Cooch Behar Panchanan Barma University

Syllabus for B.Sc. in Physics (Honours Course)

UNDER CHOICE BASED CREDIT SYSTEM

Cooch Behar Panchanan Barma University

Cooch Behar, West Bengal

Preamble

University Grants Commission (UGC) introduced, in 2018, a major reform in the higher education sector in India. Accordingly, Learning Outcomes-based Curriculum Framework (LOCF) took the centre-stage to make the curriculum student-centric, interactive and outcome-oriented with well-defined aims and objectives. The Physics Undergraduate Board of Studies of Cooch Behar Panchanan Barma University took the initiative to implement the reforms and frame the syllabus so as to increase the spirit of enquiry, analytical ability and comprehension skills among the students.

B.Sc. Honours in Physics

There will be six semesters in the three-year **B.Sc. Honours in Physics**. The Curriculum consists of 14 Core Courses (C), 2 Ability Enhancement Compulsory Courses (AECC), 2 Skill Enhancement Courses (SEC) and 4 Discipline Specific Elective (DSE) Courses and 4 Generic Elective (GE) courses [to be taken from the pool of Generic Elective courses]. Each course is of 50 marks. L stands for Lecture Hour, T for Tutorial Hour and P for Practical Hour.

Course Structure (Physics-Major)

Details of courses under B.Sc. (Honours)

Course		Credits* Theory + Practical	Theory + Tutorial
I. Core Course	**(14 Papers)**	$14 \times 4 = 56$	$14 \times 5 = 70$
Core Course Practical / Tutorial	**(14 Papers)**	$14 \times 2 = 28$	$14 \times 1 = 14$
II. Elective Course	**(8 Papers)**		
A.1. Discipline Specific Elective	**(4 Papers)**	$4 \times 4 = 16$	$4 \times 5 = 20$
A.2. Discipline Specific Elective Practical / Tutorial	**(4 Papers)**	$4 \times 2 = 8$	$4 \times 1 = 4$
B.1. Generic Elective/Interdisciplinary	**(4 Papers)**	$4 \times 4 = 16$	$4 \times 5 = 20$
B.2. Generic Elective Practical / Tutorial	**(4 Papers)**	$4 \times 2 = 8$	$4 \times 1 = 4$
• **Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester**			
III. Ability Enhancement Courses			
1. Ability Enhancement Compulsory	**(2 Papers)**		
• Environmental Studies		4	4
• English/MIL Communication		2	2
2. Ability Enhancement Elective (Skill Based) (Minimum 2)	**(2 Papers)**	$2 \times 2 = 4$	$2 \times 2 = 4$
Total credit		**142**	**142**

Institute should evolve a system/policy Interest/Hobby/Sports/NCC/NSS/related courses on its own.
*** wherever there is a practical there will be no tutorial and vice-versa.**

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.Sc Honours (Physics)

	CORE COURSE (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)
			Odd Semester		
I	• Mathematical Physics-I • Mechanics	• Environmental Studies			• GE-1
III	• Mathematical Physics-II • Thermal Physics • Digital Systems and Applications		• SEC-1		• GE-3
V	• Quantum Mechanics and Applications • Solid State Physics			• DSE-1 • DSE-2	
			Even Semester		
II	• Electricity and Magnetism • Waves and Optics	• English/ MIL Communication			• GE-2
IV	• Mathematical Physics-III • Elements of Modern Physics • Analog Systems and Applications		• SEC-2		• GE-4
VI	• Electromagnetic Theory • Statistical Mechanics			• DSE-3 • DSE-4	

SEM	COURSE OPTED	COURSE NAME	Credits
I	Ability Enhancement Compulsory Course - 1	Environmental Studies	4
	Core course - 1	Mathematical Physics-I	4
	Core course - 1 Practical	Mathematical Physics-I Lab	2
	Core course - 2	Mechanics	4
	Core course - 2 Practical	Mechanics Lab	2
	Generic Elective - 1	Mechanics	4
	Generic Elective - 1 Practical	Mechanics Lab	2
III	Core course - 5	Mathematical Physics-II	4
	Core course - 5 Practical	Mathematical Physics-II Lab	2
	Core course - 6	Thermal Physics	4
	Core course - 6 Practical	Thermal Physics Lab	2
	Core course - 7	Digital Systems and Applications	4
	Core course - 7 Practical	Digital Systems and Applications Lab	2
	Skill Enhancement Course - 1	Electrical Circuit and Network Skills	2
	Generic Elective - 3	Mechanics	4
	Generic Elective - 3 Practical	Mechanics Lab	2
V	Core course - 11	Quantum Mechanics and Applications	4
	Core course - 11 Practical	Quantum Mechanics and Applications Lab	2
	Core course - 12	Solid State Physics	4
	Core course - 12 Practical	Solid State Physics Lab	2
	Discipline Specific Elective - 1	Communication Electronics	4
	Discipline Specific Elective - 1 Practical	Communication Electronics Lab	2
	Discipline Specific Elective - 2	Classical Dynamics	5
	Discipline Specific Elective - 2 Tutorial	Classical Dynamics Tut	1

SEM	COURSE OPTED	COURSE NAME	Credits
II	Ability Enhancement Compulsory Course - 2	English/ MIL communications	2
	Core course - 3	Electricity and Magnetism	4
	Core course - 3 Practical	Electricity and Magnetism Lab	2
	Core course - 4	Waves and Optics	4
	Core course - 4 Practical	Waves and Optics Lab	2
	Generic Elective - 2	Electricity, Magnetism and EMT	4
	Generic Elective - 2 Practical	Electricity, Magnetism and EMT Lab	2
IV	Core course - 8	Mathematical Physics-III	4
	Core course - 8 Practical	Mathematical Physics-III Lab	2
	Core course - 9	Modern Physics	4
	Core course - 9 Practical	Modern Physics Lab	2
	Core course - 10	Analog Electronics	4
	Core course - 10 Practical	Analog Electronics Lab	2
	Skill Enhancement Course - 2	Renewable Energy and Energy harvesting	2
	Generic Elective - 4	Electricity, Magnetism and EMT	4
	Generic Elective - 4 Practical	Electricity, Magnetism and EMT Lab	2
VI	Core course - 13	Electromagnetic Theory	4
	Core course - 13 Practical	Electromagnetic Theory Lab	2
	Core course - 14	Statistical Mechanics	4
	Core course - 14 Practical	Statistical Mechanics Lab	2
	Discipline Specific Elective - 3	Dissertation	6
	Discipline Specific Elective - 4	Nuclear and Particle Physics	5
	Discipline Specific Elective - 4 Tutorial	Nuclear and Particle Physics Tut	1

Core Papers (C): (Credit: 06 each) (1 period/week for tutorials or 4 periods/week for practical)

	Paper	periods/week	
		Theory	Lab
1.	Mathematical Physics-I	4	4
2.	Mechanics	4	4
3.	Electricity and Magnetism	4	4
4.	Waves and Optics	4	4
5.	Mathematical Physics-II	4	4
6.	Thermal Physics	4	4
7.	Digital Systems and Applications	4	4
8.	Mathematical Physics-III	4	4
9.	Elements of Modern Physics	4	4
10.	Analog Systems and Applications	4	4
11.	Quantum Mechanics and Applications	4	4
12.	Solid State Physics	4	4
13.	Electromagnetic Theory	4	4
14.	Statistical Mechanics	4	4

Discipline Specific Elective Papers: (Credit: 06 each) (4 papers) - DSE 1-4

	Paper	periods/week		
		Theory	Lab	Tut
1.	Communication Electronics	4	4	
2.	Classical Dynamics	5		1
3.	Dissertation			
4.	Nuclear and Particle Physics	5		1

Other Discipline (Four papers of any one discipline) - GE 1-4

	Paper	periods/week		
		Theory	Lab	Tut
1.	Mathematics	5		1
2.	Chemistry	4	4	
3.	Computer Science	4	4	

Skill Enhancement Courses (Credit: 02 each) - SEC 1-2

1. Renewable Energy and Energy harvesting
2. Electrical Circuit and Network Skills

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

	Paper	periods/week	
		Theory	Lab
1.	Mechanics	4	4
2.	Electricity and Magnetism	4	4

CORE COURSE (HONOURS IN PHYSICS)

Semester I

Physics - C 1 : Mathematical Physics-I
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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.

Calculus Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation.

Ordinary Differential equations 1^{st} Order Differential Equations and Integrating Factor. Homogeneous 2^{nd} Order Differential Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. **(12 Lectures)**

Calculus of functions of more than one variable Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximisation using Lagrange Multipliers. Partial Differential Equations: Solutions to partial differential equations, using separation of variables. **(5 Lectures)**

Vector Calculus 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. **(4 Lectures)**

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, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates. **(8 Lectures)**

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). **(14 Lectures)**

Orthogonal Curvilinear Coordinates Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(4 Lectures)**

Matrices Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Eigenvalues and Eigenvectors (Degenerate and non-degenerate). Cayley-Hamiliton Theorem. Diagonalisation of Matrices. Solutions of Coupled Linear Ordinary homogeneous Differential Equations. Functions of a Matrix. **(11 Lectures)**

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. **(2 Lectures)**

Reference Books

[1] George B. Arfken, Hans J. Weber and Frank E. Harris, Mathematical Methods for Physicists: A Comprehensive Guide (7ed), Elsevier, 2012.
[2] Earl A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications, 2012.
[3] George F. Simmons, Differential Equations with Applications and Historical Notes (3ed), Taylor & Francis, 2016.
[4] James C. Nearing, Mathematical Tools for Physics, Dover Publications, 2010.
[5] Donald A. McQuarrie, Mathematical Methods for Scientists and Engineers, University Science Books, 2003.
[6] Dennis G. Zill, Advanced Engineering Mathematics (6ed), Jones & Bartlett Learning, 2016.
[7] Partha Goswami, Mathematical Physics, Cengage Learning, 2012.
[8] Srimanta Pal and Subodh C. Bhunia, Engineering Mathematics, Oxford University Press, 2015.
[9] Erwin Kreyszig, Advanced Engineering Mathematics, Wiley, 2011.
[10] K.F. Riley, M.P. Hobson and S.J. Bence, Mathematical Methods for Physics and Engineers (3ed), Cambridge University Press, 2006.

Physics Lab - C 1 Lab : Mathematical Physics-I
60 Lectures

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasise 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 basis of programming but on 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*

Review of Python/C/C++/Fortran/Scilab Programming fundamentals Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, Unconditional and Conditional Looping. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions.

Introduction to plotting graphs Basic 2D and 3D graph plotting – plotting functions and data files, polar and parametric plots, modifying the appearance of graphs, exporting plots.

Programs Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search. Matrix operations: Addition, subtraction, multiplication, Determinant of a matrix, Inverse of a matrix, trace of a matrix, diagonalisation of a matrix

Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules) Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop.

1. Plot trigonometric functions.

2. Plot Gaussian function.
3. Plot step function.
4. Differentiate simple mathematical functions numerically, e.g., (a) $3x^2$; (b) $\sin\theta$; and (c) $\ln x$.
5. Integrate simple mathematical functions numerically, e.g., (a) $\int_0^{\pi/2} d\theta \sin\theta$; and (b) Gaussian function: $\int_{-\infty}^{\infty} dx e^{-x^2}$.
6. Solution of linear and quadratic equation numerically.
7. Multiplication of two 3×3 matrices.
8. Eigenvalue and eigenvectors of

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 1 & 4 \end{pmatrix}; \quad \begin{pmatrix} 1 & -i & 3+4i \\ +i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \quad \begin{pmatrix} 2 & -i & 2i \\ +i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}.$$

9. Determination of the principal axes of moment of inertia through diagonalization.

Physics - C 2 : Mechanics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Fundamentals of Dynamics Reference frames. Inertial frames; Galilean transformations; Galilean invariance. Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket. **(6 Lectures)**

Work and Energy Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work and Potential energy. Work done by non-conservative forces. Law of conservation of Energy. **(4 Lectures)**

Collisions Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. **(3 Lectures)**

Rotational Dynamics Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. **(12 Lectures)**

Elasticity Relation between Elastic constants. Twisting torque on a Cylinder or Wire. **(3 Lectures)**

Fluid Motion Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. **(2 Lectures)**

Gravitation Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. **(3 Lectures)**

Central Force Motion Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts. **(6 Lectures)**

Oscillations SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **(7 Lectures)**

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. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. **(4 Lectures)**

Special Theory of Relativity Michelson-Morley Experiment and its outcome. 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. **(10 Lectures)**

Reference Books

[1] Daniel Kleppner and Robert Kolenkow, An Introduction to Mechanics, Cambridge University Press, 2014.
[2] Charles Kittel, et. al, Mechanics Berkeley Physics, Vol 1, Tata McGraw-Hill, 2007.
[3] Resnick, Halliday and Walker, Physics (9ed), Wiley, 2010.
[4] G.R. Fowles and G.L. Cassiday, Analytical Mechanics, Cengage Learning, 2005.
[5] R.P. Feynman, R.B. Leighton and M. Sands, Feynman Lectures, Vol 1, Pearson Education, 2008.
[6] R. Resnick, Introduction to Special Relativity, John Wiley & Sons, 2005.
[7] Ronald Lane Reese, University Physics, Thomson Brooks/Cole, 2003.
[8] D.S. Mathur, Mechanics, S. Chand, 2000.
[9] F.W. Sears, M.W. Zemansky and H.D. Young, University Physics (13ed), Addison-Wesley, 1986.
[10] Jewett and Serway, Physics for Scientists and Engineers with Modern Physics, Cengage Learning, 2010.
[11] M.R. Spiegel, Theoretical Mechanics, Tata McGraw Hill, 2006.

Physics Lab - C 2 Lab : Mechanics
60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant; (b) $\vec{g}$; and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine $\vec{g}$ and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.

10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of $\vec{g}$ using Bar Pendulum.
12. To determine the value of $\vec{g}$ using Kater's Pendulum.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.
[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] S. Panigrahi and B. Mallick, Engineering Practical Physics, Cengage Learning India Pvt. Ltd, 2015.
[5] G.L. Squires, Practical Physics (4ed), Cambridge University Press, 2015.

Semester II

Physics - C 3 : Electricity and Magnetism
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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. **(6 Lectures)**

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. **(6 Lectures)**

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(10 Lectures)**

Dielectric Properties of Matter Electric Field in matter. Polarisation, Polarisation Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector $\vec{D}$. Relations between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss' Law in dielectrics. **(8 Lectures)**

Magnetic Field Magnetic force between current elements and definition of Magnetic Field $\vec{B}$. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of $\vec{B}$: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. **(9 Lectures)**

Magnetic Properties of Matter Magnetisation vector ($\vec{M}$). Magnetic Intensity ($\vec{H}$). Magnetic Susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$, $\vec{M}$. Ferromagnetism. B-H curve and hysteresis. **(4 Lectures)**

Electromagnetic Induction Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current. **(4 Lectures)**

Electrical Circuits DC Circuits: Transient phenomena, growth and decay of currents in LR, CR and LCR circuits. AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. **(6 Lectures)**

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 circuits. **(4 Lectures)**

Ballistic Galvanometer Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. **(3 Lectures)**

Reference Books

[1] S. Mahajan and Choudhury, Electricity, Magnetism and Electromagnetic Theory, Tata McGraw-Hill, 2012.
[2] Edward M. Purcell, Electricity and Magnetism, McGraw-Hill Education, 1986.
[3] D.J. Griffiths, Introduction to Electrodynamics (3ed), Benjamin Cummings, 1998.
[4] R.P. Feynman, R.B. Leighton and M. Sands, Feynman Lectures, Vol 2, Pearson Education, 2008
[5] J.H. Fewkes and J. Yarwood, Electricity and Magnetism, Vol I, Oxford Univ. Press, 1991.
[6] M.N.O. Sadiku, Elements of Electromagnetics, Oxford University Press, 2001.

Physics Lab - C 3 Lab : Electricity and Magnetism
60 Lectures

1. Use a Multimeter for measuring (a) Resistances; (b) AC and DC Voltages; (c) Direct Current; (d) Capacitances; and (e) Checking electrical fuses.
2. To study the AC characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer/fall of potential method.
4. To determine an unknown Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx).
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency; (b) Impedance at resonance; (c) Quality factor Q; and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency; and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer.
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.
16. To determine the mutual inductance of two coaxial coils at different orientations using Ballistic Galvanometer.

17. To determine the horizontal component of the Earth's magnetic field and the magnetic moment of a magnet using a deflection and oscillation magnetometer.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

[4] D.P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Pub, 1985.

[5] S. Panigrahi and B. Mallick, Engineering Practical Physics, Cengage Learning India Pvt. Ltd, 2015.

Physics - C 4 : Waves and Optics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Superposition of Collinear Harmonic oscillations Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **(5 Lectures)**

Superposition of two perpendicular Harmonic Oscillations Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses. **(2 Lectures)**

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. **(4 Lectures)**

Velocity of Waves Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **(6 Lectures)**

Superposition of Two Harmonic Waves Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **(7 Lectures)**

Wave Optics Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(3 Lectures)**

Interference Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(9 Lectures)**

Interferometer Michelson 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. **(4 Lectures)**

Diffraction Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula and its application to rectangular slit. **(5 Lectures)**

Fraunhofer diffraction Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **(8 Lectures)**

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. **(7 Lectures)**

Holography Principle of holography and related features. **(3 Lectures)**

Reference Books

[1] Francis Crawford, Waves: Berkeley Physics Course, Vol 3, Tata McGraw-Hill, 2007.
[2] F.A. Jenkins and H.E. White, Fundamentals of Optics, McGraw-Hill, 1981.
[3] Max Born and Emil Wolf, Principles of Optics (7ed), Pergamon, 1999.
[4] Ajoy Ghatak, Optics, Tata McGraw-Hill, 2008.
[5] H. J. Pain, The Physics of Vibrations and Waves, John Wiley & Sons, 2013.
[6] N.K. Bajaj, The Physics of Waves and Oscillations, Tata McGraw Hill, 1998.
[7] A. Kumar, H.R. Gulati and D.R. Khanna, Fundamental of Optics, R. Chand Publications, 2011.

Physics Lab - C 4 Lab : Waves and Optics
60 Lectures

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2 - T$ law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarisation with: Schuster's focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (a) Na source; and (b) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] D.P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Pub, 1985.

Semester III

Physics - C 5 : Mathematical Physics-II
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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.

Fourier Series Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity. **(22 Lectures)**

Frobenius Method and Special Functions Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality. **(24 Lectures)**

Introduction to probability Independent random variables: Sample space and Probability distribution functions. Binomial, Gaussian, and Poisson distribution with examples. Mean and variance. **(6 Lectures)**

Theory of Errors Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. **(4 Lectures)**

Some Special Integrals Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **(4 Lectures)**

Reference Books

[1] George B. Arfken, Hans J. Weber, Frank E. Harris, Mathematical Methods for Physicists: A Comprehensive Guide (7ed), Elsevier, 2012.
[2] M.R. Spiegel, Fourier Analysis, Tata McGraw-Hill, 2004.
[3] Susan M. Lea, Mathematics for Physicists, Thomson Brooks/Cole, 2004.
[4] George F. Simmons, Differential Equations with Applications and Historical Notes (3ed), Taylor & Francis, 2016.
[5] S.J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover, 1993.

[6] Srimanta Pal, Subodh C. Bhunia, Engineering Mathematics, Oxford University Press, 2015.

[7] Donald A. McQuarrie, Mathematical Methods for Scientists and Engineers, University Science Books, 2003.

Physics Lab - C 5 Lab : Mathematical Physics-II
60 Lectures

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 not on the programming but on the basis of formulating the problem.

Curve fitting, Least square fit, Goodness of fit, standard deviation Ohms law to calculate R, Hooke's law to calculate spring constant.

Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigenvectors, eigenvalues problems

- Solution of mesh equations of electric circuits (3 meshes).
- Solution of coupled spring mass systems (3 masses)

Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods

- Radioactive decay.
- Current in RC, LC circuits with DC source
- Newton's law of cooling.
- Classical equations of motion.

Second order differential equation Fixed difference method

- 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

Also attempt some problems on differential equations like

1. Solve the coupled first order differential equations

$$\frac{dx}{dt} = y + x - \frac{x^3}{3}, \qquad \frac{dy}{dt} = -x,$$

for four initial conditions $x(0) = 0, y(0) = -1, -2, -3, -4$.
Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$.

2. The ordinary differential equation describing the motion of a pendulum is

$$\vartheta'' = -\sin\vartheta.$$

The pendulum is released from rest at an angular displacement α, i.e., $\vartheta(0) = \alpha, \vartheta'(0) = 0$.
Use the RK4 method to solve the equation for $\alpha = 0.1, 0.5$ and 1.0 and plot ϑ as a function of time in the range $0 \le t \le 8\pi$.
Also, plot the analytic solution valid in the small ϑ ($\sin\vartheta \approx \vartheta$).

3. Solve the differential equation

$$x^2\frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 4(1+x)y = x^3$$

with the boundary conditions: at $x = 1, y = \frac{1}{2}e^2, \frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$, in the range $1 \le x \le 3$.
Plot y and $\frac{dy}{dx}$ against x in the given range. Both should appear on the same graph.

Physics - C 6 : Thermal Physics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Include related problems for each topic.

Kinetic Theory of Gases
Distribution of Velocities Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(8 Lectures)**

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. **(4 Lectures)**

Real Gases Behaviour of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling. **(10 Lectures)**

Introduction to Thermodynamics
Zeroth and First Law of Thermodynamics Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics and Concept of Temperature, Concept of Work and Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law and various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **(8 Lectures)**

Second Law of Thermodynamics Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine and efficiency. Refrigerator and coefficient of performance, Second Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **(10 Lectures)**

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 Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(7 Lectures)**

Thermodynamic Potentials Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetisation, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations **(7 Lectures)**

Maxwell's Thermodynamic Relations Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of $C_P - C_V$, (3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **(7 Lectures)**

Reference Books

[1] M.W. Zemansky, Richard Dittman, Heat and Thermodynamics, McGraw Hill, 1981.
[2] Meghnad Saha, and B.N. Srivastava, A Treatise on Heat, Indian Press, 1958.
[3] S. Garg, R. Bansal and Ghosh, Thermal Physics (2ed), Tata McGraw Hill, 1993.
[4] Carl S. Helrich, Modern Thermodynamics with Statistical Mechanics, Springer, 2009.
[5] Francis W. Sears and Gerhard L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, 1986.
[6] S.J. Blundell and K.M. Blundell, Concepts in Thermal Physics (2ed), Oxford University Press, 2012.
[7] A. Kumar and S.P. Taneja, Thermal Physics, R. Chand Publications, 2014.

Physics Lab - C 6 Lab : Thermal Physics
60 Lectures

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance of a copper coil/Platinum Resistance Thermometer.

6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (a) Null Method; and (b) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.
8. Determination of linear expansion coefficient of a solid by optical lever method.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

[4] D.P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Pub, 1985.

Physics - C 7 : Digital Systems and Applications (Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Introduction to CRO Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(3 Lectures)**

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. **(3 Lectures)**

Digital Circuits Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realisation using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(6 Lectures)**

Boolean algebra De Morgan's 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. **(6 Lectures)**

Data processing circuits Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **(4 Lectures)**

Arithmetic Circuits Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half and Full Subtractors, 4-bit binary Adder/Subtractor. **(5 Lectures)**

Sequential Circuits SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **(6 Lectures)**

Timers IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **(3 Lectures)**

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). **(2 Lectures)**

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

Computer Organisation Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organisation and addressing. Memory Interfacing. Memory Map. **(6 Lectures)**

Intel 8085 Microprocessor Architecture Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing and Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. **(8 Lectures)**

Introduction to Assembly Language 1 byte, 2 byte and 3 byte instructions. **(4 Lectures)**

Reference Books

[1] A.P. Malvino, D.P. Leach and Saha, Digital Principles and Applications (7ed), Tata McGraw Hill, 2011.
[2] Anand Kumar, Fundamentals of Digital Circuits, PHI Learning, 2009.
[3] Venugopal, Digital Circuits and Systems, Tata McGraw Hill, 2011.
[4] G.K. Kharate, Digital Electronics, Oxford University Press, 2010.
[5] R.J. Tocci and N.S. Widmer, Digital Systems: Principles and Applications, PHI Learning, 2001.
[6] Shimon P. Vingron, Logic Circuit Design, Springer, 2012.
[7] Subrata Ghoshal, Digital Electronics, Cengage Learning, 2012.
[8] S.K. Mandal, Digital Electronics, McGraw Hill, 2010.
[9] R.S. Goankar, Microprocessor Architecture Programming and Applications with 8085, Prentice Hall, 2002.

Physics Lab - C 7 Lab : Digital Systems and Applications 60 Lectures

1. To measure (a) Voltage; and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder / 4-bit binary Adder.
9. Half Subtractor / Full Subtractor / Adder-Subtractor using Full Adder IC.
10. To build Flip-Flop (RS/Clocked RS/D-type/JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs.
12. To build a 3-bit/4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 3-bit/4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.

15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
    (a) Addition and subtraction of numbers using direct addressing mode.
    (b) Addition and subtraction of numbers using indirect addressing mode.
    (c) Multiplication by repeated addition.
    (d) Division by repeated subtraction.
    (e) Handling of 16-bit Numbers.
    (f) Use of CALL and RETURN Instruction.
    (g) Block data handling.
    (h) Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books

[1] R.P. Jain, Modern Digital Electronics (4ed), Tata McGraw Hill, 2010.
[2] P.B. Zbar, A.P. Malvino, M.A. Miller, Basic Electronics: A Text Lab Manual, McGraw Hill, 1994.
[3] R.S. Goankar, Microprocessor Architecture Programming and Applications with 8085, Prentice Hall, 2002.
[4] A. Wadhwa, Microprocessor 8085: Architecture, Programming and Interfacing, PHI Learning, 2010.

Semester IV

Physics - C 8 : Mathematical Physics-III
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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.

Complex Analysis Brief Revision of Complex Numbers and their Graphical Representation. Euler's 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. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. **(30 Lectures)**

Integrals Transforms
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, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. **(15 Lectures)**

Laplace Transforms Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1^{st} and 2^{nd} order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of

Laplace Transforms to 2^{nd} order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1^{st} order. Solution of heat flow along infinite bar using Laplace transform. **(15 Lectures)**

Reference Books

[1] K.F. Riley, M.P. Hobson and S.J. Bence, Mathematical Methods for Physics and Engineers (3ed), Cambridge University Press, 2006.
[2] P. Dennery and A.Krzywicki, Mathematics for Physicists, Dover, 1967.
[3] A.S. Fokas and M.J.Ablowitz, Complex Variables (8ed), Cambridge Univ. Press, 2011.
[4] A.K. Kapoor, Complex Variables, Cambridge Univ. Press, 2014.
[5] J.W. Brown and R.V. Churchill, Complex Variables and Applications (7ed), Tata McGraw-Hill, 2003.
[6] D.G. Zill and P.D. Shanahan, First Course in Complex Analysis with Applications, Jones & Bartlett, 1940.

Physics Lab - C 8 Lab : Mathematical Physics-III
60 Lectures

Numerically solve the following problems based on Mathematical Physics like

1. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
2. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
3. Evaluation of trigonometric functions e.g. $\sin\theta$, Given Bessel's function at N points find its value at an intermediate point.
4. Complex analysis: Integrate $\frac{1}{x^2+2}$ numerically and check with computer integration.
5. Compute the n^{th} roots of unity for $n = 2, 3$, and 4.
6. Find the two square roots of $-5 + 12j$.
7. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.
8. Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
9. Perform circuit analysis of a general LCR circuit using Laplace's transform.

Physics - C 9 : Elements of Modern Physics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions. **(14 Lectures)**

Position measurement - gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction. **(5 Lectures)**

Two slit interference experiment with photons, atoms and 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 a wave function, probabilities and normalisation; Probability and probability current densities in one dimension. **(10 Lectures)**

One dimensional infinitely rigid box - energy eigenvalues and eigenfunctions, normalisation; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential and rectangular potential barrier. **(10 Lectures)**

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 nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model (qualitative) and magic numbers. **(6 Lectures)**

Radioactivity: stability of the 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, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. **(8 Lectures)**

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 driving stellar energy (brief qualitative discussions). **(3 Lectures)**

Lasers Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. **(4 Lectures)**

Reference Books

[1] Arthur Beiser, Concepts of Modern Physics, McGraw Hill, 2002.
[2] F.K. Richtmyer, E.H. Kennard and J.N. Cooper, Introduction to Modern Physics, Tata McGraw Hill, 2002.
[3] D.J. Griffiths, Introduction to Quantum Mechanics (2ed), Pearson Education, 2005.
[4] Jewett and Serway, Physics for Scientists and Engineers with Modern Physics, Cengage Learning, 2010.
[5] G. Kaur and G.R. Pickrell, Modern Physics, McGraw Hill, 2014.
[6] A.K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Macmillan, 2004.
[7] J.R. Taylor, C.D. Zafiratos and M.A. Dubson, Modern Physics, PHI Learning, 2004.
[8] R. Gautreau and W. Savin, Theory and Problems of Modern Physics (2ed), Tata McGraw-Hill.
[9] E.H. Wichman, Quantum Physics, Berkeley Physics, Vol.4, Tata McGraw-Hill, 1971.
[10] K. Heyde, Basic Ideas and Concepts in Nuclear Physics – An Introductory Approach, IOP, 2004.
[11] T.A. Moore, Six Ideas that Shaped Physics: Particle Behave like Waves, McGraw-Hill, 2003.

Physics Lab - C 9 Lab : Elements of Modern Physics
60 Lectures

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the 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 ionisation potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing; or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunnelling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (a) wavelength; and (b) angular spread of He-Ne laser using plane diffraction grating.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

Physics - C 10 : Analog Systems and Applications
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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 for Step Junction. **(10 Lectures)**

Two-terminal Devices and their Applications (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. **(6 Lectures)**

Bipolar Junction transistors n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(6 Lectures)**

Amplifiers Transistor Biasing and Stabilisation Circuits. Fixed Bias and Voltage Divider Bias. Transistor 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. **(10 Lectures)**

Coupled Amplifier RC-coupled amplifier and its frequency response. **(4 Lectures)**

Feedback in Amplifiers Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 Lectures)**

Sinusoidal Oscillators Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley and Colpitts oscillators. **(4 Lectures)**

Operational Amplifiers (Black Box approach) Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. **(4 Lectures)**

Applications 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. **(9 Lectures)**

Conversion Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation). **(3 Lectures)**

Reference Books

[1] J. Millman and C.C. Halkias, Integrated Electronics, Tata McGraw Hill, 1991.
[2] J.D. Ryder, Electronics: Fundamentals and Applications, Prentice-Hall, 2004.
[3] B.G. Streetman and S.K. Banerjee, Solid State Electronic Devices (6ed), PHI Learning, 2009.
[4] S. Salivahanan and N.S. Kumar, Electronic Devices and Circuits (3ed), Tata McGraw Hill, 2012.
[5] A.S. Sedra, K.C. Smith, A.N. Chandorkar, Microelectronic Circuits (6ed), Oxford University Press, 2014.
[6] U.Tietze and C.Schenk, Electronic Circuits: Handbook of Design and Applications, Springer, 2008.
[7] S.M. Sze, Semiconductor Devices: Physics and Technology (2ed), Wiley India, 2002.
[8] M.H. Rashid, Microelectronic Circuits (2ed), Cengage Learning.
[9] Thomas L. Floyd, Electronic Devices (7ed), Pearson India, 2008.

Physics Lab - C 10 Lab : Analog Systems and Applications 60 Lectures

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.

13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
14. To design inverting amplifier using Op-amp (741,351) and study its frequency response.
15. To design non-inverting amplifier using Op-amp (741,351) and study its frequency response.
16. To study the zero-crossing detector and comparator.
17. To add two dc voltages using Op-amp in inverting and non-inverting mode.
18. To design a precision Differential amplifier of given I/O specification using Op-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.
21. To design a circuit to simulate the solution of a 1st/2nd order differential equation.
22. To draw V-I characteristics of a full-wave rectifier with and without filter.

Reference Books

[1] P.B. Zbar, A.P. Malvino, M.A. Miller, Basic Electronics: A Text Lab Manual, McGraw Hill, 1994.

[2] R.A. Gayakwad, OP-Amps and Linear Integrated Circuit (4ed), Prentice Hall, 2000.

[3] Albert Malvino, Electronic Principle, Tata McGraw Hill, 2008.

[4] R.L. Boylestad and L.D. Nashelsky, Electronic Devices And Circuit Theory, Pearson, 2009.

Semester V

Physics - C 11 : Quantum Mechanics and Applications (Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Time dependent Schrodinger equation Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalisation. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures)**

Time independent Schrodinger equation Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle. **(10 Lectures)**

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 eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy and uncertainty principle. **(12 Lectures)**

Quantum theory of hydrogen-like atoms Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m; s, p, d, ...shells. **(10 Lectures)**

Atoms in Electric and Magnetic Fields Electron angular momentum. Space quantisation. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. **(8 Lectures)**

Atoms in External Magnetic Fields Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). **(4 Lectures)**

Many electron atoms Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.). **(10 Lectures)**

Reference Books

[1] P.M. Mathews and K. Venkatesan, Text Book of Quantum Mechanics (2ed), McGraw Hill, 2010.
[2] Robert Eisberg and Robert Resnick, Quantum Mechanics (2ed), Wiley, 2002.
[3] Leonard I. Schiff, Quantum Mechanics (3ed), Tata McGraw Hill, 2010.
[4] G. Aruldhas, Quantum Mechanics (2ed), Prentice-Hall, 2002.
[5] Bruce Cameron Reed, Quantum Mechanics, Jones and Bartlett Learning, 2008.
[6] Arno Bohm, Quantum Mechanics: Foundations and Applications (3ed), Springer, 1993.
[7] D.A.B. Miller, Quantum Mechanics for Scientists and Engineers, Cambridge University Press, 2008.
[8] Eugen Merzbacher, Quantum Mechanics, John Wiley & Sons, 2004.
[9] D.J. Griffiths, Introduction to Quantum Mechanics (2ed), Pearson Education, 2005.
[10] Walter Greiner, Quantum Mechanics (4ed), Springer, 2001.

Physics Lab - C 11 Lab : Quantum Mechanics and Applications 60 Lectures

Numerically solve the following problems based on Quantum Mechanics like

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

$$\frac{d^2u}{dr^2} = A(r)\,u(r), \qquad A(r) = \frac{2m}{\hbar^2}\left[V(r) - E\right], \quad \text{where} \quad V(r) = -\frac{e^2}{r}.$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -10 eV. Take $e = 3.795$ (eV A)$^{1/2}$, $\hbar c = 1973$ eV A and $m = 0.511 \times 10^6$ eV$/c^2$.

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

$$\frac{d^2u}{dr^2} = A(r)\,u(r), \qquad A(r) = \frac{2m}{\hbar^2}\left[V(r) - E\right],$$

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

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e = 3.795$ (eV A)$^{1/2}$, $m = 0.511 \times 10^6$ eV/c^2, and $a = 3$ A, 5 A, 7 A. In these units $\hbar c = 1973$ eV A. 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

$$\frac{d^2u}{dr^2} = A(r)\,u(r), \qquad A(r) = \frac{2m}{\hbar^2}\left[V(r) - E\right].$$

For the anharmonic oscillator potential

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

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

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

$$\frac{d^2u}{dr^2} = A(r)\,u(r), \qquad A(r) = \frac{2\mu}{\hbar^2}\left[V(r) - E\right],$$

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

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

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take $m = 940 \times 10^6$ eV/c^2, $D = 0.755501$ eV, $\alpha = 1.44$, $r_0 = 0.131349$ A.

Laboratory based experiments

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; Hyperfine splitting.
3. Quantum efficiency of CCDs.

Physics - C 12 : Solid State Physics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Crystal Structure Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12 Lectures)**

Elementary Lattice Dynamics Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law. **(10 Lectures)**

Magnetic Properties of Matter Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **(8 Lectures)**

Dielectric Properties of Materials Polarisation. Local Electric Field at an Atom. Depolarisation Field. Electric Susceptibility. Polarisability. Clausius Mosotti Equation. Classical Theory of Electric Polarisability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. **(8 Lectures)**

Ferroelectric Properties of Materials Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(6 Lectures)**

Elementary band theory Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) and Hall coefficient. **(10 Lectures)**

Superconductivity Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation) **(6 Lectures)**

Reference Books

[1] Charles Kittel, Introduction to Solid State Physics (8ed), Wiley India Pvt. Ltd, 2004.
[2] J.P. Srivastava, Elements of Solid State Physics (2ed), Prentice-Hall, 2006.
[3] Leonid V. Azaroff, Introduction to Solids, Tata Mc-Graw Hill, 2004.
[4] N.W. Ashcroft and N.D. Mermin, Solid State Physics, Cengage Learning, 1976.
[5] H. Ibach and H. Luth, Solid State Physics, Springer, 2009.
[6] Rita John, Solid State Physics, McGraw Hill, 2014.
[7] M. Ali Omar, Elementary Solid State Physics, Pearson India, 1999.
[8] M.A. Wahab, Solid State Physics, Narosa Publications, 2011.

Physics Lab - C 12 Lab : Solid State Physics
60 Lectures

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR).
6. To determine the refractive index of a dielectric layer using SPR.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe and determine energy loss from Hysteresis.

9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.
[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] J.P. Srivastava, Elements of Solid State Physics (2ed), Prentice-Hall, 2006.

Semester VI

Physics - C 13 : Electromagnetic Theory
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Maxwell Equations Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **(12 Lectures)**

EM Wave Propagation in Unbounded Media Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionised gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. **(10 Lectures)**

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 polarisation cases, Brewster's law. Reflection and Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence). **(10 Lectures)**

Polarisation of Electromagnetic Waves Description of Linear, Circular and Elliptical Polarisation. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarisation by Double Refraction. Nicol Prism. Ordinary and extraordinary refractive indices. Production and detection of Plane, Circularly and Elliptically Polarised Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarised Light. **(12 Lectures)**

Rotatory Polarisation: Optical Rotation. Biot's Laws for Rotatory Polarisation. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. **(5 Lectures)**

Wave Guides Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **(8 Lectures)**

Optical Fibres Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). **(3 Lectures)**

Reference Books

[1] D.J. Griffiths, Introduction to Electrodynamics, Pearson Education, 2012.
[2] M.N.O. Sadiku, Elements of Electromagnetics, Oxford University Press, 2001.
[3] T.L. Chow, Introduction to Electromagnetic Theory, Jones & Bartlett Learning, 2006.
[4] M.A.W. Miah, Fundamentals of Electromagnetics, Tata McGraw Hill, 1982.
[5] R.S. Kshetrimayun, Electromagnetic Field Theory, Cengage Learning, 2012.
[6] Willian H. Hayt, Engineering Electromagnetics (8ed), McGraw Hill, 2012.
[7] G. Lehner, Electromagnetic Field Theory for Engineers and Physicists, Springer, 2010.
[8] P. Lorrain and D. Corson, Electromagnetic Fields and Waves, W.H.Freeman & Co.
[9] J.A. Edminster, Electromagnetics, Tata McGraw Hill, 2006.
[10] B. Guru and H. Hiziroglu, Electromagnetic Field Theory Fundamentals, Cambridge University Press, 2004.

Physics Lab - C 13 Lab : Electromagnetic Theory
60 Lectures

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

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.
[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] G. Lehner, Electromagnetic Field Theory for Engineers and Physicists, Springer, 2010.

Physics - C 14 : Statistical Mechanics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Classical Statistics Macrostate and Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. **(18 Lectures)**

Classical Theory of Radiation Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionisation Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. **(9 Lectures)**

Quantum Theory of Radiation Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(5 Lectures)**

Bose-Einstein Statistics B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. **(13 Lectures)**

Fermi-Dirac Statistics Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. **(15 Lectures)**

Reference Books

[1] R.K. Pathria, Statistical Mechanics (2ed), Oxford University Press, 1996.
[2] F. Reif, Statistical Physics - Berkeley Physics Course, Tata McGraw-Hill, 2008.
[3] S. Lokanathan and R.S. Gambhir, Statistical and Thermal Physics, Prentice Hall, 1991.
[4] Francis W. Sears and Gerhard L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, 1986.
[5] Carl S. Helrich, Modern Thermodynamics with Statistical Mechanics, Springer, 2009.
[6] R.H. Swendsen, An Introduction to Statistical Mechanics and Thermodynamics, Oxford University Press, 2002.

Physics Lab - C 14 Lab : Statistical Mechanics
60 Lectures

Numerically solve the problems based on Statistical Mechanics like

1. Computational analysis of the behaviour of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:

(a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations;
(b) Study of transient behaviour of the system (approach to equilibrium);
(c) Relationship of large N and the arrow of time;
(d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution;
(e) Computation and study of mean molecular speed and its dependence on particle mass;
(f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed.

2. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:

   (a) Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation ΔE, specific heat at constant volume C_v, depend upon the temperature, total number of particles N and the spectrum of single particle states;
   (b) Ratios of occupation numbers of various states for the systems considered above;
   (c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3. Plot Planck's law for Black Body radiation and compare it with Wein's Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
4. 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 the three laws.
5. Plot the following functions with energy at different temperatures

   (a) Maxwell-Boltzmann distribution;
   (b) Fermi-Dirac distribution;
   (c) Bose-Einstein distribution.

Reference Books

[1] K.E. Atkinson, Elementary Numerical Analysis (3ed), Wiley India, 2007.
[2] R.K. Pathria, Statistical Mechanics (2ed), Oxford University Press, 1996.
[3] D. Chandler, Introduction to Modern Statistical Mechanics, Oxford University Press, 1987.
[4] Francis W. Sears and Gerhard L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, 1986.
[5] Carl S. Helrich, Modern Thermodynamics with Statistical Mechanics, Springer, 2009.
[6] Harvey Gould and Jan Tobochnik, Statistical and Thermal Physics with Computer Applications, Princeton University Press, 2010.

Discipline Specific Elective

Physics - DSE : Communication Electronics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Electronic communication Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio. **(8 Lectures)**

Analog Modulation Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver. **(12 Lectures)**

Analog Pulse Modulation Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing. **(9 Lectures)**

Digital Pulse Modulation Need for digital transmission, Pulse Code Modulation,Digital Carrier Modulation Techniques, Sampling, Quantisation and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). **(10 Lectures)**

Introduction to Communication and Navigation systems
Satellite Communication Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. **(10 Lectures)**

Mobile Telephony System Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). **(10 Lectures)**

GPS navigation system (qualitative idea only) **(1 Lectures)**

Reference Books

[1] D. Roddy and J. Coolen, Electronic Communications, Pearson Education India.
[2] Tomasi, Advanced Electronics Communication Systems (6ed), Prentice Hall.
[3] G. Kennedy, Electronic Communication Systems, Tata McGraw Hill, 1999.
[4] L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields (4ed), Elsevier, 2003.
[5] Frenzel, Principles of Electronic Communication Systems (3ed), McGraw Hill.
[6] S. Haykin, Communication Systems, Wiley India, 2006.
[7] Blake, Electronic Communication System (5ed), Cengage.
[8] Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2015.

Physics Lab - DSE Lab : Communication Electronics
60 Lectures

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

Reference Books

[1] G. Kennedy, Electronic Communication Systems, Tata McGraw Hill, 1999.

Physics - DSE : Classical Dynamics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

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.

Classical Mechanics of Point Particles Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalised coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta and Hamiltonian. Hamilton's equations of motion.

Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy. **(22 Lectures)**

Small Amplitude Oscillations Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N - 1) - identical springs. **(10 Lectures)**

Special Theory of Relativity Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time -dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle. **(33 Lectures)**

Fluid Dynamics Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number. **(10 Lectures)**

Reference Books

[1] H.Goldstein, C.P. Poole and J.L. Safko, Classical Mechanics (3ed), Pearson Education, 2002.

[2] L.D. Landau and E.M. Lifshitz, Mechanics, Pergamon, 1976.

[3] J.D. Jackson, Classical Electrodynamics (3ed), Wiley, 1998.

[4] L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields (4ed), Elsevier, 2003.

[5] D.J. Griffiths, Introduction to Electrodynamics, Pearson Education, 2012.

[6] P.S. Joag and N.C. Rana, Classical Mechanics, McGraw Hall.

[7] R. Douglas Gregory, Classical Mechanics, Cambridge University Press, 2015.

[8] Dieter Strauch, Classical Mechanics: An Introduction, Springer, 2009.

[9] O.L. Delange and J. Pierrus, Solved Problems in Classical Mechanics, Oxford University Press, 2010.

Physics - DSE : Nuclear and Particle Physics (Credits: Theory-05, Tutorials-01) Theory: 75 Lectures

General Properties of Nuclei Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, 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 excites states. **(10 Lectures)**

Nuclear Models Liquid drop model approach, semi empirical mass formula and significance of its various terms, α and β nuclear stability from semi empirical mass formula, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. **(17 Lectures)**

Radioactivity decay (a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) Beta decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission and kinematics, internal conversion. **(9 Lectures)**

Nuclear Reactions Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures)**

Interaction of Nuclear Radiation with matter Energy loss due to ionisation (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. **(6 Lectures)**

Detector for Nuclear Radiations Gas detectors: estimation of electric field, mobility of particle, for ionisation chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. **(6 Lectures)**

Particle Accelerators Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(5 Lectures)**

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, concept of quark model, color quantum number and gluons. **(14 Lectures)**

Reference Books

[1] Kenneth S. Krane, Introductory Nuclear Physics, Wiley India Pvt. Ltd., 2008.
[2] Bernard L. Cohen, Concepts of Nuclear Physics, Tata Mcgraw Hill, 1998.
[3] R.A. Dunlap, Introduction to the Physics of Nuclei and Particles, Thomson Asia, 2004.
[4] D.H. Perkins, Introduction to High Energy Physics, Cambridge Univ. Press.
[5] D.J. Griffith, Introduction to Elementary Particles, John Wiley & Sons.
[6] F. Halzen and A.D. Martin, Quarks and Leptons, Wiley India.
[7] K. Heyde, Basic Ideas and Concepts in Nuclear Physics – An Introductory Approach, IOP, 2004.
[8] G.F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 2000.
[9] Syed Naeem Ahmed, Physics and Engineering of Radiation Detection, Academic Press, 2007.
[10] J.M. Blatt and V.F. Weisskopf, Theoretical Nuclear Physics, Dover, 1991.

Physics - DSE : Dissertation
(Credits: Theory-06)

A dissertation involves a theoretical or experimental project which gives the student exposure to research/development. The HoD/coordinator of the department of each college should arrange a supervisor for each student to carry on a dissertation. The student has to submit a report based on his/her studies on the specific topic during the entire semester. It will develop the ability of scientific writing among the students.

The evaluation of the student for this paper will be based on the following criteria:

- 10 marks : Internal assessment based on performance like sincerity, regularity, quality of work done etc., awarded by supervisor.
- 15 marks : Written project report, awarded by internal and external examiners.
- 25 marks : Presentation, awarded by internal and external examiners.

Skill Enhancement Course

Physics - SEC : Renewable Energy and Energy Harvesting (Credits: 02) Theory: 30 Lectures

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. **(3 Lectures)**

Solar energy Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat 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. **(6 Lectures)**

Wind Energy harvesting Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **(3 Lectures)**

Ocean Energy Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. **(3 Lectures)**

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. **(2 Lectures)**

Geothermal Energy Geothermal Resources, Geothermal Technologies. **(2 Lectures)**

Hydro Energy Hydropower resources, hydropower technologies, environmental impact of hydro power sources. **(2 Lectures)**

Piezoelectric Energy harvesting Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power. **(4 Lectures)**

Electromagnetic Energy Harvesting Linear generators, physics mathematical models, recent applications. **(2 Lectures)**

Carbon captured technologies, cell, batteries, power consumption. **(2 Lectures)**

Environmental issues and Renewable sources of energy, sustainability. **(1 Lectures)**

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 voltage using thermoelectric modules.

Reference Books

[1] G.D. Rai, Non-conventional Energy Sources, Khanna Publishers.
[2] M.P. Agarwal, Solar Energy, S Chand.
[3] Suhas P. Sukhative, Solar Energy, Tata McGraw-Hill.
[4] Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford Univ. Press, 2004.

[5] P. Jayakumar, Solar Energy: Resource Assesment Handbook, 2009.
[6] J. Balfour, M. Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich.
[7] http://en.wikipedia.org/wiki/Renewable_energy

Physics - SEC : Electrical Circuit and Network Skills (Credits: 02)
Theory: 30 Lectures

Basic Electricity Principles Voltage, Current, Resistance, and Power. Ohm's law.Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarisation with multimeter, voltmeter and ammeter. **(3 Lectures)**

Understanding Electrical Circuits Main electric circuit elements and their combination. Rules to analyse DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyse AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(4 Lectures)**

Electrical Drawing and Symbols Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **(4 Lectures)**

Generators and Transformers DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. **(3 Lectures)**

Electric Motors Single-phase, three-phase and DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed and power of AC motor. **(4 Lectures)**

Solid-State Devices Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources. **(3 Lectures)**

Electrical Protection Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device). **(4 Lectures)**

Electrical Wiring Different types of conductors and cables. Basics of wiring-star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board. **(5 Lectures)**

Reference Books

[1] B L Theraja and A K Theraja, A Text Book in Electrical Technology, S Chand & Co.
[2] M G Say, Performance and design of AC machines, ELBS Edn.

Generic Elective

Physics - GE : Mechanics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Vectors Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **(4 Lectures)**

Ordinary Differential Equations 1^{st} order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **(6 Lectures)**

Laws of Motion Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **(10 Lectures)**

Momentum and Energy Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. **(6 Lectures)**

Rotational Motion Angular velocity and angular momentum. Torque. Conservation of angular momentum. **(5 Lectures)**

Gravitation Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts. **(8 Lectures)**

Oscillations Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(6 Lectures)**

Elasticity Hooke's law - Stress-strain diagram - Elastic moduli - Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum - Determination of Rigidity modulus and moment of inertia - q, η and σ by Searle's method. **(8 Lectures)**

Special Theory of Relativity Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. **(7 Lectures)**

Note: *Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate*

Reference Books

[1] F.W. Sears, M.W. Zemansky and H.D. Young, University Physics (13ed), Addison-Wesley, 1986.

[2] Charles Kittel, et. al, Mechanics Berkeley Physics, Vol 1, Tata McGraw-Hill, 2007.

[3] Resnick, Halliday and Walker, Physics (9ed), Wiley, 2010.

[4] Basudeb Bhattacharya, Engineering Mechanics (2ed), Oxford University Press, 2015.

[5] Ronald Lane Reese, University Physics, Thomson Brooks/Cole, 2003.

Physics Lab - GE Lab : Mechanics
60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant/free fall method.
3. To determine the Moment of Inertia of a Flywheel/metallic bar axis passing through the centre of gravity.
4. To determine the Young's Modulus of a wire/bar by Optical Lever/flexure Method.
5. To determine the Modulus of Rigidity of a wire by Maxwell's needle method.
6. To determine the Modulus of Rigidity of a wire by dynamical method.
7. To determine the Modulus of Rigidity of a wire by static method.
8. To determine the Elastic Constant/Young's modulus of a wire by Searle's method.
9. To determine g by Bar Pendulum.
10. To determine g by Kater's Pendulum.
11. To determine g and velocity for a freely falling body using Digital Timing Technique/free fall method.
12. To study the Motion of a Spring and calculate (a) Spring Constant, (b) value of g.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

[4] S. Panigrahi and B. Mallick, Engineering Practical Physics, Cengage Learning India Pvt. Ltd, 2015.

Physics - GE : Electricity, Magnetism and EMT
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Vector Analysis Review of vector algebra (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). **(12 Lectures)**

Electrostatics Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(16 Lectures)**

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 ferro-magnetic materials. **(10 Lectures)**

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. **(6 Lectures)**

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. **(10 Lectures)**.

Electrical Circuits AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) quality Factor, and (4) Band Width. Parallel LCR Circuit. Measurement of a High resistance by the method of leakage of charge of a capacitor. Transient in Mutually coupled circuits. **(6 Lectures)**

Reference Books

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

Physics Lab - GE Lab : Electricity, Magnetism and EMT
60 Lectures

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. To determine a Low Resistance by fall of potential method.
3. To compare capacitances using De'Sauty's/Anderson'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 the Characteristics of a Series LR circuit.
7. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor.
8. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
9. To determine the value of a Low Resistance by Carey Foster's Bridge.
10. To verify the Thevenin and Norton theorems.
11. To verify the Superposition, and Maximum Power Transfer Theorems.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] S. Panigrahi and B. Mallick, Engineering Practical Physics, Cengage Learning India Pvt. Ltd, 2015.

Cooch Behar Panchanan Barma University

Syllabus for B.Sc. in Physics (Programme Course)

UNDER CHOICE BASED CREDIT SYSTEM

Cooch Behar Panchanan Barma University

Cooch Behar, West Bengal

Preamble

University Grants Commission (UGC) introduced, in 2018, a major reform in the higher education sector in India. Accordingly, Learning Outcomes-based Curriculum Framework (LOCF) took the centre-stage to make the curriculum student-centric, interactive and outcome-oriented with well-defined aims and objectives. The Physics Undergraduate Board of Studies of Cooch Behar Panchanan Barma University took the initiative to implement the reforms and frame the syllabus so as to increase the spirit of enquiry, analytical ability and comprehension skills among the students.

B.Sc. with Physics

There will be six semesters in the three-year **B.Sc. with Physics**. The Curriculum consists of 12 Core Courses (C), 2 Ability Enhancement Compulsory Courses (AECC), 2 Skill Enhancement Courses (SEC) and 6 Discipline Specific Elective (DSE) Courses. Each course is of 50 marks. L stands for Lecture Hour, T for Tutorial Hour and P for Practical Hour.

Details of Courses under Undergraduate Programmme (B.Sc.)

Course		Credits* Theory + Practical	Theory + Tutorial
I. Core Course 4 Papers from each of the 3 disciplines of choice	**(12 Papers)**	$12 \times 4 = 48$	$12 \times 5 = 60$
Core Course Practical / Tutorial 4 Papers from each of the 3 disciplines of choice	**(14 Papers)**	$12 \times 2 = 24$	$12 \times 1 = 12$
II. Elective Course 2 papers from each discipline of choice including paper of interdisciplinary nature.	**(6 Papers)**	$6 \times 4 = 24$	$6 \times 5 = 30$
Elective Course Practical / Tutorial 2 papers from each discipline of choice including paper of interdisciplinary nature.	**(6 Papers)**	$6 \times 2 = 12$	$6 \times 1 = 6$
• **Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester**			
III. Ability Enhancement Courses			
1. Ability Enhancement Compulsory	**(2 Papers)**		
• Environmental Studies		4	4
• English/MIL Communication		2	2
2. Ability Enhancement Elective (Skill Based) (Minimum 2)	**(2 Papers)**	$4 \times 2 = 8$	$4 \times 2 = 8$
Total credit		**122**	**122**

Institute should evolve a system/policy Interest/Hobby/Sports/NCC/NSS/related courses on its own.
*** wherever there is a practical there will be no tutorial and vice-versa.**

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.Sc. with Physics

	CORE COURSE (12)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (4)	Discipline Specific Elective (DSE) (6)
		Odd Semester		
I	• Mechanics • DSC 2A • DSC 3A	• Environmental Studies		
III	• Thermal Physics and Statistical Mechanics • DSC 2C • DSC 3C		• SEC-1	
V			• SEC-3	• DSE-1A • DSE-2A • DSE-3A
		Even Semester		
II	• Electricity, Magnetism and EMT • DSC 2B • DSC 3B	• English/ MIL Communication		
IV	• Waves and Optics • DSC 2D • DSC 3D		• SEC-2	
VI			• SEC-4	• DSE-1B • DSE-2B • DSE-3B

SEM	COURSE OPTED	COURSE NAME	Credits
I	Ability Enhancement Compulsory Course - 1	Environmental Studies	4
	Core course - 1	Mechanics	4
	Core course - 1 Practical	Mechanics Lab	2
	Core course - 2	DSC 2A	6
	Core course - 3	DSC 3A	6
III	Core course - 7	Thermal Physics and Statistical Mechanics	4
	Core course - 7 Practical	Thermal Physics and Statistical Mechanics Lab	2
	Core course - 8	DSC 2C	6
	Core course - 9	DSC 3C	6
	Skill Enhancement Course - 1	Renewable Energy and Energy harvesting	2
V	Skill Enhancement Course - 3	Basic Instrumentation Skills	2
	Discipline Specific Elective - 1	Digital, Analog and Instrumentation	6
	Discipline Specific Elective - 2	DSE 2A	6
	Discipline Specific Elective - 3	DSE 3A	6

SEM	COURSE OPTED	COURSE NAME	Credits
II	Ability Enhancement Compulsory Course - 2	English/ MIL communications	2
	Core course - 4	Electricity, Magnetism and EMT	4
	Core course - 4 Practical	Electricity, Magnetism and EMT Lab	2
	Core course - 5	DSC 2B	6
	Core course - 6	DSC 3B	6
IV	Core course - 10	Waves and Optics	4
	Core course - 10 Practical	Waves and Optics Lab	2
	Core course - 11	DSC 2D	6
	Core course - 12	DSC 3D	6
	Skill Enhancement Course - 2	Electrical Circuit and Network Skills	2
VI	Skill Enhancement Course - 4	Computational Physics Skills	2
	Discipline Specific Elective - 4	Nuclear and Particle Physics	6
	Discipline Specific Elective - 5	DSE 2A	6
	Discipline Specific Elective - 6	DSE 3A	6

Core Papers (C): (Credit: 06 each) (1 period/week for tutorials or 4 periods/week for practical)

	Paper	periods/week	
		Theory	Lab
1.	Mechanics	4	4
2.	Electricity and Magnetism	4	4
2.	Thermal Physics and Statistical Mechanics	4	4
4.	Waves and Optics	4	4

Discipline Specific Elective Papers: (Credit: 06 each) (2 papers) - DSE 1-2

	Paper	periods/week		
		Theory	Lab	Tut
1.	Digital, Analog and Instrumentation	4	4	
2.	Nuclear and Particle Physics	5		1

Skill Enhancement Courses (Credit: 02 each) - SEC 1-4

1. Renewable Energy and Energy harvesting
2. Electrical Circuit and Network Skills
3. Basic Instrumentation Skills
4. Computational Physics Skills

Semester I

Physics - DSC 1A : Mechanics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Vectors Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **(4 Lectures)**

Ordinary Differential Equations 1^{st} order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **(6 Lectures)**

Laws of Motion Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **(10 Lectures)**

Momentum and Energy Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. **(6 Lectures)**

Rotational Motion Angular velocity and angular momentum. Torque. Conservation of angular momentum. **(5 Lectures)**

Gravitation Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts. **(8 Lectures)**

Oscillations Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(6 Lectures)**

Elasticity Hooke's law - Stress-strain diagram - Elastic moduli - Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum - Determination of Rigidity modulus and moment of inertia - q, η and σ by Searle's method. **(8 Lectures)**

Special Theory of Relativity Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. **(7 Lectures)**

Note: *Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate*

Reference Books

[1] F.W. Sears, M.W. Zemansky and H.D. Young, University Physics (13ed), Addison-Wesley, 1986.
[2] Charles Kittel, et. al, Mechanics Berkeley Physics, Vol 1, Tata McGraw-Hill, 2007.
[3] Resnick, Halliday and Walker, Physics (9ed), Wiley, 2010.
[4] Basudeb Bhattacharya, Engineering Mechanics (2ed), Oxford University Press, 2015.
[5] Ronald Lane Reese, University Physics, Thomson Brooks/Cole, 2003.

Physics Lab - DSC 1A Lab : Mechanics
60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant/free fall method.
3. To determine the Moment of Inertia of a Flywheel/metallic bar axis passing through the centre of gravity.
4. To determine the Young's Modulus of a wire/bar by Optical Lever/flexure Method.
5. To determine the Modulus of Rigidity of a wire by Maxwell's needle method.
6. To determine the Modulus of Rigidity of a wire by dynamical method.
7. To determine the Modulus of Rigidity of a wire by static method.
8. To determine the Elastic Constant/Young's modulus of a wire by Searle's method.
9. To determine g by Bar Pendulum.
10. To determine g by Kater's Pendulum.
11. To determine g and velocity for a freely falling body using Digital Timing Technique/free fall method.
12. To study the Motion of a Spring and calculate (a) Spring Constant, (b) value of g.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

[4] S. Panigrahi and B. Mallick, Engineering Practical Physics, Cengage Learning India Pvt. Ltd, 2015.

Semester II

Physics - DSC 2A : Electricity, Magnetism and EMT
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Vector Analysis Review of vector algebra (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). **(12 Lectures)**

Electrostatics Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(16 Lectures)**

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 ferro-magnetic materials. **(10 Lectures)**

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. **(6 Lectures)**

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. **(10 Lectures)**.

Electrical Circuits AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) quality Factor, and (4) Band Width. Parallel LCR Circuit. Measurement of a High resistance by the method of leakage of charge of a capacitor. Transient in Mutually coupled circuits. **(6 Lectures)**

Reference Books

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

Physics Lab - DSC 2A Lab : Electricity, Magnetism and EMT 60 Lectures

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. To determine a Low Resistance by fall of potential method.
3. To compare capacitances using De'Sauty's/Anderson'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 the Characteristics of a Series LR circuit.
7. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor.
8. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
9. To determine the value of a Low Resistance by Carey Foster's Bridge.
10. To verify the Thevenin and Norton theorems.
11. To verify the Superposition, and Maximum Power Transfer Theorems.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] S. Panigrahi and B. Mallick, Engineering Practical Physics, Cengage Learning India Pvt. Ltd, 2015.

Semester III

Physics - DSC 3A : Thermal Physics and Statistical Mechanics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Laws of Thermodynamics
Thermodynamic description of system Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle and theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(22 Lectures)**

Thermodynamic Potentials Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for $(C_P - C_V), C_P/C_V, TdS$ equations. **(10 Lectures)**

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. **(10 Lectures)**

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. **(6 Lectures)**

Statistical Mechanics Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(12 Lectures)**

Reference Books

[1] S. Garg, R. Bansal and Ghosh, Thermal Physics (2ed), Tata McGraw Hill, 1993.
[2] Meghnad Saha, and B.N. Srivastava, A Treatise on Heat, Indian Press, 1958.
[3] Enrico Fermi, Thermodynamics, Dover, 1956.
[4] M.W. Zemansky, Richard Dittman, Heat and Thermodynamics, McGraw Hill, 1981.
[5] Francis W. Sears and Gerhard L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, 1986.
[6] Ronald Lane Reese, University Physics, Thomson Brooks/Cole, 2003.
[7] A. Kumar and S.P. Taneja, Thermal Physics, R. Chand Publications, 2014.

Physics Lab - DSC 3A Lab
60 Lectures

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of copper/good conductor by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of copper by Angstrom's Method / Bad conductor by cylindrical heat flow method.

   OR

   Determination of thermal conductivity of glass in the form of tube.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature coefficient 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.
11. Determination of temperature coefficient of resistance by using meter bridge.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.
[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] D.P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Pub, 1985.

Semester IV

Physics - DSC 4A : Waves and Optics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Superposition of Two Collinear Harmonic Oscillations Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). **(4 Lectures)**

Superposition of Two Perpendicular Harmonic Oscillations Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(2 Lectures)**

Waves Motion - General Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. **(7 Lectures)**

Fluids Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity: Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of a liquid with temperature lubrication. Physics of low pressure - production and measurement of low pressure - Rotary pump - Diffusion pump - Molecular pump - Knudsen absolute gauge - penning and pirani gauge – Detection of leakage. **(6 Lectures)**

Sound Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria. **(6 Lectures)**

Wave Optics Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. **(3 Lectures)**

Interference Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. **(10 Lectures)**

Michelson's Interferometer Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index and Visibility of fringes. **(3 Lectures)**

Diffraction Fraunhofer diffraction: Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(14 Lectures)**

Polarization Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(5 Lectures)**

Reference Books

[1] F.A. Jenkins and H.E. White, Fundamentals of Optics, McGraw-Hill, 1981.
[2] B.K. Mathur, Principles of Optics, Gopal Printing, 1995.
[3] A. Kumar, H.R. Gulati and D.R. Khanna, Fundamental of Optics, R. Chand Publications, 2011.
[4] F.W. Sears, M.W. Zemansky and H.D. Young, University Physics (13ed), Addison-Wesley, 1986.

Physics Lab - DSC 4A Lab
60 Lectures

1. To investigate the motion of coupled oscillators.
2. To determine the frequency of an electric/mechanical tuning fork by Melde's experiment and verify $\lambda^2 - T$ law.
3. To determine the frequency of an electric/mechanical tuning fork by sonometer.

4. To study Lissajous Figures.
5. Familiarization with Schuster's focussing; determination of angle of prism.
6. To determine the Refractive Index of the Material of a given Prism using Sodium Light / Mercury source.
7. To determine Dispersive Power of the Material of a given Prism using Mercury Light / Sodium source.
8. To determine the value of Cauchy Constants of a material of a prism.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light/sodium source using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium and (2) spectrum of 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] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

[4] D.P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Pub, 1985.

Discipline Specific Elective

Physics - DSE : Digital, Analog and Instrumentation
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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. **(4 Lectures)**

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. **(5 Lectures)**

Binary Addition. Binary Subtraction using 2's Complement Method).Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor. **(4 Lectures)**

UNIT-2

Semiconductor Devices and Amplifiers Semiconductor Diodes: p and n type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow

Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs (2) Photodiode (3) Solar Cell. **(5 Lectures)**

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff, and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. 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. **(12 Lectures)**

UNIT-3

Operational Amplifiers (Black Box approach) Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and 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. **(13 Lectures)**

Sinusoidal Oscillators Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator. **(5 Lectures)**

UNIT-4

Instrumentations Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(3 Lectures)**

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. **(6 Lectures)**

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator. **(3 Lectures)**

Reference Books

[1] J. Millman and C.C. Halkias, Integrated Electronics, Tata McGraw Hill, 1991.

[2] S. Salivahanan and N.S. Kumar, Electronic Devices and Circuits (3ed), Tata McGraw Hill, 2012.

[3] M.H. Rashid, Microelectronic Circuits (2ed), Cengage Learning.

[4] Helfrick and Cooper, Modern Electronic Instrumentation and Measurement Tech., PHI Learning, 1990.

[5] A.P. Malvino, D.P. Leach and Saha, Digital Principles and Applications (7ed), Tata McGraw Hill, 2011.

[6] A.S. Sedra, K.C. Smith, A.N. Chandorkar, Microelectronic Circuits (6ed), Oxford University Press, 2014.

[7] A. Anand Kumar, Fundamentals of Digital Circuits (2ed), PHI Learning, 2009.

[8] R.A. Gayakwad, OP-AMP & Linear Digital Circuits, PHI Learning, 2000.

Physics Lab - DSE Lab : Digital, Analog and Instrumentation 60 Lectures

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 / 4-bit Binary Adder.

5. Adder-Subtractor using Full Adder IC.
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 / 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 using Op-amp 741 or study its frequency response.
12. To design a non-inverting amplifier using Op-amp 741or study its Frequency Response.
13. To study a precision Differential Amplifier using Op-amp.
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] P.B. Zbar, A.P. Malvino, M.A. Miller, Basic Electronics: A Text Lab Manual, McGraw Hill, 1994.
[2] J.D. Ryder, Electronics: Fundamentals and Applications, Prentice-Hall, 2004.
[3] R.A. Gayakwad, OP-AMP & Linear Digital Circuits, PHI Learning, 2000.
[4] Albert Malvino, Electronic Principle, Tata McGraw Hill, 2008.

Physics - DSE : Nuclear and Particle Physics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

General Properties of Nuclei Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, 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 excites states. **(10 Lectures)**

Nuclear Models Liquid drop model approach, semi empirical mass formula and significance of its various terms, α and β nuclear stability from semi empirical mass formula, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. **(17 Lectures)**

Radioactivity decay (a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) Beta decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission and kinematics, internal conversion. **(9 Lectures)**

Nuclear Reactions Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures)**

Interaction of Nuclear Radiation with matter Energy loss due to ionisation (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. **(6 Lectures)**

Detector for Nuclear Radiations Gas detectors: estimation of electric field, mobility of particle, for ionisation chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. **(6 Lectures)**

Particle Accelerators Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(5 Lectures)**

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, concept of quark model, color quantum number and gluons. **(14 Lectures)**

Reference Books

[1] Kenneth S. Krane, Introductory Nuclear Physics, Wiley India Pvt. Ltd., 2008.
[2] Bernard L. Cohen, Concepts of Nuclear Physics, Tata Mcgraw Hill, 1998.
[3] R.A. Dunlap, Introduction to the Physics of Nuclei and Particles, Thomson Asia, 2004.
[4] D.H. Perkins, Introduction to High Energy Physics, Cambridge Univ. Press.
[5] D.J. Griffith, Introduction to Elementary Particles, John Wiley & Sons.
[6] F. Halzen and A.D. Martin, Quarks and Leptons, Wiley India.
[7] K. Heyde, Basic Ideas and Concepts in Nuclear Physics – An Introductory Approach, IOP, 2004.
[8] G.F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 2000.
[9] Syed Naeem Ahmed, Physics and Engineering of Radiation Detection, Academic Press, 2007.
[10] J.M. Blatt and V.F. Weisskopf, Theoretical Nuclear Physics, Dover, 1991.

Skill Enhancement Course

Physics - SEC : Renewable Energy and Energy Harvesting (Credits: 02)

Theory: 30 Lectures

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. **(3 Lectures)**

Solar energy Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat 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. **(6 Lectures)**

Wind Energy harvesting Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **(3 Lectures)**

Ocean Energy Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. **(3 Lectures)**

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. **(2 Lectures)**

Geothermal Energy Geothermal Resources, Geothermal Technologies. **(2 Lectures)**

Hydro Energy Hydropower resources, hydropower technologies, environmental impact of hydro power sources. **(2 Lectures)**

Piezoelectric Energy harvesting Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power. **(4 Lectures)**

Electromagnetic Energy Harvesting Linear generators, physics mathematical models, recent applications. **(2 Lectures)**

Carbon captured technologies, cell, batteries, power consumption. **(2 Lectures)**

Environmental issues and Renewable sources of energy, sustainability. **(1 Lectures)**

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 voltage using thermoelectric modules.

Reference Books

[1] G.D. Rai, Non-conventional Energy Sources, Khanna Publishers.
[2] M.P. Agarwal, Solar Energy, S Chand.
[3] Suhas P. Sukhative, Solar Energy, Tata McGraw-Hill.
[4] Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford Univ. Press, 2004.
[5] P. Jayakumar, Solar Energy: Resource Assesment Handbook, 2009.
[6] J. Balfour, M. Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich.
[7] http://en.wikipedia.org/wiki/Renewable_energy

Physics - SEC : Electrical Circuit and Network Skills
(Credits: 02)
Theory: 30 Lectures

Basic Electricity Principles Voltage, Current, Resistance, and Power. Ohm's law.Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarisation with multimeter, voltmeter and ammeter. **(3 Lectures)**

Understanding Electrical Circuits Main electric circuit elements and their combination. Rules to analyse DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyse AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(4 Lectures)**

Electrical Drawing and Symbols Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **(4 Lectures)**

Generators and Transformers DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. **(3 Lectures)**

Electric Motors Single-phase, three-phase and DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed and power of AC motor. **(4 Lectures)**

Solid-State Devices Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources. **(3 Lectures)**

Electrical Protection Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device). **(4 Lectures)**

Electrical Wiring Different types of conductors and cables. Basics of wiring-star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board. **(5 Lectures)**

Reference Books

[1] B L Theraja and A K Theraja, A Text Book in Electrical Technology, S Chand & Co.
[2] M G Say, Performance and design of AC machines, ELBS Edn.

Physics - SEC : Basic Instrumentation Skills
(Credits: 02)
Theory: 30 Lectures

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. **(4 Lectures)**

Electronic Voltmeter Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance. **(4 Lectures)**

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. **(6 Lectures)**

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. **(3 Lectures)**

Signal Generators and Analysis Instruments Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **(4 Lectures)**

Impedance Bridges and Q-Meters Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of a Q- Meter. Digital LCR bridges. **(3 Lectures)**

Digital Instruments Principle and working of digital meters. Comparison of analog and digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **(3 Lectures)**

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. **(3 Lectures)**

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 observe the limitations of a multimeter for measuring high frequency voltage and currents.
4. To measure Q of a coil and its dependence on frequency, using a Q- meter.
5. Measurement of voltage, frequency, time period and phase angle using CRO.
6. Measurement of time period, frequency, average period using universal counter/ frequency counter.
7. Measurement of rise, fall and delay times using a CRO.
8. Measurement of distortion of a RF signal generator using distortion factor meter.
9. 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).

Reference Books

[1] B L Theraja and A K Theraja, A Text Book in Electrical Technology, S Chand & Co.
[2] M G Say, Performance and design of AC machines, ELBS Edn.
[3] Venugopal, Digital Circuits and Systems, Tata McGraw Hill, 2011.
[4] Shimon P. Vingron, Logic Circuit Design, Springer, 2012.
[5] Subrata Ghoshal, Digital Electronics, Cengage Learning, 2012.

[6] S. Salivahanan and N.S. Kumar, Electronic Devices and Circuits (3ed), Tata McGraw Hill, 2012.
[7] U.Tietze and C.Schenk, Electronic Circuits: Handbook of Design and Applications, Springer, 2008.
[8] Thomas L. Floyd, Electronic Devices (7ed), Pearson India, 2008.

Physics - SEC : Computational Physics
(Credits: 02)
Theory: 30 Lectures

The aim of this course is not just to teach computer programming and numerical analysis but to emphasise its role in solving problems in Physics.

Highlights the use of computational methods to solve physical problems.
Use of computer language as a tool in solving physics problems (applications).
Course will consist of hands on training on the Problem solving on Computers.

Introduction Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor.

Algorithms and Flowcharts Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin (x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. **(4 Lectures)**

Scientific Programming Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialisation and Replacement Logic. Examples from physics problems. **(5 Lectures)**

Control Statements Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO- WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming

1. Exercises on syntax on usage of FORTRAN.
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.

4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at $x = 1$.

(6 Lectures)

Scientific word processing Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages.

Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. **(6 Lectures)**

Visualization Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot.

Hands on exercises

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices.
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

(9 Lectures)