SYLLABUS FOR
Bachelor of Science (Honours)
PHYSICS

THREE YEAR DEGREE COURSE
SEMESTER SYSTEM
(Under New UGC CBCS Guidelines)

2021

COURSE STRUCTURE

SEM	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Mathematical Physics (Theory)	PHC 1.11	4
		Mathematical Physics (Practical)	PHC 1.12	2
	Core 2	Mechanics (Theory)	PHC 1.21	4
		Mechanics (Practical)	PHC 1.22	2
II	Core 3	Electricity and Magnetism (Theory)	PHC 2.11	4
		Electricity and Magnetism (Practical)	PHC 2.12	2
	Core 4	Waves and Optics (Theory)	PHC 2.21	4
		Waves and Optics (Practical)	PHC 2.22	2
III	Core 5	Mathematical Physics II (Theory)	PHC 3.11	4
		Mathematical Physics II (Practical)	PHC 3.12	2
	Core 6	Thermal Physics (Theory)	PHC 3.21	4
		Thermal Physics (Practical)	PHC 3.22	2
	Core 7	Analog Systems and Applications (Theory)	PHC 3.31	4
		Analog Systems and Application (Practical)	PHC 3.32	2
	Skill Enhancement Course 1	Basic Instrumentation Skills (Practical) OR Physics Workshop Skill (Practical)	PHS 3.12(a) PHS 3.12(b)	2
IV	Core 8	Mathematical Physics III (Theory)	PHC 4.11	4
		Mathematical Physics III (Practical)	PHC 4.12	2
	Core 9	Elements of Modern Physics (Theory)	PHC 4.21	4
		Elements of Modern Physics (Practical)	PHC 4.22	2
	Core 10	Digital Systems and Applications (Theory)	PHC 4.31	4
		Digital Systems and Applications (Practical)	PHC 4.32	2
	Skill Enhancement Course 2	Computational Physics (Practical) OR Radiation Safety (Practical)	PHS 4.12(a)	2

			PHS 4.12(b)	
V	**Core 11**	**Quantum Mechanics and Applications (Theory)**	**PHC 5.11**	**4**
		Quantum Mechanics and Applications (Practical)	**PHC 5.12**	**2**
	Core 12	**Solid State Physics (Theory)**	**PHC 5.21**	**4**
		Solid State Physics (Practical)	**PHC 5.22**	**2**
	Discipline Specific Elective 1	**Classical Dynamics** **OR** **Digital signal processing theory**	**PHD 5.11(a)** **PHD 5.11(b)**	**5** **4**
		Classical Dynamics (Tutorial) **OR** **Digital signal processing theory Lab**	**PHD 5.12(b)**	**1** **2**
	Discipline Specific Elective 2	**Nano Material and Applications (Theory)** **OR** **Nuclear and Particle Physics (Theory)**	**PHD 5.21(a)** **PHD 5.21(b)**	**4** **5**
		Nano Material and Applications (Practical) **OR** **Nuclear and Particle Physics (Tutorial)**	**PHD 5.22(a)**	**2** **1**
VI	**Core 13**	**Electromagnetic Theory (Theory)**	**PHC 6.11**	**4**
		Electromagnetic Theory (Practical)	**PHC 6.12**	**2**
	Core 14	**Statistical Mechanics (Theory)**	**PHC 6.21**	**4**
		Statistical Mechanics (Practical)	**PHC 6.22**	**2**

VI	Discipline Specific Elective 3	Advance Mathematical Physics-I (Theory) OR Advance Mathematical Physics-II (Theory)	PHD 6.11(a) PHD 6.11(b)	4 5
		Advance Mathematical Physics-I Lab OR Advance Mathematical Physics-II (Tutorial)	PHD 6.12(a)	2 1
	Discipline Specific Elective 4	Astronomy and Astrophysics (Theory) OR Atmospheric Physics (Theory) OR Physics of Earth (Theory) OR Biological Physics (Theory)	PHD 6.21(a) PHD 6.21(b) PHD 6.21(c) PHD 6.21(d)	5 4 5 5
		Astronomy and Astrophysics (Tutorial) OR Atmospheric Physics (Practical) OR Physics of Earth (Tutorial) OR Biological Physics (Tutorial)	PHD 6.22(b)	1 2 1 1

Core

SEMESTER - I

CORE 1(PHC 1.11)
MATHEMATICAL PHYSICS-I
Credits: Theory-04
Teaching hours: 60

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

UNIT 1: Calculus: Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).
First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers**.** (12 hours)

UNIT II: 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.
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. (12 hours)

UNIT III: 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). (12 hours)

UNIT IV: Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. (12 hours)

UNIT V: Introduction to probability:Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance.Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.
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.
(12 hours)

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, Goswami, 1st edition, Cengage Learning
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

CORE 1(PHC1.12)

MATHEMATICAL PHYSICS-I

Practical Credit: 2

Teaching Hours: 60

The aim of this practical is to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- *Highlights the use of computational methods to solve physical problems*
- *The course will consist of lectures (both theory and practical) in the Lab*
- *Evaluation done not on the programming but on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved*
- *Students can use any one operating system Linux or Microsoft Windows*
- In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources

Topic	Description with Applications
Introduction and Overview Of C/C++	Computer architecture and organization, memory and input/output devices, introduction to Linux operating system, introduction to C/C++ compilers, algorithms and flow charts. Basic structure of C/C++ programming
C /C++ Programming fundamentals	• Header section • Library function • Constant, variable and data type • Operators and expressions • Managing Input/output operation • Decision making and branching • Decision making and looping • Array • User defined function
Graphic programming	• Introduction to graphic programming, • Graphic library function, • program to plots the basic shape

Basic Programs	• Area of circle, area of square, volume of sphere. • Coordinate transformations • Sum and average of a list of numbers, • To find the largest of a given list of numbers, and its location in the list, • Sorting of numbers, in ascending, descending order. • calculation of sin(x) as a series, • To find the roots of a quadratic equation • Matrix operations (addition, subtraction, multiplication). • To compile a frequency distribution and evaluate mean and standard deviation. • To evaluate sum of finite series and the area under a curve. • Plotting Lissajous figures. • Plotting a trajectory of a projectile thrown at an angle with the horizontal.

Recommended Books and Recommended Books and References:

1. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
2. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rdEdn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher& C. Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis, K.E. Atkinson, 3rdEdn., 2007, Wiley India Edition.
6. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
7. An Introduction to computational Physics, T. Pang, 2ndEdn., 2006, Cambridge Univ. Press
8. Computational Physics, Darren Walker, 1stEdn., 2015, Scientific International Pvt. Ltd

CORE 2 (PHC 1.21)
MECHANICS
Theory Credit: 4
Teaching Hours: 60

UNIT I

Fundamentals of Dynamics: Reference frames: Inertial and non inertial frames. Review of Newton's Laws of Motion. Galilean transformation equations (position and time); its application to transformation of length, velocity and acceleration. Invariance of Galilean transformation to Newton's law of motion, the law of conservation of momentum and the law of conservation of energy. Variable mass system: Motion of Rocket. Centre of mass; its velocity and acceleration, total linear momentum about the centre of mass. Principle of conservation of linear momentum. Impulse.

Work and Energy: Concepts of work and energy, kinetic energy, work-energy principle. Conservative and non conservative forces. Potential energy, conservative force as gradient of potential energy, curl of conservative force. Potential energy curve. Elastic potential energy, Work and potential energy. Law of conservation of energy, Non-conservative force and the general law of conservation of energy. (12 hours)

UNIT II

Collisions: Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque and its relation with angular momentum, angular impulse. Principle of conservation of angular momentum. Angular momentum under central force. Rotation about a fixed axis: Moment of Inertia and radius of gyration. Theorem of perpendicular and parallel axes. Calculation of moment of inertia for rectangular, circular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. (12 hours)

UNIT III

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.

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. 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). (12 hours)

UNIT IV

Elasticity: Introduction; Elastic constants, Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

Fluid Motion: Kinematics of Moving Fluids; Viscosity; Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.

Oscillations: Oscillatory and Simple harmonic motion. Differential equation of SHM and its solutions in different forms. Velocity, acceleration, time period, frequency SHM. Energy of Simple Harmonic Oscillator, Time–average values of KE and PE. Damped oscillation; Differential equation of motion of damped harmonic oscillator and its solution. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. (12 hours)

UNIT V

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Length contraction, Time dilation; Twin Paradox. Relativity of Simultaneity, Invariance of Space-time interval. Transformation of velocity- Relativistic addition of velocities. Variation of mass with velocity. Mass less Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. (12 hours)

Recommended Books and Recommended Books and References:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
8. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
9. Physics for Degree Students (B.Sc. First Year), C.L Arora and Dr. P.S.Hemne, S Chand.

CORE 2 (PHC 1.22)
MECHANICS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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) **g** and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine **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 g using Bar Pendulum.

12. To determine the value of g using Kater's Pendulum.

Recommended Books and Recommended Books and References:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11thEdn, 2011, Kitab Mahal
4. Engineering Practical Physics, S.Panigrahi& B.Mallick,2015, Cengage Learning India Pvt. Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

SEMESTER - II

CORE 3 (PHC 2.11)
ELECTRICITY AND MAGNETISM
Theory Credit: 4
Teaching Hours: 60

UNIT I
Electric Field and Electric Potential: Electric field: Electric field lines. Area vector, Electric flux. Gauss' Law, Gaussian surface; applications to charge distributions with spherical, cylindrical and planar symmetry. Field; Scalar field, vector field and conservative field. Conservative nature of Electrostatic Field. Electrostatic Potential. Divergence of a vector field, Gauss's divergence theorem and differential form of Gauss's law. Laplace's and Poisson equations. The Uniqueness Theorem. Electric dipole; Dipole moment, Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. (12 Hours)

UNIT II
Electrical Images: Method of electrical Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.
Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant.
Capacitor: Capacitance of an isolated conductors, Parallel-plate capacitor without and with di-electric medium. Spherical and cylindrical capacitors filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. *(12 Hours)*

UNIT III
Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **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 **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.
Magnetic Properties of Matter: Magnetization vector (**M**). Magnetic Intensity(**H**). Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis.
(12 Hours)

UNIT IV
Electromagnetic Induction: Magnetic flux, 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.
Electrical Circuits: DC Transients: Current growth and decay in LR, CR, LCR circuits with a direct current input 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. (12 Hours)

UNIT V

Network theorems: Ideal Constant-voltage and Constant-current Sources. Mesh currents, Mesh equations, Matrix methods and circuit analysis, Source transformation, Two-port Network. Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. (12Hours)

Recommended Books and Recommended Books and References:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
6. Electricity and Magnetism, D.Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
7. Undergraduate Physics Vol II, AB Bhattacharya, R Bhattacharya, New Central Book Agency (P) Ltd.

CORE 3 (PHC 2.12)
ELECTRICITY AND MAGNETISM (PRACTICAL)

Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
4. To determine an unknown Low 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.
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

Recommended Books and Recommended Books and References:

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

CORE 4 (PHC 2.21)

WAVES AND OPTICS

Theory Credit: 4

Teaching Hours: 60

UNIT I **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. Energy in a progressive waves and intensity of waves.

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. (12 Hours)

UNIT II **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.

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. *(12 Hours)*

UNIT III **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. Dispersive and non-dispersive media. Melde's Experiment. Laws of vibrating stretched strings. Description of electrically maintained tuning fork, longitudinal and transverse mode. Longitudinal vibration of air column in open and closed pipes.
Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes.
Superposition of N Harmonic Waves. *(12 Hours)*

UNIT IV **Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.
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:Reflected and tramsimtted light. Measurement of wavelength and refractive index.
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. *(12 Hours)*

UNIT V **Diffraction:** Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula.(Qualitative discussion only)

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

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate, Zone plate as a convex lens. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.
Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

(12 Hours)

Recommended Books and Recommended Books and References:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw Hill

3. Principles of Optics, Max Born and Emil Wolf, 7thEdn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

CORE 4 (PHC 2.22)
WAVES AND OPTICS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization 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 (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

Recommended Books and Recommended Books and References:

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

2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

SEMESTER – III

CORE 5 (PHC 3.11)
MATHEMATICAL PHYSICS-II
Theory Credit: 4
Teaching Hours: 60

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

UNIT I **Fourier Series:** 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. (12 Hours)

UNIT II **Series Solution of Second Order Differential Equation**: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to solve differential equations.

Legendre, Differential Equation, Properties of Legendre Polynomials, Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials.

(12 Hours)

UNIT III

Bessel, Differential Equation, Bessel Functions of the First Kind: Generating Function, and Orthogonality, recurrence relations. Zeros of Bessel Functions, $J_o(x)$ and $J_1(x)$) of Bessel equation.

Hermite Differential Equation, generating function of Hermite polynomials (Rodrigues formula), orthogonal property recurrence formulae for $H_n(x)$ of Hermite equation

Laguerre Differential Equation, Laguerre functions for different value of n, generating function of Laguerre polynomials , orthogonal property, reccurrence relations.

(12 Hours)

UNIT IV

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

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line. (12 Hours)

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

(12 Hours)

Recommended Books and Recommended Books and References:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press
7. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

CORE 5 (PHC 3.12)
Mathematical Physics -II (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Computer Lab. Evaluation done not on the basis of programming but on the basis of formulating the problem. At least two programs must be attempted from each programming section. In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

Topics	**Description with Applications**
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables

	in Scilab, Multidimensional arrays, Sub-array, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization. User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program.
Curve fitting, Least square fit, Goodness of fit, standard deviation using Scilab	Ohms law calculate R, Hooke"s law Calculate spring constant given Bessel"s function at N points find its value at an intermediate point.
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalisation of matrices, Inverse of a matrix, Eigen vectors, eigen-values problems	Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function
Solution of ODE First order Differential equation Euler, modified Euler and RungeKutta (RK) second and Fourth order methods Second order differential equation Fixed difference method Partial differential equations	First order differential equation: •Radioactive decay • Current in RC, LC circuits with DC source • Newton"s law of cooling • Classical equations of motion • Second order Differential Equation: Harmonic oscillator (no friction) • Damped Harmonic oscillator o Overdamped o Critical damped o Oscillatory •Forced Harmonic oscillator o Transient and o Steady state solution Apply above to LCR circuits also • Solve

	$$x^2 \frac{d^2y}{d\,x^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$$ with the boundary conditions at $x = 1$, $y = \frac{1}{2}e^2$, $\frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$, in the range $1 \le x \le 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph. Partial Differential Equation: • Wave equation • Heat equation • Poisson equation • Laplace equation
Using Scicos/xcos	•Generating sine wave, square wave, sawtooth wave • Solution of harmonic oscillator • Study of heat phenomenon • Phase space plots

Recommended Books and Recommended Books and References:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Complex Variables, A.S. Fokas& M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
3. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
4. Computational Physics, D.Walker, 1stEdn., 2015, Scientific International Pvt. Ltd.
5. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rdEdn., Cambridge University Press
6. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
7. Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
8. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand& Company
9. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
10. www.scilab.in/textbook_companion/generate_book/291

CORE 6 (PHC 3.21)
THERMAL PHYSICS
Theory Credit: 4

Teaching Hours: 60

(Include related problems for each topic)

UNIT I

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. 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. (12 Hours)

UNIT II

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 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. (12 Hours)

UNIT III

Introduction to Thermodynamics: Zeroth and First Law of Thermodynamics: Extensive and intensive ThermodynamicVariables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. 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 & efficiency. Refrigerator & coefficient of performance, 2nd 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. (12 Hours)

UNIT IV

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law ofThermodynamics 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.
Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy,Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. (12 Hours)

UNIT V
Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) 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. (12 Hours)

Recommended Books and Recommended Books and References:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

CORE 6 (PHC 3.22)
THERMAL PHYSICS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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 by Platinum Resistance Thermometer (PRT).
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 (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Recommended Books and Recommended Books and References:

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

CORE 7 (PHC 3.31)
ANALOG SYSTEMS AND APPLICATIONS
Theory Credit: 4
Teaching Hours: 60

UNIT I

Semiconductor P-N junction diodes: P and N type semiconductors.. PN Junction Fabrication (Simple Idea). Transport phenomena in semiconductors (Drift and Diffusion current). Electrical conductivity of semiconductors. Barrier Formation in PN Junction diode Field analysis of P-N junction. Derivation for barrier potential and space charge width for Step Junction. P-N Junction under biased conditions. I-V characterstic and resistance of P-N junction diode. A brief idea about different types of P-N junction diode (12 Hours)

UNIT II

Applications of P-N junction diodes: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, (2) Zener Diode and Voltage Regulation.

Bipolar Junction transistors (BJT): n-p-n and p-n-p Transistors , transistor in CB, CE and CC Configurations. Current gains α and β and their relation . Characteristic curve of transistor for CE configuration and its DC Load Line analysis

Transistor biasing and stabilization, Physical mechanism of Current Flow, Biasing of a CE transistor by using Voltage Divider network . AC model or Ebers-Moll model of a transistior, AC resistance of the emitter diode. (12 Hours)

UNIT III

Voltage Amplifier: CE amplifier, DC and AC equivalent circuit. AC load line. gain of an amplifier. H-parameter model of a transistor. Analysis of a single-stage CE amplifier using H-parameter Model. Input and Output Impedance. Current and Voltage Gains.

Emitter follower and its gain. Brief idea about the Class A, B & C power amplifiers.

Coupled Amplifier: Two stage RC-coupled amplifier, its frequency response and bandwidth Voltage gain in mid, low and high frequency range. (12 Hours)

UNIT IV

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift, Hartley & Colpitts oscillators. Determination of their frequency and condition of sustained oscillation . (12 Hours)

UNIT V

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. 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. Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution.A/D Conversion (successive approximation) (12 Hours)

Recommended Books and References:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S.Salivahanan& N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6thEdn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India 303

CORE 7 (PHC 3.32)
ANALOG SYSTEMS AND APPLICATIONS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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 & power curves of solar cells and find maximum power point & 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) & 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.

Recommended Books and References:

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

SEMESTER – IV

CORE 8 (PHC 4.11)
MATHEMATICAL PHYSICS-III
Theory Credit: 4
Teaching Hours: 60

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

UNIT I

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. (12 Hours)

UNIT II

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. (12 Hours)

UNIT III

Integrals Transforms: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & 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. (12 Hours)

UNIT IV

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd 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. (12 Hours)

UNIT V

Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform. (12 Hours)

Recommended Books and Recommended Books and References:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
3. Complex Variables, A.S. Fokas& M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
5. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
6. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett299

CORE 8 (PHC 4.12)
MATHEMATICAL PHYSICS-III (PRACTICAL)
***PRACTICAL CREDIT*: 2**
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

Scilab (or equivalent) based simulations experiments based on Mathematical Physics problems like

1. Solve:

   $dy/dx = e^{-x}$ with $y = 0$ and $x = 0$

   $dy/dx + e^{-x} y = x^2$

   $d^2y/dy^2 + 2dy/dt = -y$

   $d^2y/dt^2 + e^{-1}dy/dt = -y$

2. Dirac Delta function:

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{-\frac{(x-2)^2}{2\sigma^2}} (x+3)dx \quad for \quad \sigma = 1, 0.1, 0.01$ and show it tends to 5

3. Evaluation of the coefficients of a Fourier series and plot its functions.

4. Frobenius' method and special functions:

   $\int_{-1}^{+1} P_n(\mu) P_m(\mu) d\mu = \delta_{n,m}$ Plot $P_n(x), j_v(x)$ Show recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (Choose any two)
6. Calculation of least square fitting manually, without giving weightage to error, confirmation of least square fitting of data through computer program
7. Evaluation of trigonometric functions eg. $\sin\theta$, . Given Bessel's function at N points, find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.

8. Compute the n^{th} roots of unity for $n = 2, 3$ and 4..
9. Find the two square roots of $-5+12j$
10. Integral transform FFT of e^{-x^2}
11. Solve Kirchoff's Current Law for any node of an arbitrary circuit using Laplace's transform.
12. Perform circuit analysis of a general LCR circuit using Laplace's transform.

Recommended Books and Recommended Books and References:

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

CORE 9 (PHC 4.21)
ELEMENTS OF MODERN PHYSICS
Theory Credit: 4
Teaching Hours: 60
UNIT I

Planck's quantum theory: distribution of energy in the spectrum of a black body, Planck's hypothesis, Planck's law of radiation and its reduction to Wien's formula and Rayleigh-Jeans formula.
Dual nature: Wave-particle duality, Photo-electric effect, Einstein's photoelectric equation, Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.
Wave mechanics: Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Position measurement- gamma ray microscope through experiment; 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. *(12 Hours)*

UNIT II

Quantum mechanics I: Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence. Wave amplitude and wave functions, properties and requirements of wavefunction. Wave mechanical atom model; particle in a box. Basic postulates of wave mechanics. Schrodinger equation for non-relativistic particles.Eigen function and eigen values.

Momentum and Energy operators; stationary states. Probabilities and Normalization; Relation between probability density and probability current density in one dimension. *(12Hours)*

UNIT III

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

Nucleus: 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 and magic numbers. *(12 Hours)*

UNIT IV

Radioactivity: Natural radioactivity, Properties of alpha, beta and gamma rays. Soddy Fajan's displacement law. Law of radioactive decay; Mean life, half life and decay constant; Law of successive disintegration. Radioactive dating: the age of the Earth. Alpha decay: Gamow's theory of alpha decay and its experimental verification. Beta decay: Beta ray spectra, Pauli's prediction of neutrino and Neutrino theory of beta decay. Gamma ray emission: Origin, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. *(12 Hours)*

UNIT V

Nuclear Fission and Fusion: Nuclear fission; mass deficit and generation of energy, Bohr and Wheeler's theory of nuclear fission, Chain reaction, multiplication factor and critical size.

Nuclear reactor; slow neutrons interacting with Uranium 235. Nuclear Fusion: Sources of stellar energy, thermonuclear reactions.

Laser: Absorption, Emission and metastable states. Einstein's A and B coefficients and their relation. Principle of Laser: Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Properties of laser, application and holography. *(12 Hours)*

Recommended Books and Recommended Books and References:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill 301
6. Quantum Mechanics: Theory & Applications, A.K.Ghatak&S.Lokanathan, 2004, Macmillan
7. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
8. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2ndEdn, Tata McGraw-Hill Publishing Co. Ltd.
9. Modern Physics, R Murugeshan, Er. Kiruthiga Sivaprasath, Revised Edition, S Chand

CORE 9 (PHC 4.22)
ELEMENTS OF MODERN PHYSICS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization 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 tunneling 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 (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

Recommended Books and Recommended Books and References:

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

CORE 10 (PHC 4.31)
DIGITAL SYSTEMS AND APPLICATIONS
Theory Credit: 4
Teaching Hours: 60

UNIT I

Digital Circuits: Difference between Analog and Digital Circuits. Analysis of a Transistor as a switch. Binary, Decimal and Hexadecimal number systems and their inter conversions . Binary and hexadecimal, addition and subtraction. Realization of AND, OR and NOT Gates using transistor.NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. Integrated Circuits (Qualitative treatment only), Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Standard logic families (TTL, ECL, CMOS), Configuration of Digital TTL lCs for AND, OR, NOT, NAND and NOR logic gates.
(12 Hours).

UNIT II

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. Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. Arithmetic Circuits: Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. (12 Hours)

UNIT III

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. Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. 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). (12 Hours)

UNIT IV

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous **Counter. Computer Organization**: Input/Output Devices. Data storage (idea of RAM and ROM).Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. (12 Hours)

UNIT V

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram.Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry.

Timing states. Instruction cycle, Timing diagram of MOV and MVI. Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions. (12 Hours)

Recommended Books and Recommended Books and References:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2ndEdn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate ,2010, Oxford University Press
5. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
8. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

CORE 10 (PHC 4.32)
DIGITAL SYSTEMS AND APPLICATIONS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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

14. .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.).

Recommended Books and References:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.

2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

4. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009,Pearson

SEMESTER – V

CORE 11 (PHC 5.11)
QUANTUM MECHANICS
Theory Credit: 4
Teaching Hours: 60

UNIT I 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. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. (12 Hours)

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. (12 Hours)

UNIT II 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 & uncertainty principle. (12 Hours)

UNIT III 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 & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells. (12 Hours)

UNIT IV Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. 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.
Atoms in External Magnetic Fields:- Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). (12 Hours)

UNIT V Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atomsL-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.). (12 Hours)

Recommended Books and References:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer.
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press.
8. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
9. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education.
10. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.
11. A Modern Approach to Quantum Mechanics, 2010, University Science Books.
12.

CORE 11 (PHC 5.12)
QUANTUM MECHANICS AND APPLICATIONS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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

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

   Where, m is the reduced mass of the electron. Obtain the energy eigen values and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(\text{eVÅ})^{1/2}$,ħc = 1973 (eV Å) and m = 0.511×10^6 eV/c^2.

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

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

Where m is the reduced mass of the hydrogen atom.,for the screened coulomb potential, $V(r) = -\frac{e^2}{r}e^{-r/a}$

3. Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)$^{1/2}$, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these, ħc= 1973units(eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

4. Solve the S wave radial Schroedinger equation for a particle of mass m

$\frac{d^2y}{dr^2} = A(r)u(r) \ \ where A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ for a anharmonic oscillator potential $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$ for the ground state energy in MeV, of a particle of accuracy of three significant digits. Also plot the corresponding wave function. Choose m=940 MeV/c^2,k=100Mev /fm^{-2}, b=0,10,30 Mevfm^{-3}, . In these units, $c\hbar = 197.3 MeVfm.$ The ground state energy is expected to lie between 90 and 110 Mev in all three cases

5. Solve the s-wave radial Schrodinger equation for the vibrations of $\frac{d^2y}{dr^2} = A(r)u(r) \ \ where A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ where μ is the reduced mass of the two atom system for the Morse potential, $V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'}),\ r' = \frac{r - r_0}{r}$. Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take $m = 940 \times 10^6 eV / C^2,\ D = 0.755501 eV, \alpha = 1.44, r_0 = 0.131349 A^0$

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. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs.

Recommended Books and Recommended Books and References:

1. Schaum's outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge University Press.

3. An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.
5. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
6. Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274

CORE 12 (PHC 5.21)
SOLID STATE PHYSICS
Theory Credit: 4
Teaching Hours: 60

UNIT I **Crystal Structure:** Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Coordination number and packing density. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. (12 Hours)

UNIT II **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. T3 law. (12 Hours)

UNIT III **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. 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). (12 Hours)

UNIT IV **Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability.Dielectric hysteresis. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency and Plasmons, (12 Hours)

UNIT V **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. 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) & Hall coefficient. (12 Hours)

Recommended Books and Recommended Books and References:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.

2. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India

3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill

4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning

5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer

6. Solid State Physics, Rita John, 2014, McGraw Hill

7. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India 8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

CORE 12 (PHC 5.22)
SOLID STATE PHYSICS (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.

3. To determine the Coupling Coefficient of a Piezoelectric crystal.

4. To measure the Dielectric Constant of a dielectric Materials with frequency

5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)

6. To determine the refractive index of a dielectric layer using SPR

7. To study the PE Hysteresis loop of a Ferroelectric Crystal.

8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150oC) and to determine its band gap.

10. To determine the Hall coefficient of a semiconductor sample.

Recommended Books and Recommended Books and References:

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

2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

SEMESTER – VI

CORE 13 (PHC 6.11)
ELECTROMAGNETIC THEORY
Theory Credit: 4
Teaching Hours: 60
UNIT I: Maxwell Equations

Maxwell's Equations, Equation of continuity, Displacement Current, Characteristics of displacement current, Vector and Scalar Potentials, Potential formulation of electrodynamics, Non-uniqueness of electromagnetic potential, Gauge Transformations, Lorentz and Coulomb Gauge, four dimensional Poisson's equations, Boundary Conditions at Interface between Different Media, Poynting Theorem and Poynting Vector, Electromagnetic (EM) Energy Density, Physical Concept of Electromagnetic Field Energy Density. *(12 Hours)*

UNIT II: EM Wave Propagation in Unbounded Media:

The wave equation, second order wave equation in terms of the field vector, Plane electromagnetic (EM) waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, to show that electric and magnetic field vectors are mutually perpendicular to the propagation vector, refractive index and dielectric constant, wave impedance, calculation of the wave impedance of free space, Propagation of plane electromagnetic through conducting media, spatially attenuation of the amplitudes of field vectors, , skin depth, Lorentz- Drude expression for conductivity, Wave propagation through dilute plasma, plasma frequency, application to propagation through ionosphere. *(12 Hours)*

UNIT III EM Wave in Bounded Media:

Reflection & Refraction of plane electromagnetic waves at normal incidence, reflection and transmission coefficient for a plane electromagnetic wave at normal incidence, propagation of plane electromagnetic waves in accordance with the law of conservation of energy, Reflection & Refraction of plane waves at plane interface between two dielectric media- Laws of Reflection & Refraction, Fresnel's equations for polarization of electromagnetic waves, Brewster's law, Reflection & Transmission coefficients, evanescent waves. *(12 Hours)*

UNIT IV Polarization of Electromagnetic Waves:

Polarization of electromagnetic waves, plane polarised light, plane of vibration, Dichorism, Birefringence, Double Refraction, Ordinary & extraordinary rays, optic axis and principal axis, Anisotropic crystals, Uniaxial and Biaxial Crystals, Double refraction through Uniaxial, Crystal, negative and positive crystal, Nicol Prism, construction and action of a Nicol prism, production and analyses of plane polarised light, Description of Linear, Circular and Elliptical Polarization, Production & detection of Plane polarised light, Analysis of Polarized Light, Phase Retardation Plates: Quarter-Wave and Half-Wave Plates, theory and construction of a quarter wave plate, working of a half wave plate, thickness of a half wave plate, Babinet Compensator and its uses *(12Hours)*

UNIT V: Rotatory Polarization, Wave Guides & Optical Fibres

Rotatory Polarization: Optical Rotation, Biot's Laws for Rotatory Polarization, Fresnel's Theory of optical rotation, Calculation of angle of rotation, Experimental verification of Fresnel's theory, Optically active substance, Specific rotation. Laurent's half-shade polarimeter. *(5 Hours)*

Wave Guides: Planar optical wave guides, planar dielectric wave guide, condition of continuity at interface, Phase shift on total reflection, Eigen value equations, and Phase and group velocity of guided wave. *(4 Hours)*

Optical Fibres: Numerical Aperture. Types of optical fibre based on the modes of propagation and structure, Step and Graded Indices (Definitions Only), Single and Multiple Mode Fibres (Concept and Definition Only). *(3 Hours)*

Recommended Books and Recommended Books and References:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
6. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
7. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
8. Electromagnetic Fields & Waves, P. Lorrain & D. Corson, 1970, W.H. Freeman & Co.
9. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
10. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

CORE 13 (PHC 6.12)
ELECTROMAGNETIC THEORY (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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

Recommended Books and Recommended Books and References:

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

CORE 14 (PHC 6.21)
STATISTICAL MECHANICS
Theory Credit: 4
Teaching Hours: 60

UNIT I Classical Statistics: Microstate& 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. *(12 Hours)*

UNIT II 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 Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. *(12 Hours)*

UNIT III 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. *(12 Hours)*.

UNIT IV Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law *(12 Hours)*

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

CORE 14 (PHC 6.22)
STATISTICAL MECHANICS (PRACTICAL)
PRACTICAL CREDIT: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   b) Study of transient behavior of the system (approach to equilibrium)
   c) Relationship of large N and the arrow of time
   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   e) Computation and study of mean molecular speed and its dependence on particle mass
   f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function (Z) 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 partition function (Z), average energy <E>, 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.
   c) Ratios of occupation numbers of various states for the systems considered above
   d) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.
3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
   a) Maxwell-Boltzmann distribution
   b) Fermi-Dirac distribution
   c) Bose-Einstein distribution

Recommended Books and Recommended Books and References:

- Elementary Numerical Analysis, K.E.Atkinson, 3rdEdn. 2007, Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

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Discipline Specific Elective (DSE)

DISCIPLINE SPECIFIC ELECTIVES 1 (PHD 5.11(a))
CLASSICAL DYNAMICS
Theory Credit: 5
Teaching Hours: 75
Tutorials: 1

UNIT I: Classical Mechanics of Point Particles & Lagrangian Formulation

Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, Constrained motion and degrees of freedom, Generalized coordinates and velocities, Generalised acceleration, Limitations of Newton's Law, Calculus of variations, Hamilton' principle, Lagrangian and the Euler-Lagrange equations, Lagrangian for a charged particle in an electromagnetic field, Gyroscopic forces, non conservative forces, one-dimensional examples of the Euler-Lagrange equations : one-dimensional Simple Harmonic Oscillations, Linear Harmonic oscillator, simple pendulum and falling body in uniform gravity; applications to simple systems such as coupled oscillators. *(15 Hours)*

UNIT II: Hamiltonian Formulation

Introduction to Hamiltonian formulation, Hamiltonian, Hamilton's canonical equations of motion, physical significance of Hamiltonian, advantages of Hamiltonian approach ,Applications of Hamiltonian equation's of motion to a simple pendulum and compound pendulum, Hamiltonian for a harmonic oscillator, particle in a central force field- conservation of angular momentum and energy, Hamiltonian of a charged particle in an electromagnetic field.
(15 Hours)

UNIT III: Small Amplitude Oscillations

Small oscillations, Stable and unstable equilibrium**,** minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, example of N identical masses connected in a linear fashion to (N -1) - identical springs, normal modes of vibration, normal coordinates of a system, normal modes of oscillations, Lagrange equations of motion for small oscillations, normal frequencies of vibrations for a parallel pendula. *(15 Hours)*

UNIT IV: 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, Relativistic generalization of Newton's Laws, proper time, Four-velocity-and acceleration-Four-momentum, Four force. *(15 Hours)*

UNIT V: Basic Relativistic Kinematics & Fluid Dynamics

Basic Relativistic Kinematics: 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. *(5 Hours)*

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

Recommended Books and References:

1. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rdEdn. 2002,Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
3. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
4. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4thEdn., 2003, Elsevier.
5. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
7. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
8. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
9. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford

DISCIPLINE SPECIFIC ELECTIVES 1(PHD 5.11(b))
DIGITAL SIGNAL PROCESSING THEORY
Credit: 4
Teaching Hours: 60

UNIT I

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response. (12 Hours)

UNIT II

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z-Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System,Solving Difference Equations. (12 Hours)

UNIT III

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters. Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, 319 Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing. (12 Hours)

UNIT IV

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms. Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; DirectForm I.(12 Hours)

UNITV

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital

Differentiators. Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method. (12 Hours)

Recommended Books and References:

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 1998, 3rdEdn. Oxford University Press. 4. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
5. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
6. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

DISCIPLINE SPECIFIC ELECTIVES 1(PHD 5.12(b))
DIGITAL SIGNAL PROCESSING THEORY (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

Scilab/C/C++ based simulation experiments:

1. Write a program to generate and plot the following sequences:
 (a) Unit sample sequence δ(n) .
 (b) unit step sequence u(n).
 (c) ramp sequence r(n) .
(d) real valued exponential sequence $x(n)=(0.8)^{n}u(n)$ for $0 \leq n \leq 50$.

2. Write a program to compute the convolution sum of a rectangle signal (or gate function)with itself for N=5

$$x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \leq n \leq N \\ 0 & otherwise \end{cases}$$

3. An LTI system is specified by the difference equation :

$$y(n) = 0.8y(n-1) + x(n)$$

(a) Determine $H(e^{jw})$

(b) Calculate the plot of the steady state response $y_{ss}(n)$to

$$x(n) = \cos(0.5\pi n)\, u(n)$$

4. Given the casual system:

$$y(n) = 0.9\, y(n-1) + x(n)$$

(a) Find H(z) and sketch the pole-zero plot.

(b) Plot the frequency response $|H(e^{jw})|$ and $\angle H(e^{jw})$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t$. The sampling frequency is f_s= 500 Hz . Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let x(n) be a 4-point sequence:

$$x(n) = \underset{\uparrow}{\{1,1,1,1\}} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$

Compute the DTFT $X(e^{jw})$ and plot its magnitude.

(a) Compute and plot the 4 point DFT of x(n).

(b) Compute and plot the 8 point DFT of x(n) (by appending 4 zeros)

(c) Compute and plot the 16 point DFT of x(n) (by appending 12 zeros)

7. Let x(n) and h(n) be the two four point sequences,

$$x(n) = \{1,\underset{\uparrow}{2},2,1\}$$

$$h(n) = \{1,\underset{\uparrow}{-1},-1,1\}$$

Write a program to compute their linear convolution using circular convolution.

8. Using rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specification:

a) Pass-band edge F_p = 2 KHz

b) Stop-band edge F_s = 5 KHz

c) Pass-band attenuation A_p= 2 dB

d) Stop band attenuation A_s= 42 dB

e) Sampling frequency F_s = 20 KHz

10. The frequency response of a linear phase differentiator is given by

$$H_d(e^{jw}) = jwe^{-j\tau w} \quad |w| \leq \pi$$

Using a Hamming window of length M = 21 , design a digital FIR differentiator. Plot the amplitude response.

Recommended Books and References:

1. Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.

2. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rdEdn., Cambridge University Press

3. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.

4. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.

5. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.

6. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

7. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444

8. Scilab Image Processing: L.M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

DISCIPLINE SPECIFIC ELECTIVES 2 (PHD 5.21(a))
NANO MATERIALS AND APPLICATIONS
Theory Credit: 4
Teaching Hours: 60

UNIT I **Nanoscale Systems:** Length scales in physics, Nanostructures: 1D, 2D and 3Dnanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. *(12 Hours)*

UNIT II **Synthesis of Nanostructure Materials:** Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

Characterization:X-Ray Diffraction. Optical Microscopy. Electron Scanning Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. *(12 Hours)*

UNIT III **Optical Properties:** Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of hetero structures and nanostructures. *(12 Hours)*

UNIT IV **Electron Transport**: Carrier transport in nano structures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. *(12 Hours)*

UNIT V **Applications:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). *(12 Hours)*

Recommended Books and References:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook

(Elsevier, 2007).
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

DISCIPLINE SPECIFIC ELECTIVES 2 (PHD 5.22(a))
NANO MATERIALS AND APPLICATIONS (PRACTICAL)
PRACTICAL CREDIT: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1) XRD pattern of nanomaterials and estimate particle size.
2) To determine the average particle size and chemical analysis from FESEM and EDS images.
3) Analysis of UV/Vis absorption spectrum of nanomaterials
4) To Determine refractive index, thickness and band gap of a semiconductor sample using UV-Vis-NIR spectroscopy data.
5) Surface morphology characterization of nanomaterials from AFM images.
6) Surface morphological characterization of nanomaterials from TEM images.
7) Synthesis of semiconductor nanoparticles.
8) Fabricate a thin film of nanoparticles by spin coating (or dip coating) and study transmittance spectra in UV-Vis region.

Recommended Books and References:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
3. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

DISCIPLINE SPECIFIC ELECTIVES 2 (PHD 5.21(b))
NUCLEAR AND PARTICLE PHYSICS
Theory Credit: 5 **Teaching Hours: 75**
Tutorials: 1

UNIT I 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 quadrapole moments. *(15 Hours)*

UNIT II Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermi 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. *(15 Hours)*

UNIT III Radioactivity decay: (a) Alpha decay: basics of α-decay processes, theory of α emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. 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). *(15 Hours)*

UNIT IV Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe Block formula), energy loss of electrons,. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

(15 Hours)

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

(15 Hours)

Recommended Books and References:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
6. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
7. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP Institute of Physics Publishing, 2004).
8. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
9. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007). 10. Theoretical Nuclear Physics, J.M. Blatt & V.F. Weisskopf (Dover Pub. Inc., 1991)

DISCIPLINE SPECIFIC ELECTIVES 3 (PHD 6.11(a))
ADVANCED MATHEMATICAL PHYSICS-I
Theory Credit: 4
Teaching Hours: 60
The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

UNIT I

Linear Vector Spaces: Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.
(12 Hours)

UNIT II
Matrices: Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular 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. Inner Product. Eigen-values and Eigenvectors. Cayley-Hamiliton Theorem. Diagonalization of

Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix. (12 Hours)

UNIT III

Cartesian Tensors: Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Anti-symmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry. (12 Hours)

UNIT IV

Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.(12 Hours)

UNIT V

General Tensors: Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor. (12 Hours)

Recommended Books and References:

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications

2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.

3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press

4. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.

5. Linear Algebra, W. Cheney, E.W. Cheney & D.R. Kincaid, 2012, Jones & Bartlett Learning

6. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole

7. Mathematical Methods for Physicis & Engineers, K.F. Riley, M.P. Hobson, S.J. Bence, 3rd Ed., 2006, Cambridge University Press .

DISCIPLINE SPECIFIC ELECTIVES 3 (PHD 6.12(a))
ADVANCED MATHEMATICAL PHYSICS-I (PRACTICAL)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

Scilab/ C++ based simulations experiments based on Mathematical Physics problems like

1. Linear algebra:
   - Multiplication of two 3 x 3 matrices.
   - Eigenvalue and eigenvectors of

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

2. Orthogonal polynomials as eigen functions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.

Recommended Books and References:

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
2. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444 3. Scilab Image Processing: L.M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

DISCIPLINE SPECIFIC ELECTIVES 3 (PHD 6.11(b))
ADVANCED MATHEMATICAL PHYSICS-II
Theory Credit: 5
Teaching Hours: 75
Tutorials: 1

UNIT I: Calculus of Variations: Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics.Concept of Lagrangian. Generalized co-ordinates. Definition of Generalized Force ,Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One dimensional harmonic oscillator). *(15 Hours)*

UNIT II: Definition of Canonical Momenta. Canonical Pair of Variables ,Definition of Hamiltonian (Legendre Transformation). Hamilton's Principle. Canonical transformation of variables. Poisson Brackets and their properties. Lagrange Brackets and their properties.

(15 Hours)

UNIT III Group Theory: Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup,Co-sets of a subgroup, cyclic group. Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups,Some special groups with operators. Matrix Representations: Reducible and Irreducible. *(15 Hours)*

UNIT IV Advanced Probability Theory: Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions. Expectation and Variance. *(15 Hours)*

UNIT V: Special Probability distributions: The binomial distribution, The Poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares, Line regression (straight line fitting). *(15 Hours)*

Recommended Books and References:

1. Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.

2. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.

3. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.

4. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover

5. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press

6. Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill

DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.21(a))
ASTRONOMY AND ASTROPHYSICS
Theory Credit: 5
Teaching Hours: 75
Tutorials: 1

UNIT I **Astronomical Scales:** Astronomical distance, mass and time, radiant flux and luminosity, Brightness, magnitude system, apparent and absolute magnitude scale, distance modulus.Measurement of Astronomical distances, determination of distance by Parallex method,

Gravitational potential energy of a star, internal temperature of a star, internal pressure of a star. Stellar spectra, stellar spectral classification, Hertzsprung-Russell diagram. *(15 Hours)*

UNIT II **Basic Concepts of positional astronomy:**Basics of spherical trigonometry, the celestial sphere, circles on celestial sphere, cardinal points, spherical triangle, season, different motions of earth- spin, revolution, obliquity, tilt, eccentricity. Equinoctial points, solstices, constellations Geographic coordinate systems, Astronomical coordinate systems- equatorial, ecliptic and galatic. Diurnal motion of stars, circumpolar star. Measurement of time, sidereal time, apparent solar time mean solar time, equation of time *(15 Hours)*

UNIT III **Astronomical techniques:** Basic optical definitions for astronomy (magnification, light gather power, resolving power, diffraction limit, atmospheric windows), optical telescopes(Types of reflecting telescopes, telescope mounting, space telescopes, detectors and their use with telescopes types of detectors- photographic plates, photo multiplier tube (PMT),charge couples devices(CCD), detection limits with telescopes.*(15 Hours)*

UNIT IV **Solar system:** Origin and evolution of the solar system: The sun: solar parameters, solar photosphere, solar atmosphere, chromospheres, corona, solar activity, physical characteristics of sun-rotation, magnetic field, granulation, sunspots, other chromatic activities, Inner planets Jovian planets, dwarf planets.

Asteroids: classification, origin, Comets: discovery and designation, physical nature, classification, origin, Meteors and meteorites. Star formation and evolution, end states of star: supernova, Neutron star and Black hole.*(15 Hours)*

UNIT V **General relativity and Cosmology:** Equivalence principle, inertial and gravitational mass, general theory of relativity, test of general relativity, Expansion of universe Hubble law cosmic background radiation, total no of blackbody photons, Big bang cosmology, neutrino decoupling, deuterium formation, helium abundance, photon decoupling, Big-bang feature, neutrino background gravity waves, helium abundance, matter density of the universe and the deceleration parameter, Doppler red shift, gravitational red shift and cosmological red shift. Critical density of universe and its future evidence of dark matter and dark energy. *(15 Hours)*

Recommended Books and references:

1. Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wesley Publishing co.
2. The physical universe: an introduction to astronomy, F. Shu, Mill Valley: University Science Books
3. Fundamentals of Astronomy (fourth Edition), H. Karttunen et al. Springer
4. Text book of spherical astronomy, W.M. Smart
5. An Introduction to Cosmology, J. V. Narlikar, Cambridge university press
6. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

7. An Introduction to Astrophysics, B. Basu, T Chattopadhyay and S.N. Biswas.PHI learning private limited

DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.21(b))
ATMOSPHERIC PHYSICS
Theory Credit: 4
Teaching Hours: 60
UNIT I

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms. (12 Hours)

UNIT II

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semiannual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics. (12 Hours)

UNIT III

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a non homogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration(12 Hours)

UNIT IV

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques. (12 Hours)

UNIT V

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars. (12 Hours)

Recommended Books and References:

• Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996

• The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rdedn. 2002.

• An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004 •

Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014323

DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.22(b))
ATMOSPHERIC PHYSICS (Practical)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

Scilab/C/C++ based simulations experiments based on Atmospheric Physics problems like

1. Numerical Simulation for atmospheric waves using dispersion relations (a) Atmospheric gravity waves (AGW) (b) Kelvin waves (c) Rossby waves, and mountain waves

2. Offline and online processing of radar data (a) VHF radar, (b) X-band radar, and (c) UHF radar

3. Offline and online processing of LIDAR data

4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.

5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique

6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

Recommended Books and References:

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996

2. The Physics of Atmosphere – J.T. Houghton; Cambridge Univ. Press; 3rdedn. 2002.

3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

4. Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

DISCIPLINE SPECIFIC ELECTIVES 4 (PHD 6.21(c))
Physics of Earth
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures
Unit 1: The Earth and the Universe:

(a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.

(b) General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth’s orbit and spin, the Moon’s orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids, Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.

(c)Energy and particle fluxes incident on the Earth.

(d) The Cosmic Microwave Background.

(15 Hours)

Unit 2: Structure

(a) The Solid Earth: Mass, dimensions, shape and topography, internal structure,magnetic field, geothermal energy. How do we learn about Earth’s interior?

(b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.
(c) The Atmosphere: variation of temperature, density and composition with altitude, clouds.

(d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers.

(e) The Biosphere: Plants and animals. Chemical composition, mass. Marine andland organisms.

(15 Hours)

Unit 3: Dynamical Processes

(a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy,Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.

(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosionand beach processes. Tides, Tsunamis.

(c) The Atmosphere: Atmospheric circulation. Weather and climati changes. Earth's heat budget,Cyclones.

Climate:
i. Earth's temperature and greenhouse effect.

ii. Paleoclimate and recent climate changes.

iii. The Indian monsoon system.

(d) Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.
(15Hours)

Unit4:Evolution
Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geo chronological methods in their application in geological studies. History of development inconcepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.

1. Time line of major geological and biological events.

2. Origin of life on Earth.

3. Role of the biosphere in shaping the environment.

4. Future of evolution of the Earth and solar system: Death of the Earth.

(15 Hours)

Unit 5: Disturbing the Earth – Contemporary dilemmas

1. Human population growth.
2. Atmosphere: Green house gas emissions, climate change, air pollution.

a. Hydrosphere: Fresh water depletion.
b. Geosphere: Chemical effluents, nuclear waste.
c. Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems *(15 Hours)*

Recommended Books and References :

1. Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011
2. Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books.
3. Holme's Principles of Physical Geology. 1992. Chapman & Hall.
4. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

PHYSICS-DSE: Biological Physics (PHD 6.21(d))
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

Unit 1
Overview: **(9 lectures)**
The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution.
Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.

Unit 2
Molecules of life: **(22 lectures)**
Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.
Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

Unit 3

The complexity of life:Single cell (15 lectures)

At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem.

Unit 4

The complexity of life: Multi cell (15 lectures)

At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.

At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and selfsustaining ecosystems.

Unit 5

Evolution: (14 lectures)

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

References:

 Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)

 Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)

 Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)

 An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)

 Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Skill Enhancement Course (SEC)

SKILL ENHANCEMENT COURSE 1 (PHS 3.12(a))
BASIC INSTRUMENTATION SKILLS
Practical Credit: 2
Teaching Hours: 30

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

This course is to get exposure with various aspects of instruments and their usage through hands on mode. Experiments listed below are to be done in continuation of the topics.

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Electronic Voltmeter: Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/. AC milli voltmeter: Type of AC milli voltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac milli voltmeter, specifications and their significance.

Multimeter: Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance, Block diagram and working of a digital multimeter.

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

Signal Generators and Frequency Counter: 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. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

Impedance Bridges: Block diagram of bridge. working principles of basic(balancing type) RLC bridge, Digital LCR bridges.

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. Trouble shooting a circuit
8. Balancing of bridges

Laboratory Exercises:

1. To analyze the voltage divider resistive network.
2. To analyze a L-C-R circuit.
3. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
4. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
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 R, L and C using a LCR bridge/ universal bridge.

Recommended Books and References:

1. Performance and design of AC machines - M G Say ELBS Edn.
2. A text book in Electrical Technology - B L Theraja - S Chand and Co.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan& N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
7. Electronic circuits: Handbook of design and applications, U. Tietze, Ch. Schenk, 2008, Springer
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.

SKILL ENHANCEMENT COURSE 1 (PHS 3.12(b))
PHYSICS WORKSHOP SKILL
Practical Credit: 2
Teaching Hours: 30

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meterscale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

Mechanical Skill: Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood.

Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet 327 using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.

Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.

Recommended Books and References:

• A text book in Electrical Technology - B L Theraja – S. Chand and Company.
• Performance and design of AC machines – M.G. Say, ELBS Edn.
• Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
• Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rdEdn., Editor Newnes [ISBN: 0750660732]
• New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

SKILL ENHANCEMENT COURSE 2
(PHS 4.12(a)) COMPUTATIONAL PHYSICS

Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

The aim of this course is not just to teach numerical analysis but to emphasize 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.*

Numerical Computation	• Error calculation • Evaluation of trigonometric function • Taylor series expansion of a given functions • Maclaurin's series expansion of given function
Solution of Algebraic and Transcendental equations,	Method • Newton Raphson • Bisection, Hands on exercise • Solution of the given algebraic and Transcendental equations.
Numerical differentiation,	Method Forward and Backward difference formula Hands on exercise • Differentiation of a given function • Gradient, divergence and curl of a function

Integration,	Method • Trapezoidal rule • Simpson rules. • Hands on exercise Integration of a given function
Solution of First order Ordinary Differential Equations (ODE). .	Runge Kutta (RK) 2nd and 4th order methods First order differential equation (i) Radioactive decay (ii) Current in RC, LC circuits (DC) (iii) Newton's law of Cooling (iv) Classical equations of motion Attempt following using RK 4th order methods: $\frac{dy}{dt} = y + x - \frac{x^3}{3}\ ;\ \frac{dy}{dx} = -x$ For x(0)=0, y(0)=-1,-2,-3,-4 Plot x vrs. y for each of the four conditions on the same screen for $0 \leq t \leq 15$.

Recommended Books and References:

1. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
2. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi (1999)
3. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
4. Elementary Numerical Analysis, K.E. Atkinson, 3rdEdn., 2007, Wiley India Edition.

SKILL ENHANCEMENT COURSE 2 (PHS 4.12(b))
RADIATION SAFETY
Practical Credit: 2
Teaching Hours: 30

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic
and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma
decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, **Interaction of Photons -** Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, **Interaction of Charged Particles:** Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping
Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), **Interaction of Neutrons**- Collision, slowing down and Moderation.

Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC).

Radiation detection: Basic concept and working principle of *gas detectors* (Ionization Chambers,
Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), *Scintillation Detectors* (Inorganic and Organic Scintillators), *Solid States Detectors* and *Neutron Detectors*, *Thermoluminescent Dosimetry*.

Radiation safety management: *Biological effects of ionizing radiation*, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation,
introduction of safety and risk management of radiation. Nuclear waste and disposal

management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil.

Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.

Experiments:

1) Study the background radiation levels using Radiation meter

Characteristics of Geiger Muller (GM) Counter:

2) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).

3) Study of counting statistics using background radiation using GM counter.

4) Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.

5) Study of absorption of beta particles in Aluminum using GM counter.

6) Detection of α particles using reference source & determining its half life using spark counter

7) Gamma spectrum of Gas Light mantle (Source of Thorium)

Recommended Books and References:

1. W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)

2. G.F. Knoll, Radiation detection and measurements

3. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)

4. W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.

5. J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.

6. Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey,
Cambridge University Press, U.K., 2001

7. A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.

8. NCRP, ICRP, ICRU, IAEA, AERB Publications.

9. W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981

Revised SYLLABUS
FOR
Bachelor of Science (Honours)
GENERIC ELECTIVES
THREE YEAR DEGREE COURSE SEMESTER SYSTEM
(Under New UGC CBCS Guidelines)

Syllabus Structure

SEM	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Generic Elective 1	Mechanics (Theory)	PHG 1.11	4
		Mechanics (Practical)	PHG 1.12	2
II	Generic Elective 2	Electricity and Magnetism (Theory)	PHG 2.11	4
		Electricity and Magnetism (Practical)	PHG 2.12	2
III	Generic Elective 3	Waves and Optics (Theory)	PHG 3.11	4
		Waves and Optics (Practical)	PHG 3.12	2
IV	Generic Elective 4	Elements of Modern Physics (Theory)	PHG 4.11	4
		Elements of Modern Physics (Practical)	PHG 4.12	2

SEMESTER- I

GENERIC ELECTIVE 1 (PHG 1.11)

MECHANICS

Theory Credit:4

Teaching Hours: 60

UNIT I **Vectors:** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. Scalar and vector fields.

Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. Limitations of Newtonian Mechanics. Momentum of a system of particle. (12 Hours)

UNIT II **Central Force motion:** Reduction of two body problem to one body problem, Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum. (12 Hours)

UNIT III **Gravitation:** Inertial and gravitational mass. Newton's Law of Gravitation. Gravitational potential and field due to spherical shell and solid sphere. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity isconstant). 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.

Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. Relativity of simultaneity. (12 Hours)

UNIT IV **Ordinary Differential Equations:** 1^{st}order homogeneous differential equations. 2^{nd}order homogeneous differential equations with constant coefficients.

Oscillations: Simple harmonic motion(SHM). Terms related to SHM. Characteristic of SHM. SHM and reference circle. Displacement, velocity, acceleration and force in SHM. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. Compound pendulum: Bar Pendulum and Katers Pendulum. (12 Hours)

UNIT V **Elasticity:** Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method. **Surface tension:** Molecular origin of surface tension. Relation between free surface energy and surface tension. Newton's Law of Viscosity, critical velocity. (12 Hours)

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

Recommended Books and References:

1. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley
2. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

GENERIC ELECTIVE 1 (PHG 1.12)
MECHANICS (Practical)

Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. Measurements of length (or diameter) using verniercaliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

Recommended Books and References:

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

2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

SEMESTER-II

GENERIC ELECTIVE 2 (PHG 2.11)
ELECTRICITY AND MAGNETISM
Theory Credit: 4
Teaching Hours: 60

UNIT I

Vector Analysis: Scalar product; Geometrical interpretation and properties. Vector product (detail study). Field: Scalar and Vector field. 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. (12 Hours)

UNIT II

Electrostatics: Electrostatic Field, Electric field lines, Area vector, 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. (12 Hours)

UNIT III

Capacitors: Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation. Electrical susceptibility and Dielectric Constant. Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. (12 Hours)

UNIT IV

Magnetism: Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferromagnetic materials. (12 Hours)

UNIT V

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

Maxwell’s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. (12 Hours)

Recommended Books and References:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.
6. Electricity and Magnetism, D.Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
7. Undergraduate Physics Vol II, AB Bhattacharya, R Bhattacharya, New Central Book Agency (P

GENERIC ELECTIVE 2 (PHG 2.12)
ELECTRICITY AND MAGNETISM (Practical)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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

Recommended Books and References:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4thEdition, reprinted 1985, Heinemann Educational Publishers

3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed.2011, Kitab Mahal
4. BSc. Practical Physics, C.L.Arora, S Chand.

SEMESTER -III

GENERIC ELECTIVE 3 (PHG 3.11)

WAVES AND OPTICS

Theory Credit:4

Teaching Hours: 60

UNIT I **Superposition of Two Collinear Harmonic oscillations**: Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Transverse waves and longitudinal waves. Equation of a plane progressive harmonic waves. Differential equation of progressive wave equation. Energy and progressive waves. Newton's formula for the velocity of sound and Laplace's correction. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. (12 Hours)

UNIT II **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 - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature- lubrication. Newton's Law of Viscosity. Streamline and turbulent motion. Critical velocity.

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. (12 Hours)

UNIT III **Wave Optics:** Electromagnetic nature of light. Definition and Properties of wavefront. Huygens Principle. Dispersive and non-dispersive medium.

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. Newton's rings by reflected and transmitted light. (12 Hours)

UNIT IV Michelson's Interferometer: (1) Idea of form of fringes (no theory needed), (2)Determination of wavelength, (3) Wavelength difference, (4) Refractive index, and(5) Visibility of fringes.

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

Holography: Principle and Theory of Holography as interference between two plane waves. (12 Hours)

UNIT V Diffraction: Fraunhofer diffraction- Single slitand circular aperture; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Fresnel assumptions. Explanation of Rectilinear propagation of Light. Half-period zones. Zone plate. Half-period zones, Multiple foci of a zone plate.Fresnel Diffractionpattern of a straight edge, a slit and a wire using half-period zone analysis. Fresnel Integral. (12 Hours)

Recommended Books and References:

1. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
4. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison Wesley

GENERIC ELECTIVE 3 (PHG 3.12)
WAVES AND OPTICS (Practical)
Practical Credit: 2
Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experimentand to verify λ^2 – T Law.
3. To study Lissajous Figures.
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).

6. To determine the Refractive Index of the Material of a Prism using Sodium Light. 7.To determine Dispersive Power of the Material of a Prism using Mercury Light
8. To determine the value of Cauchy Constants.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Recommended Books and References:

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

SEMESTER IV

GENERIC ELECTIVE 4 (PHG 4.11)

ELEMENTS OF MODERN PHYSICS

Theory Credit: 4

Teaching Hours: 60

UNIT I

Planck's quantum theory: distribution of energy in the spectrum of a black body, Planck's hypothesis, Planck's law of radiation. Photoelectric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.

Rutherford's experiment on scattering of α-particle, Rutherford atom model- instability of atoms and observation of discrete atomic spectra; Bohr atom model: quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence. (12 Hours)

UNIT II

Matter waves and wave amplitude. Wave function; properties and requirements. Basic postulates of wave mechanics. Schrodinger equation for non-relativistic particles, Eigen function and eigen values. Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension. (12 Hours)

UNIT III

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

UNIT IV

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. (12 Hours)

UNIT V

Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy. Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission: Origin, energy-momentum conservation, electron-positron pair creation by gamma photons in the vicinity of a nucleus. (12 Hours)

Recommended Books and References:

1. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
2. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning
3. Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
4. Quantum Physics, Berkeley Physics, Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
5. Modern Physics, R Murugeshan, Er. Kiruthiga Srivaprasath, Revised Edition, S Chand

GENERIC ELECTIVE 4 (PHG 4.12)

ELEMENTS OF MODERN PHYSICS (Practical)

Practical Credit: 2

Teaching Hours: 60

N.B: In certain situations, the concern teacher may take the liberty to replace a given experiment(s) by a similar type of experiment(s) depending upon the available resources.

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

Recommended Books and References:

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

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