



**FAKIR MOHAN UNIVERSITY**  
**VYASA VIHAR, BALASORE**

**SYLLABUS FOR UNDERGRADUATE**  
**COURSE IN**  
**PHYSICS**

Effective from the academic session 2019-20

**UNDER CHOICE BASED CREDIT SYSTEM**

## Course structure of UG Physics Honors

Framework of CBCS Syllabus for PHYSICS (Honours) from 2019-20					
Full Forms of Course Codes Used: CC = Core Course, AECC = Ability Enhancement Compulsory Course, SEC = Skill Enhancement Course, DSE = Discipline Specific Elective (Related to Core Subject), GE = Generic Elective (Not related to Core Subject; One subject with 4 papers <b>or</b> 2 different subjects of 2 papers each).					
<b>Total Marks: CC+DSE (1400+400) + AECC (200) + SEC (200) + GE (400) = 2600</b>					
Semester	cc 14 Papers 100 x 14 = 1400	AECC 2 Papers 100 x 2 = 200	SEC 2 Papers 100 x 2 = 200	DSE 4 Papers 100 x 4 = 400	4 Papers 100 x 4 = 400
I	CC-I: Mathematical Physics-I	AECC 1 MIL Communication			GE A Paper I/GE Paper I (Title as applicable)
	CC-II: Mechanics				
II	CC-III: Electricity and Magnetism	AECC 2 Environmental Science			GE A Paper II/GE Paper II (Title as applicable)
	CC-IV: Waves and Optics				
III	CC-V: Mathematical Physics-II		SEC 1 (To be selected from the list of SEC courses)		GE B Paper I/GE Paper III (Title as applicable)
	CC-VI: Thermal Physics				
	CC-VII: Analog Systems and Applications				
IV	CC-VIII: Mathematical Physics-III		SEC 2 (To be selected from the list of SEC courses)		GE B Paper II/GE Paper IV (Title as applicable)
	CC-IX: Elements of Modern Physics				
	CC-X: Digital Systems and Applications				
V	CC-XI: Quantum Mechanics & Applications			DSE-I: Classical Dynamics	
	CC-XII: Solid State Physics			DSE-II: Nuclear and Particle Physics	
VI	CC-XIII: Electro-magnetic Theory			DSE-III: Nano Materials and Applications	
	CC-XIV: Statistical Mechanics			DSE-IV: Basic Instrumentation OR Project work (if eligible)	

Note: AECC and SEC Syllabi are meant for all. So they have been given separately.

<b>SEMESTER</b>	<b>COURSE OPTED</b>	<b>COURSE NAME</b>	<b>Credits</b>
<b>I</b> <b>4 Papers</b>  <b>(400 Marks)</b>	<b>Ability Enhancement Compulsory Course-I</b>	<b>AECC-1</b>	<b>4</b>
	<b>Core course-I</b>	<b>Mathematical Physics-I</b>	<b>4</b>
	<b>Core Course-I Practical/Tutorial</b>	<b>Mathematical Physics-I Lab</b>	<b>2</b>
	<b>Core course-II</b>	<b>Mechanics</b>	<b>4</b>
	<b>Core Course-II Practical/Tutorial</b>	<b>Mechanics Lab</b>	<b>2</b>
	<b>Generic Elective -1</b>	<b>GE-1</b>	<b>4</b>
	<b>Generic Elective -1</b>	<b>Practical/Tutorial</b>	<b>2</b>
<b>II</b> <b>4 Papers</b>  <b>(400 Marks)</b>	<b>Ability Enhancement Compulsory Course-II</b>	<b>AECC-II</b>	<b>4</b>
	<b>Core course-III</b>	<b>Electricity and Magnetism</b>	<b>4</b>
	<b>Core Course-III Practical/Tutorial</b>	<b>Electricity and Magnetism Lab</b>	<b>2</b>
	<b>Core course-IV</b>	<b>Waves and Optics</b>	<b>4</b>
	<b>Core Course-IV Practical/Tutorial</b>	<b>Waves and Optics Lab</b>	<b>2</b>
	<b>Generic Elective -2</b>	<b>GE-2</b>	<b>4</b>
	<b>Generic Elective -2</b>	<b>Practical/Tutorial</b>	<b>2</b>
<b>III</b> <b>5 Papers</b>  <b>(500 Marks)</b>	<b>Core course-V</b>	<b>Mathematical Physics-II</b>	<b>4</b>
	<b>Core Course-V Practical/Tutorial</b>	<b>Mathematical Physics-II Lab</b>	<b>2</b>
	<b>Core course-VI</b>	<b>Thermal Physics</b>	<b>4</b>
	<b>Core Course-VI Practical/Tutorial</b>	<b>Thermal Physics Lab</b>	<b>2</b>
	<b>Core course-VII</b>	<b>Analog Systems and Applications</b>	<b>4</b>
	<b>Core Course-VII Practical/Tutorial</b>	<b>Analog Systems &amp; Applications Lab</b>	<b>2</b>
	<b>Skill Enhancement Compulsory Course -1</b>	<b>SECC-1</b>	<b>4</b>
	<b>Generic Elective -3</b>	<b>GE-3</b>	<b>4</b>
	<b>Generic Elective -3</b>	<b>Practical/Tutorial</b>	<b>2</b>
<b>IV</b> <b>5 Papers</b>  <b>(500 Marks)</b>	<b>Core course-VIII</b>	<b>Mathematical Physics III</b>	<b>4</b>
	<b>Core Course-VIII Practical/Tutorial</b>	<b>Mathematical Physics-III Lab</b>	<b>2</b>
	<b>Core course-IX</b>	<b>Elements of Modern Physics</b>	<b>4</b>
	<b>Core Course-IX Practical/Tutorial</b>	<b>Elements of Modern Physics Lab</b>	<b>2</b>
	<b>Core course-X</b>	<b>Digital Systems and Applications</b>	<b>4</b>
	<b>Core Course-X Practical/Tutorial</b>	<b>Digital Systems &amp; Applications Lab</b>	<b>2</b>
	<b>Skill Enhancement Compulsory Course -2</b>	<b>SECC -2</b>	<b>4</b>
	<b>Generic Elective -4</b>	<b>GE-4</b>	<b>4</b>
<b>Generic Elective -4</b>	<b>Practical/Tutorial</b>	<b>2</b>	
<b>V</b>	<b>Core course-XI</b>	<b>Quantum Mechanics &amp;</b>	<b>4</b>

4 Papers (400 Marks)		Applications	
	Core Course-XI Practical/Tutorial	Quantum Mechanics Lab	2
	Core course-XII	Solid State Physics	4
	Core Course-XII Practical/Tutorial	Solid State Physics Lab	2
	Discipline Specific Elective -1	DSE-1	5
	Discipline Specific Elective -1	Practical/Tutorial	1
	Discipline Specific Elective -2	DSE-2	5
	Discipline Specific Elective- 2	Practical/Tutorial	1
VI 4 Papers (400 Marks)	Core course-XIII	Electro-magnetic Theory	4
	Core Course-XIII Practical/Tutorial	Electro-magnetic Theory Lab	2
	Core course-XIV	Statistical Mechanics	4
	Core Course-XIV Practical/Tutorial	Statistical Mechanics Lab	2
	Discipline Specific Elective -3	DSE-3	5
	Discipline Specific Elective -3	Practical/Tutorial	1
	Discipline Specific Elective-4	DSE-4	4/5
	Discipline Specific Elective -4	Practical/Tutorial	2/1
	Alternative to Discipline Specific Elective-4	(Eligible Students may do a Project in DSE-IV)	6
		Total Credits	148

**Generic Elective Papers (GE) (Minor-Physics) for other Departments/Disciplines: (Credit: 06 each)**

**Depending on their requirements, Universities may choose 2 (two )GE subjects with 2 papers from each subject or only one GE subject with 4 papers from it.**

**Two papers GE subject will be :**

- 1. GE-I** (Mechanics & Properties of matter, Oscillation & Waves, Thermal Physics, Electricity and Magnetism & Electronics) + Lab
- 2. GE-II** (Optics, Special Theory of Relativity, Atomic Physics, Quantum Mechanics and Nuclear Physics)+ Lab

A student who chooses to read only Physics subject GE will take 4 DSC papers of the Pass Course as below

- 1. GE-I** as **DSC-1**(Mechanics )+ Lab
- 2. GE-II** as **DSC-2**,( Electricity, Magnetism & Emt) )+ Lab
- 3. GE-III** as **DSC-3**,(Thermal Physics & Statical Mechanics) )+ Lab
- 4. GE-IV** as **DSC-4** (Waves and Optics )+ Lab

(GE-I same paper as DSC-1,GE-II same as DSC-2 ,GE-III same as DSC-3,GE-IV same as DSC-4)

SEC papers can be chosen from the general pool or physics specific courses as indicated.

# PHYSICS

## HONOURS PAPERS:

Core course – 14 papers

Discipline Specific Elective – 4 papers (out of the 5 papers suggested)

Generic Elective for non Physics students – 4 papers. In case University offers 2 subjects as GE, then papers 1 and 2 will be the GE paper.

Marks per paper –

For practical paper: Mid term : 15 marks, End term : 60 marks, Practical- 25 marks

For non practical paper: Mid term : 20 marks, End term : 80 marks

Total – 100 marks Credit per paper – 6

Teaching hours per paper –

Practical paper-40 hours theory classes + 20 hours Practical classes Non Practical

paper-50 hours theory classes + 10 hours tutorial

## CC-1

### MATHEMATICAL PHYSICS-I

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

#### UNIT-I

**Calculus -I:** Plotting of functions, Intuitive ideas of continuous, differentiable functions and plotting of curves, Approximation: Taylor and binomial series (statements only), First Order Differential Equations and Integrating Factor, Second Order Differential equations: Homogeneous Equations with constant coefficients, Wronskian and general solution, Statement of existence and Uniqueness Theorem for Initial Value Problems, Particular Integral.

#### UNIT-II

**Calculus-II:** Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration, Constrained Maximization using Lagrange Multipliers,

**Vector algebra:** 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-III

**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems, Comparison of velocity and acceleration in cylindrical and spherical coordinate system

**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.

#### UNIT-IV

**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

**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 (no rigorous proofs)

#### Text Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris • (2013, 7th Edition., Elsevier)
2. Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India) , 2008.

#### Reference books:

1. Mathematical Physics C. Harper (Prentice Hall India), 2006.
2. Complex Variable: Schaum's Outlines Series M. Spiegel ( 2nd Edition , Mc-• Graw Hill Education)
3. Complex variables and applications, J. W. Brown and R.V.Churchill •  
•  
Mathematical Physics, Satya Prakash (Sultan Chand)
4. Mathematical Physics, B. D. Gupta (4th edition, Vikas Publication), 2009.  
•
5. Mathematical Physics and Special Relativity, M. Das, P.K. Jena and B.K.Dash (Srikrishna Prakashan) ,2009
6. Mathematical Physics–H.K.Dass, Dr. Rama Verma (S. Chand Publishing) , 2011

## CC-I LAB:

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

**Introduction and Overview:** Computer architecture and organization, memory and Input/output devices.

**Basics of scientific computing:** Binary and decimal arithmetic, Floating pointnumbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow emphasize the importance of making equations in terms of dimension less variables, Iterative methods. Algorithm

**Errors and error Analysis:** Truncation and round off errors, Absolute and relative errors, Floating point computations. Systematic and Random Errors, Propagation of Errors, Normal Law of Errors, Standard and Probable Error.

**Review of C and C++ Programming:** Introduction to Programming, constants, variables and Fundamentals data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data format- ting, Control statements (decision making and looping statements) (If Statement, Ifelse Statement, Nested If structure, Else If Statement, Ternary operator, Go to Statement. Switch Statement. Unconditional and Conditional Looping.While Loop. DoWhile Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D and 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects

**Programs:** Sum and 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  $\pi$  and applications in physics lab.

### Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edition., 2012, PHI • Learning Pvt. Ltd.

2. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al., 3rd Edition. 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
6. Numerical Methods for Scientists and Engineers, R.W. Hamming, 1973, Courier Dover Pub.
7. An Introduction to computational Physics, T. Pang, 2<sup>nd</sup> Edn., 2006, Cambridge Univ. Press.

## CC-II MECHANICS

### UNIT-I

**Rotational Dynamics:** Centre of Mass, Motion of CoM, Centre of Mass and Laboratory frames, Angular momentum of a particle and system of particles, Principle of conservation of angular momentum, Rotation about a fixed axis, Moment of Inertia, Perpendicular and Parallel Axis Theorems, Routh Rule, Calculation of moment of inertia for cylindrical and spherical bodies, Kinetic energy of rotation, Eulers Equations of Rigid Body motion, Motion involving both translation and rotation. Moment of Inertia of a Fly wheel.

**Non-Inertial Systems:** Non-inertial frames and fictitious forces, Uniformly rotating frame, Laws of Physics in rotating coordinate systems, Centrifugal force, Coriolis force and its applications.

**UNIT-II Elasticity:** Relation between Elastic constants, Twisting torque on a Cylinder or Wire, Bending of beams, External bending moment, Flexural rigidity, Single and double cantilever  
Surface Tension: Excess pressure across a curved membrane, Quink's drop

**Fluid Motion:** Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube, Surface tension, Gravity waves and ripple  
**Viscosity:** Poiseuille's Equation for Flow of a Liquid with corrections.

**UNIT-III Gravitation and Central Force Motion:** Law of gravitation, Gravitational potential energy, Inertial and gravitational mass, Potential and field due to spherical shell and solid sphere, Motion of a particle under a central force field, Two-body problem and its reduction to one-body



problem and its solution, Differential Equation of motion with central force and its solution, The first Integrals (two), Concept of power Law Potentials, Keplers Laws of Planetary motion, Satellites: Geosynchronous orbits, Weightlessness, Basic idea of global positioning system (GPS), Physiological effects on astronauts.

#### **UNIT-IV**

**Oscillations:** Simple Harmonic Oscillations. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Equation of motion and solution (cases of oscillatory, critically damped and over damped) Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor, Bar Pendulum, Katers Pendulum

**Special Theory of Relativity:** Michelson-Morley Experiment and its out- come, Postulates of Special Theory of Relativity, Lorentz Transformations, Simultaneity and order of events, Lorentz contraction, Time dilation, Relativistic transformation of velocity, Frequency and wave number, Relativistic addition of velocities, Variation of mass with velocity, Massless Particles, Mass-energy Equivalence, Relativistic Doppler effect, Relativistic Kinematics, Transformation of Energy and Momentum.

#### **Text Books:**

1. Mechanics, D.S. Mathur, PS Hemne (S. Chand Publishing) ,2012.
  2. Introduction to Special Relativity, R. Resnick (John Wiley), 2007
- Reference Books:**
1. Introduction to Mechanics Daniel Klapnner and Robert Kolenkow, • McgrawHill.2007
  2. Mechanics by K.R Simon, 1971.
  3. Mechanics, Berkeley Physics, vol.1, C.Kittel, W. Knight, etal (Tata McGraw-• Hill), 2007
  4. Physics, Resnick, Halliday and Walker (8/e.2010,Wiley)
  5. Theoretical Mechanics-M.R. Spiegel (Tata McGraw Hill), 2017
  6. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands (Pearson),2012
  7. Mechanics-M.Das, P.K.Jena and R.N. Mishra (Srikrishna Publications), 2009

## CC-II LAB

( minimum 5 experiments are to be done):

1. To study surface tension by capillary rise method •
2. To determine the height of a building using a Sextant.
3. To study the Motion of Spring and calculate (a) Spring constant, (b) g and • (c) Modulus of rigidity.
4. To determine the Moment of Inertia of a Flywheel. •
5. To determine Coefficient of Viscosity of water by Capillary Flow Method • (Poiseuilles method).
6. To determine the Modulus of Rigidity of a Wire by Maxwells needle.
7. To determine the value of g using Bar Pendulum.
8. To determine the value of g using Kater's Pendulum

### Reference Books:

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

## CC-III

### ELECTRICITY AND MAGNETISM

#### UNIT-I

##### Electric Field and Electric Potential

**Electric field:** Electric field lines, Electric flux, Gauss Law with applications to charge distributions with spherical, cylindrical and planar symmetry, Conservative nature of Electrostatic Field. Electrostatic Potential, Potential and

Electric Field of a dipole, Force and Torque on a dipole placed in electric field, Potential calculation indifferent simple cases, Laplace and Poisson's equations, The Uniqueness Theorem, Method of Images and its application to (1) Plane Infinite Sheet and (2) Sphere.

Electrostatic energy of system of charges, Electrostatic energy of a charged sphere, Conductors in an electrostatic Field, Surface charge and force on a conductor.

## UNIT-II

**Magnetic Field:** Magnetic Force, Lorentz Force, Biot Savarts Law, Current Loop as a Magnetic Dipole and its Dipole Moment (analogy with Electric Dipole), Amperes Circuital Law and its application to (1) Solenoid (2) Toroid  
(3) Helmholtz coil, Properties of B: curl and divergence, Vector Potential, Ballistic Galvanometer: Torque on a current Loop, Current and Charge Sensitivity, Electromagnetic damping, Logarithmic damping, CDR.

## UNIT-III

**Dielectric Properties of Matter:** Electric Field in matter, Polarization, Polarization Charges, Electrical Susceptibility and Dielectric Constant, Capacitor (parallel plate, spherical, cylindrical) filled with dielectric, Displacement vector D, Relations between E, P and D, Gauss Law in dielectrics. **Magnetic Properties of Matter:** Magnetization vector (M), Magnetic Intensity (H), Magnetic Susceptibility and permeability, Relation between B, H, M, Ferromagnetism, B-H curve and hysteresis.

**Electromagnetic Induction:** Faradays Law, Lenzs Law, Self Inductance and Mutual Inductance, Reciprocity Theorem, Energy stored in a Magnetic Field, Introduction to Maxwell's Equations

## UNIT-IV

**Electrical Circuits:** AC Circuits: Kirchoff's laws for AC circuits, Complex Reactance and Impedance, Series LCR Circuit: (1) Resonance (2) Power Dissipation (3) Quality Factor, (4) Band Width, Parallel LCR Circuit.

**Network theorems:** Ideal Constant-voltage and Constant-current Sources, Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem, Applications to DC and AC circuits.

Transient Currents Growth and decay of current in RC and LR circuits.

### Text Books:

1. Introduction to Electrodynamics – D.J. Griffiths (Pearson, 4th edition, 2015)
2. Foundations of Electromagnetic Theory-Ritz and Milford (Pearson) 4<sup>th</sup>

### Edition Reference Books:

1. Classical Electrodynamics, J. D. Jackson (Wiley), 1998.

2. Electricity and Magnetism D. C. Tayal (Himalaya Publishing house), 2014.
- 
3. Electricity, Magnetism and Electromagnetic Theory- S. Mahajan and Choudhury ( Tata McGraw Hill)-2012
4. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands ( Pearson)-2008.
5. Electricity and Magnetism, J. H. Fewkes and J. Yarwood. Vol. I • (Oxford Univ. Press)

### CC-III1

( minimum of 6 experiments are to be done)

Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer. •
3. To • determine an unknown Low Resistance using Carey Fosters  
•  
Bridge.
4. And compare capacitances using DeSautys bridge.
5. Measurement of field strength B and its variation in a solenoid/ • artificial coil (determine dB/dx)
6. To verify the Thevenin and Norton theorems. •
7. To determine self inductance of a coil by Andersons bridge. •
8. To • study response curve of a Series LCR circuit and determine its (a) Reso- nant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
9. To study the response curve of a parallel LCR circuit and determine its (a) • Antiresonance frequency and (b) Quality factor Q.

#### Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, • 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th • Ed., 2011, Kitab Mahal

3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, • 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, • D.P.Khandelwal, 1985, Vani Pub.

## **CC-1V: WAVES AND OPTICS**

### **UNIT - I**

**Geometrical Optics :** Fermats principle, reflection and refraction at plane interface, Matrix formulation of geometrical Optics, Cardinal points and Cardinal planes of an optical system, Idea of dispersion, Application to thick Lens and thin Lens, Ramsden and Huygens eyepiece. **Wave Optics :** Electromagnetic nature of light. Definition and properties of wave front Huygens Principle. Temporal and Spatial Coherence.

### **UNIT - II**

**Wave Motion :** Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Traveling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation, Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave. Superposition of two perpendicular Harmonic Oscillations : Graphical and Analytical Methods, Lissajous Figures (1:1 and 1:2) and their uses, Superposition of N harmonic waves.

### **UNIT- III**

**Interference :** Division of amplitude and wave front, Young's double slit experiment, Lloyds Mirror and Fresnels Bi-prism, Phase change on reflection: Stokes treatment, Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination (Haidinger Fringes), Fringes of equal thickness (Fizeau Fringes), Newton's Rings: Measurement of wavelength and refractive index. Interferometer : Michelsons Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes, Fabry-Perot interferometer.

## UNIT - IV

**Fraunhofer diffraction:** Single slit, Circular aperture, Resolving Power of a telescope, Double slit, Multiple slits, Diffraction grating, Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions, Fresnel's Half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light, Theory of a Zone Plate: Multiple Foci of a Zone Plate, Fresnel's Integral, Fresnel diffraction pattern of a straight edge, as lit and a wire.

### Text Books:

1. Optics P.K.Chakrabarty, New Central Agency 3<sup>rd</sup> Edition 2012
2. Optics - Ajoy Ghatak (McGraw Hill.)- 2017
2. Optics-E.Hecht (Pearson)-2008
3. Fundamentals of Optics- F.A. Jenkins and H.E.White (McGraw-Hill)-2017
4. Geometrical and Physical Optics R.S. Longhurst (Orient Black swan)-1986
5. A text book of Optics N. Subrahmanyam and Brij Lal (S.Chand Publishing), 2006
6. The Physics of Vibrations and Waves- H.J. Pain (JohnWiley)-2013
7. Principles of Optics- Max Born and Emil Wolf(Pergamon Press) 7<sup>th</sup> Edition 1999
8. The Physics of Waves and Oscillations-N.K.Bajaj (McGraw Hill)-1998

### CC-IV LAB

#### ( minimum 5 experiments are to be done)

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify  $2T$  law.
2. To plot the I-D curve and to determine the refractive index of a prism.
3. To determine refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine wavelength of sodium light using Newton's Rings.
6. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
7. To determine dispersive power and resolving power of a plane diffraction grating.

## Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, • 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th • Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, • 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D. P. • Khandelwal, 1985, Vani

## CC-V MATHEMATICAL PHYSICS-II

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

### UNIT-I

**Fourier Series-I:** 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 and Application, Summing of Infinite Series, Term-by-Term differentiation and integration of Fourier Series, Parseval Identity.

### UNIT-II

**Frobenius Method and Special Functions:** Singular Points of Second Order Linear Differential Equations and their importance, Singularities of Bessel's and Laguerre Equations, Frobenius method and its applications to differential equations: Legendre and Hermite Differential Equations, Legendre and Hermite Polynomials: Rodrigue's Formula, Generating Function, Orthogonality.

### UNIT-III

**Polynomials:** Simple recurrence relations of Legendre and Hermite Polynomials, Expansion of function in a series of Legendre Polynomials, Associated Legendre Differential

Equation, Associated Legendre polynomials, Spherical Harmonics

**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. Conducting and dielectric sphere in an external uniform electric field. Wave equation and its solution for vibrational modes of a stretched string

#### **Text Books:**

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris • (2013, 7th Edn., Elsevier)
2. Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India) 9<sup>th</sup> Edition 2011

#### **Reference Books:**

1. Mathematical Physics and Special Relativity, M. Das, P.K. Jena and • B.K. Dash (Srikrishna Prakashan)-2009
2. Mathematical Physics—H. K. Dass, Dr. Rama • Verma (S. Chand Publishing) -2011
3. Mathematical Physics C. Harper (Prentice Hall India)-1978
4. Schaum's Outlines Series M. Spiegel (2nd Edition, McGraw Hill Education)2004
5. Complex variables and applications J.W.Brown and R.V.Churchill-2017
6. Mathematical Physics, Satya Prakash (Sultan Chand)-2014
7. Mathematical Physics B.D. Gupta (4th edition, Vikas Publication-2009



## CC-V LAB

The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done on the basis of formulating the problem but not on the programming

### Topics

**Introduction to Numerical computation software Scilab:** Introduction to Scilab, Advantages and disadvantages, Scilab computation software 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 and logical operators, the while loop, for loop, details of loop operations, break and 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 constant Deviation:**

Ohms law to calculate R, Hooke's law to calculate spring constant

**Solution of Linear system of equations by Gauss elimination Solution method and Gauss Seidal method. Diagonalization matrices, Inverse of a matrix, Eigen vectors, problems:** Solution of mesh equations of electric circuits(3meshes),Solution of coupled spring mass systems (3masses)

### **Solution of ODE :**

**First order Differential equation Euler, modified Euler, Runge- Kutta methods, Second order differential equation. Fixed difference method: First order differential equations**

- Radioactive decay
- Current in RC and 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

### Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F. Riley, M.P.Hobson and S. J.20 Bence, 3rd ed., 2006, Cambridge University Press
2. Complex Variables, A.S. Fokas and M.J. Ablowitz, 8th Ed., 2011,• Cambridge Univ. Press
3. First course in complex analysis is with applications, D.G.Zill and• P.D.Shanahan, 1940, Jones and Bartlett
4. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB:• Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernndez. 2014 Springer
5. Scilab by example: M. Affouf 2012, ISBN: 978-1479203444. •
6. Scilab (A free software to Matlab): •  
H.Ramchandran,A.S.Nair.2011S.Chand and Company
7. Scilab Image Processing: Lambert M. Surhone. 2010 Beta script Publishing

## CC-VI THERMAL PHYSICS

### UNIT-I

**Introduction to Thermodynamics** Recapitulation of Zeroth and First law of thermodynamics,

**Second Law of Thermodynamics:** Reversible and Irreversible process with examples, Kelvin-Planck and Clausius Statements and their Equivalence, Carnots Theorem, Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

**Entropy:** Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy, Entropy of a perfect gas, Principle of increase of

Entropy, Entropy Changes in Reversible and Irreversible processes with examples, Entropy of the Principle of Increase of Entropy, Temperature Entropy diagrams for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.

## UNIT-II

**Thermodynamic Potentials:** Extensive and Intensive Thermodynamic Variables, **Thermodynamic Potentials:** Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy, Their Definitions, Properties and Applications, Surface Films and Variation of Surface Tension with Temperature, Magnetic Work, Cooling due to adiabatic demagnetization

**Phase Transitions:** First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

**Maxwell's Thermodynamic Relations:** Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation (2) Relation between  $C_p$  and  $C_v$ , (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases (5) Energy equations (6) Change of Temperature during Adiabatic Process.

## UNIT-III

### Kinetic Theory of Gases

**Distribution of Velocities:** Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification, Sterns Experiment, Mean, RMS and Most Probable Speeds, Degrees of Freedom, Law of Equipartition of Energy (No proof required), Specific heats of Gases.

**Molecular Collisions:** Mean Free Path, Collision Probability, Estimates of Mean Free Path,

**Transport Phenomenon in Ideal Gases:** (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

## UNIT-IV

**Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation, The Virial Equation, Andrews Experiments on  $\text{CO}_2$  Gas. Critical Constants, Continuity of Liquid and Gaseous State. Vapour and Gas, Boyle Temperature, Van der Waals Equation of State for Real Gases, Values of Critical Constants, Law of Corresponding States, Comparison with Experimental Curves, P-V Diagrams, Joules Experiment, Free Adiabatic Expansion of a Perfect Gas, Joule- Thomson Porous Plug Experiment, Joule- Thomson Effect for Real and Van der Waal Gases, Temperature of Inversion, Joule-Thomson Cooling

**Text Books:**

1. Thermal Physics, A. B. Gupta (Books and allied Ltd)-2010.
2. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman • (McGraw- Hill)-1981

**Reference Books:**

1. Theory and experiments on thermal Physics, P.K.Chakrabarty (New • central book agency limited)-2017
2. Thermodynamics, Kinetic Theory and Statistical Thermodynamics-• Sears and Salinger(Narosa)-1988
3. A Treatise on Heat- Meghnad Saha and B.N.Srivastava (The Indian • Press) Heat, Thermodynamics and Statistical Physics, N.Subrahmanyam and Brij Lal (S.Chand Publishing)-2008
4. Thermal and Statistical Physics M.Das, P.K. Jena, S. Mishra, • R.N.Mishra (Shri Krishna Publication)-2009

**CC-VI LAB****(minimum 5 experiments are to be done):**

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barnes • constant flow method.
2. To determine the Coefficient of Thermal Conductivity of a bad • conductor by Lee and Charltons disc method.
3. To determine the Temperature Coefficient of Resistance by Platinum • Resistance Thermometer (PRT).
4. To study the variation of Thermo-emf of a Thermocouple with Difference of • Temperature of its Two Junctions.
5. To determine the specific heat of liquid by the method of cooling
6. To determine the specific heat of solid by applying radiation correction.

**Reference Books:**

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, • 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th • Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn,• 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal,• 1985, Vani Publications.

# CC-VII ANALOG SYSTEMS AND APPLICATIONS

## UNIT-I

**Semiconductor Diodes:** P and N type semiconductors, energy level diagram, conductivity and Mobility, Concept of Drift velocity, PN junction fabrication (simple idea), Barrier formation in PN Junction Diode, Static and Dynamic Resistance, Current flow mechanism in Forward and Reverse Biased Diode, Drift velocity, derivation for Barrier Potential, Barrier Width and current Step Junction.

**Two terminal device and their applications:** (1) Rectifier Diode:

HalfwaveRectifiers.centertappedandbridgetypeFull-waveRectifiers,Calculation of Ripple Factor and Rectification Efficiency, L and C Filters (2) Zener Diode and Voltage Regulation, Principle and structure of LEDES, (2) Photo diode(3) Solar Cell.

## UNIT II

**Bipolar Junction Transistors:** n-p-n and p-n-p transistors, Characteristics of CB, CE and CC Configurations, Current gains  $a$  and  $b$ , Relation between  $a$  and  $b$ , Load line analysis of Transistors, DC Load line and Q-point, Physical mechanism of current flow, Active, Cut-off and Saturation Regions.

**Transistors Biasing:** Transistor Biasing and Stabilization circuits, Fixed Bias and Voltage Divider Bias.

**Amplifiers:** Transistors as 2-port network h-parameter Equivalent Circuit, Analysis of a single stage CE amplifier using Hybrid Model, Input and Output impedance, Current, Voltage and Power Gains, Classification of class A, B and C amplifiers, Push-pull amplifier (class B)

## UNIT-III

**Coupled Amplifier:** RC-coupled amplifier and its frequency response.

**Feedback in Amplifiers:** Effect of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain Stability, Distortion and Noise. Sinusoidal

Oscillations: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency, Hartley and Colpitt's oscillators.

## UNIT-IV

**Operational Amplifiers (Black Box approach):** Characteristics of an Ideal and Practical OP-AMP (IC741). Open-loop and Closed loop Gain. Frequency Response. CMRR, Slew Rate and concept of virtual ground.

**Application of Op-Amps:** (1) Inverting and non-inverting amplifiers (2) Adder (3) Subtractor (4) Differentiator, (5) Integrator (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.

**Text Books:**

- 
- 1. Foundations of Electronics-Raskhit and Chattopadhyay (New age International Publication), 15<sup>th</sup> Edition-2018
- 2. Concept of Electronics- D.C.Tayal (Himalay Publication)-2018

**Reference Books:**

- 1. Electronic devices and circuits R.L.Boylstad (Pearson India)-2009
- 2. Electronic Principles- A.P.Malvino (Tata McGraw Hill)-2008
- 3. Electronic Devices and Circuits- S.Salivahar and NS Kumar -(Tata McGraw Hill)
  - 
  - 3<sup>rd</sup> Edition-2012
- 4. OP-Amps and Linear Integrated Circuit-R. A. Gayakwad (Prentice Hall) 4<sup>th</sup> Edition, 2000
- 5. Physics of Semiconductor devices, Donald A Neamen (Prentice Hall) 6.

**CC-VII LAB**

**( minimum 5 experiments are to be done)**

- 1. To study the V-I characteristics of a Zener diode and its use as voltage • regulator.
- 2. Study of V-I and power curves of solar cells, and find maximum power • point and efficiency.
- 3. To study the characteristics of a Bipolar Junction Transistor in CE • configuration and draw load line
- 4. To study the various biasing configurations of BJT for normal class A • operation.
- 5. To study the frequency response of voltage gain of a RC-coupled transistor• amplifier.
- 6. To design and study OP Amp-IC (741/351) as inverting and non inverting amplifier
- 7. To design and study OP Amp-IC (741/351) as integrator and differentiation and study frequency response.
- 8. To design and study OP Amp-IC (741/351) as adder and subtractor.
- 9. To design a Wien bridge oscillator for given frequency using a nop-amp.
- 10. To design a phase shift oscillator of given specifications using BJT.
- 11. To study the Colpitt's oscillator.

**Reference Books:**

- 1. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGrawHill. • 2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. • Miller, 1994, Mc-Graw Hill.
- 3. Microprocessor Architecture Programming and applications with 8085, • R.S. Goankar, 2002, Prentice Hall.
- 4. Microprocessor 8085:Architecture, Programming and interfacing, A. • Wadhwa, 2010, PHI Learning.

## CC-VIII MATHEMATICAL PHYSICS-III

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems; known or unknown.

### UNIT-I

**Complex Analysis:** Brief Revision of Complex Numbers and their Graphical Representation Eulers formula, De Moivre's theorem, Roots of complex Numbers, Functions of Complex Variables, Analyticity and Cauchy-Riemann Conditions, Examples of analytic functions, Singular functions: poles and branch points, order of singularity, branch cuts, Integration of a function of a complex variable, Cauchys Inequality, Cauchys Integral formula, Simply and multiply connected region, Laurent and Taylors expansion, Residues and Residue Theorem, Application in solving simple Definite Integrals.

### UNIT-II

**Integral Transforms-I:** Fourier Transforms: Fourier Integral theorem, Fourier Transform, Examples, Fourier Transform of trigonometric, Gaussian, finite wave train and other functions, Representation of Dirac delta function as a Fourier Integral, Fourier transform of derivatives, Inverse Fourier Transform.

### UNIT-III

**Integral Transforms-II :** Convolution theorem, Properties of Fourier Transforms (translation, change of scale, complex conjugation), Three dimensional Fourier transforms with examples, Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat flow Equations.

### UNIT-IV

**Laplace Transforms:** Laplace Transforms (LT) of Elementary functions,

**Properties of Laplace Transforms:** Change of Scale Theorem, Shifting Theorem, LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions, Inverse LT, Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

### Text Books:

1. Mathematica I Methods for Physicists, G.B.Arffen, H.J.Weber, F.E.Harris. (2013,7th Edn., Elsevier)
2. Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India) 10<sup>th</sup> Edition 2014

### Reference Books:

1. Mathematical Physics and Special Relativity–M.Das, • P.K. Jena and B.K. Dash (Srikrishna Prakashan)-2009
2. Mathematical Physics–H. K. Das, Dr. Rama Verma (S. Chand Publishing) • 2011
3. Complex Variable: Schaum's Outlines Series M. Spiegel (2nd Edition , Mc- Graw• Hill Education)-2004
4. Complex variables and applications J.W.Brown and R.V.Churchill 7<sup>th</sup> Edition 2003
5. Mathematical Physics, Satya Prakash (Sultan Chand)-2014
6. Mathematical Physics B.D.Gupta (4<sup>th</sup> edition, Vikas Publication)-2009
- 7.

### CC-VIII LAB 20 clases (2 hrs. duration each)

Scilab based simulations (XCos) experiments based on Mathematical Physics problems like

☐ Solve Simple Differential Equations like  $\frac{dy}{dx}$

$=e^x$ , with  $y(x=0)=0$

$\frac{dy}{dx} + e^x = x$ , with  $y(x=0)=0$

$\frac{dy}{dx} + 2y = -y$ , with  $y(x=0)=0$ ,  $y(x=0)=1$

$\frac{d^2y}{dx^2} - x \frac{dy}{dx} = \dots$

$\frac{d^2y}{dx^2} + 2y = -y$ , with  $y(x=0)=0$ ,  $y(x=0)=1$

$\frac{dy}{dx}$

☐ Direct Delta Function



Evaluate  $\int_{-3}^3 dx \frac{(x+3)}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-2)^2}{2\sigma^2}}$ , for  $\sigma = 0.1, 0.01, 0.001$  and show that it tends to 5.

• **Fourier Series:**

Program to sum

Evaluate the Fourier coefficients of a given periodic function (square wave)

• **Frobenius method and Special functions:**

$$\int_{-1}^1 d\mu P_n(\mu) P_m(\mu) = \frac{2}{2n+1} \delta_{m,n}$$

Plot  $P_n(x)$ , Legendre polynomial of degree  $n$ , and  $J_n(x)$ , Bessel function of first kind.

Show recursion relation

• Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

• Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

• Evaluation of trigonometric functions e.g.  $\sin \theta$ , Given Bessels function at N points find its value at an intermediate point.

Complex analysis: Calculate  $\int \frac{dx}{(x^2+2)}$  and check it with computer integration.

• Integral transform: FFT of  $e^{-x^2}$

**Reference Books:**

1. Mathematical Methods for Physics and Engineers, K.F • Riley, M.P.Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, • P.Dennery and .Krzywicki,1967,DoverPublications
3. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB:• Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernandez. 2014 Springer ISBN: 978-3319067896
4. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444.
5. Scilab(A free software to matlab):H.Ramchandran, A.S.Nair. 2011 S. • Chand and Company
6. Scilab Image Processing: Lambert M. Surhone. 2010 Beta script Publishing

## CC-IX ELEMENTS OF MODERN PHYSICS

### UNIT- I

**Atomic Spectra and Models:** Inadequacy of classical physics, Brief Review of Black body Radiation, Photoelectric effect, Compton Effect, dual nature of radiation wave nature of particles, Atomic spectra, Line spectra of hydrogen atom, Ritz Rydberg combination principle, Alpha Particle Scattering, Rutherford Scattering Formula, Rutherford Model of atom and its limitations.

**Atomic Model:** Bohrs Model of Hydrogen atom, explanation of atomic spectra, correction for finite mass of the nucleus, Bohr correspondence principle, limitations of Bohr model, discrete energy exchange by atom, Frank Hertz Experiment, Sommerfelds modification of Bohr's Theory.

### UNIT- II

**Wave Packet:** superposition of two waves, phase velocity and group velocity, wave packets, Gaussian Wave Packet, spatial distribution of wave packet, Localization of wave packet in time, Time development of a wave packet, Wave Particle Duality, Complementarity.

**Wave Particle Duality:** de Broglie hypothesis, Experimental confirmation of matter wave, Davisson Germer Experiment, velocity of deBroglie wave, wave particle duality, Complementarity.

**Uncertainty Principle:** Heisenberg Uncertainty Principle, Illustration of the Principle through thought Experiments of Gamma ray microscope and electron diffraction through a slit, Estimation of ground state energy of harmonic oscillator and hydrogen atom, non existence of electron in the nucleus, Uncertainty and complementarities.

**UNIT- III Nuclear Physics- I:** Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle, Nature of the nuclear force, NZ graph, Liquid Drop model: semi empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

## UNIT- IV

**Nuclear Physics- II:** Radioactivity, stability of the nucleus, Law of radioactive decay, Mean life and Half life Alpha decay, Beta decay-energy released, spectrum and Paulis prediction of neutrino, Gamma ray emission energy-momentum conservation: electronpositron pair creation by gamma photons in the vicinity of a nucleus, Fission and fusion mass deficit, relativity and generation of energy, Fission- nature of fragments and emission of neutrons, Nuclear reactor: slow neutron interacting with Uranium 235, Fusion and thermo nuclear reactions driving stellar energy (brief qualitative discussion).

### Text Books:

1. Concepts of Modern Physics Arthur Beiser (McGraw Hill)-2002
2. Modern Physics Murugeshan and Sivaprasad (S.Chand) 18<sup>th</sup> Edition 2016

### Reference Books:

1. QuantumMechanics:TheoryandApplications,A.K.GhatakandS.Lokanathan, (Macmillan)2004
2. Introduction to Quantum Theory, David Park (Dover Publications)-1974
3. Theory and Problems of Modern Physics, Schaum's outline, R.Gautreau and W.Savin- (Tata McGraw-Hill) 2<sup>nd</sup> Edition
4. Physics for scientists and engineer with Modern Physics-Jewell and Serway - (CENGAGE Learnings) 2010.
5. Modern Physics of Atoms and Molecules Bransden and Joachim (Pearson India)-2003
6. Atomic and Nuclear Physics-A.B.Gupta (New Central)-2009
7. Theoretical Nuclear Physics , J.M.Blatt and V.F. Weisskof (Springer)-2003

### CC-IX LAB

**(minimum 4 experiments are to be done):**

1. To show the tunneling effect in tunnel diode using I-V characteristics.
2. To determine the wavelength of laser source using diffraction of single slit.
3. To determine the wavelength of laser source using diffraction of double slits.
4. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.
5. To determine the Plancks constant using LEDs of at least 4 different colours.
6. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
7. To setup the Millikan oil drop apparatus and determine the charge of an electron.

## Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, • Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, • 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text • Books Book of Practical Physics, I. Prakashand Ramakrishna, 11th Edn, 2011, Kitab Mahal

## CC-X

### DIGITAL SYSTEMS AND APPLICATIONS

#### UNIT-I

**Integrated Circuits (Qualitative treatment only):** Active and 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 ICs.

**Digital Circuits:** Difference between Analog and Digital Circuits, Binary Numbers, Decimal to Binary and Binary to Decimal Conversation, BCD, Octal and Hexadecimal numbers, AND, OR and NOT. Gates (realization using Diodes and Transistor), NAND and NOR Gates as Universal Gates, XOR and XNOR Gates and application as Parity Checkers.

#### UNIT-II

**Boolean algebra:** De Morgans Theorems: Boolean Laws, Simplification of Logic Circuit using Boolean Algebra, Fundamental Products, Idea of Minterms and Maxterms, Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

**Introduction to CRO:** Block Diagram of CRO, Electron Gun, Deflection system and Time Base, Deflection Sensitivity,

**Applications of CRO:** (1) Study of Wave Form, (2) Measurement of Voltage, Current, Frequency and Phase Difference.

#### UNIT-III

**Data Processing Circuits:** Basic Idea of Multiplexers, De-multiplexers, Decoders, Encoders.

**Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2s complement. Half and Full Adders. Half and Full Subtractors, 4 bit binary Adder/ Subtractor. **Timers: IC 555:** block diagram and application is Astable multivibrator and Monostable multivibrator.

#### UNIT-IV

**Introduction to Computer Organization:** Input/output Devices, Data storage (idea of RAM and ROM), Computer memory, Memory organization and addressing, Memory Interfacing, Memory Map.

**Shift registers:** Serial-in-serial-out, Serial-in-Parallel-out, Parallel-in-Serial- out and Parallel-in-Parallel-out. Shift Registers (only up to 4 bits)

**Counters (4 bits):** Ring Counter, Asynchronous counters, Decade Counter. Synchronous Counter.

**Text Books:**

1. Foundation of Electronics-Rakshit Chattopadhaya (New Age) -2015
2. Digital Circuits and Logic design: Samuel C. Lee( Printice Hall)-1976
3. Digital Principles and Applications - A.P. Malvino, D.P.Leach and Saha (Tata McGraw)- 7<sup>th</sup> Edition 2011

**Reference Books:**

1. The Art of Electronics by Paul Horowitz and Wilfield Hill ,Cambridge University - 2006
2. Electronics by Allan R. Hambley, Prentice Hall - 1994
3. Digital Logic and Computer design M. Morris Mano (Pearson) -2016
4. Concepts of Electronics D.C.Tayal (Himalaya Publishing house) -2018

**CC-X LAB**

**( minimum 6 experiments are to be done):**

1. Student should know how to measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to test a Diode and Transistor using a Millimeter.
2. To design a switch (NOT gate) using a transistor.
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. Half Adder, Full Adder and 4-bit binary Adder.
5. Half Subtractor, Full Subtractor, Adder- Subtractor using Full AdderI.C.
6. To build Flip-Flop(RS,Clocked RS,D- type and JK) circuits using NAND gates.
7. To design an stable multivibrator of given specifications using 555Timer.
8. To design a monostable multivibrator of given specifications using 555 Timer.

**Reference Books:**

1. Basic Electronics: A Text Books lab manual, P.B. Zbar, A.P. Malvino,•
2. M.A. Miller, 1994, Mc-Graw Hill.
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition,• 2000, Prentice Hall.
4. Electronic Principle, Albert Malvino, 2008, • Tata Mc-Graw Hill. •  
Electronic Devices and circuit Theory, R.L.Boylestad and L.D. Nashelsky, 2009, Pearson

## CC-XI

# QUANTUM MECHANICS AND APPLICATIONS

### UNIT- I

**Schrodinger equation** : Time dependent Schrodinger equation , Properties of Wave Function, Interpretation of wave function, Probability and probability current densities in three dimensions, Conditions for Physical Acceptability of Wave Function, Normalization, Linearity and Superposition Principles. Wave function of a free particle ,Wave Packet, Fourier Transform and momentum space Wave function  
,Spread of Gaussian Wave packet, Evolution with time, Position and Momentum Uncertainty.

### UNIT-II

**Operators:** Operators, Commutator Algebra, Position, Momentum Angular Momentum and Energy operators, Hermitian Operators, Expectation values of position and momentum, Ehrenfest Theorem, Eigenvalues and Eigen functions of Hermitian Operator, Energy Eigen Spectrum, Degeneracy, Orthonormality of Eigen functions, Linear Dependence.

Orthogonalisation.

### UNIT-III

Time Independent Schrodinger equation in one dimension (1d), 2d and 3d, Hamiltonian, stationary states and energy eigen values, expansion of an arbitrary wave function as a linear combination of energy eigen functions, General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states. General Discussion of Bound states in an arbitrary potential: Continuity of wave function, Boundary condition and emergence of discrete energy levels, Application to one dimensional problem-Square well potential, Quantum mechanics of simple Harmonic Oscillator-Energy Levels and energy eigen functions, ground state, zero point energy and uncertainty principle, One dimensional infinitely rigid box energy eigen values and eigen functions, normalization, quantum dot as example, Quantum mechanical scattering and tunnelling in one dimension across a step potential and rectangular potential barrier.

### UNIT-IV

**Atoms in Electric and Magnetic Fields:** Electron angular momentum. Space quantization, Electron Spin and Spin Angular Momentum, Larmors Theorem, Spin Magnetic Moment, Stern Gerlach Experiment, Vector Atom Model, L-S and

J-J coupling, Zeeman Effect, Electron Magnetic Moment and Magnetic Energy, Gyro magnetic Ratio and Bohr Magnet on Atoms in External Magnetic Fields:- Normal and Anomalous Zeeman Effect, Paschenback and Stark Effect  
(qualitative Discussion only)

**Text Books:**

1. Introduction to Quantum Theory, D. J. Griffiths(Pearson)-2015
2. Introduction to Quantum Theory David Park (Dover Publications)-1974

**Reference Books :**

1. Quantum Mechanics, Theory and applications A. Ghatak and S. Lokanathan (McMillan India)-2004
2. Quantum Mechanics-G.Aruldas (Printice Hall of India)-2008
3. Quantum Physics–S. Gasiorowicz (Wiley)-2007
4. Quantum Mechanics -J.L. Powell and B. Craseman (Narosa)-1998
5. Introduction to Quantum Mechanics M.Das and P.K.Jena (Shri Krishna Publication)-2006

**CORE PAPER- XI LAB**

*Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like (Use finite difference method, matrix method, ODE Solver method in all cases)*

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

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

where m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is  $\sim -13.6\text{eV}$ . Take  $e = 3.795\sqrt{(eV\text{\AA})}$ ,  $\hbar c = 1973(eV\text{\AA})$  and  $m = 0.511 \times 10^6 eV/c^2$

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

$\frac{d^2y}{dr^2} = A(r)u(r)$ ,  $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ , 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 wave function. Take  $e = 3.795\sqrt{(eV\text{\AA})}$ ,  $\hbar c = 1973(eV\text{\AA})$  and  $m = 0.511 \times 10^6 eV/c^2$ , and  $a = 3\text{\AA}, 5\text{\AA}, 7\text{\AA}$ . 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:

$\frac{d^2y}{dr^2} = A(r)u(r)$ ,  $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ , for the anharmonic oscillator potential:  $V(r) = \frac{kr^2}{2} + \frac{br^3}{3}$ .

Find the ground state energy (in MeV) of the particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose  $m = 940\text{MeV}/c^2$ ,  $k = 100\text{MeV}/\text{fm}^2$ ,  $b = 0, 10, 30\text{MeV}/\text{fm}^3$ . In these Units,  $c = 197.3 \text{ MeV fm}$ . [The ground state energy is 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:  $\frac{d^2y}{dr^2} = A(r)u(r)$ ,  $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ , where  $m$  is the reduced mass of the two-atom system for the Morse potential  $V(r) = D(e^{-2\alpha r} - e^{-\alpha r})$ , where  $r = r - r_0$ . Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave functions for the choices given below:

a)  $m = 940 \times 10^6 \text{ eV}/c^2$ ,  $D = 0.755501 \text{ eV}$ ,  $\alpha = 1.44$ ,  $r_0 = 0.131349 \text{ \AA}$

b)  $m = 940 \times 106 \text{ eV}/c^2$ ,  $D = 0.755501 \text{ eV}$ ,  $\alpha = 1.44$ ,  $r_0 = 0.131349 \text{ \AA}$

### Laboratory Based Experiments : (to be taken up depending on availability of equipment)

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyper fine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs

### Reference Books:

1. Schaum's• outline of Programming with C++.  
J.Hubbard,2000,McGraw– Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al.,• 3rd Edition., 2007, Cambridge University Press.
3. An introduction to computational Physics, T. Pang, 2nd Edn.,2006,• Cambridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB:• Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernandez.2014 Springer.
5. Scilab (A • Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011S. Chand and Co.
6. Scilab Image Processing: L.M.Surhone.2010 Beta script Publishing • ISBN:9786133459274



## CC-XII

### SOLID STATE PHYSICS

#### UNIT-I

**Crystal Structure:** Solids, Amorphous and Crystalline Materials, Lattice translation Vectors, Lattice with a Basis. Central and Non-Central Elements. Unit Cell, Miller Indices, Types of Lattices, Reciprocal Lattice, Brillouin zones, Diffraction of X-rays by crystals, Bragg Law, Atomic and Geometrical Factor

#### UNIT-II

**Elementary Lattice Dynamics:** Lattice Vibrations and Phonons: Linear, Monatomic and Diatomic Chains, Acoustical and Optical Phonons, Qualitative Description of the phonon spectrum in solids, Dulong and Petits Law, Einstein and Debye theories of specific heat of solids,  $T^3$  Law

**Magnetic Properties of Matter:** Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevins theory of dia and Paramagnetic Domains, Curies law, Weiss Theory of Ferro magnetism and Ferro magnetic Domains, Discussion of B-H Curve, Hysteresis and Energy Loss.

#### UNIT-III

**Dielectric Properties of Materials:** Polarization Local Electrical Field at an Atom, Depolarization Field, Electric Susceptibility, Polarizability, Clausius Mosotti Equation, Classical theory of Electronic Polarizability.

**Lasers:** Einsteins A and B coefficients, Meta stable States, Spontaneous and Stimulated emissions, Optical Pumping and population Inversion, Three Level and Four Level Lasers, Ruby Laser and He-Ne Laser.

#### UNIT-IV

**Elementary band theory:** Kronig-Penny model of band Gap, Conductor, Semiconductor (P and N type) and insulator, Conductivity of Semiconductor, mobility, Hall Effect, Measurement of conductivity (04 problem method) and Hall Coefficient.

**Superconductivity:** Experimental Results, Critical Temperature, Critical magnetic field, Meissner effect, Type I and type II Superconductors, Londons Equation and Penetration Depth, Isotope effect, Idea of BCS theory (No derivation)

**Text Books:**

1. Introduction to Solid State Physics- Charles Kittel (Wiley India) 8<sup>th</sup> Edition 2012
2. LASERS: Fundamentals and Applications-Thyagarajan and Ghatak (McMillan India)-2011

**Reference Books:**

1. Solid State Physics-N. W. Ashcroft and N.D. Mermin(Cengage)-2003
2. Solid State Physics- R.K.Puri and V.K. Babbar (S.Chand Publication)-2010
3. Solid State Physics S. O. Pillai (New Age Publication)-2008
4. Lasers and Non linear Optics B.B.Laud (Wiley Eastern)-2011
5. Elements of Solid State Physics-J.P. Srivastava (Prentice Hall of India)-2014
6. Elementary Solid State Physics-Ali Omar (Addison Wiley)-2002

**CC-XII LAB ( minimum 4 experiments are to be done)**

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube- Method)
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Materials and variation with frequency
4. To determine the Hall coefficient of a semiconductor sample.
5. To draw the BH curve of Fe using solenoid and to determine the energy loss from Hysteresis
6. To measure the resistivity and band gap of a given semiconductor by fourproblem method.
7. To study PE hysteresis loop of a ferroelectric crystal

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, • 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn,• 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Books Book of Practical Physics, I. Prakashand Ramakrishna, • 11 Ed., 2011, Kitab Mahal
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, • Prentice- Hall of India.

## CC-XIII ELECTROMAGNETIC THEORY

### UNIT-I

**Maxwell Equations:** 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, Electro- magnetic (EM) Energy Density, Physical Concept of Electromagnetic Field Energy 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, 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 and Refraction of plane waves at plane interface between two dielectric media, Laws of Reflection and Refraction, Fresnel's Formulae for perpendicular and parallel polarization cases, Brewster's law, Reflection and Transmission coefficients, Total internal reflection, evanescent waves, Metallic reflection (normal Incidence)

### UNIT IV

**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystal, Double Refraction, Polarization by Double Refraction, Nicol Prism, Ordinary and extraordinary refractive indices, Production and detection of Plane, Circularly and Elliptically Polarized Light,

**Phase Retardation Plates:** Quarter-Wave and Half- Wave Plates. Babinet's 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.

### Text Books:

1. Introduction to Electrodynamics, D.J. Griffiths ( Pearson)-2015
2. Principles of Optics- Max Born and E. Wolf- Cambridge University Press-1999

**Reference Books:**

1. Classical Electrodynamics by J.D. Jackson (Willey)-2007
2. Foundation of electromagnetic theory: Ritz and Milford (Pearson)-2008
3. Electricity and Magnetism : D C Tayal (Himalaya Publication)-2014
4. Optics : A.K.Ghatak (McGraw Hill Education)- 2017
5. Electricity and Magnetism: Chattopadhyaya, Rakhit (New Central)-2018

**CC-XIII LAB****( minimum 4 experiments are to be done):**

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 Babinets compensator.
4. To determine the refractive index of liquid by total internal reflection using Wollastonsair-film.
5. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eye piece.
6. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
7. To verify the Stefan's law of radiation and to determine Stefan's constant.
8. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
9. To determine wavelength and velocity of ultrasonic wave in liquid.

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop,• 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn,• 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text • Books Book of Practical Physics, I.Prakashand Ramakrishna, 11 Ed., 2011, Kitab Mahal Electromagnetic Field Theory for Engineers and Physicists, G. Lehner, 2010, Springer

**STATISTICAL MECHANICS**

**UNIT- I**

**Classical Statistics-I:** Macrostate and Microstate, Elementary Concept of Ensemble, Micro canonical, Canonical and Grand Canonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function.

**UNIT- II**

**Classical Statistics-II :** Thermodynamic Functions of an Ideal Gas, classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of equi partition of Energy (with proof)- Applications to Specific Heat and its Limitations, Thermodynamic Functions of a two energy levels system, Negative Temperature.

**UNIT-III**

**Quantum Statistics:** Identical particles, macrostates and microstates, Fermions and Bosons, Bose Einstein distribution function and Fermi- Dirac distribution function. Bose- Einstein Condensation, Bose deviation from Plancks law, Effect of temperature on Fermi-Dirac distribution function, degenerate Fermi gas, Density of States Fermi energy.

**UNIT-IV**

**Radiation:** Properties of Thermal Radiation, Blackbody Radiation, Pure Temperature dependence, Kirchhoffs law, Stefan Boltzmann law: Thermodynamic proof, Radiation Pressure, Weins Displacement law, Wiens distribution Law, Sahas Ionization Formula, Rayleigh Jeans Law, Ultra Violet catastrophe.

**Plancks Law of Black body Radiation:** Experimental verification, Deduction of (1) Wiens Distribution Law, (2) Rayleigh Jeans Law, (3) Stefan Boltzmann Law, (4) Weins Displacement Law from Plancks Law.

**Text Books:**

1. Introduction to Statistical Physics by Kerson Huang(Wiley).-2008
2. Statistical Physics ,Berkeley Physics Course, F.Reif (Tata McGraw-Hill)2017

**ReferenceBooks:**

1. Statistical Mechanics, B.K.Agarwal and Melvin Eisner (New Age Inter- national)-2013
2. Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Francis W.Sears and Gerhard L. Salinger (Narosa) 1998
3. Statistical Mechanics: R.K.Pathria and Paul D. Beale (Academic Press)- 2011

## CC-XIV LAB

Use C/C++/ Sci lab for solving the problems based on Statistical Mechanics like

1. Plot Plancks law for Black Body radiation and compare it with Weins law and find Wein's constant and Stefan constant
2. plot Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
3. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases
4. Plot Maxwell-Boltzmann distribution function
5. Plot Fermi-Dirac distribution function
6. Plot Bose-Einstein distribution function.

### Reference Books:

1. Elementary Numerical Analysis, K.E. Atkinson, 3rdEdn. 2007, Wiley • India Edition
2. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Edition, • 1996, Oxford University Press.
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, • Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, • 2009, Springer
5. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: • Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernandez. 2014 Springer ISBN: 978-3319067896
6. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444. •
7. Scilab Image Processing: L. M. Surhone. 2010, Betascript Pub., ISBN: 978- • 6133459274

# Discipline Specific Elective Paper-1

## CLASSICAL DYNAMICS

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

### UNIT-I

Generalised co-ordinates and Velocities, Generalised Force, Principle of virtual work Derivation of Lagranges equation of motion from D Alemberts Principles, Lagrangian and its Application to Simple, Compound and Double Pendulums, Single Particle in Space, At woods Machine, Dumbbell, Linear harmonic oscillator.

### UNIT-II

Hamiltons Principle, Calculus of Variation and derivation of Euler-Lagranges equation, Langranges Equations derived from Hamiltons Principles, Hamiltoian and its applications to Shortest Distance between two points in a plane, Geodesic Problem, minimum surface of revolution, Brachistochrone problem, The Equations of motion and first integrals, The equivalent one-dimensional problem and classification of orbits, canonical momenta, Hamiltons equations of motion, Motion of charged particles in external electric and magnetic fields, Applications to central force motion and coupled oscillators.

### 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, Times-dilation, length contraction and Twin paradox, Variation of mass with velocity mass energy relation

### UNIT- IV

**Four Vectors:** Space Like, Time-like and light-like. Four velocity and acceleration, Four momentum and energy-momentum relation. Doppler effects from a four vector perspective, Concept of four-force, Conservation of four momentum, Application to two body decay of an unstable particle

**Text Books:**

1. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko (Pearson) - 2012.
2. Classical Mechanics N C Rana and P S Joag.-2017

**Reference Books:**

1. Mechanics-D.S. Mathur (Sultan Chand)-2000
2. Solved problems in Classical Mechanics, O.L. Delange and J. Pierrus (Oxford Press)(2010)
3. Classical Mechanics-M. Das, P.K. Jena, M. Bhuyan, R.N. Mishra (Srikrishna Prakashan)-2009
4. Mathematical Physics with Classical Mechanics-Satya Prakash (Sultan Chand and sons)-2014
5. Introduction to classical dynamics R.K. Takwale and S. Puranik (Tata McGraw Hill)-2017
6. Classical Mechanics J.C. Upadhyay (Himalayan Publisher)-2017
7. Classical Dynamics of particles and systems -S.T. Thornton and Marion (Cengage publication)-2012

**Discipline Specific Elective Paper-1I****Nuclear and Particle Physics****UNIT-I**

**General properties of Nuclei:** Constituents of nucleus and their intrinsic properties, Quantitative facts about mass, radius, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment electric moments, nuclear excited states.

**Radioactivity decays:** (a) Alpha decay: basics of alpha-decay processes, theory of alpha-emission, Gamow factor, Geiger Nuttall law (b) beta-decay: energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis.

(c) Elementary idea of Gamma decay.

**UNIT-II**

**Nuclear Models:** Liquid drop model approach, semi empirical mass formula and significance of its various terms, conditions of nuclear stability, two nucleon separation energies, evidence for nuclear shell structure, nuclear magic number, basic assumption of shell models.



### UNIT-III

**Detector for nuclear radiations:** Detector for nuclear radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic Principle of Scintillation Detectors and Construction of photomultiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge Particle and photo detection (Concept of charge carrier and mobility), neutron detector. **Particle Accelerators:** Van-de Graff generator (Tandem Accelerator), Linear accelerator, Cyclotron, Synchrotrons

### UNIT-IV

**Particle Physics:** Particle interactions, basic features, types of particles and its families, **Symmetries and conservation laws:** Energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, strangeness and charm, Elementary ideas of quarks and gluons.

#### Text Books:

1. Introduction to Nuclear Physics By Roy and Nigam-2014
2. Atomic and Nuclear Physics- N.Subramanyam, Brij Lal and Jivan Seshan (S. Chand Publishing)-2007

#### Reference Books:

1. Introduction to Modern Physics- H.S.Mani and G.K. Mehta(Affiliated east and west) - 2018
2. Introductory nuclear Physics-Kenneth S. Krane (Wiley India Pvt. Ltd)-1987
3. Introduction to Elementary Particles-D. Griffith (John Wiley and Sons)-2008
4. Concepts of Nuclear Physics - Bernard L. Cohen. (Tata Mcgraw Hill). 2017
5. Concepts of Modern Physics-Arthur Beiser ( McGraw Hill)-2017

### Discipline Specific Elective Paper- III

#### Nano Materials and Applications

### UNIT-I

**Nanoscale Systems:** Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, size effects in nano systems, Quantum confinement Applications of Schrodinger equation-infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructure and its consequences.

## **UNIT-II**

**Synthesis of Nanostructure Materials:** Top down and bottoms up approach, Photo lithography Ball milling. Gas phase condensation, Vacuum deposition, Physical vapour deposition (PVT): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition, Chemical vapour deposition (CVD), Sol-Gel Electrodeposition, Spraypyrolysis, Hydrothermal synthesis, Preparation through colloidal methods, MBE growth of quantum dots.

## **UNIT-III**

**Characterization:** X-Ray Diffraction, Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy

## **UNIT-IV**

**Applications:** Applications of nano particles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron devices (no derivation). CNT based transistors. Nonmaterial Devices: Quantum dots hetero structure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS)

### **Text Books:**

1. S.K. Kulkarni, Nanotechnology: Principles and Practices (Capital Publishing Company)-3<sup>rd</sup> Edition 2014
2. Nano science and nano technology, K.K. Choudhary (Narosa)-2016

### **Reference Books:**

1. Nano Science and nano technology, Sundar Singh (Pragati Prakashan)-2017
2. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.)-2007
3. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons)-2005
4. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007)
5. K.K. Chattopadhyaya and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited)-2009

## Discipline Specific Elective Paper-1V Project

OR

### Basic Instrumentation

#### Basic Instrumentation

##### 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.

**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 mill voltmeter:** Type of AC mill voltmeters: Amplifier- rectifier, and rectifier amplifier. Block diagram ac mill voltmeter, specifications and their significance.

##### UNIT-II

**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 and 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-III

**Signal Generators and Analytical 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-IV

**Digital Instruments:** Principle and working of digital meters, Comparison of analog and digital instruments, Characteristics of a digital meter, Working principles of digital voltmeter.

**Digital Multimeter:** 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.

The test of lab skills will be of the following test items:

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,
6. Winding a coil /transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

**Laboratory 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 voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/universal bridge.

**Open Ended Experiments:**

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter) More emphasis should be given on hands-on experiments.

**Text Books:**

1. A Text Books book of electrical technology-B.L.Theraja and A.K. Theraja (S. Chand Publishing)-2014
2. Digital circuits and systems Venugopal (Tata McGraw Hill)-2011

**Reference Books**

:

1. Digital Electronics-Subrata Ghoshal (Cengage Learning)-2017
2. Electronic Devices and circuits - S. Salivahanan and N. S.Kumar (Tata Mc-Graw Hill)-2012
3. Electronic Devices-Thomas L. Floyd (Pearson)-2015

**Additional Reference Books for Practical papers:**

1. An advanced course in Practical Physics- Chattopadhyay, RakshitCentral-2013
2. Practical Physics-B.B.Swain (Kitab Mahal)-2014
3. Advanced practical Physics-B.Ghosh and KG Majumdar (Vol. I and II)Shreedhar Publication-2004
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal (Vani Publication)-1985
5. B.Sc. Practical Physics- C.L.Arora (S.Chand Publishing)-2010
6. B.Sc. Practical Physics H. Singh and P.S. Hemne (S. Chand Publishing)-2002

(For the student who obtained 2 GE Subject of 2 Papers each)

**GENERIC ELECTIVE**

**GE Paper I/ GE A Paper I/ GE B paper I**

**(Mechanics and Properties of matter, Oscillation and Waves, Thermal Physics, Electricity and Magnetism and Electronics**

**UNIT-I :Mechanics and Properties of Matter**

Moment of Inertia Parallel axis and perpendicular axis theorem, M.I. of a Solid sphere and Solid cylinder, Gravitational potential and field due to a thin spherical shell and a solid sphere at external points and internal points, Relation among elastic constants, depression at free end of a light cantilever, Surface tension, pressure, difference across a curved membrane, viscous flow, Poiseuille's formula.

**UNIT-II :Oscillation and Waves**

Simple harmonic motion, damped harmonic motion, under damped, over damped and critically damped motion, Forced vibration, Resonance, Wave equation in a medium, Velocity of Longitudinal waves in an elastic medium and velocity of transverse wave in a stretched string, Composition of SHM, Lissajous figures for superposition of two orthogonal simple harmonic vibrations (a) with same frequency, (b) frequency with 2:1.

**UNIT-III :Thermal Physics**

Entropy, change in entropy in reversible and irreversible process, Carnot engine and its efficiency. Carnot Theorem, Second law of thermodynamics, Kelvin-Planck, Clausius formula. Thermal conductivity, differential equation for heat flow in one dimension, Maxwell thermodynamic relation (statement only), Clausius Clapeyron equation, Black body radiation, Planck radiation formula (No derivation).

**UNIT-IV :Electricity and Magnetism**

Gauss law of electrostatics, use of Gauss law to compute electrostatic field due to a linear charge distribution, Magnetic induction B, Lorentz force law, Biot Savart's law, Magnetic induction due to long straight current carrying conductor, and in the axis of a current carrying circular coil, Amperes Circuital law, its differential form, The law of electromagnetic equations, its differential and integral form, Maxwells electro-magnetic equations and their physical significance, Growth and decay of currents in LR and RC circuits, time constant, alternating currents in RC, RL and LCR circuits, impedance, power factor, resonance.

P-type and N-type semiconductors, PN-Junction as rectifier, Half wave and Full wave rectifiers (Bridge type), efficiency, ripple factor, use of RC, LC, and filters, working of PNP and NPN transistors, transistor configurations in CE and CB circuits and relation between  $\alpha$  and  $\beta$ . JFET, its operation and characteristics of  $V_I$  curve.

**Text Books:**

1. Elements of Properties of Matter D.S. Mathur (S. Chand Publication)-2010
2. Heat and Thermodynamics A.B. Gupta and H.B. Ray (New Central Book Agency)-2010
3. A Text Books book of oscillations, waves and acoustics(5thed.)M. Ghosh and D. Bhattacharya (S. Chand Publication)-2018
4. Electricity and magnetism- R. Murugesan (S.Chand publishing)-2017
5. Fundamentals of Electronics-Raskhit and Chattopadhyay (New age International Publication)-2018

**Reference Books:**

1. Physics of Degree students Vol.I M. Das, P.K. Jena etal (Sri krishna Prakashan)-2006
2. Physics of Degree students Vol.II M. Das, P.K. Jena etal (Sri krishna Prakashan)2006
3. Waves and Oscillations (2nd ed) N. Subramaniam and Brij Lal (Vikas Publications)-1994
4. A Text Books book of Sound (2nd ed) - N. Subramaniam and Brij Lal (S. Chand Publications)-1999

**Generic Elective Paper I Lab- ( minimum 6 experiments are to be done)**

1. To determine the moment of inertia of a fly wheel.
2. To determine the Young's modulus  $Y$  of a wire by Searl's method.
3. To determine the modulus of rigidity of a wire by Maxwell's needle/Torsion Pendulum (Dynamic method).
4. To determine  $g$  by bar pendulum.
5. To determine the value of  $Y$  of a rubber by using travelling microscope.
6. To determine the Rigidity of modulus by static method.
7. To determine the frequency of a telescope by using Sonometer.
8. Verification of Laws of Vibration of a string by using Sonometer.
9. To compare capacitances using De Sauty bridge.
10. To determine the Law of resistance by using Foster bridge.
11. Compare the specific heat of two liquids by method of Cooling.

**Reference Books:**

1. Advanced Practical Physics for students, B.L. Flintand H.T.Worsnop, 1971, Asia Publishing House
2. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal (1985), Vani Publication
3. A Text Books of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition (2011), Kitab Mahal, NewDelhi

(For the student who obtained 2 GE Subject of 2 Papers each)

**GENERIC ELECTIVE**  
**GE Paper II/ GE A Paper II/ GE B paper II**

**(Optics, Special Theory of Relativity, Atomic Physics, Quantum Mechanics and Nuclear Physics)**

**UNIT-I:Optics-I**

Elementary ideas of monochromatic aberrations and their minimization, chromatic aberration, achromatic combination, Theory of formation of primary and secondary rainbow, condition of interference, coherent sources, Young's double slit experiment, biprism and measurement of wave length of light of by it, color of thin films and Newton's rings, Fresnel and Fraunhofer diffraction, diffraction by single slit plane transmission grating.

**Optics-II :** Electromagnetic nature of light, polarized and unpolarized light, polarization by reflection and refraction, Brewster's Law, Malus Law, Double refraction, Ordinary and extraordinary rays.

**UNIT-II: Atomic Physics**

Inadequacy of classical physics, brief outline of Rayleigh Jeans theory and Planck's quantum theory of radiation, particle nature of electromagnetic radiation photo electric effect, Compton effect, dual nature of radiation, wave nature of particles, deBroglie hypothesis, matter wave, wave-particle duality, Davisson- Germer experiment.

Bohr's theory of Hydrogen atom, explanation of Hydrogen Spectra, correction for finite mass of the nucleus, Bohr's correspondence principle, limitations of Bohr's theory, Discrete energy, exchange by atom Frank Hertz experiment.

**UNIT-III :Quantum Mechanics**

Heisenberg's Uncertainty relation, Time dependent Schrodinger's wave equation in one dimension and three dimensions, The physical interpretation of the wave function, Probability density and probability current density, Equation of continuity, Normalization of the Wave function, Expectation value of an observable, Ehrenfest's theorem. Time independent Schrodinger's wave equation in one dimension particle in a box, energy eigen values and eigen functions.

**UNIT-IV:Nuclear Physics**

Properties of the nucleus Charge, Size, Spin, Magnetic Moment, Mass, Mass defect, Binding energy, Packing fraction, Nuclear force and its characteristics features, Radioactive decay laws, average life, half life, nuclear fission, nuclear fusion, Linear accelerators, and cyclotron.

**Relativity:** Galilean transformation, Newtonian relativity and its limitation, Michelson Morley experiment and its consequence, postulates of special theory of relativity. Lorentz transformation, length contraction, time dilation, relativistic mass and momentum, mass energy relation.

**Text Books:**

1. University Physics, H. D. Young, R. A. Freedman (Person)-2017
2. Fundamentals of Physics, Resnick, Halliday, Walker (Wiley)-2015

**Reference Books:**

1. A Text Books book of Optics N. Subrahmanyam and Brij Lal (S.Chand Publishing)2006
2. Introduction to Special Relativity-R. Resnick (John Wiley)-2007
3. Concepts of Modern Physics Arthur Beiser (McGraw Hill)-2017
4. Modern Physics H.S. Mani and G.K.Mehta-2018.

---

**Generic Elective Paper II LAB**

**(minimum 6 experiments are to be done):**

1. Determination of E.C.E. of a Copper by taking 3 readings.
2. Determination of Refractive index of the material of a prism using Sodium light.
3. To determine the wavelength of light using plane diffraction grating.
4. To determine the wavelength of light using Newton's ring.
5. Determination of refractive index of (a) glass and (b) liquid by using travelling microscope.
6. To plot the I-D curve and to determine the refractive index of a prism
7. Determination of radius of curvature of a convex/concave mirror by using Kohlrausch's method.
8. To determine the magnifying power of a given telescope.
9. To Obtain the static characteristics of a P-N-P/N-P-N transistor/ Triode Valve.
10. To determine the reduction factor of a tangent Galvanometer.
11. To study the Variation of magnetic field along the axis of a circular coil carrying current.

**Reference Books:**

1. Advanced Practical Physics for students, B.L.Flint and H.T. Worsnop, (1971), Asia Publishing House
2. A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal (1985), Vani Publication
3. A Text Books of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition (2011), Kitab Mahal, New Delhi



(For the student who obtained One GE Subject of Physics with 4 papers)

## GENERIC ELECTIVE

### GE-1

## MECHANICS

### UNIT-I

**Rotational Dynamics:** Centre of Mass, Motion of CM, Centre of Mass and Laboratory frames. Angular momentum of a particle and system of particles. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Perpendicular and Parallel Axis Theorems, Routh Rule, Calculation of moment of inertia for cylindrical and spherical bodies. Kinetic energy of rotation. Euler's Equations of Rigid Body motion, Motion involving both translation and rotation. Moment of Inertia of a Flywheel

**Non Inertial frames and fictitious Forces:** Uniformly Rotating frame, laws of Physics in rotating Coordinate system, centrifugal Forces, Coriolis force and its applications.

### UNIT-II

**Gravitation:** Newton's Law of gravitation. Gravitational field Intensity and Potential, Potential and field Applications.

**Central Force:**

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. Differential Equation of motion with central force and its solution. The first Integrals (two), Concept of power Law Potentials, Kepler's Laws of Planetary motion.

Satellites: Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

Physiological effects on astronauts.

### UNIT-III

**Elasticity:** Relation between Elastic constants. Torsion of a right circular cylinder, torsional wire, Bending of Beams, External Bending Moment, flexural rigidity, single Cantilever, double cantilever (weightless cantilever, and with its own weight)

**Fluid Properties:**

**Surface Tension-** Excess Pressure across a curved membrane, S.T., Quincke's drop, gravity waves and ripple,

**Viscosity:** Poiseuille's Equation for Flow of a Liquid with corrections.

### Unit-IV

**Oscillations:** Simple Harmonic Oscillations. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Equation of motion and solution, (cases of oscillatory, critically damped and over damped) Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. Bar Pendulum, Kater's Pendulum. Composition of two SHMs propagating perpendicularly to each other (with frequency in the ratio 1:1, 2:1) Lissajous figures

**Text Books:**

1. Mechanics, D.S. Mathur (S. Chand Publishing )-2010
2. Introduction to Special Relativity-R. Resnick (John Wiley)-2007

**Reference Books :**

1. Mechanics, Berkeley Physics, vol.1, C.Kittel, W. Knight, etal (Tata McGraw-Hill)2017
2. Physics, Resnick- Halliday and Walker (8/e. 2008,Wiley)
3. Schaum's outline of theoretical Mechanics-M.R. Spiegel (Tata McGraw Hill)-1980
4. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands ( Pearson)-2012
5. Mechanics-M.Das, P.K.Jena and R.N. Mishra (Srikrishna Publications)

**GE-I LAB ( minimum 6 experiments are to be done)**

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

**Reference Books**

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

(For the student who obtained One GE Subject of Physics with 4 papers)

## GENERIC ELECTIVE

### GE-II

## ELECTRICITY, MAGNETISM AND EMT

### UNIT-I

**Vector Analysis:** Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

**Electrostatics:** Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential.

### UNIT-II

Electrostatic Energy 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-III

#### **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.

**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.

**Text:**

1. Introduction to Electricity and Magnetism – D.C.Tayal (Himalaya Publishing house)-2014

**References:**

1. Electricity, Magnetism & Electromagnetic Theory- S. Mahajan and Choudhury ( Tata McGraw Hill)-2017
2. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands ( Pearson)-2012
3. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I (Oxford Univ. Press)2016
4. Foundations of Electromagnetic Theory-Ritz and Milford (Pearson)-2008

**GE-II LAB ( minimum 6 experiments are to be done)**

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
  - (i) Measurement of charge and current sensitivity
  - (ii) Measurement of CDR
  - (iii) Determine a high resistance by Leakage Method
  - (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine  $\frac{dB}{dx}$ )
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

**Reference Books:**

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

(For the student who obtained One GE Subject of Physics with 4 papers)

## GENERIC ELECTIVE

### GE-III

#### THERMAL PHYSICS AND STATISTICAL MECHANICS

##### UNIT-I :Laws of Thermodynamics

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

**Thermodynamical Potentials:** Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thomson Effect, Clausius- Clapeyron Equation, Expression for  $(CP - CV)$ ,  $CP/CV$ , TdS equations.

##### UNIT-II :Kinetic Theory of Gases

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

##### UNIT-III :Theory of Radiation

Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

##### UNIT-IV :Classical Statistical Mechanics

Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical, Canonical and grand canonical ensemble. Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox.

##### Text:

1. Thermal Physics, A. B. Gupta (Books and allied Ltd)-2010
2. Theory and experiments on thermal Physics, P.K.Chakrabarty (New central book agency limited)-2011

##### References:

1. Thermal and Statistical Physics – M.Das, P.K. Jena, S. Mishra, R.N.Mishra (Shri Krishna Publication)
2. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman (McGraw-Hill)2017
3. Thermal Physics, S. Garg, R. Bansal and Ghosh-(Tata McGraw-Hill)-2017
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics- Sears & Salinger (Narosa)-1998
5. A Treatise on Heat- Meghnad Saha and B.N.Srivastava (The Indian Press)-1973
6. Heat, Thermodynamics and Statistical Physics-- N.Subrahmanyam and Brij Lal (S.Chand Publishing)-2008

### **GE-III LAB ( minimum 6 experiments are to be done)**

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

#### **Reference Books:**

1. Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
3. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

(For the student who obtained One GE Subject of Physics with 4 papers)

## GENERIC ELECTIVE

### GE-IV

## WAVES AND OPTICS

### UNIT-I

**Geometrical optics:** Fermat's principle, reflection and refraction at plane interface, Matrix formulation of geometrical Optics. Idea of dispersion. Cardinal Points and cardinal planes of an optical system, location of cardinal points and cardinal planes of (1) thick lens(2) thin lens and (3) co axial combination of two thin lenses using matrix formulation.

Aberrations: Chromatic Aberration and remedy, Monochromatic Aberration: Spherical Aberration and remedy, Simple idea on Coma, Distortion, Astigmatism and Curvature and their

Remedy, Huygens eyepiece, Ramsden eye piece and their comparison.

### UNIT-II

**Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves.

Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves:

Ripple and Gravity Waves.

**Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front Huygens Principle. Temporal and Spatial Coherence

### UNIT-III

**Interference-I-** Division of amplitude and wave front. Young's double slit experiment.

Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment

### Interference-II:

Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

**Interferometer:** Michelson Interferometer-(1) Idea of form of fringes (No theory required), Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and Visibility of Fringes. Fabry- Perot interferometer. Fabry Perot etalon with theory. Applications Determination of wavelength (2) Wavelength difference of two sodium dlines.

### UNIT-IV

**Fraunhofer diffraction:** Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

**Fresnel Diffraction:** Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

### Text:

1. A text book of Optics – N. Subrahmanyam and Brij Lal (S.Chand Publishing)
2. Optics - Ajoy Ghatak (McGraw Hill)

**Reference:**

1. Optics-E.Hecht (Pearson)-4<sup>th</sup> Edition 2008
2. Fundamentals of Optics- F.A. Jenkins and H.E. White (McGraw-Hill)-2017
3. Geometrical and Physical Optics– R.S. Longhurst(Orient Blackswan)-1974
4. The Physics of Vibrations and Waves- H. J. Pain( John Wiley)-2006
5. Principles of Optics – B.K. Mathur, Gopal Printing-1964
6. Principles of Optics-Max Born and Emil Wolf (Cambridge University Press)-7<sup>th</sup> Edition 1999

**GE-IV LAB ( minimum 6 experiments are to be done)**

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

**Reference Books:**

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



## Course structure of UG Physics Pass

Framework of CBCS Syllabus for PHYSICS (Pass) from 2019-20					
Full Forms of Course Codes Used: DSC = Discipline Specific Core, AECC = Ability Enhancement Compulsory Course, SEC = Skill Enhancement Course, DSE = Discipline Specific Elective (Related to Core Subject), GE = Generic Elective					
<b>Total Marks: DSC (1200) + AECC (200) + SEC (400) + DSE (600) = 2400</b>					
Semester	DSC 12 Papers 100 x 12 = 1200	AECC 2 Papers 50 x 2 = 100	SEC 4 Papers 50 x 4 = 200	DSE 6 Papers 100 x 6 = 600	GE
I	DSC-A-I	AECC 1 MIL Communication			
	DSC-B-I				
	DSC-C-I				
II	DSC-A-II	AECC 2 Environmental Science			
	DSC-B-II				
	DSC-C-II				
III	DSC-A-III		SEC I (To be selected from the list of SEC courses)		
	DSC-B-III				
	DSC-C-III				
IV	DSC-A-IV		SEC II (To be selected from the list of SEC courses)		
	DSC-B-IV				
	DSC-C-IV				
V			SEC III (To be selected from the list of SEC courses)	DSE-A-I	
				DSE-B-I	
				DSE-C-I	
VI			SEC IV (To be selected from the list of SEC courses)	DSE-A-II	
				DSE-B-II	
				DSE-C-II	

Note: AECC and SEC Syllabi are meant for all. So they have been given separately.

DSE-A is the same subject as chosen for DSC-A

Similarly, DSE-B is the same subject as chosen for DSC-B and

DSE-C is the same subject as chosen for DSC-C

Semester	Course	Course Name	Credits	Total marks
<b>I</b>	DSC-I	Mechanics	04	75
	DSC-I	Practical	02	25
<b>II</b>	DSC-II	Electricity, Magnetism & EMT	04	75
	DSC-II	Practical	02	25
<b>III</b>	DSC-III	Thermal Physics & Statistical Mechanics	04	75
	DSC-III	Practical	02	25
<b>IV</b>	DSC-IV	Waves and Optics	04	75
	DSC-IV	Practical	02	25
<b>V</b>	DSE-I	Digital and Analog Circuits & Instrumentation	04	75
	DSE-I	Practical	02	25
<b>VI</b>	DSE-II	Elements of Modern Physics	04	75
	DSE-II	Practical	02	25
			<b>36</b>	<b>600</b>

### **PHYSICS PAPERS FOR PASS STUDENTS**

Discipline Specific Core – 4 papers

Discipline Specific Elective – 2 papers

Marks per paper –

Practical paper: Mid term : 15 marks, End term : 60 marks, Practical: 25 marks

For non practical paper: Mid term : 20 marks, End term : 80 marks

Total – 100 marks Credit per paper – 6

Teaching hours per paper –

Practical papers: 40 hours + 20 hours practical

Non practical papers: 50 hours + 10 hours tutorial

## Discipline Specific Core Paper 1

### MECHANICS

#### UNIT-I

**Rotational Dynamics:** Centre of Mass, Motion of CM, Centre of Mass and Laboratory frames.

Angular momentum of a particle and system of particles. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Perpendicular and Parallel Axis Theorems, Routh Rule, Calculation of moment of inertia for cylindrical and spherical bodies.

Kinetic energy of rotation. Euler's Equations of Rigid Body motion, Motion involving both translation and rotation. Moment of Inertia of a Flywheel

**Non Inertial frames and fictitious Forces:** Uniformly Rotating frame, laws of Physics in rotating Coordinate system, centrifugal Forces, Coriolis force and its applications.

#### UNIT-II

**Gravitation:** Newton's Law of gravitation. Gravitational field Intensity and Potential, .

Potential and field Applications.

#### Central Force:

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. Differential Equation of motion with central force and its solution. The first Integrals (two), Concept of power Law Potentials, Kepler's Laws of Planetary motion.

Satellites: Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.

#### UNIT-III

**Elasticity:** Relation between Elastic constants. Torsion of a right circular cylinder,

torsional wire, Bending of Beams, External Bending Moment, flexural rigidity, single

Cantilever, double cantilever (weightless cantilever, and with its own weight)

#### Fluid Properties:

**Surface Tension-** Excess Pressure across a curved membrane, S.T., Quincke's drop, gravity waves and ripple,

**Viscosity:** Poiseuille's Equation for Flow of a Liquid with corrections.

#### Unit-IV

**Oscillations:** Simple Harmonic Oscillations. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Equation of motion and solution, (cases of oscillatory, critically damped and over damped) Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. Bar Pendulum, Kater's Pendulum. Composition of two SHMs propagating perpendicularly to each other (with frequency in the ratio 1:1, 2:1) Lissajous figures

**Text Books:**

1. Mechanics, D.S. Mathur (S. Chand Publishing )-2010
2. Introduction to Special Relativity-R. Resnick (John Wiley)-2007

**Reference Books :**

1. Mechanics, Berkeley Physics, vol.1, C.Kittel, W. Knight, etal (Tata McGraw-Hill)2017
2. Physics, Resnick- Halliday and Walker (8/e. 2008,Wiley)
3. Schaum's outline of theoretical Mechanics-M.R. Spiegel (Tata McGraw Hill)-1980
4. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands ( Pearson)-2012
5. Mechanics-M.Das, P.K.Jena and R.N. Mishra (Srikrishna Publications)

**Discipline Specific Core Paper I LAB ( minimum****6 experiments are to be done)**

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

**Reference Books**

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

## Discipline Specific Core Paper-1I

### ELECTRICITY, MAGNETISM AND EMT

#### UNIT-I

**Vector Analysis:** Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

**Electrostatics:** Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential.

#### UNIT-II

Electrostatic Energy 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-III

##### **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.

**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.

**Text:**

1. Introduction to Electricity and Magnetism – D.C.Tayal (Himalaya Publishing house)-2014

**References:**

1. Electricity, Magnetism & Electromagnetic Theory- S. Mahajan and Choudhury ( Tata McGraw Hill)-2017
2. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands ( Pearson)-2012
3. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I (Oxford Univ. Press)2016
4. Foundations of Electromagnetic Theory-Ritz and Milford (Pearson)-2008

**Discipline Specific Core Paper II LAB**  
**( minimum 6 experiments are to be done)**

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
  - (i) Measurement of charge and current sensitivity
  - (ii) Measurement of CDR
  - (iii) Determine a high resistance by Leakage Method
  - (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit 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

**Reference Books:**

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

**Discipline Specific Core Paper III**  
**THERMAL PHYSICS AND STATISTICAL**  
**MECHANICS**

**UNIT-I :Laws of Thermodynamics**

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

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

**UNIT-II :Kinetic Theory of Gases**

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

**UNIT-III :Theory of Radiation**

Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

**UNIT-IV :Classical Statistical Mechanics**

Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical, Canonical and grand canonical ensemble. Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox.

**Text:**

1. Thermal Physics, A. B. Gupta (Books and allied Ltd)-2010
2. Theory and experiments on thermal Physics, P.K.Chakrabarty (New central book agency limited)-2011

**References:**

1. Thermal and Statistical Physics – M.Das, P.K. Jena, S. Mishra, R.N.Mishra (Shri Krishna Publication)
2. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman (McGraw-Hill)2017
3. Thermal Physics, S. Garg, R. Bansal and Ghosh-(Tata McGraw-Hill)-2017
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics- Sears & Salinger (Narosa)-1998
5. A Treatise on Heat- Meghnad Saha and B.N.Srivastava (The Indian Press)-1973
6. Heat, Thermodynamics and Statistical Physics-- N.Subrahmanyam and Brij Lal (S.Chand Publishing)-2008

## Discipline Specific Core Paper III LAB

( minimum 6 experiments are to be done)

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

1. Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
3. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.



## Discipline Specific Core Paper IV

### WAVES AND OPTICS

#### UNIT-I

**Geometrical optics:** Fermat's principle, reflection and refraction at plane interface, Matrix formulation of geometrical Optics. Idea of dispersion.

Cardinal Points and cardinal planes of an optical system, location of cardinal points and cardinal planes of (1) thick lens(2) thin lens and (3) co axial combination of two thin lenses using matrix formulation.

Aberrations: Chromatic Aberration and remedy, Monochromatic Aberration: Spherical Aberration and remedy, Simple idea on Coma, Distortion, Astigmatism and Curvature and their Remedy, Huygens eyepiece, Ramsden eye piece and their comparison.

#### UNIT-II

**Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

**Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front Huygens Principle. Temporal and Spatial Coherence

#### UNIT-III

**Interference-I-** Division of amplitude and wave front. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment

#### **Interference-II:**

Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

**Interferometer:** Michelson Interferometer-(1) Idea of form of fringes (No theory required), Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and Visibility of Fringes. Fabry- Perot interferometer. Fabry Perot etalon with theory.ApplicationsDetermination of wavelength (2) Wavelength difference of two sodium dlines.

#### UNIT-IV

**Fraunhofer diffraction:** Single slit. Circular aperture, Resolving Power of a telescope. Doubleslit. Multiple slits. Diffraction grating. Resolving power of grating.

**Fresnel Diffraction:** Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

**Text:**

1. A text book of Optics – N. Subrahmanyam and Brij Lal (S.Chand Publishing)

2. Optics - Ajoy Ghatak (McGraw Hill) **Reference:**

1. Optics-E.Hecht (Pearson)-4<sup>th</sup> Edition 2008
2. Fundamentals of Optics- F.A. Jenkins and H.E. White (McGraw-Hill)-2017
3. Geometrical and Physical Optics– R.S. Longhurst(Orient Blackswan)-1974
4. The Physics of Vibrations and Waves- H. J. Pain( John Wiley)-2006
5. Principles of Optics – B.K. Mathur, Gopal Printing-1964
6. Principles of Optics-Max Born and Emil Wolf (Cambridge University Press)-7<sup>th</sup> Edition 1999

**Discipline Specific Core Paper IV LAB**  
**( minimum 6 experiments are to be done)**

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

**Reference Books:**

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

## **Discipline Specific Elective (DSE) - Pass**

**( two papers are to be selected)**

### **Discipline Specific Elective Paper –I DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION**

#### **UNIT-1:**

##### **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 (1) Sum of Products Method and (2) Karnaugh Map.

#### **UNIT-II**

##### **Semiconductor Devices and Amplifiers:**

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.

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

#### **UNIT-III BJT and**

##### **Amplifiers**

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains  $\alpha$  and  $\beta$ . Relations between  $\alpha$  and  $\beta$ . Load Line analysis of Transistors. DC Load line and Q-point. Active, Cutoff, and Saturation Regions. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Class A, B, and C Amplifiers. Class B Push Pull Amplifier.

Feedback in Amplifiers ,Positive and Negative feedback,Effects of Feedback Oscillators:Hartley and Colpitt's Oscillator

#### **UNIT-IV:**

##### **Operational Amplifiers (Black Box approach) :**

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop & Closed-loop 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.

#### **Instrumentations:**

Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

**Text:**

1. Electronics: Fundamentals and applications – D. Chattopadhyay and P.C.Rakshit (New Age International)-2018
2. Digital Principles and Applications - A.P. Malvino, D.P.Leach and Saha (Tata McGraw)-2017
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall-2015

**References :**

1. Principles of Electronics – V.K.Mehta and Rohit Mehta (S.Chand Publishing)-2014
2. Hand book of electronics – Gupta Kumar (Pragati Prakashan)-2016
3. Digital Logic and Computer design – M. Morris Mano (Pearson)-2016
4. Text book of Electronics – B. B. Swain (Kitab Mahal)
5. Concepts of Electronics – D.C.Tayal (Himalaya Publishing house)-2018
6. Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd-2016

**Discipline Specific Elective Paper –I LAB**  
**DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTS**  
**( minimum 6 experiments are to be done)**

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using a 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 a 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 a precision Differential Amplifier of given I/O specification using Opamp.
14. To investigate the use of an op-amp as a Differentiator
15. To design a Wien Bridge Oscillator using an op-amp.

**Reference Books:**

1. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, McGraw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
4. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

**Discipline Specific Elective Paper II**  
**ELEMENTS OF MODERN PHYSICS**

**UNIT-I**

Planck's quantum, Planck's constant and Compton scattering. De Broglie experiment. light as a collection of photons; Photoelectric effect, 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**

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.

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 wave function, probabilities and normalization; Probability and probability current densities in one dimension.

**UNIT-III**

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

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

**UNIT-IV**

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life;  $\alpha$  decay;  $\beta$  decay - energy released, spectrum and Pauli's prediction of neutrino;  $\gamma$ -ray emission.

Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.

**Text:**

1. Concepts of Modern Physics – Arthur Beiser (McGraw Hill)-2017
2. Modern Physics – Murugesan and Sivaprasad (S.Chand)-2016 **Reference:**
1. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, (Macmillan)
2. Introduction to Quantum Mechanics, David J. Griffith (Pearson)-2015
3. Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W.Savin- (Tata McGraw-Hill)-1978
4. Modern Physics- Serway and Jewett (CENGAGE Learnings)-2017
5. Physics of Atoms and Molecules – Bransden and Joachin (Pearson India)-2003
6. Quantum Mechanics– Satya Prakash (Pragati Prakashan)-2012
7. Atomic and Nuclear Physics-A.B.Gupta (New Central)

## **DSE II LAB: ELEMENTS OF MODERN PHYSICS**

**( minimum 6 experiments are to be done)**

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine 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.

### **Reference Books:**

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

## SKILL ENHANCEMENT COMPULSORY COURSES (SECC)

---

### Optional for SECC II paper

#### Skill Enhancement Compulsory Courses (SECC Option-I)

### APPLIED OPTICS

---

The quest to understand the 'nature of light' is a favourite inquiry of mankind since ancient times. By the advent of lasers, holography, and optical fibres in twentieth century the optics now-a-days finds application in several branches of science and engineering. This paper provides the conceptual understanding of these branches of modern optics to the students.

Theory includes only qualitative explanation. Minimum three experiments should be performed covering minimum three sections.

#### Unit-I

##### (i) Photo-sources and Detectors

Lasers: an introduction, Planck's radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein's coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers; Light Emitting Diode (LED) and photo-detectors.

##### (ii) Elementary ideas of Fourier Optics

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens.

#### Unit-II

##### Holography

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition.

##### Photonics: Fibre Optics

##### (ii) Photonics: Fibre Optics

Optical fibres: Introduction and historical remarks, Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

#### Skill Enhancement Compulsory Courses (SECC Option-I) LAB

Minimum three experiments should be performed covering minimum two sections.

### **Experiments on Lasers:**

1. To determine the grating radial spacing of the Compact Disc (CD) by reflection using HeNe or solid state laser.
2. To find the width of the wire or width of the slit using diffraction pattern obtained by a HeNe or solid state laser.
3. To find the polarization angle of laser light using polarizer and analyzer
4. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

### **Experiments on Semiconductor Sources and Detectors:**

1. V-I characteristics of LED
2. Study the characteristics of solid state laser
3. Study the characteristics of LDR
4. Characteristics of Photovoltaic Cell/ Photodiode.
5. Characteristics of IR sensor **Experiments on Fibre Optics**

1. To measure the numerical aperture of an optical fibre
2. To measure the near field intensity profile of a fibre and study its refractive index profile

### **Reference Books:**

1. LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
2. Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press-2016
3. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
4. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press
5. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.



## **Skill Enhancement Compulsory Courses (SECC Option-II)**

### **RENEWABLE ENERGY AND ENERGY HARVESTING**

The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible

#### **Unit-I**

**Fossil fuels and Alternate Sources of energy:** Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

**Solar energy:** Solar energy, its importance, storage of solar energy, solar pond, non plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

#### **Unit-II**

**Wind Energy harvesting:** Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

**Ocean Energy:** Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

**Geothermal Energy:** Geothermal Resources, Geothermal Technologies.

**Hydro Energy:** Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

### **Skill Enhancement Compulsory Courses (SECC Option-II)-LAB**

#### **Demonstrations and Experiments**

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into volta geusing thermoelectric modules.

**Reference Books:**

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi-2004
2. Solar energy - M P Agarwal - S Chand and Co. Ltd-1983
3. Solar energy - Suhas P Sukhatime Tata McGraw - Hill Publishing Company Ltd-2017
4. Godfrey Boyle and J K Nayak “Renewable Energy, Power for a sustainable future”, 2004, Oxford University Press, in association with The Open University.
5. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
6. The Art and Science of Photovoltaic J.Balfour, M. Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA)-Jones and Bartlett learning-2013

**Faculty Training to be imparted in the following Topics**

Computational Physics Lab—C, C++,

Scilab Programming for Core I,C-V,C-VIII,C-XI and C-XIII Practicals.

2. Digital Electronics. Theory and Practicals.

3. Quantum Mechanics Problem Solving

4. Solid State Physics- Elementary Band Theory and Superconductivity

5. Statistical Mechanics.-Quantum Distribution

6. Nanotechnology.

**ESSENTIAL LABORATORY EQUIPMENT RECOMMENDED :**

**Every college must have CRO, Function generator, Laser and Logic Gate packages.**