Kumaun University, Nainital

B.Sc. Honours (PHYSICS)

THREE-YEAR FULL-TIME PROGRAMME (Six Semesters Course)
(AS PER UGC GUIDELINES)

Faculty of Science
Department of Physics
(UGC-Centre of Advanced Study)

COURSE CONTENTS

Kumaun University, Nainital

(2020)

Semester	Core Course (CC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Discipline Specific Course (DSC)	Generic Course (GC)
I	CC-1 Mathematical Physics CC-2 Mechanics	English/MIL Communication/ Environmental Science			GC-1 Basic Electricity and Magnetism
II	CC-3 Electricity and Magnetism CC-4 Waves and Oscillations	Environmental Science/English/ MIL Communication			GC-2 Fundamental Mechanics
III	CC-5 Optics CC-6 Thermal Physics CC-7 Basic Electronics (Analog System)		SEC-1 Electrical Circuits and Network Skills		GC-3 Digital and Analog Circuits and Instrumentation
IV	CC-8 Modern Physics CC-9 Digital Electronics (Digital System and Applications) CC-10 Advanced Mathematical Physics		SEC-2 Basic Instrumentation Skills		GC-4 Elements of Modern Physics
V	CC-11 Quantum Mechanics and Applications CC-12 Solid State Physics			DSC-1 Classical Dynamics DSC-2 Physics of Electronic Device and Communication	
VI	CC-13 Statistical Mechanics CC-14 Electromagnetic Theory			DSC-3 Communication Electronics DSC-4 Astronomy and Astrophysics **or** **Dissertation**	

B.Sc. (Honours) Physics Course (Three Years, Six Semesters)

Semester-I

A. Core Courses (CC)	:	CC-1: **Mathematical Physics** [MM: 75 (55+20)]	+	Practicals [MM:25]
		CC-2: **Mechanics** [MM: 75 (55+20)]	+	Practicals [MM:25]
B. Generic Course (GC)*:		GC-1: **Basic Electricity and Magnetism** [MM: 75 (55+20)]	+	Practicals [MM:25]
C. Ability Enhancement Course (AEC) $	:	AEC-1: **English/MIL Communication/ Environmental Science** [MM: 50 (35+15)]		

Total Courses (for B.Sc. Honours Physics Semester-I)

Core Courses	:	2 (CC-1 and CC-2)
Generic Courses	:	2 (One from Chemistry and One from Maths)
AEC Courses	:	1 (AEC-1)
Total Marks	:	450

*** Generic Courses (GC) are meant for the students opting for B.Sc. Honours other than Physics.**

$ Ability Enhancement Courses (AEC) are compulsory for all students (opting for Physics, Chemistry or Maths).

CC-1: Mathematical Physics

Unit-I Recapitulation of Vectors

Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Unit-II Vector Differentiation

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Unit-II Vector Integration

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications.

Unit-IV Orthogonal Curvilinear Coordinates

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Unit-V Dirac Delta function and its properties

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. Beta and Gamma Functions and Relation between them.
Expression of Integrals in terms of Gamma Functions.

CC-1: LAB Mathematical Physics

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics. Highlights the use of computational methods to solve physical problems The course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem
Aim at teaching students to construct the computational problem to be solved. Students can use any one operating system Linux or Microsoft Windows

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (**π**)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha\,;\;\; I = I_0 \left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc.*
Numerical differentiation (Forward and Backward difference	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop

formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion Attempt following problems using RK 4 order method: • Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3}$; $\frac{dy}{dx} = -x$ for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for $0 \le t \le 15$ The differential equation describing the motion of a pendulum is $\frac{d^2\vartheta}{dt^2} = -\sin(\vartheta)$. The pendulum is released from rest at an angular displacement α, i. e. $\vartheta(0) = \alpha$ and $\vartheta'(0) = 0$. Solve the equation for α = 0.1, 0.5 and 1.0 and plot ϑ as a function of time in the range $0 \le t \le 8\pi$. Also plot the analytic solution valid for small ϑ ($\sin(\vartheta) = \vartheta$

Books Recommended:

1. G.B. Arfken, H.J. Weber, F.E. Harris : Mathematical Methods for Physicists, 2013, 7th Edn. Elsevier.
2. James Nearing : Mathematical Tools for Physics
3. D.A. McQuarrie : Mathematical methods for Scientists and Engineers, 2003, Viva Book
4. D.G. Zill and W.S. Wright : Advanced Engineering Mathematics
5. Goswami : Mathematical Physics
6. S.Pal and S.C. Bhunia : Engineering Mathematics 2015, Oxford University Press
7. Erwin Kreyszig : Advanced Engineering Mathematics
8. K.F.Riley & M.P.Hobson : Essential Mathematical Methods 2011, Cambridge Univ. Press
9. B. S. Rajput : Mathematical Physics for Engineers
10. H.K. Daas : Mathematical Physics
11. S.S. Sastry : Introduction to Numerical Analysis
12. J. Hubbard : Schaum's Outline of Programming with C++.
13. W.H. Pressetal : Numerical Recipes in C: The Art of Scientific Computing, , 3rd Edn.
14. U.M. Ascher & C. Greif : A first course in Numerical Methods
15. K.E. Atkinson : Elementary Numerical Analysis, Third Edn.
16. R.W. Hamming : Numerical Methods for Scientists & Engineers
17. T.Pang : An Introduction to Computational Physics, 2nd Edn.
18. Darren Walker : Computational Physics, First Edn.

CC-2: Mechanics

Unit-I Gravitation field and potential

Gravitational field and potential, Gravitational potential energy, Gravitational field Intensity and potential due to a ring, a spherical shell, solid sphere and circular disc, gravitational self energy, Inverse square law of forces, Kepler's laws of planetary motion.

Unit-II Conservation Laws

Concept of inertial and Non-inertial frames of references, Work energy theorem, Conservative and non-Conservative forces, Linear restoring force, Gradient of potential, Conservation of energy for the particle; Energy function, Concept of Centre of mass, Angular momentum and torque, Laws of conservation of total energy, total linear momentum and total angular momentum alongwith their examples.

Unit-III Dynamics of rigid body and Moment of Inertia

Translatory and Rotatory motion, Equation of motion for Rotating rigid body, angular momentum vector and moment of inertia, Theorem of parallel and perpendicular axes, Moment of inertia of a cylinder, rod, lamina, ring, disc, spherical shell, solid sphere, kinetic energy of rotation, rolling along a slope, Application to compound pendulum.

Unit-IV Properties of Matter

Basic concept, Elastic constants and their Interrelations, torsion of cylinder, bending of beam, bending moment, Cantilever, shape of Girders/ rail tracks.

Viscosity, Stokes's law, Posieuille's formula, Equation of continuity, Bernoulli's theorem, Surface tension and its molecular interpretation.

CC-2: LAB Mechanics

1. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of rigidity.
2. To determine the Moment of Inertia of a Flywheel.
3. To determine **g** and velocity for a freely falling body using Digital Timing Technique.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of a Wire by Optical Lever Method.
6. To determine the Young's Modulus by bending of beam.
7. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.To determine the elastic Constants of a wire by Searle's method.
8. To determine the value of g using Bar Pendulum.
9. To determine the value of g using Kater's Pendulum.
10. To determine Surface Tension.

Books Recommended:

1. R. Resnick and D. Hilliday	:	Physics Vol-I
2. Berkeley Physics Course	:	Mechanics Vol-I
3. R.P. Feynman, R.B.Lightan and M.Sand	:	The Feynman Lectures in Physics.
4. D.S. Mathur	:	Mechanics
5. D.S. Mathur	:	Elements of Properties of Matter
6. B.S. Rajput	:	Physics for Engineers
7. J.C. Upadhayay	:	General Properties of Matter

GC-1: Basic Electricity and Magnetism

Unit-I 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.

Unit-II Magnetism

Magnetostatics: Biot-Savart's law and 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 ferromagnetic materials.

Unit-III 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.**)**

Unit-IV 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.

GC-1: LAB: Basic Electricity and Magnetism
(at least eight experiments which cover the understanding of theory course)

1. To use a Multimeter for measuring
 (a) Resistances
 (b) AC and DC Voltages
(c) DC Current
(d) checking electrical fuses.
2. Ballistic Galvanometer:
    (a) Measurement of charge and current sensitivity
    (b) Measurement of CDR
    (c) Determine a high resistance by Leakage Method
    (d) 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 LCR circuit and determine its
    (a) Resonant frequency
    (b) Quality factor
7. To study a 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 theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

Books Recommended:

1.	Edward M. Purcell	:	Electricity and Magnetism
2.	J.H. Fewkes & J.Yarwood	:	Electricity & Magnetism, Vol. I
3.	D C Tayal	:	Electricity and Magnetism
4.	Ronald Lane Reese	:	University Physics
5.	D.J.Griffiths	:	Introduction to Electrodynamics, 3rd Edn.
6.	B.L.Flint & H.T.Worsnop	:	Advanced Practical Physics for Students
7.	M. Nelson and J. M. Ogborn	:	Advanced level Physics Practicals, 4th Ed
8.	I.Prakash & Ramakrishna	:	A Text Book of Practical Physics, 11th Ed
9.	S.Panigrahi & B.Mallick	:	Engineering Practical Physics

AEC1. **English/MIL Communication/ Environmental Science**

(To be formulated by associated departments)

B.Sc. (Honours) Physics Course (Three Years, Six Semesters)

Semester-II

A.	Core Courses (CC) :	CC-3	**Electricity and Magnetism** [MM: 75 (55+20)]	+	Practicals [MM:25]
		CC-4	**Waves and Oscillations** [MM: 75 (55+20)]	+	Practicals [MM:25]
B.	Generic Course (GC)*:	GC-2	**Fundamental Mechanics** [MM: 75 (55+20)]	+	Practicals [MM:25]
C.	Ability Enhancement Course (AEC) $:	AEC-2	**Environmental Science/ English/MIL Communication** [MM: 50 (35+15)]		

Total Courses (for B.Sc. Honours Physics Semester-II)

Core Courses	:	2 (CC-3 and CC-4)
Generic Courses	:	2 (One from Chemistry and One from Maths)
AEC Courses	:	1 (AEC-2)
Total Marks	:	450

*** Generic Courses (GC) are meant for the students opting for B.Sc. Honours other than Physics.**

$ Ability Enhancement Courses (AEC) are compulsory for all students (opting for Physics, Chemistry or Maths).

CC-3: Electricity and Magnetism

Unit-I Electric field and potential

Coulomb law, Gauss' theory, its integral and differential forms, line integral of Electric field, Electric field and potential due to an arbitrary charge distribution. Electrostatic energy, energy stored in an Electric field. Electric field and potential due to long charged wire, Spherical shell, sphere, disc, dipole.

Unit-II Electric and Magnetic fields in Matter

Moments of charge distributions, Polar and non-polar molecule, polarization vector, electric displacement vector, three electric vectors, dielectric susceptibility and permittivity, polarizability, Clausius-Mossotti relation.

Magnetization, magnetic susceptibility, diamagnetic, paramagnetic and ferromagnetic substances, Hysteresis and B-H curve, Langevin's theories of Diamagnetism and paramagnetism, Weiss theory of ferromagnetism.

Unit-III Electric Currents (AC and DC)

Electric Current, Equation of continuity, electrical conductivity, Lorentz-Drude theory, Wiedmann-Frenz law, Transient currents, R-C circuit, Time constant.

Impedance, admittance and reactance, R-C, R-L and L-C circuits with alternative e.m.f. source, series and parallel L-C-R circuits, resonance and sharpness, Power in A-C circuits, choke coil.

Unit-IV Magnetostatics

Lorentz force, Bio-Savert's law, Ampere's law, Application of Biot-Savert law, magnetic field due steady current in a long straight wire, Interaction between two wires, field due a Helmholtz coil, solenoid and current loop, magnetic vector potential, permeability, Energy stored in Magnetic field.

Unit-V Electromagnetic Induction

Faraday's laws of induction, Lenz's law, Electromotive force, Measurement of magnetic field, Eddy current, Skin effect, Mutual inductance, Self inductance.

CC-3: LAB Electricity and Magnetism

(at least eight experiments which cover the understanding of theory course)

1. Calibration of ammeter by potentiometer.
2. Calibration of voltmeter by potentiometer.
3. Specific resistance determination.
4. Conversion of Galvanometer in to a voltmeter.
5. Conversion of Galvanometer in to a ammeter.
6. Charging and discharging through a capacitor.
7. De Sauty's bridge- C1/C2.
8. R1/R2 by potentiometer.
9. To determine High Resistance by Leakage of a Capacitor.
10. Determination of Ballistic Constant.
11. Comparison of capacities by Ballistic Galvanometer.
12. Variation of magnetic field along the axis of a current carrying circular coil.
13. Hysteresis.
14. Determination of self inductance/ Mutual inductance.
15. Study of R-C, LCR circuits.
16. Ballistic Galvanometer:
    (a) Measurement of charge and current sensitivity
    (b) Measurement of CDR
    (c) Determine a high resistance by Leakage Method
    (d) To determine Self Inductance of a Coil by Rayleigh's Method.

Books Recommended:

1. Berkeley Physics Course : Electricity and Magnetism Vol.II
2. R. Resnick and D. Hilliday : Physics Vol-II
3. D.C. Tayal : Electricity and Magnetism
4. Mahajan and Rangwala : Electricity and Magnetism
5. B.B.Laud : Electricity and Magnetism
6. K.K Tewari : Electricity and Magnetism

CC-4: Waves and Oscillations

Unit-I Analysis of wave motion

Characteristics, Differential equation of a wave motion, principle of superposition, Interference, Beats, stationary waves, Energy of stationary waves, Wave velocity and group velocity, Fourier theorem, Fourier analysis of square, triangular and saw-tooth waves.

Energy density of plane acoustic waves, Acoustic intensity, Measurement of acoustic intensity – the dB scale, Characteristics and loudness of Musical sound, Acoustic impedance, Reflection and transmission of acoustic waves. Acoustics of buildings, reverberation time, Sabine's formula, Principle of sonar system.

Unit-II Ultrasonics

Classification of Sound waves, Ultrasonics, Quartz crystal and Piezo electric effect, Magnetostriction effect, Properties of Ultrasonic, Detection of ultrasonic waves, Determination of velocity of ultrasonic waves in liquid (Acoustic grating method) . Application of Ultrasonics.

Unit-III Simple Harmonic Oscillations

Periodic motion, SHM in mechanical systems, Energy of Simple harmonic oscillator, Superposition of SHM(s), Oscillations of two masses connected by a spring, Non-linear (An-harmonic) oscillator and its applications to simple pendulum. Applications of Simple harmonic motion in compound pendulum, Torsional pendulum and LC circuit, Composition of two SHM(s) of different frequency ratio, Lissajous' figures for equal frequencies ratio and 2:1 frequencies ratio

Unit-IV Damped and Forced Harmonic Oscillations

Damping force, Different cases for over, critical and under damping, Mechanical damped harmonic oscillators, Logarithmic decrement, Power Dissipation, Relaxation time & Quality Factor.

Forced oscillations, Mechanical driven harmonic oscillators, Transient and steady state behavior, Power absorption, phenomenon of resonance, amplitude resonance, velocity resonance, sharpness of resonance/Fidelity, Bandwidth and quality factor.

CC-4: LAB Waves and Oscillations

(at least eight experiments which cover the understanding of theory course)

1. Oscillations of mass spring system.
2. Study of compound (Kater's) pendulum.
3. Study of compound (Bar) pendulum.
4. Study of relaxation in a simple pendulum.
5. Study of under damped harmonic oscillator.
6. Torsional oscillations (Maxwell's needle experiment).
7. Melde's Experiment.
8. Lissajous figures.
9. Determination of Ultrasonic velocity.
10. To prove the laws of vibrating strings and determine the frequency of A.C mains.

Books Recommended:

1. R. Resnick and D. Hilliday	:	Physics Vol-I
2. D.S. Mathur	:	Mechanics
3. Brijlal and Subrahmanyam	:	Waves and Oscillations
4. B.S.Semwal and M.S.Panwar	:	Wave Phenomena and Material Science
5. Berkeley Physics Course	:	Mechanics Vol-I
6. R.K.Ghose	:	The mathematics of waves an Vibrations
7. D.P.Khandelwal	:	Oscillations and Waves
8. I.I.Pain	:	Physics of Vibration
9. A. P. French	:	Vibrations and Waves
10. B.S. Rajput	:	Physics for Engineers
11. Berkeley Physics Course	:	Waves

GC-2: Fundamental Mechanics

Unit-I Vectors Algebra and Ordinary Differential Equations

Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.
1st order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients.

Unit-II Translatory and Rotatary Motion and Conservation Laws

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass, Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets, Angular velocity and angular momentum. Torque. Conservation of angular momentum.

Unit-III 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). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.

Unit-IV Oscillations

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages.Damped oscillations, Quality factors.

Unit-V Elasticity

Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire – Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method.

Unit-VI Special Theory of Relativity

Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

GC-2: LAB Fundamental Mechanics

1. To determine the Moment of Inertia of a Flywheel.
2. To determine the Young's Modulus of a Wire by Optical Lever Method.
3. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
4. To determine the Elastic Constants of a Wire by Searle's method.
5. To determine g by Bar Pendulum.
6. To determine g by Kater's Pendulum.
7. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

Books Recommended:

1. Sears, Zemansky and Young	:	University Physics
2. Berkeley Physics Course	:	Volume-1 Mechanics
3. Resnick, Halliday & Walker		Fundamentals of Physics
4. Basudeb Bhattacharya	:	Engineering Mechanics 2nd Edn
5. Ronald Lane Reese	:	University Physics
6. B.L. Flint and H.T. Worsnop	:	Advanced Practical Physics for Students
7. Michael Nelson and Jon M. Ogborn	:	Advanced level Physics Practicals
8. S.Panigrahi & B.Mallick	:	Engineering Practical Physics
9. Indu Prakash and Ramakrishna	:	A Text Book of Practical Physics

AEC-2: **Environmental Science/English/MIL Communication**

(To be formulated by associated departments)

B.Sc. (Honours) Physics Course (Three Years, Six Semesters)

Semester-III

A.	Core Courses (CC)	:	CC-5: **Optics** [MM: 75 (55+20)]	+	Practicals [MM:25]
			CC-6: **Thermal Physics** [MM: 75 (55+20)]	+	Practicals [MM:25]
			CC-7: **Basic Electronics (Analog Systems)** [MM: 75 (55+20)]	+	Practicals [MM:25]
B.	Generic Course (GC)*:		GC-3: **Digital and Analog Circuits and Instrumentation** [MM: 75 (55+20)]	+	Practicals [MM:25]
C.	Skill Enhancement Course (SEC) @	:	SEC-1: **Electrical Circuits and Network Skills** [MM: 75 (55+20)]	+	Practicals [MM:25]

Total Courses (for B.Sc. Honours Physics Semester-III)

Core Courses	:	3 (CC-5, CC-6 and CC-7)
Generic Courses	:	2 (One from Chemistry and One from Maths)
SEC Courses	:	1 (SEC-1)
Total Marks	:	600

*** Generic Courses (GC) are meant for the students opting for B.Sc. Honours other than Physics.**

$ Skill Enhancement Courses (SEC) are compulsory for all students (opting for Physics, Chemistry or Maths).

CC-5: Optics

Unit-I Geometrical Optics

Fermat's principle of extremum path and its application to deduce laws of reflection and refraction, Refraction at concave surface, Principal foci, Lateral and longitudinal magnifications, Aplanatic points of spherical surface.

Gauss's general theory of image formation, Coaxial symmetrical system, Cardinal points of an optical system, General relationships, Thick and Thin lens, lens combinations, Newton's formula, Coaxial lens system, Lagrange's equation of magnification, Refraction through a thick lens, Aberrations in images, Spherical aberration, Monochromatic and Chromatic aberration, Condition of achromatism, Achromatic combination of lenses in contact and separated lenses, Spherical mirrors and Schmidt corrector plates, Theory of dispersion.

Unit-II Physical Optics: Interference

The principle of superposition, Two slit interference, coherence, Division of wave front and amplitude, Optical path retardations lateral shift of fringes, Fresnel biprism, Interference with multiple reflection, Thin films, Application for precision measurements, Haidinger fringes, Fringes of equal thickness and equal inclination.

Unit-III Physical Optics: Diffraction

Fresnel's and Fraunhofer diffraction: Diffraction of single slit, Zone plates, intensity distribution, Resolution of image, Rayleigh criterion, Resolving power of telescopes and microscopes, Diffraction due to 2-slits and N-slits, Diffraction grating, Resolving power of grating and comparison with resolving powers of prisms.

Unit-IV Physical Optics: Polarization

Plane polarized, Circular polarized and elliptically polarized light, Malus law, Brewster's law, Double reflection and uniaxial crystals, Application of bi-refringence, Dichroism, Optical rotation, Rotation of plane of polarization, Optical rotation in liquids and crystals, Polarimeter.

Unit-V Optical Instruments

Nodal Slide, Eyepiece, Ramsden's, Huygen's and Gaussian eyepieces, Their comparison, Astronomical refracting telescope, Microscopes, Spectrometer and its uses, Oil immersion objectives meniscus lens, Michelson intereferometer and its application for precise measurement of wavelength, Wavelength difference and width of spectral lines, Twyman-Green interferometer, Tolansky fringes, Fabry-Perot interferometer and Etalon.

CC-5: LAB Optics

(at least eight experiments which cover the understanding of theory course)

1. Nodal slide assembly, Location of cardinal points of lens system.
2. Newton's formula.
3. Dispersive power of prism.
4. Resolving power of a telescope.
5. To determine the Resolving Power of a Prism.
6. Biprism- determination of λ.
7. Newton's ring experiment- Determination of λ.
8. Determination of λ by a transmission grating.
9. Cauchy's formula.
10. Zone-plate experiment study of different orders.
11. Absorption of light.
12. Malus' Law.
13. Specific rotation in cane sugar solution.
14. To determine the thickness of mica-sheet by using Biprism.

Books Recommended

1. D.P. Khandelwaland : Optics and Atomic Physics
2. Jenkins and White : Fundamentals of Optics
3. A.K. Ghatak : Physical Optics
4. Brijlal and Subrahmanyam : Optics
5. K.D. Moltev : Optics
6. B. K. Mathur : Optics
7. Resnick, Halliday : Physics, Volume-I/ II

CC-6: Thermal Physics

Unit-I Basic concepts and First law of thermodynamics

Thermodynamic Systems, Thermal equilibrium and Zeroth law of thermodynamics, Equation of state and First law of thermodynamics, Discussion of Heat and Work, Quasi-static Work; Reversible and Irreversible; Path Dependence; Heat Capacities Adiabatic Processes, Vander Wall equation, Distinction between Joule, Joule-Thompson and Adiabatic expansion of a gas.

Unit-II Second law of Thermodynamics and Entropy

Insufficiency of first law of thermodynamics, Condition of Reversibility, Carnot's Engine and Carnot's Cycle, Second law of thermodynamics, Carnot's Theorem, Thermodynamic scale of temperature and its identity to perfect gas, scale of temperature. Entropy, Mathematical formulation of Second law of thermodynamics, Entropy of an ideal gas, T-S diagram and its applications, Evaluation of Entropy changes in simple cases, Third law of thermodynamics.

Unit-III Thermodynamic Relations

Thermodynamic potentials, Maxwell's equation from thermodynamic potentials, some useful manipulations with partial derivatives (cooling in adiabatic processes and Adiabatic stretching of a wire), The Clausius–Clapeyron's equations, Triple point, Applications of Maxwell's thermo dynamical relations.

Unit-IV Transport of Heat

Modes of heat transfer via Conduction, Convection and Radiation, Fourier's law, One dimensional steady state conduction, Heat conduction through plane. Thermal conductivity and its experimental detection, Newton's law of cooling, Dimensional analysis applied to forced and free convection.

Black body radiation, Thermodynamics of radiations inside a hollow enclosure, Kirchoff's Laws, Derivation of Stefan Boltzmann Law, Wein's displacement law, Black body spectrum formula-early attempts, Raleigh Jean's Law, Quantum theory of Radiation, Planck's formula for black body spectrum, Wien's law, Radiation as a photon gas.

Unit-V Kinetic Theory of Gases

Microscopic description of an Ideal gas, Degrees of freedom, Law of Equipartition of Energy, Distribution law of velocities, Most probable speed, Average speed and root mean square velocity of molecules, Pressure exerted by a perfect gas, Kinetic Interpretation of Temperature.

Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. JouleThomson Effect for Real and Van der Waal Gases. Temperature of Inversion. JouleThomson Cooling.

CC-6: LAB Thermal Physics

(at least eight experiments which cover the understanding of theory course)

1. Thermal conductivity of bad conductor-Lee's disc method.
2. Mechanical equivalent of heat by Searle's method.
3. Thermal conductivity of a good conductor by Searle's method.
4. To study the variation of Thermo-emf of a Thermocouple with Different Temperature.
5. Stefan's Law and to determine the Stefan's constant.
6. Platinum resistance thermometer.
7. J by Callendar and Barne's method.
8. Newton's law of cooling - Specific heat of kerocene oil.
9. To determine the Critical temperature and critical pressure of a gas.
10. To measure temperature with the help of Joule's constant volume air thermometer.

Books Recommended

1. S. Loknathan : Thermodynamics, Heat and Statistical Physics
2. Sharma and K.K. Sarkar : Thermodynamics, and Statistical Physics
3. Brijlal and Subrahmanyam : Heat and Thermodynamics
4. Saha and Srivastav : Treatise on Heats
5. Garg, Bansal and Ghose : Thermal Physics
6. Zemansky and Dittman : Heat and Thermodynamics
7. Resnick, Halliday : Physics, Volume-I/ II

CC-7: Basic Electronics

Unit–I Network Theorems

Kirchhoff's Laws, Superposition Theorem, Constant voltage source and constant current source, Conversion of voltage source into current source, Thevenin's Theorem and procedure for finding thevenin equivalent circuit, Norton's Theorem and procedure for finding Norton equivalent circuit, Maximum power transfer theorem, Applications of Network Theorems, Four terminal Network and h-parameters.

Unit-II Power Supplies

Semiconductor diode: P-N Junction diode, Diode Parameters, Equation of diode current, Diode circuits with DC and AC Voltage sources, Diode as a rectifier: Half and Full wave rectifiers, Bridge rectifiers, Peak inverse voltage, Efficiency, Ripple factor, Filters: Low pass and High pass filters, Band pass and Band stop filters, L and π – filters (Series inductor, Shunt capacitor, LC, CLC filters), Zener diode, its characteristics, Voltage regulation.

Unit-III Solid State Devices

Special Diodes: Tunneling effect, Tunnel diode, Varactor diode, Point contact diode, V-I characteristic of these diodes, Optoelectronic devices: Light emitting diode, Photodiode, Photo multiplier tube, Bipolar junction transistor, Transistor operation and its Biasing rule, Transistor currents, Transistor circuit configuration (CB, CE, and CC configuration), Transistor characteristics in different configuration, cut-off and saturation points, Active region, Leakage current in transistor and thermal runaway, Relation between transistor current in various configuration, General idea of FETs.

Unit-IV Amplifiers

Single-stage transistor amplifiers, Common base (CB) amplifier, various gains of a CB amplifier, Common emitter (CE) amplifier, various gains of a CE amplifier, characteristics of a CE amplifier, Common collector (CC) amplifier, various gains of a CC amplifier, characteristic of a CC amplifier, Comparison of a amplifier configurations, Amplifier classification based on biasing condition, Power amplifiers (Class A, Push-Pull amplifier, Class B and Class C), Noise and Distortion in amplifiers, Multistage amplifier, Amplifier coupling, RC- coupled two stage amplifier and its frequency response, Advantage of RC coupling, Transformer coupled two stage amplifiers and its frequency response, Advantage of transformer coupling.

Unit-V Feedback Amplifiers

Principle of feedback amplifiers, Classification of positive and negative feedback, Advantage of negative feedback, gain stability, Decreased distortion, Increased bandwidth, Forms of negative feedback, Shunt-derived series fed voltage feedback amplifier, Current-series feedback amplifier, Voltage-shunt negative feedback amplifier, Current-shunt negative feedback amplifier, Positive feedback and its advantage

CC-7: LAB Basic Electronics

(at least eight experiments which cover the understanding of theory course)

1. To study characteristics of R-C coupled Amplifier with and without feedback.
2. To study the characteristics of integrating and differentiating circuit.
3. To draw the characteristics of P-N junction diode.
4. To draw the characteristics of PNP and NPN junction transistor.
5. Measurements of h-parameters of a transistor.
6. Study of different types of Rectifiers and Filters.
7. Verification of Network theorems.
8. Child Langmuir law.
9. Triode/ Tetrode/ Pentode characteristics and constants.
10. Study of power supply (Ripple factor).
11. Study of Zener diode and regulation (taking different source voltage and loads).
12. Phase measurement using a C.R.O.
13. Study characteristics of T.C. Amplifier and B.W.
14. To study the Characteristics of a Photo-diode.
15. Inverse square law using Photo-Voltaic Cell.

Books Recommended:

1. M.K. Baagde, S.P. Singh and Kamal Singh : Elements of Electronics
2. B.L. Theraja : Basic Electronics
3. V.K. Mehta : Elements of Electronics
4. J.D. Ryder : Networks, Lines and Fields
5. J.D. Ryder : Electronic Fundamentals and Applications.
6. Millman and Halkias : Integrated Electronics.

GC-3 : Digital and Analog Circuits and Instrumentation

Unit-I Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by Sum of Products Method and Karnaugh Map. Binary Addition, Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

Unit-II Semiconductor Devices and Amplifiers

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Qpoint. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers.

Unit-III Operational Amplifiers (Black Box approach):

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closedloop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Zero crossing detector.

Unit-IV Sinusoidal Oscillators:

Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator.

Unit-V Instrumentations

Introduction to CRO: Block Diagram of CRO, Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation, Timer IC: IC 555 Pin diagram and its application as Astable and Monostable, Multivibrator.

GC-3: Lab Digital and Analog Circuits and Instrumentation.

(at least eight experiments which cover the understanding of theory course)

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To minimize a given logic circuit.
4. Half adder, Full adder and 4-bit Binary Adder.
5. Adder-Subtractor using Full Adder I.C.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.
8. To study IV characteristics of PN diode, Zener and Light emitting diode
9. To study the characteristics of a Transistor in CE configuration.
10. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
11. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
12. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
13. To study Differential Amplifier of given I/O specification using Op-amp.
14. To investigate a differentiator made using op-amp.
15. To design a Wien Bridge Oscillator using an op-amp.

Books Recommended:

1. J. Millman and C.C. Halkias	:	Integrated Electronics.
2. S. Salivahanan & N.S. Kumar	:	Electronic devices & Circuits
3. M.H. Rashid	:	Microelectronic Circuits
4. Helfrick and Cooper	:	Modern Electronic Instrumentation and Measurement Tech.
5. A.P. Malvino, D.P. Leach and Saha	:	Digital Principles and Applications, 7^{th} Ed.
6. A.S. Sedra, K.C. Smith, A.N. Chandorkar	:	Microelectronic Circuits 6^{th} Edn.
7. A. Anand Kumar	:	Fundamentals of Digital Circuits, 2nd Edition,
8. R.A. Gayakwad	:	OP-AMP & Linear Digital Circuits
9. P.B. Zbar, A.P. Malvino, M.A. Miller	:	Basic Electronics: A text lab Manual
10. J.D. Ryder	:	Electronics: Fundamentals and Applications
11. Albert Malvino	:	Electronic Principle

SEC-1: Electrical Circuits and Network Skills

Unit-I Basic Electricity Principles and Understanding of Electrical Circuits

Voltage, Current, Resistance, and Power. Ohm's law, Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity, Familiarization with multimeter, voltmeter and ammeter, Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

Unit-II Electrical Drawing and Symbols

Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

Unit-III Generators, Transformers and Electric Motors

DC Power sources. AC/DC generators. Inductance, capacitance, and impedance, Operation of transformers, Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.

Unit-IV Solid-State Devices

Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources

Unit-V Electrical Protection and Electrical Wiring

Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device), Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.

SEC-1: Lab Electrical Circuits and Network Skills

(at least eight experiments which cover the understanding of theory course)

A. Skills

1. Circuit tracing of Laboratory electronic equipment.
2. Winding a coil / transformer.
3. Study the layout of receiver circuit.
4. Trouble shooting a circuit.
5. Balancing of bridges

B. Lab Exercises

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of time period, frequency, average period using universal counter/ frequency counter.
5. Measurement of distortion of a RF signal generator using distortion factor meter.
6. Measurement of R, L and C using a LCR bridge/ universal bridge.
7. Converting the range of a given measuring instrument (voltmeter, ammeter).

Books Recommended

1.	B. L. Theraja	:	A text book in Electrical Technology.
2.	A K Theraja	:	A text book of Electrical Technology.
3.	M G Say	:	Performance and design of AC machines
4.	B L Theraja	:	A text book in Electrical Technology.
5.	Venugopal	:	Digital Circuits and Systems.
6.	Shimon P. Vingron	:	Logic Circuit Design.
7.	Subrata Ghoshal	:	Digital Electronics
8.	S. Salivahanan & N. S.Kumar	:	Electronic Devices and Circuits, 3rd Edn.
9.	U.Tietze, Ch.Schenk	:	Electronic circuits: Handbook of design and Applications
10.	Thomas L. Floyd	:	Electronic Devices

B.Sc. (Honours) Physics Course (Three Years, Six Semesters)

Semester-IV

A.	Core Courses (CC)	:	CC-8: **Modern Physics** [MM: 75 (55+20)]	+	Practicals [MM:25]
			CC-9: **Digital Electronics** (Digital System and Applications) [MM: 75 (55+20)]	+	Practicals [MM:25]
			CC-10: **Advanced Mathematical Physics** [MM: 75 (55+20)]	+	Practicals [MM:25]
B.	Generic Course (GC)*:		GC-4: **Elements of Modern Physics** [MM: 75 (55+20)]	+	Practicals [MM:25]
C.	Skill Enhancement Course (SEC) @	:	SEC-2: **Basic Instrumentation Skills** [MM: 75 (55+20)]	+	Practicals [MM:25]

Total Courses (for B.Sc. Honours Physics Semester-IV)

Core Courses	:	3 (CC-8, CC-9 and CC-10)
Generic Courses	:	2 (One from Chemistry and One from Maths)
SEC Courses	:	1 (SEC-2)
Total Marks	:	600

*** Generic Courses (GC) are meant for the students opting for B.Sc. Honours other than Physics.**

$ Skill Enhancement Courses (SEC) are compulsory for all students (opting for Physics, Chemistry or Maths).

CC-8: Modern Physics

Unit-I Atomic Models

Thomson model, Rutherford model, Bohr model and spectra of hydrogen atom, Fine structure, Bohr Magnetron, Larmor's precession, Somerfield model, Stern-Gerlach experiment, Vector atomic model, Space Quantization and Spinning of an electron.

Unit-II Optical Spectra and X-rays

Optical spectra, Spectral notations, L-S, J-J coupling, Selection rules and intensity rules, Explanation of fine structure of Sodium D line, Zeeman effect, X-ray spectra(characteristics and continuous), Moseley's law.

Unit-III Theory of Lasers

Einstein A and B coefficients, Spatial and Temporal coherence, Optical pumping, Population inversion, Laser action, Basic idea of LASER and MASER, Ruby Laser and He-Ne laser, Some applications.

Unit-IV Fundamentals of Molecular Spectroscopy

Franck-Condon Principle, Molecular spectra, Rotational, Vibration and Electronic spectra of diatomic molecules, General features of electronic spectra, Luminescence, Basics of Raman effect.

Unit-V Subatomic Physics

Structure of atomic nucleus, nuclear properties (charge, mass, spin, shape), nuclear binding energy, liquid drop model and semi-empirical mass formula, Law's of radioactive decay, Basic idea of α, β and γ-decay.

CC-8: LAB Modern Physics

(at least eight experiments which cover the understanding of theory course)

1. Frank-Hertz Experiment.
2. Determination of 'h' Planck's constant by Photoelectric effect.
3. Spectrum of Hydrogen and Rydberg constant.
4. 'e/m' by Thomson method.
5. 'e/m' Magnetron method.
6. 'e/m' Helical method
7. Ionization potential of mercury.
8. To determine the Planck's constant using LEDs of at least 4 different colours.
9. To determine the wavelength of H-alpha emission line of Hydrogen atom.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

Books Recommended

1. H.S. Mani and Mehta : Introduction to Modern Physics
2. A. Beiser : Perspective of Modern Physics
3. Ahmad and Lal, : Modern Physics
4. B.V.N. Rao : Modern Physics
5. R. Murugeshan : Modern Physics
6. S.N. Ghosal : Nuclear Physics
7. Paul A. Tipler : Modern Physics
8. C. B. Banwell : Fundamentals of Molecular Spectroscopy
9. B.L. Flint and H.T. Worsnop : Advanced Practical Physics for Students.
10. M. Nelson and Jon M. Ogborn : Advanced level Physics Practicals.
11. I.Prakash & Ramakrishna : A Text Book of Practical Physics

CC-9: Digital Electronics (Digital Systems and Applications)

Unit–I: Oscillators

Classification of oscillators, Frequency of oscillating current, Frequency stability of an oscillator, Essential of a feedback LC oscillator, Tuned base oscillator, Tuned collector oscillator, Hartley oscillator, Colpitt oscillator, Clapp oscillator, Tunel diode oscillator, Crystal oscillator, Phase shift oscillator, Wien Bridge oscillator, Relaxation oscillator, Multivibrators (Astable, monostable and bistable), Schmitt trigger, Saw-tooth generator, Blocking oscillators.

Unit–II: Integrated Circuit

Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs

Unit-III: Number System and Boolean Algebra

Number systems, Decimal, Binary, Octal and Hexadecimal number systems, Binary to decimal conversion, Double-Dadd method, Binary operations, Binary addition, Binary subtravtion, Complement of a number (1's complement and 2's complement), Binary divison, Representation of a Binary number as electrical signals, Conversion of Binary to octal, Binary to hexadecimal and vice-versa (Inter-conversion), BCD, GREY, EXCESS-3 codes, Boolean algebra, Features of Boolean algebra, Laws of Boolean algebra, Equivalent switching circuit, Demorgan's theorems and Duals, Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions.

Unit–IV: Logic Gates

Positive and Negative logic, Two input OR gate, Diode OR gate and transistor OR gate, Three input OR gate and its truth table, Exclusive OR gates, The AND gate, Diode AND gate and transistor AND gate, The NOT gate, Bubbled gates, The NOR gate, The NAND gate, NAND and NOR as universal gates, The XNOR gate, Adders and subtractors, Half Adders, Full adders, Paralled binary adder, Half subtractor and Full subtractor.

Unit-V: Data processing and Sequential Circuits

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders, SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

CC-9: LAB Digital Electronics (Digital Systems and Applications)

(at least eight experiments which cover the understanding of theory course)

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
8. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To build JK Master-slave flip-flop using Flip-Flop ICs.
10. Application of assembly languages.

Books Recommended

1. M.K. Baagde, S.P.Singh and K. Singh	:	Elements of Electronics
2. B.L.Thereza	:	Basic Electronics
3. V.K.Mehta	:	Elements of Electronics
4. Brophy	:	Communication Electronics
5. R Boylested	:	Electronic Devices & Circuit theory
6. R.P. Jain	:	Modern Digital Electronics
7. P.B. Zbar, A.P. Malvino, M.A. Miller	:	Basic Electronics: A Text Lab Manual
8. A.P. Malvino, D.P.Leach and Saha	:	Digital Principles and Applications
9. Venugopal	:	Digital Circuits and Systems
10. G K Kharate	:	Digital Electronics

CC-10: Advanced Mathematical Physics

Unit-I Fourier Series

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

Unit-I I Frobenius Method and Special Functions

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre Differential Equation. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials.

Unit-III Some Special Integrals

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

Unit-IV Partial Differential Equations

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Unit-V Elements of Group Theory

Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups with operators. Matrix Representations, Reducible and Irreducible representations of groups.

Unit-VI Theory of Errors

Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line.

CC-10: LAB: Advanced Mathematical Physics

(at least eight experiments which cover the understanding of theory course)

Topics	**Description with Applications**
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2)
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function
Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion Second order Differential Equation • Harmonic oscillator (no friction) • Damped Harmonic oscillator

	• Over damped • Critical damped • Oscillatory • Forced Harmonic oscillator • Transient and • Steady state solution • Apply above to LCR circuits also • Solve $x^2 \frac{d^2y}{dx^2}$ - 4x(1+x) $\frac{dy}{dx}$ + 2(1+x)y = x^3 with the boundary conditions at x=1, y=$\frac{1}{2}e^2$, $\frac{dy}{dx} = -\frac{3}{2}e^2$ - 0.5, in the range $1 \leq x \leq 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph. Partial Differential Equation: • Wave equation • Heat equation • Poisson equation • Laplace equation
Using Scicos / xcos	Generating square wave, sine wave, saw tooth wave • Solution to harmonic oscillator • Study of beat phenomenon • Phase space plots

Books Recommended:

1. Rajput B.S. : Mathematical Physics
2. Pipes L.I. : Mathematical Physics
3. Chattopadhyay P.K. : Mathematical Physics
4. Afriken G. : Mathematical methods for Physics
5. Charlie Harper : Introduction to Mathematical Physics
6. Mathews and Walker : Mathematical Methods of Physics
7. Morse and Feshbach : Methods of Theoretical Physics
8. Riley, Hobson and Bence : Mathematical Methods for Physics and Engineers
9. D.Walker : Computational Physics, 1st Edn.
10. Hunt, Lipsman, Rosenberg : A Guide to MATLAB, 3rd Edn.
11. Wouwer, Saucez, Fernández : Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications:.
12. M. Affouf : Scilab by example: 2012,
13. H.Ramchandran, A.S.Nair : Scilab (A free software to Matlab): 2011
14. Lambert M. Surhone : Scilab Image Processing: 2010.
15. www.**scilab**.in/textbook_companion/generate_book/29.

GC-4: Elements of Modern Physics

Unit-I Quantum Mechanics and Bohr Atom Model

Planck's quantum, Planck's constant and light as a collection of photons; Photoelectric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.

Unit-II Quantum Systems and Heisenberg Uncertainty Principle

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

Unit-III Matter Waves and Schrödinger Equation

Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.

Unit-IV Motion in a Potential Well

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.

Unit-V Nuclear Structure and Nuclear Phenomena

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy, Basics of α, β and γ decays.

GC-4: LAB Elements of Modern Physics

(at least eight experiments which cover the understanding of theory course)

1. To determine value of Boltzmann constant using V-I characteristic of PN junction diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck's constant using LEDs of at least 4 different colours.
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 and measure its intensity variation using Photo sensor & compare with incoherent source – Na.
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 (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

Books Recommended

1.	Arthur Beiser	:	Concepts of Modern Physics
2.	J.R. Taylor, C.D. Zafiratos	:	Modern Physics
3.	Thomas A. Moore	:	Six Ideas that Shaped Physics: Particle Behave like Waves
4.	Berkeley Physics Course	:	Vol.4 (Quantum Physics)
5.	Serway, Moses, and Moyer	:	Modern Physics
6.	G. Kaur and G.R. Pickrell	:	Modern Physics
7.	B.L. Flint and H.T. Worsnop	:	Advanced Practical Physics for Students
8.	Michael Nelson and Jon M. Ogborn	:	Advanced level Physics Practicals, , 4th Edition,.
9.	Indu Prakash and Ramakrishna	:	A Text Book of Practical Physics, , 11th Edn.

SEC-2: Basic Instrumentation Skills

Unit-I Basic of Measurement

Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

Unit-II Electronic Voltmeter

Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter, Multimeter and their significance. **AC millivoltmeter:** Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter**,** specifications and their significance.

Unit-III Cathode Ray Oscilloscope

Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

Unit-IV Signal Generators and Analysis Instruments:

Block diagram, explanation and specifications of low frequency signal generators. Pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

Unit-V Digital Instruments

Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time- base stability, accuracy and resolution.

SEC-2: Lab Basic Instrumentation Skills

(at least eight experiments which cover the understanding of theory course)

A. Skills

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages.
5. Circuit tracing of Laboratory electronic equipment

B. Lab Exercises

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. Measurement of voltage, frequency, time period and phase angle using CRO.
4. Measurement of time period, frequency, average period using universal counter/ frequency counter.
5. Measurement of rise, fall and delay times using a CRO.
6. Measurement of distortion of a RF signal generator using distortion factor meter.
7. Measurement of R, L and C using a LCR bridge/ universal bridge.
8. Converting the range of a given measuring instrument (voltmeter, ammeter).

Books Recommended

1. B L Theraja : A text book in Electrical Technology
2. M G Say : Performance and design of AC machines
3. Venugopal : Digital Circuits and Systems
4. P. Vingron, Shimon : Logic Circuit Design
5. Subrata Ghoshal : Digital Electronics.
6. S. Salivahanan & N. S.Kumar : Electronic Devices and Circuits, , 3rd Edn
7. U.Tietze, Ch.Schenk : Electronic circuits: Handbook of design and Applications
8. Thomas L. Floyd : Electronic Devices, 7/e, 2008, Pearson, India.

B.Sc. (Honours) Physics Course (Three Years, Six Semesters)

Semester-V

A. Core Courses (CC)	:	CC-11:**Quantum Mechanics and Applications** [MM: 75 (55+20)]	+	Practicals [MM:25]
		CC-12: **Solid State Physics** [MM: 75 (55+20)]	+	Practicals [MM:25]
B. DS Courses (DSC)#	:	DSC-1:**Classical Dynamics** [MM: 75 (55+20)]	+	Practicals [MM:25]
	:	DSC-2: **Physics of Electronic Devices and Communication** [MM: 75 (55+20)]	+	Practicals [MM:25]

Total Courses (for B.Sc. Honours Physics Semester-V)

Core Courses	:	3 (CC-11 and CC-12)
DS Courses	:	2 (DSC-1 and DSC-2)
Total Marks	:	400

 # Discipline Specific Courses (DSE), in addition to Core Courses (CC), are meant for the students opting for B.Sc. Honours in Physics.

CC-11: Quantum Mechanics and Applications

Unit-I Rudiments of Old Quantum Mechanics

Origin of quantum theory, limitation of Classical Physics, Black body Radiation, Planck's radiation law and Einstein's explanation, The photo electric effect and Einstein correction, Compton effect.

De Broglie's Hypothesis, Wave-Particle Duality, Davisson-Germer Experiment, G.P Thomson experiment, Taylor's experiment, Wave description of Particles by Wave Packets, Group and Phase Velocities, Principle of Complimentarity, Heisenberg Uncertainty principle, Gamma ray microscope, Single slit experiment.

Unit-II Operator Formulation of Quantum Mechanics

Linear vector space, Linear Operator, Definition of position, momentum , Energy and Angular momentum operator, Eigen value and Eigen functions, Hermitian operators, Postulates and basic theorems of Quantum mechanics, Operator method for solving Eigen values problem, Energy of Harmonic oscillator.

Unit-III Formulation of Non-Relativistic Quantum Mechanics

Origin of non relativistic Quantum Mechanics, Overview of wave mechanics, Simple one dimensional quantum system Oscillator, Time independent and time dependent one dimensional Schrödinger equation, Steady state solutions, Physical interpretation of wave functions, probability current density, Ehrenfest's theorem.

Unit-IV Applications of Schrödinger Equation

Particle in a box, continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential, Idea of Tunneling, Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

Unit-V Quantum Theory of Hydrogen Atom

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.shells.

CC-11: LAB **Quantum Mechanics and Applications**
(at least eight experiments which cover the understanding of theory course)

1. **Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like**
   Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dx^2} = A(r)u(r),\ \ A(r) = \frac{2m}{\hbar^2}[V(r)-E] \text{ where } V(r) = -\frac{e^2}{r}$$

   Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈-13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x106 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dx^2} = A(r)u(r),\ \ A(r) = \frac{2m}{\hbar^2}[V(r)-E]$$

   where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = -\frac{e^2}{r}\, e^{-r/a}$$

   Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)1/2, m = 0.511x106 eV/c2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dx^2} = A(r)u(r),\ \ A(r) = \frac{2m}{\hbar^2}[V(r)-E]$$

   For the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

   for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b = 0, 10, 30 MeV fm-3In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dx^2} = A(r)u(r),\ \ A(r) = \frac{2\mu}{\hbar^2}[V(r)-E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'}), r' = \frac{r-r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take: m = 940x106eV/C^2, D = 0.755501 eV, α = 1.44, r_0 = 0.131349 Å

Laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs

Books Recommended

1. L.I. Schiff : Quantum Mechanics
2. B.S. Rajput : Advanced Quantum Mechanics
3. Ghatak and Lokanathan : Quantum Mechanics
4. Mathew and Venkatesan : Quantum Mechanics
5. A. Beiser : Perspective of Modern Physics
6. David Mc mohan : Quantum Mechanics
7. J.Hubbard : Schaum's outline of Programming with C++
8. W.H. Pressetal : Numerical Recipes in C: The Art of Scientific Computing, 3rd Edn.
9. T.Pang : An introduction to computational Physics, 2nd Edn.
10. Wouwer, Saucez, Fernández: Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications
11. H. Ramchandran, A.S. Nair : Scilab (A Free Software to Matlab): 2011
12. Hunt, Lipsman, Rosenberg : A Guide to MATLAB, 2014, 3rd Edn.
13. L.M.Surhone : Scilab Image Processing:2010 Betascript Publishing ISBN:978-6133459274

CC-12: Solid State Physics

Unit-I Crystal Structure

Single crystals and polycrystalline forms, Lattice, Basis and crystal structure, Translational symmetry and basis vectors, Unit cell (primitive and non-primitive), Two dimensional point groups and Bravais lattices, Miller indices, SC, BCC and Sodium Chloride structures, closed packed structures (FCC and HCP). Reciprocal lattice, X-rays diffraction, Bragg's law, Laue and powder methods of X-rays diffraction, Introductory electron and neutron diffraction, Ewald construction and Brillouin zones.

Unit II Lattice Dynamics

Lattice vibrations, Monoatomic lattice, Phonons, Free electron theory of metals, limitations of Lorentz Drude theory, Somerfield theory, Specific heat and paramagnetism of free electrons, Dulong and Petit's law, Departure of the law at low temperatures, Einstein's theory of specific heat and its limitations, Debye's theory of specific heat of solids.

Unit-III Band theory of Solids

Motion of an electron in periodic potential (one dimensional), Results of Kronig-Penny model, Distinction between conductors, Semiconductors and Insulators, Intrinsic and Extrinsic semiconductors, Effective mass of electron, Concept of holes.

Unit-IV Magnetic and Dielectric Properties of Matter

Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss, Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

Unit-V Superconductivity

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

CC-12: LAB Solid state Physics

(at least eight experiments which cover the understanding of theory course)

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Books Recommended

1. Dekker	:	Solid State Physics
2. C.kittel	:	Introduction to Solid State Physics
3. S.O.Pillai	:	Solid State Physics
4. Saxena,Gupta and Saxena	:	Fundamental of Solid State Physics
5. B.B.Laud	:	Introductions to Statistical Mechanics
6. J.P. Srivastava	:	Elements of Solid State Physics
7. J.P. Srivastava	:	Elements of Solid State Physics
8. Leonid V. Azaroff	:	Introduction to Solids
9. N.W. Ashcroft and N.D. Mermin	:	Solid State Physics
10. H. Ibach and H. Luth	:	Solid-state Physics
11. Rita John	:	Solid State Physics
12. M. Ali Omar	:	Elementary Solid State Physics
13. M.A. Wahab	:	Solid State Physics

DSC-1: Classical Dynamics

Unit-I Classical Mechanics of Point Particles

Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy.

Unit-II Small Amplitude Oscillations

Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs.

Unit-III Special Theory of Relativity

Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

Unit-IV Fluid Dynamics

Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number, Basic physics of fluids: The continuum hypothesisconcept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid, properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows,separated & unseparated flows. Flow visualization - streamlines, pathlines, Streaklines

DSC-1: LAB Classical Dynamics

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. Computational Flow visualization - streamlines, pathlines, Streaklines.
5. All experiments related to Simple Harmonic Motion (SHM).
6. All experiments related to Damped Harmonic Motion (DHM).
7. All experiments related to Forced Harmonic Motion (FHM).

Book recommended:

1. B S Rajput	:	Mathematical Physics
2. H. Goldstein	:	Classical Mechanics
3. N.C. Rana & P. S. Jog	:	Classical Mechanics
4. Landau and Lifshitz	:	Mechanics
5. Sommerfeld	:	Mechanics
6. Whittaker	:	Analytical Dynamics of Particles and Rigid Bodies
7. Raychaudhuri	:	Classical Mechanics
8. Bhatia Narosa	:	Classical Mechanics
9. G.K.Batchelor	:	An Introduction to Fluid Dynamics
10.L. D. Landau and E. M. Lifshitz	:	Fluid Mechanics
11.O.L. Delange and J. Pierrus	:	Solved Problems in Classical Mechanics

DSC-2: Physics of Electronic Devices and Communication

Unit I Electronic Devices

Characteristic and small signal equivalent circuits of UJT and JFET. Metalsemiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.

Unit II Power supply and Filters and Multivibrators

Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. Multivibrators: Astable and Monostable Multivibrators using transistors. Phase Locked Loop(PLL): Basic Principles, Phase detector(XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046).

Unit III Processing of Devices

Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation.

Unit IV Digital Data Communication Standards

Serial Communications: RS232, Handshaking, Implementation of RS232 on PC. Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART). Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.

Unit V Introduction to Communication System

Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

DSC-2: LAB Physics of Electronic Devices and Communication

(at least eight experiments which cover the understanding of theory course)

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET.
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.
11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.
16. Design and study the series and parallel LCR circuits
17. Design, study and Verification of op-amp as integrator and differentiator
18. Design and study of clocked SR and JK Flip-Flop`s using NAND Gates
19. Design and study of an Astable multivibrator using IC555 of given duty cycle.

Books Recommended:

1.	S.M. Sze & K.K. Ng	:	Physics of Semiconductor Devices
2.	A.K. Singh	:	Electronic Devices and Integrated Circuits.
3.	R.A.Gayakwad	:	Op-Amps & Linear Integrated Circuits,
4.	A. Mottershead	:	Electronic Devices and Circuits
5.	G. Kennedy	:	Electronic Communication Systems
6.	A.K. Ghosh	:	Introduction to Measurements & Instrumentation
7.	D.A. Neamen	:	Semiconductor Physics and Devices
8.	N.Mathivanan	:	PC basedIinstrumentation; Concepts Practice.
9.	Zbar, Malvino, Miller	:	Basic Electronics:A Text Lab Manual
10.	J. Millman and C.C. Halkias	:	Integrated Electronics
11.	J.D. Ryder	:	Electronics : Fundamentals and Applications
12.	M.H. Rashid	:	Introduction to PSPICE using ORCAD for Circuits & Electronics.

B.Sc. (Honours) Physics Course (Three Years, Six Semesters)

Semester-VI

A. Core Courses (CC)	:	CC-13:**Statistical Mechanics** [MM: 75 (55+20)]	+	Practicals [MM:25]
		CC-14:**Electromagnetic Theory** [MM: 75 (55+20)]	+	Practicals [MM:25]
B. DS Courses (DSC)#	:	DSC-3:**Communication Electronics** [MM: 75 (55+20)]	+	Practicals [MM:25]
		DSC-4:**Astronomy and Astrophysics** [MM: 75 (55+20)]	+	Practicals [MM:25]
		or **Dissertation** [MM: 100 (75+25)]		

Total Courses (for B.Sc. Honours Physics Semester VI)

Core Courses	:	2 (CC-13 and CC-14)
DS Courses	:	2 (DSC-3 and DSC-4 or Dissertation)
Total Marks	:	400

 # Discipline Specific Courses (DSE), in addition to Core Courses (CC), are meant for the students opting for B.Sc. Honours in Physics.

CC-13: Statistical Mechanics

Unit-I: Basic Concepts in Statistical Physics

Basic postulates of Statistical Physics, Macro and Micro States, Phase Space, Density distribution in phase space, μ space representation and its division, Statistical average values, Condition of equilibrium, Stirling's Approximation, Entropy and Thermodynamic probability, Boltzmann entropy relation.

Unit-II Ensembles and Thermodynamic connections

Ensembles, Micro -canonical, Canonical and Grand Canonical ensembles, Statistical definition of temperature and interpretation of second law of thermodynamic, Pressure, Entropy and Chemical potential. Entropy of mixing and Gibb's paradox, Partition function and Physical significances of various statistical quantities.

Unit-III Classical Statistics

Maxwell-Boltzmann statistics and Distribution law, Energy distribution function, Maxwell Boltzmann law of velocity distribution (most probable velocity, average velocity, RMS velocity), Limitations of M-B statistics, Elementary idea of quantum statistics.

Unit-IV Bose-Einstein Statistics

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas, Bose derivation of Planck's law.

Unit-V Fermi-Dirac Statistics

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

CC-13: LAB Statistical Mechanics

(at least eight experiments which cover the understanding of theory course)

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
    a. Study of local number density in the equilibrium state (i) average (ii) fluctuations.
    b. Study of transient behavior of the system (approach to equilibrium).
    c. Relationship of large N and the arrow of time.
    d. Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution.
    e. Computation and study of mean molecular speed and its dependence on particle mass.
    f. Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics:
    a. Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation ΔE, specific heat at constant volume C_v, depend upon the temperature, total number of particles N and the spectrum of single particle states.
    b. Ratios of occupation numbers of various states for the systems considered above.
    c. Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.
3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.

4. Plot Specific Heat of Solids :
    a. Dulong-Petit law
    b. Einstein distribution function.
    c. Debye distribution functions for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
    a. Maxwell-Boltzmann distribution
    b. Fermi-Dirac distribution
    c. Bose-Einstein distribution

Books Recommended

1. B.B.Laud	:	Introductions to Statistical Mechanics
2. Bhattarjee J.K.	:	Statistical Physics (Allied Publishers)
3. F.Reif	:	Statistical Physics (Mc.Graw Hill)
4. Kamal Singh	:	Elements of Statistical Mechanics
5. K.Hung	:	Statistical Physics (Chapman and Hall/CRC)
6. J.P. Srivastava	:	Elements of Solid State Physics
7. K.E.Atkinson	:	Elementary Numerical Analysis
8. R.K. Pathria, B. Heinemann	:	Statistical Mechanics
9. D. Chandler	:	Introduction to Modern Statistical Mechanics, Oxford University Press, 1987
10. F W. Sears, G. L. Salinger	:	Thermodynamics, Kinetic Theory and Statistical Thermodynamics, 1986, Narosa.
11. Carl S. Helrich	:	Modern Thermodynamics with Statistical Mechanics, , 2009, Springer
12. H. Gould and J. Tobochnik	:	Statistical and Thermal Physics with Computer applications
13. Wouwer, Saucez,Fernández	:	Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications:. 2014 Springer ISBN: 978-3319067896.
14. M. Affouf	:	Scilab by example:, 2012. ISBN: 9781479203444.
15. L.M.Surhone	:	Scilab Image Processing: 2010, Betascript Pub., ISBN: 9786133459274

CC-14: Electromagnetic Theory

Unit-I Maxwell Equations

Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.

Unit-II EM Wave Propagation in Unbounded Media

Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

Unit-III EM Wave in Bounded Media

Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection and Refraction, Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves, Metallic reflection (normal Incidence)

Unit-IV Polarization of Electromagnetic Waves

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light. Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

Unit-V Wave Guides and Optical Fibres

Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

CC-14: LAB Electromagnetic Theory

(at least eight experiments which cover the understanding of theory course)

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves.
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan`s law of radiation and to determine Stefan's constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Books Recommended

1. D.J. Griffiths	:	Introduction to Electrodynamics
2. M.N.O. Sadiku	:	Elements of Electromagnetics
3. T.L. Chow	:	Introduction to Electromagnetic Theory
4. M.A.W. Miah	:	Fundamentals of Electromagnetics
5. R.S. Kshetrimayun	:	Electromagnetic field Theory
6. Willian H. Hayt	:	Engineering Electromagnetic
7. G. Lehner	:	Electromagnetic Field Theory for Engineers & Physicists, 2010, Springer
8. P.Lorrain & D.Corson	:	Electromagnetic Fields & Waves
9. J.A. Edminster	:	Electromagnetics, Schaum Series, 2006
10. B. Guru and H. Hiziroglu	:	Electromagnetic field theory fundamentals, , 2004,Cambridge University Press.
11. B.L. Flint and H.T. Worsnop	:	Advanced Practical Physics for Students
12. Michael Nelson and J. M. Ogborn	:	Advanced level Physics Practicals
13. I.Prakash & Ramakrishna	:	A Text Book of Practical Physics

DSC-3: Communication Electronics

Unit-I Electronic communication

Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals, Concept of Noise, signal-to-noise (S/N) ratio.

Unit-II Analog Modulation

Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver **.**

Unit-III Analog Pulse Modulation

Channel capacity, Sampling theorem, Basic Principles PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

Unit-IV Introduction to Communication and Navigation systems: Satellite Communication

Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station, Uplink and downlink.

Unit-V Mobile Telephony System

Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only), GPS navigation system (qualitative idea only).

DSC-3: LAB Communication Electronics

(at least eight experiments which cover the understanding of theory course)

1. To design and study an Amplitude Modulator using Transistor.
2. To study envelope detector for demodulation of AM signal.
3. To study FM - Generator and Detector circuit.
4. To study AM Transmitter and Receiver.
5. To study FM Transmitter and Receiver.
6. To study Time Division Multiplexing (TDM).
7. To study Pulse Amplitude Modulation (PAM).
8. To study Pulse Width Modulation (PWM).
9. To study Pulse Position Modulation (PPM).

Books Recommendation:

1.	D. Roddy and J. Coolen	:	Electronic Communications
2.	Tomasi	:	Advanced Electronics Communication Systems
3.	G. Kennedy	:	Electronic Communication Systems.
4.	Frenzel	:	Principles of Electronic Communication Systems
5.	S. Haykin	:	Communication Systems
6.	Blake, Cengage	:	**E**lectronic Communication System
7.	Andrea Goldsmith	:	Wireless Communications

DSC-4 Astronomy and Astrophysics

Unit-I Astronomical Scales

Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature, Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

Unit-II Astronomical techniques

Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes).

Unit-III The Sun

Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification.

Unit-IV Galaxies

Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms. Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus, Elementary idea of neutron star and black holes.

Unit-V Physical Principles, Large Scale Structure and Expanding Universe

Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium, Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).

DSC-4: LAB **Astronomy and Astrophysics**

(At least four experiments which cover the understanding of theory course)

1. Study of Hubble's law (from given data).
2. Study of constant density neutron star.
3. Study of star cluster from a given data.
4. Study of Extinction coefficients.
5. Verification of Limb darkening using the solar data.
6. Verification of Solar Cycle using the given data.
7. Determination of Solar Constant.

Books Recommended:

1. B.W. Carroll & D.A. Ostlie	:	Modern Astrophysics
2. M. Zeilik and S.A. Gregory	:	Introductory Astronomy and Astrophysics
3. F.Shu, Mill Valley	:	The physical Universe: An Introduction to Astronomy
4. H. Karttunen et al	:	Fundamental of Astronomy
5. K.S. Krishnasamy	:	Astro Physics a Modern Perspective
6. Baidyanath Basu	:	An Introduction to Astrophysics
7. V.B. Bhatia	:	Textbook of Astronomy and Astrophysics with Elements of Cosmology