Sampling Frame, Sample Size, Characteristics of a Good Sample, Random Sampling, Systematic Sampling, Practical Considerations in Sampling and Sample Size, Data Preparation, Univariate and Bivariate analyses.

Reference Books:

1. Research Methodology: Methods & Techniques, C.R.Kothari, New Age International Publishers.
2. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell, SAGE Publications Inc.
3. Research Methodology, Mukul Gupta & Deepa Gupta, PHI Learning Private Ltd, New Delhi.
4. Research Methodology, Uma Sekaran & Roger Bougie, NMIMS Global Access
5. The Scientific Endeavor, Jeffrey A. Lee, Pearson India

B.Sc. (Physics) Honours with Research

Semester - VII

Minor - I

Optical Fibers

(Credits: Theory – 02)

Optical fibers and fabrication: Fiber materials, Fiber fabrication, step-index and graded-index, Mechanical properties of fibers, Attenuation, Signal distortion in optical waveguides, Pulse broadening in graded index waveguides, Mode coupling, Design optimization of single mode fibers.

Power launching and coupling: Source-to-fiber launching, fiber-to-fiber joints, LED coupling to single-mode fibers, Fiber splicing, Optical fiber connectors.

Photodetectors: The pin photodetector, Avalanche photodiodes, Photodetector noise, Detector response time, Structures for In GaAs APDs, Temperature effect on avalanche gain,

Optical amplifiers and Optical Receivers: Fundamental receiver operation, Pre-amplifier types, Optical amplifiers, Semiconductor optical amplifiers, Erbium-doped fiber amplifiers, Amplifier noise, System applications.

Reference Books:

1. Cherin, A.H., An Introduction to Optical Fibers for Engineers and Physicists, McGraw-Hill Inc.
2. Agarwal G.P., Nonlinear fibre optics, Academic Press, Elsevier.
3. Senior, J.M., Optical Fiber Communications – Principles and Practice, Pearson Education, India.
4. Keiser, G., Optical Fiber Communications, McGraw-Hill Education.
5. Yariv, A., Quantum Electronics, John Wiley & Sons Inc.

B.Sc. (Physics) Honours with Research

Semester - VII

Minor Practical

(Credits: 02)

List of experiments:

At least five experiments are to be performed

1. Study of IC- Based Power supply
2. Study of operational amplifier
3. Study of photovoltaic cell
4. Study of Light Emitting Diode
5. Study of Light Depended Resistor
6. Study of De-morgans theorem
7. Study of logic gates
8. Fiber Optics communication
9. Transmission of Light between two fibers
10. Study of losses in optical fibers

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, Asia Publishing House.
2. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, New Delhi.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers

B.Sc. (Physics) Honours with Research

Semester - VIII

Core Major - I

Atomic and Molecular Physics

(Credits: Theory – 05)

Atomic Spectroscopy:

Fine structure of Hydrogen lines, alkali atom Spectra, penetrating and non-penetrating orbits, Hunde's rule Spectra of two valence electron atoms (Helium, Magnesium), selection rules for atomic transitions, multielectron spectra, Central field approximation Hartree self-consistent field theory, Thomas Fermi statistical model.

Pauli's exclusion principle and determination of ground state, electron spin-orbit interaction, L-S and J-J coupling schemes, Zeeman Effect, Paschen Back Effect, Hyperfine structure, Stark effect, width of spectral lines, lamb shift.

Molecular Spectroscopy:

Rotational spectra of diatomic molecules, nonrigid rotator, vibrational spectra enharmonic oscillator explanation of rotational, vibrational spectra in infrared, molecular dissociation and calculation of dissociation energy, Raman effect and intensity alternation of the rotational bands, Applications of infrared and Raman spectroscopy.

Born Oppenheimer approximation, Molecular orbital theory, Heitler-Loudon treatment of Hydrogen molecule ion and Hydrogen molecule, Electronic spectra of molecules, Fortrat Parabola, Deslandres table, vibrational structure of electronic bands, Intensities of electronic transitions, Franek Condon principle, Condon parabola.

Reference Books:

1. Atomic Spectra: H.E. white, Cambridge University Press, New York
2. Principle of Atomic Spectra: B.W. Shore and H.D. Menzel, John Wiley & Sons
3. Spectra of Diatomic Molecules: G. Herzberg, Krieger Publishing Company
4. Fundamentals of Molecular Spectroscopy: C.N. Banwell and E.M. McCash, Tata McGraw Hill, New Delhi
5. Molecular Structure and Spectroscopy: G. Aruldhas, Prentice Hall India

B.Sc. (Physics) Honors with Research

Semester - VIII

Core Major Elective – II

Electronics – B

(Credits: Theory – 04)

Modulation and Demodulation: Amplitude Modulation - Theory, Plate Modulated Class C Amplifier, Balanced Modulator, Single Side Band Modulation (Phase Shift Method). Frequency Modulation - Theory, Reactance Tube Modulator, Transistor Reactance Modulator, FET Reactance Modulator. Demodulation - Envelope Diode Detector, Super Regenerative Detection, Foster-Seely Phase Discriminator, Ratio Detector, A.M. Transmitter, F.M. Transmitter, TRF Receiver, Super Heterodyne Receiver, Amplitude Limiting.

Transmission Lines and Antennas: TL Equations and Their Solutions, Characteristic Impedance, Lossless Open and Short-Circuited Lines, Standing Wave Ratio and Reflection Coefficient, Stub Matching, Quarter and Half Wavelength Lines. Antenna - Radioactive Field Strength, Power & Radiation Patterns of an Elementary Electric Doublet and Linear Antenna, Effects of Ground Reflection. Hertz Antenna, Marconi Antenna, Yagi Antenna, Loop Antenna, Direction Finding, Resonant & Non-Resonant Antenna, Antenna array (Broadside & End fire arrays), T.V. aerials. Horn Antenna, Parabolic reflectors, Lens Antenna.

Propagation of Radio Waves: Eccles-Larmor Theory, Appleton–Hartree Theory of Sky Wave Propagation, Skip Distance and Maximum Usable Frequency, Chapman's Theory of Layer Formation. Pulse Method for Measuring the Height of the Ionospheric Region.

Television and Radar Systems: General Principles of Image Transmission and Reception of Signals, pick-up Instruments (Iconoscope, Image Orthicon, and Videocon), Image Scanning Sequence, Scanning Synchronization, Composite Video Signal, Colour Television. Radar Systems - Principle of Radar, Basic Arrangement of Radar System, Azimuth and Range Measurement, Operating Characteristics of Systems, Radar Transmitters and Receivers, Duplexers, Indicator Unit, Maximum Range of a Radar Set.

References Books:

1. F.E. Terman: Electronics and Radio Engineering, McGraw-Hill
2. G. Kennedy: B. Davis & SRM Prasanna, Electronic Communication Systems, McGraw-Hill
3. G.K. Mithal: Radio Engineering Vol. II, Khanna Publishers
4. S.L. Gupta & V. Kumar: Handbook of Electronics, Pragati Prakashan
5. Frenzel, Communication Electronics: Principles and Applications, McGraw-Hill
6. D. Rody & J. Coolen: Electronics Communication Systems, Pearson India
7. W. Tomasi: Electronic Communications System, Pearson Education

B.Sc. (Physics) Honors with Research

Semester - VIII

Core Major Elective – II

Laser Physics – B

(Credits: Theory – 04)

Optical Modulation Techniques: Electro-optic effect, longitudinal and transverse phase modulation, consideration of modulator designs and circuit aspects, acousto-optic effect, Raman-Nath and Bragg regimes, acousto-optic modulators, magneto-optic effect, integrated optics, optical directional couplers and optical switches, phase modulators.

Optical sources and detectors: Laser devices, radiation pattern and modulation, LED structures, light source materials, liquid crystal diodes, photoelectric, photovoltaic and photconductive methods of detection of light, photodiodes: structure, materials and working, PIN photodiodes, avalanche photodiodes, microchannel plates, photodetector noise responsivity and efficiency, photomultipliers, image intensifier tubes, Videocon and CCD.

Fibre optics: Basic characteristics of optical fibres, fibre structure and fundamentals of waveguides, step and graded index fibres, signal degradation in optical fibres, absorption scattering, radiation and core cladding losses, Design considerations of a fibre optical communication system, analogue and digital modulation, optical fibre amplifiers.

Holography: Basic principles, construction and reconstruction of holograms, applications of holography, laser interferometry, laser applications in industry and medicine

Reference Books:

1. A. Ghatak and K. Thyagarajan: Optical Electronics, Cambridge India
2. J. Wilson and J. Hawkes: Optoelectronics, Pearson Education
3. G. Keiser: Optical Fibre Communications, McGraw-Hill Education
4. A. Ghatak and K. Thyagarajan: Introduction to fibre optics, Cambridge University Press
5. I.P. Csorba: Image tubes, Longman Higher Education
6. Eds. L.M. Biberman and S. Nudelman: Photoelectronic Imaging Devices, Kluwer Academic/Plenum Publishers

B.Sc. (Physics) Honours with Research

Semester - VIII

Core Major Elective – II

Principles of Communication Systems (Swayam Course)

(Credits: Theory – 04)

Prof. Aditya K. Jagannatham, IIT Kanpur

B.Sc. (Physics) Honours with Research

Semester - VIII

Major Practical

(Credits: 03)

List of experiments:

At least ten experiments are to be performed

1. Ionization potential of Mercury using gas-filled diodes
2. To determine Planck's constant using Photocell
3. Michelson interferometer
4. Fabry Perot interferometer
5. To plot the magnetic hysteresis loop of a ferromagnetic rod
6. Lecher wire experiment
7. Determination of magnetic susceptibility of a solution of paramagnetic salt
8. Determine the velocity of ultrasonic waves
9. Determination of elastic constant of crystals by optical methods
10. Measurement of Dielectric constant of a ferroelectric material
11. Determination of the Hall coefficient using the Hall effect
12. Determination of Energy gap of a semiconductor by four probe method

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, Asia Publishing House.
2. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, New Delhi.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers

B.Sc. (Physics) Honours with Research

Semester - VIII

Dissertation

(Credits: 12)

Students will perform the research work and submit a dissertation at the end of the semester (Mandatory).

B.Sc. (Physics) Honours with Research

Semester - VIII

Minor – II

(Credits: Theory - 02)

Numerical Methods: Roots of non-linear equations, Newton-Raphson Method, Interpolation-equal and unequal intervals, central and inverse interpolation, Numerical integration, Numerical solution of ordinary differential equations: Euler's method, Runge-Kutta Method, least square curve fitting method, power and Jacobi method, solution of simultaneous linear equations Gauss- elimination, Pivoting, Jacobi iterative method, matrix inversion, Eigen value and eigen vector.

Programming Languages: Basic Structure of **Compiled programming languages C++ and Fortran 90/95**- constants and variables, arithmetic and logical expressions, input-output statements, control statements, loops, arrays, format statements, function and subprograms, character string, pointers.

Interpreted Programming Languages and Application Software: Basic Knowledge of Python and JavaScript, Application software- MAPLE, MATLAB, MATHEMATICA and LaTeX.

Reference Books:

1. B D Hahn: Fortran 90 for Scientists and Engineers.
2. V Rajaraman: Computer Programming in C.
3. V Rajaraman: Computer Programming in FORTRAN 90/95.
4. V Rajaraman: Computer Oriented numerical methods.
5. Samuel S M Wong: Computational methods in Physics and engineering.
6. S Balachandra Rao: Numerical Methods.
7. Stephen J Chapman: Fortran 90/95 for Scientists and Engineers.
8. E Balagurusamy: Numerical methods
9. G Shanker Rao: Numerical analysis
10. Walter Gander J R: Solving Problems in Scientific Computing using **Maple**

B.Sc. (Physics) Honours with Research

Semester - VIII

Minor Practical

(Credits: 02)

List of experiments:

At least five experiments are to be performed

1. Solution of simultaneous non-linear equations using Newton Raphson method
2. Calculating Eulers number using exp(x) series evaluated at x=1.
3. To printout natural even/odd numbers between given limits
4. Find the area of the Triangle, Rectangle, etc.
5. To find the sum of two matrices.
6. Motion of a projectile using simulation and plot the output for visualization.
7. Write a C++ program to convert a binary number to a decimal number.
8. Write a JavaScript code display the browser specifications.
9. Write a Python program to demonstrate Local and Global variables.

Reference Books:

1. Numerical Methods in Engineering & Science with Programs in C, C++ & MATLAB, B.S. Grewal, Khanna Publishers
2. Object Oriented Programming with C++, E. Balagurusamy, McGraw Hill
3. A Textbook of Java Programming, Surbhi Kakar, Dreamtech Press
4. Python: The Complete Reference, Martin C Brown, McGraw Hill