Department of Physics

Integrated Master Program in Physics
Doon University
(Since 2015)

List of Courses

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B. Sc. Honours (Physics) under the Program MSc Integrated Physics

Semester	CORE COURSE	Ability Enhancement Compulsory Course (AECC) (2)	Ability Enhancement Elective Course (AEEC) (2) (Skill Based)	Elective: Discipline Specific DSE (4)	Elective: Generic (GE) (4)
I	Mathematical Physics-I	(English/MIL Communication) /Environmental Science			GE-1
	Mechanics				
II	Electricity& Magnetism	Environmental Science/ (English/MIL Communication)			GE-2
	Waves and Optics				
III	Mathematical Physics–II		AECC -1		GE-3
	Thermal Physics				
	Analog Systems &Applications				
IV	Mathematical Physics–III		AECC -2		GE-4
	Elements ofModernPhysics				
	Digital Systems and Applications				
V	Quantum Mechanics and Applications			DSE-1	
	Electromagnetic Theory			DSE -2	
VI	Solid State Physics			DSE -3	
	Statistical Mechanics			DSE -4	

Semester I			
Course Code	**Title**	**Course Type**	**Credit**
PHC-101	Mathematical Physics I	Core	6
PHC-102	Mechanics	Core	6
PHM-152	Mechanics, heats and oscillations	Generic Elective	6
EES-110	Environmental Science	Ability Enhancement Compulsory Course	2
TOTAL			20
Semester II			
PHC-151	Electricity and Magnetism	Core	6
PHC-152	Waves and Optics	Core	6
PHM-151	Introduction to Electromagnetic Theory	Generic Elective	6
Eng-151	(English/MIL Communication)	Ability Enhancement Compulsory Course	2
TOTAL			20
Semester III			
PHC-201	Mathematical Physics–II	Core	6
PHC-202	Thermal Physics	Core	6
PHC-203	Analog Systems and Applications	Core	6
PHG-203	Digital, Analog and Instrumentation	Generic Elective	6
PHS-201/PHS202	Electrical Circuit Network Skills/ Computational Physics Skills	Ability Enhancement Elective Course	2
TOTAL			26
Semester IV			
PHC-251	Mathematical Physics-III	Core	6
PHC-252	Elements Modern Physics	Core	6
PHC-253	Digital Systems and Applications	Core	6
PHG-252	Elements of Modern Physics (Genetic Elective)	Generic Elective	6
PHS-252	Basic Instrumentation Skills	Ability Enhancement Elective Course	2
TOTAL			26
Semester V			
PHC-301	Quantum Mechanics and Applications	Core	6
PHC-302	Electromagnetic Theory	Core	6
PHD-306	Classical Dynamics	Elective: Discipline Specific	6
PHD-307	Nuclear and Particle Physics	Elective: Discipline Specific	6
TOTAL			24
Semester VI			
PHC-351	Solid State Physics	Core	6
PHC-352	Statistical Mechanics	Core	6
PHD-312	Advanced Mathematical Physics	Elective: Discipline Specific	6
PHD-313	Bio Physics	Elective: Discipline Specific	6
TOTAL			24
TOTAL (BSc Honours)			**140**

Semester VII			
Course Code	**Title**	**Course Type**	**Credit**
PHC-411	Classical Mechanics	Core	3
PHC-412	Classical Electrodynamics	Core	3
PHC-413	Electronics & Communication	Core	3
PHC-414	Computational Physics	Core	3
PHP-415	Lab I	Core	6
TOTAL			18
Semester VIII			
PHC-461	Thermodynamics and Statistical Mechanics	Core	3
PHC-462	Quantum Mechanics II	Core	3
PHC-463	Condensed Matter Physics I	Core	3
PHC-464	Atomic and Molecular Physics	Core	3
PHP-465	Lab II	Core	6
TOTAL			18
Semester IX			
PHC-511	Condensed Matter Physics II	Core	4
PHC-512	Nuclear and Particle Physics	Core	4
PHD-513*	Optoelectronics I (Lasers and Detectors)	Discipline Specific Elective	4
PHE-501**	Research Methodology	Elective	3
PHC-514	Lab III	Core	6
TOTAL			18
Semester X			
PHP-563	Project	Core	15
TOTAL			15
TOTAL			**69**

*Discipline Specific Elective

** Elective Course

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

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

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

1. Experimental Techniques
2. Embedded systems- Introduction to Microcontroller
3. Physics of Devices and Instrumentation
4. Advanced Mathematical Physics
5. Classical Dynamics
6. Applied Dynamics
7. Nuclear and Particle Physics
8. Astronomy and Astrophysics
9. Atmospheric Physics
10. Nano Materials and Applications
11. Earth Science
12. Medical Physics
13. Biophysics
14. Dissertation

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

1. Mathematics
2. Chemistry
3. Economics
4. Computer Science

Any other discipline of importance

Skill Enhancement Courses (02 to 04 papers) (Credit: 02 each) - SEC1 to SEC4

1. Physics Workshop Skills
2. Computational Physics Skills
3. Electrical circuit network Skills
4. Basic Instrumentation Skills
5. Renewable Energy and Energy harvesting
6. Mechanical Drawing
7. Radiation Safety
8. Applied Optics
9. Weather Forecasting

Generic Elective Papers (GE) (any four) for other Departments/Disciplines: (Credit: 06 each)

1. Mechanics
2. Electricity and Magnetism
3. Thermal Physics
4. Waves and Optics
5. Digital, Analog and Instrumentation
6. Elements of Modern Physics
7. Mathematical Physics
8. Solid State Physics
9. Quantum Mechanics
10. Embedded System: Introduction to microcontroller
11. Nuclear and Particle Physics
12. Mechanics, Heat and Oscillation
13. Introduction to Electromagnetic Theory
14. Fundamentals of electronic materials and devices

Program Objectives:

- To motivate and inspire the students to create deep interest in Physics.
- To develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.
- To learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.
- To develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.
- To provide the student the vast scope of Physics as a theoretical and experimental science with applications in solving most of the problems in nature
- To emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.
- To emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.

Program Outcomes:

The student graduating with the Degree B.Sc (Honours) Physics should be able to

- Acquire

1. a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Materials science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Bio Physics, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Environmental sciences, Computer science, Information Technology;
2. procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;

- Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems.

- Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages.

- Demonstrate relevant generic skills and global competencies such as

1. problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;

2. investigative skills, including skills of independent investigation of Physics-related issues and problems, communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information.

Semester I

PHC101: MATHEMATICAL PHYSICS-I

L	T	P	Cr
4	0	2	6

Course Objective:
This is a basic course in Physics which will lead to:

1. Revision of concepts of limit, continuity and differentiability of various functions
2. Developing skill to solve problems of differential equations and vector calculus.
3. Emphasize in solving problems in Physics.

Course Content:

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 Differential Equations and Integrating Factor. **(4 Lectures)**

Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral **(13 Lectures)**

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(6 Lectures)**

Vector Calculus:

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. **(5 Lectures)**

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates. **(8 Lectures)**

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (norigorousproofs). **(14 Lectures)**

Orthogonal Curvilinear Coordinates:

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

(6 Lectures)

Dirac Delta function and its properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. **(4 Lectures)**

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7^{th} Edn., Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K.F.Riley & M. P. Hobson, 2011, Cambridge Univ. Press

LAB Mathematical Physics (PHC-101):

The aim of this Lab is to emphasize its role in solving problems in Physics.

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow-emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. TernaryOperator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search

Random number generation	Area of circle, area of square, volume of sphere, value of π
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha; I = I_O[(\sin\alpha)/\alpha]^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop

Referred Books:

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

Course Learning Outcome:

After going through the course, the student should be able to

1. Determine limit, continuity and differentiability of various functions, expand functions in Taylor's series, binomial series.
2. Solve first order differential equations and second order differential equations with constant coefficients, and partial derivatives.
3. Explain the concepts of scalar and vector product of two and three vectors, explain the concepts of gradient, divergence and curl of physical quantities and determine their values.
4. Use of divergence and curl theorem's, determine line, surface and volume integrals.
5. Explain the concept of Dirac delta function and its properties

PHC102: MECHANICS

L	T	P	Cr
4	0	2	6

Course Objective:

This is a basic course in Physics which deals with

1. Fundamentals of Dynamics (Newton's law of motion, frames of references and transformation laws).

2. The students will also be introduced about the forces, angular momentum and knowledge about the center of mass and moment of Inertia.
3. The course provides the knowledge of the basics of potentials and fields, central forces and Kepler's laws, basics of fluid dynamics and elastic properties of matter.
4. To introduce the concept of special relativity and its applications to Physical Sciences.
5. Experimental demonstration of above discussed topics will help them to develop understanding of basic physics in their daily life.

Course Content:

Fundamentals of Dynamics: Reference frames. Inertial frames; Galilean transformations; Galilean invariance. Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket. **(13 Lectures)**

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

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

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

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solidsphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts. **(9 Lectures)**

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

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriol is force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. **(4 Lectures)**

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

Momentum Four Vector. **(10 Lectures)**

Reference Books:

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley andSons.
  University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

- Mechanics, D.S. Mathur, S. Chand and Company Limited,2000
- University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

LAB Mechanics (PHC-102)

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.

Reference Books

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

Course Learning Outcome:

On completion of the course,

1. Students would have grasped the fundamentals of different types of frames of references and transformation laws.
2. Learned conservation laws of energy and linear and angular momentum and apply them to solve

problems.

3. Learned the basics of potentials and fields, central forces and Kepler's laws.
4. Students develop understanding about Fundamental ideas of special theory of relativity such as length contraction and time dilation and mass –energy invariance.
5. Students develop ability to perform experiments and develop understanding about gravity, angula momentum, Moment of Inertia and elastic property.
6. Experimental demonstration of above discussed topics will help them to develop understanding o basic physics in their daily life.

Semester II

PHC: 151 ELECTRICITY AND MAGNETISM

L	T	P	Cr
4	0	2	6

Course Objective:

1. To learn the concepts of charge, fields and potentials and how do they interact with each other.
2. To be able to use the basic laws of Laplace's and Poisson's equations.
3. To learn concepts of magnetic fields and use them to estimate field due to various structure like solenoid, to roid.
4. To learn the concepts of electromagnetic induction and its applications

Course Content:

Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. **(6 Lectures)**

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

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

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

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. **(9 Lectures)**

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. **(4 Lectures)**

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current. **(6 Lectures)**

Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. **(5 Lectures)**

Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. **(6 Lectures)**

Reference Books:

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TataMc Graw
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.

LAB Electricity and Magnetism (PHC151)

List of Experiments

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.
3. To determine an unknown Low Resistance using Potentiometer.
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 (determined B/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Bandwidth.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer

13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.

Reference Books

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

Course Learning Outcome:

After going through the course, student should be able to

1. Explain and determine electric field and potential due various charge configuration. Explain gauss's law and use it to determine electric field.
2. Describe the concepts of Laplace's and Poisson's equations and Uniqueness theorem.
3. Explain the concept of Capacitor's and use the method of images and determine potential due to various charge distributions.
4. Explain the concept of magnetic fields, and determine field due to solenoid and toroid. Classified matter based on their magnetic properties.
5. Explain the concept of electromagnetic induction, and its application in various electric instruments, describe various electric circuit and determine their reactance and impedance. Explain the concept and use of ballistic galvanometer.
6. Experimental demonstration of above discussed topics will help them to develop understanding of basic physics in their daily life.

PHC152: WAVES AND OPTICS

L	T	P	Cr
4	0	2	6

Course Objective:

1. To introduce basic concepts of wave motion and principle of superposition
2. To understand the mathematical oscillator equation and wave equation, and derive these equations for certain systems.
3. To able to use the concepts of Interference, diffraction and polarization in wave optical applications
4. To Explain several phenomena, we can observe in everyday life that can be explained aswave phenomena.

Course Content:

Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and

(2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **(5 Lectures)**

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

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. **(4 Lectures)**

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

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

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

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

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. **(4 Lectures)**

Diffraction: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula and its application to rectangular slit. **(3 Lectures)**

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

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. **(9 Lectures)**

Reference Books

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, TataMcGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGrawHill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley andSons.

- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGrawHill.

LAB Waves and Optics (PHC-152)

List of Experiments

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –Tlaw.
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.

Reference Books

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

Course Learning Outcome:

After going the course, the student should be able to

1. Describe examples of oscillating systems, describe superposition principle and its application in explaining beats and concepts of phase and group velocities.
2. Explain Lissajous's Figure's and their use in determining frequency ratio of two signals.
3. Explain wave motions, its components, its type, and able to write wave equation.
4. Explain electromagnetic waves, principle of interference, diffraction and difference between them.

Semester III

L	T	P	Cr
4	0	2	6

PHC 201: MATHEMATICAL PHYSICS-II

Course Objective:

The objective of the course is to make the student understand about

1. Fourier series, periodic functions and their analysis.
2. Applications of Fourier analysis in physical systems.
3. Special functions and Frobenius method and its applications to differential equations.
4. Understand about theory of errors and partial differential equations.

Course Content:

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

(20 Lectures)

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. **(16 Lectures)**

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. **(10 Lectures)**

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. **(14 Lectures)**

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.

- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

LAB Mathematical Physics II (PHC-201)

Topics	Description with Applications
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensionalarrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program(2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring Constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	Solution of mesh equations of electric circuits (3meshes) Solution of coupled spring mass systems (3masses)

Solution of ODE
 	
First order Differential equation Euler, modified Euler and Runge-Kutta second order methods
 	
Second order differential equation Fixed difference method
	First order differential equation
	• Radioactive decay
	• Current in RC, LC circuits with DC source
	• Newton's law of cooling
	• Classical equations of motion
	Second order Differential Equation
	• Harmonic oscillator (no friction)
	• Damped Harmonic oscillator
	  • Over damped
	  • Critical damped
	  • Oscillatory
	• Forced Harmonic oscillator
	  • Transient and
	  • Steady state solution
	• Apply above to LCR circuits also

Using Scicos / xcos	• Generating square wave, sine wave, saw toothwave • Solution to harmonic oscillator • Study of beat phenomenon • Phase space plots

Reference Books:

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

Course Learning Outcome:

After the successful completion of the course, the student will learn:

1. Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
2. about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
3. about the beta, gamma and the error functions and their applications in doing integrations.
4. Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.
5. In the laboratory course, learn the basics of the Scilab software, their utility, advantages and disadvantages.

PHC-202: THERMAL PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

The objective of this course is to build-up basic understanding of,

1. concepts of work, power, and heat in thermodynamics; determine work and heat sign conventions; determine work involved with moving boundary systems (graphical and analytical methods which will develop understanding of mass, energy, heat, work, efficiency, ideal and real thermodynamic cycles and processes.
2. first laws of thermodynamics, perfect gas law, properties of real gases, and the general energy equation for closed systems.
3. necessary the second law of thermodynamics, including why and how it is defined (Kelvin-Planck and Clausius), the nature of irreversibility, and the Carnot cycle.

Course Content:

Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, 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 C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **(8 Lectures)**

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **(10 Lectures)**

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(7 Lectures)**

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

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation,(2)Values of C_p-C_V,

(3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **(7 Lectures)**

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. **(7 Lectures)**

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(4 Lectures)**

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

Reference Books:

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B. N. Srivastava, 1958, IndianPress
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, TataMcGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press

LAB Thermal Physics (PHC-202)

List of Experiments

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. TocalibrateathermocoupletomeasuretemperatureinaspecifiedRangeusing (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books

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

Course Learning Outcomes:

After successful completion of the course, the student will

1. become familiar with various thermodynamic process and work done in each of these process.
2. have a clear understanding about reversible and irreversible process and also working of a Carnot engine, and knowledge of calculating change in entropy for various process.
3. Realize the importance of Thermo dynamical functions and applications of Maxwell's relations.
4. Perform energy analysis of refrigeration and heat pump thermodynamic cycles.
5. become familiar with kinetic theory of Gasses (behaviour of real gas).

PHC-203: ANALOG SYSTEMS AND APPLICATIONS

L	T	P	Cr
4	0	2	6

Course Objective:

1. To understand the concepts of P and N type semiconductors, conductivity and motility, PN junction barriers and their fabrication.
2. To learn the applications of PN junction diodes in rectifiers, LED's, solar cells, Zener diode and voltage regulators.
3. To understand how unipolar junctions are different from bipolar junctions and learning the concept of n-p-n and p-n-p transistors.
4. To understand the concept of amplifiers and feedback amplifiers by using transistors.
5. To learn about oscillators, operational amplifiers and their applications.

Course Content:

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. **(11 Lectures)**

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) SolarCell. **(10 Lectures)**

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(7 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage DividerBias.Transistoras2-portNetwork.h-parameterEquivalentCircuit.Analysisofa single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(10 Lectures)**

Coupled Amplifier: RC-coupled amplifier and its frequency response. **(2 Lectures)**

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

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

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. **(6 Lectures)**

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

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-GrawHill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, PrenticeHall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHILearning
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-GrawHill
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, PrenticeHall
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008,Springer
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, WileyIndia
- Electronic Devices, 7/e Thomas L. Floyd, 2008, PearsonIndia

LAB Analog Systems and Applications (PHC-203)

List of Experiments:

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 Colpitts'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 usingOp-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.

Reference Books:

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

Course Learning Outcome:

At the end of the course the student is expected to versed with the following:

1. Understand the n- and p- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions, unipolar junctions, Zener diode.
2. Application of PN junctions in LED's, photodetectors, solarcells, rectifiers and voltage regulators.
3. Bipolar npn and pnp junctions, transistors.
4. Hybrid parameters.
5. Biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators
6. Understand the operational amplifies and their applications as adder, differentiator, integrator etc.
7. To apply the concepts of theory in performing the experiments in the laboratory related to PN junction, transistors, Zener Diode and operational amplifiers.

Semester IV

PHC-251 MATHEMATICAL PHYSICS-III

L	T	P	Cr
4	0	2	6

Course Objective:

1. The emphasis of the course is on applications in solving problems of interest to physicists.
2. The purpose of the course is to introduce students the method of mathematical physics and to develop required mathematical skill to solve the problems.
3. To impart knowledge about various mathematical tools employed to study physics problem.

Course Content

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality. **(20 Lectures)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **(10 Lectures)**

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. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/HeatFlow Equations. **(15 Lectures)**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits. **(15 Lectures)**

Reference Books:

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

PHYSICS LAB (PHC-251)

Scilab based simulations experiments based on Mathematical Physics problems like

1. Solve differential equations:

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

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

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

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

2. Dirac Delta Function:

   Evaluate

   $$\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\quad 2}} (x+3)dx$$

   For σ =1, 0.1, 0.01 and show it tends to 5.

3. Frobenius method and Special functions:

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

   Plot $P_n(x), j_\nu(x)$

   Show recursion relation

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

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

6. Evaluation of trigonometric functions e.g. *sin θ,* 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.

7. Integral transform: FFT of e^{-x^2}

Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN:978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN:978-1479203444
- Scilab (A free software to Matlab): H. Ramchandran, A.S. Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

Course Learning Outcome:

Upon successful completion of this course, it is intended that a student will be able to:

1. Demonstrate competence with the basic ideas of linear algebra including concepts of linear systems.
2. Use the method of Laplace transforms to solve initial-value problems for linear differential equations with coefficient.
3. Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.
4. In the laboratory course, the students should apply their C++/Scilab programming language to solve the following problems: (i) Solution first- and second- order ordinary differential equations with appropriate boundary conditions, (ii) Evaluation of the Gaussian integrals, Evaluation of the Fourier coefficients of a given periodic function

PHC-252: ELEMENTS OF MODERN PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

1. To understand concepts of black body radiation and plank's law.
2. To learn Schrodinger wave equation and use it to estimate various wave parameters.
3. To Acquire knowledge in the content areas of nuclear and particle physics, focusing on concepts that are commonly used in this area
4. To understand basic lasing action, study various types of lasers

Course Content:

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

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

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical

interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. **(10 Lectures)**

One dimensional infinitely rigid box-energy eigen values and eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potentialbarrier. **(10 Lectures)**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. **(6 Lectures)**

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. **(8 Lectures)**

Fission and fusion: mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). **(3 Lectures)**

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

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- Quantum Mechanics: Theory & Applications, A. K. Ghatak & S. Lokanathan, 2004, Macmillan

. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.

- Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill Co.
- Basic ideas and concepts in Nuclear Physics, K. Heyde, 3rd Edn., Institute of Physics Pub.
- Six Ideas that Shaped Physics: Particle Behavelike Waves, T.A. Moore, 2003, McGraw Hill

LAB Modern Physics (PHC-252)

List of Experiments

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the 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) Barmagnet.
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

Reference Books

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

Course Learning Outcome:

After the successful completion of the course the student is expected to be conversant with the following:

1. Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
2. Understand the theory of quantum measurements, wave packets and uncertainty principle.

of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.

4. Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
5. Understand various interactions of electromagnetic radiation with matter. Electron positron pair creation.

PHC-253: DIGITAL SYSTEMS AND APPLICATIONS

L	T	P	Cr
4	0	2	6

Course Objective:

1. To understand the basics of cathode ray oscilloscope along with the working.
2. Acquainting with the integrated circuits with the basic ideas of scale of integration.
3. Explaining about the difference between analog and digital systems and introduction to the binary systems.
4. To understand the various conversions, binary function, Boolean algebra, logic gates and their applications.
5. Explaining about the arithmetic and data processing circuits.
6. Explaining the construction of adder circuits, gates and combinational circuits experimentally.

Course Content:

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **(4 Lectures)**

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs. **(4 Lectures)**

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodesand Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(8 Lectures)**

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(8 Lectures)**

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, y Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors,4-bit binary Adder/Subtractor. **(4 Lectures)**

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **(13 Lectures)**

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

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to4bits). **(2 Lectures)**

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

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. **(10 Lectures)**

Reference Books:

- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.

LAB Digital Systems and Applications (PHC-253)

List of Experiments

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

13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555Timer.
15. To design a monostable multivibrator of given specifications using 555Timer.
16. Write the following programs using 8085Microprocessor
    a) Addition and subtraction of numbers using direct addressing mode
    b) Addition and subtraction of numbers using indirect addressing mode

eated subtraction.

e) Handling of 16-bitNumbers.
f) Use of CALL and RETURN Instruction.
g) Block data handling.
h) Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books:

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

Course Learning Outcome:

After the successful completion of the course the student is expected to be conversant with the following:

1.Basic working of an oscilloscope including its different components and to employ the same to study different wave forms and to measure voltage, current, frequency and phase.

2. Have a better idea of different components including both active and passive components to gain an insight into circuits using discrete components and also to learn about integratedcircuits.

3.To learn about analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.

4.Understand and solve Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.

5.Sequential systems by choosing Flip Flop as a building bock- construct multivibrators, counters to provide a basic idea about memory including RAM, ROM and also about memory organization.

6.Experimentally, can construct the logic and combinational gates.

Semester V

PHC 301: QUANTUM MECHANICS AND APPLICATIONS

L	T	P	Cr
4	0	2	6

Course Objective:

This course will build up basic understanding about quantum mechanics to bachelor students. The objective of the course is

1. To study the basic principles of quantum mechanics.
2. Explain the operator formulation of quantum mechanics.
3. Student will learn the concept of wave function, Schrodinger equation and their applications.
4. To study role of uncertainty in quantum physics.
5. To describe the structure of the hydrogen atom and show an understanding of quantization of angular momentum.
6. To give a broad knowledge of the most important characteristics of atoms, molecules and the interaction with electromagnetic fields.

Course Content:

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. Eigen values and Eigen functions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures)**

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

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigen functions using Frobenius method; Hermite polynomials; ground state, zero-point energy & uncertainty principle. **(12 Lectures)**

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & 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. **(10 Lectures)**

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. **(8 Lectures)**

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

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

Reference Books:

- A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGrawHill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference:

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

PHYSICS LAB (PHC-301)

Use C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics like

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

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

Here, 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 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511×10^6 eV/c^2.

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

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

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

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511×10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

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

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

For the anharmonic oscillator potential

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

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

Laboratory based experiments:

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

Reference Books:

- Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw‐HillPublication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge UniversityPress.
- An introduction to computational Physics, T.Pang, 2ndEdn.,2006, Cambridge Univ.Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand &Co.
- Scilab Image Processing: L.M. Surhone.2010 Betascript PublishingISBN:978-6133459274

Course Learning Outcome:

On successful completion of the course students will be able to understand

1. How to apply principles of quantum mechanics to calculate observables on known wave functions
2. How to solve time-dependent and time-independent Schrödinger equation for simple potentials
3. The structure and dynamics of atoms and simple molecules.
4. The interaction between atoms, molecules and electromagnetic fields.
5. Quantum mechanics formulation for Hydrogen atom.

PHC-302: ELECTROMAGNETIC THEORY

L	T	P	Cr
4	0	2	6

Course Objective:

1. To understand basic concepts about Maxwell's equations and Electromagnetic waves
2. To learn wave propagation in the ionosphere
3. To learn various concepts of polarization of light waves, their generation and detection
4. To learn concepts of wave propagation through waveguide
5. Understand the magnetic effects of electric current.
6. To learn about the unification of electric and magnetic phenomena.

Course Content:

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

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

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence). **(8 Lectures)**

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light.
Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. **(15 Lectures)**

Wave Guides: Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **(10 Lectures)**
Optical Fibres:- Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). **(5 Lectures)**

Reference Books:

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, BenjaminCummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford UniversityPress.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & BartlettLearning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGrawHill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, CengageLearning
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman &Co.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGrawHill.
- Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge UniversityPress

LAB ElectroMagnetic Theory (PHC-302)

List of Experiments

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'sair-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.

Reference Books

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

Semester VI

PHC 351: SOLID STATE PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

This course will build up basic understanding about solid state Physics to bachelor students. The objectives of the course are:

1. To understand about the crystal structure, lattice, unit cell and miller indices.

2. To know the difference between amorphous and crystalline materials.
3. To understand about the elementary concepts of lattice vibrations and various theories related to that.
4. To understand about the magnetism in materials and various concepts related to that.
5. To learn about the dielectric and ferroelectric properties in materials.
6. To understand about the concepts of band theory and basics of superconductivity.

Course Content:

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

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

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

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. **(8 Lectures)**

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

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

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

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt.Ltd.
  Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-GrawHill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, CengageLearning

- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, PearsonIndia
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

LAB Solid State Physics (PHC-351)

List of Experiments

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 150 ^{o}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books

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

Course Learning Outcome:

1. A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays by crystalline materials.
2. Understanding of lattice vibrations, phonons and learning of Einstein and Debye theory of specific heat of solids.
3. Better understanding of magnetism (dia, para, ferro) and theories related to that.
4. Secured an understanding about the dielectric and ferroelectric properties of materials.
5. Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
6. Understand the basic idea about superconductors and their classifications.
7. To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

PHC-352: STATISTICAL MECHANICS

L	T	P	Cr
4	**0**	**2**	**6**

Course Objective:

The objective of this course is to learn the basic concepts and definition of

1. Physical quantities in classical statistics and classical distribution law.
2. To learn the application of classical statistics to theory of radiation.
3. To comprehend the failure of classical statistics and need for quantum statistics.

Course Content:

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

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

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

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

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

Reference Books:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford UniversityPress.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, TataMcGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, PrenticeHall
- 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
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

LAB (Statistical Mechanics)- PHC-352

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

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

Reference Books:

- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. 2007, Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- 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

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

Course Learning Outcome:

Students would achieve the ability to:

1. Find the connection between statistics and thermodynamics.
2. Differentiate between different ensemble theories used to explain the behavior of the systems.
3. Differentiate between classical statistics and quantum statistics.
4. Explain the statistical behavior of ideal Bose and Fermi systems.
5. Apply the statistical distribution in real life problems and understand their problems.

PHYSICS-DSE (ELECTIVES)

PHD 305: CLASSICAL DYNAMICS

L	T	P	Cr
5	1	0	6

Course Objective:

The objective of this course is

1. To learn how to apply the Newtonian laws using various mathematical formulations to describe the motions of macroscopic objects using generalized coordinates, momentum, forces and energy.
2. The classical dynamics would be helpful in understanding of advanced branches of modern physics.

Course Content:

Classical Mechanics of Point Particles: Generalised coordinates and velocities. Hamilton's Principle, Lagrangian and Euler-Lagrange equations. Applications to simple systems such as coupled oscillators. Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, particle in a central force field. Poisson brackets. Canonical transformations. **(25 Lectures)**

Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction & twin paradox. Four-vectors: space-like, time-like & light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle. The Electromagnetic field tensor and its transformation under Lorentz transformations: relation to known transformation properties of **E** and **B**. Electric and magnetic fields due to a uniformly moving charge. Equation of motion of charged particle & Maxwell's equations in tensor form. Motion of charged particles in external electric and magnetic fields. **(35 Lectures)**

Electromagnetic radiation: Review of retarded potentials. Potentials due to a moving charge: Lienard Wiechert potentials. Electric & Magnetic fields due to a moving charge: Power radiated, Larmor’s formula and its relativistic generalisation. **(15 Lectures)**

Reference Books:

- Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998,Wiley.

- The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
- Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

Course Learning Outcome:

Students would achieve the ability to:

1. Define generalised coordinates, generalised velocities, generalised force and write Lagrangian for mechanical system in terms of generalised coordinates.
2. Gain the knowledge of Lagrangian and the Hamiltonian formulations of classical dynamics and their applications in appropriate physical problems.
3. Recapitulate and learn the special theory of relativity-postulates of the special theory of relativity, Lorentz transformations on space-time and other four vectors.
4. Explain the retarded potentials and derive potentials due to a moving charge, Lienard Wiechert potentials etc.

PHD 307: NUCLEAR AND PARTICLE PHYSICS

L	T	P	Cr
5	1	0	6

Course Objective:

This is a basic course in Physics which deals with

1. the phenomena taking place in the nuclear domain.
2. Students will be given an insight into the dimensions of a nucleus.
3. The aim of the course is to tell them about the stability of nucleus and various other properties.
4. The students will learn about various types of radiations and their interaction with matter.
5. The course is such designed to teach students about various types of nuclear model, Radioactivity decay, nuclear reactions and their energetics.
6. A brief introduction of elementary particles and their classification will also be taught to the students

Course Content:

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(10 Lectures)**

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

(12 Lectures)

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. **(10 Lectures)**

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

Nuclear Astrophysics: Early universe, primordial nucleo synthesis (particle nuclear interactions), stellar nucleo synthesis, concept of gamow window, heavy element production: r- and s-process path. **(4 Lectures)**

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. **(8 Lectures)**

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. **(8 Lectures)**

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

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. **(10 Lectures)**

Reference Books:

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

Course Learning Outcome:

On successful completion of the course students will be able to understand about

1. The nuclear forces, size, shape, density and constituent of nucleus and all its properties.
2. Interaction of various types of radiation with matter which they observe in their daily life.
3. Detecting methods, and instruments for different types of charged and neutral particle.
4. Bosonic, Fermionic and Elementary particles, their interactions and various decays.

PHD312: ADVANCED MATHEMATICAL PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

The purpose of the course is to introduce students to the method of Mathematical Physics. The student will:

1. Understand about linear algebra and various properties of vector spaces.
2. Understand about matrices and their properties, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices.
3. Learn the basic concept about tensors and their properties.
4. The concepts understood in the course will be explored for lab.

Course Content:

Linear Algebra: Vector Spaces: Vector Spaces over Fields of Real and Complex numbers. Examples. Vector space of functions. Linear independence of vectors. Basis and dimension of a vector space. Change of basis. Subspace. Isomorphisms. Inner product and Norm. Inner product of functions: the weight function. Triangle and CauchySchwartz Inequalities. Orthonormal bases. Sine and cosine functions in a Fourier series as an orthonormal basis. Gram Schmidt orthogonalisation. **(10 Lectures)**

Linear Transformations: Introduction. Identity and inverse. Singular and non-singular transformations. Representation of linear transformations by matrices. Similarity transformation. Linear operators. Differential operators as linear operators on vector space of functions. Commutator of operators. Orthogonal and unitary operators and theirmatrix representations. Adjoint of a linear operator. Hermitian operators and their matrix representation. Hermitian differential operators and boundary conditions. Examples. Eigenvalues and eigenvectors of linear operators. Properties of eigenvalues and eigenvectors of Hermitian and unitary operators. Functions of Hermitian operators/ matrices. **(15 Lectures)**

Tensors: Tensors as multilinear transformations (functionals) on vectors. Examples: Moment of Inertia, dielectric susceptibility. Components of a tensor in basis. Symmetric and antisymmetric tensors. The completely antisymmetric tensor. Non-orthonormal and reciprocal bases. Summation convention. Inner product of vectors and the metric tensor. Coordinate systems and coordinate basis vectors. Reciprocal coordinate basis.

Components of metric in a coordinate basis and association with infinitesimal distance.

Change of basis: relation between coordinate basis vectors. Change oftensor components under change of coordinate system. Example: Inertial coordinates & bases in Minkowski space, Lorentz transformations as coordinate transformations, Elelctromagnetic tensor and change in its components under Lorentz transformations. **(20 Lectures)**

Calculus of Variations

Variational Principle: Euler's Equation. Application to Simple Problems (shape of a soap film, Fermat's Principle, etc.). Several Dependent Variables and Euler's Equations. Example: Hamilton's Principle and the Euler-Lagrange equations of motion. Geodesics: geodesic equation as a set of Euler's equations.

Constrained Variations: Variations with constraints. Applications: motion of a simple pendulum, particle constrained to move on a hoop. **(15 Lectures)**

Reference Books:

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970,Elsevier.
- Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
- Linear Algebra, W. Cheney, E.W. Cheney & D.R. Kincaid, 2012, Jones & Bartlett Learning
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicis & Engineers, K.F. Riley, M.P. Hobson, S.J. Bence, 3rd Ed., 2006, Cambridge University Press

LAB Advanced Mathematical Physics (PHD-312)

Scilab based simulations experiments based on Mathematical Physics problems like

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

Reference Books:

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

Course Learning Outcome:

After successful completion of the course, the students will:

1. Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
2. Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices.
3. Students will learn to find eigen values and eigen vectors.
4. Understand basic properties tensors, their symmetric and antisymmetric nature, the Cartesian tensors, the general tensors, contravariant, covariant and mixed tensors and their transformation properties under coordinate transformations, physical examples of tensors such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.
5. In the laboratory course, the students are expected to solve the related problems using the Scilab/C++ computer language.

PHD-313: BIO-PHYSICS

L	T	P	Cr
5	1	0	6

Course Objective:

This Bio-Physics course will develop Physics students to

1. Deal with principles of physics and related sciences to understand the various phenomenon of living cells and organism.
2. Relates the concepts in routine observations, functions of chloroplast and mitochondria, body temperature, heat transfer thermodynamics of living organism and its regulation.
3. Recall and describe the structure of cell membrane, membrane transport systems and membrane potential.
4. Relate and differentiate various biopotential measuring instruments.
5. Understand Bioenergetics and Molecular motors: Kinesins, Dyneins, and microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in biomolecules, vibrational spectraofbio-biomolecules.
6. Solve qualitative and quantitative problems, using appropriate statistical mechanics.

Course Content:

Building Blocks & Structure of Living State: Atoms and ions, molecules essential for life, what is life. **Living state interactions:** Forces and molecular bonds, electric & thermal interactions, electric dipoles, casimir interactions, domains of physics in biology.

(10 Lectures)

Heat Transfer in biomaterials: Heat Transfer Mechanism, The Heat equation, Joule heating of tissue. **Living State Thermodynamics:** Thermodynamic equilibrium, first law of thermodynamics and conservation of energy. Entropy and second law of thermodynamics, Physics of many particle systems, Two state systems, continuous energy distribution, Composite systems, Casimir contribution of free energy, Protein folding and unfolding. **(20 Lectures)**

Open systems and chemical thermodynamics: Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis & synthesis, Entropy of mixing, The grand canonical ensemble, Hemoglobin. **(15 Lectures)**

Diffusion and transport Maxwell-Boltzmann statistics, Fick's law of diffusion, sedimentation of Cell Cultures, diffusion in a centrifuge, diffusion in an electric field, Lateral diffusion in membranes, Navier stokes equation, low Reynold's Number Transport, Active and passive membrane transport. **(15 Lectures)**

Fluids: Laminar and turbulent fluid flow, Bernoulli's equation, equation of continuity, venture effect, Fluid dynamics of circulatory systems, capillary action. **Bioenergetics and Molecular motors:** Kinesins, Dyneins, and microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in biomolecules, vibrational spectra of bio-biomolecules. **(15 Lectures)**

Reference Books:

- Introductory Biophysics, J. Claycomb, JQP Tran, Jones & Bartelett Publishers
- Aspects of Biophysics, Hughe S W, John Willy and Sons.
- Essentials of Biophysics by P Narayanan, New Age International

Course Learning Outcome:

After successful completion of the course, the students will be able to understand about

1. Biological structure and molecular forces.
2. Important role of heat transfer, thermodynamics, statistical mechanics and diffusion in biological domain.
3. Fluid dynamics and motion of bodies in fluid media.
4. Bioenergatics, molecular motors and light absorption of biomolecules
5. Biophysical phenomenon such as diffusion, establishment of membrane potential, bio impedance, and the electrical response of cells and organelles to external fields.

EXPERIMENTAL TECHNIQUES

L	T	P	Cr
4	0	2	6

Course Objective:

Through the course of experimental Physics, the student will

1. Understand about various measurement techniques such as accuracy and precision, error and uncertainity, standard deviation etc.
2. Understand about the concept of noise and fluctuations in various systems along with

the grounding and shielding.
3. Understand about transducers, their working, efficiency and applications.
4. Get acquaint with the concepts of digital multimeter and impedance bridges.
5. Understand about the basics of vacuum systems and their working.

Course Content:

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution. **(6 Lectures)**

Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise,1/f noise. **(8 Lectures)**

Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference. **(6 Lectures)**

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector. **(20 Lectures)**

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. **(6 Lectures)**

Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge. **(4 Lectures)**

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, pumping speed, Pressure gauges (Pirani, Penning, ionization). **(10 Lectures)**

Reference Books:

- Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
- Experimental Methods for Engineers, J.P. Holman, McGraw Hill
- Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
- Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
- Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill

- Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
- Electronic circuits: Handbook of design & applications, U.Tietze, Ch. Schenk, Springer

DSE LAB: Experimental Techniques

List of Experiments:

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of level using capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.
5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
8. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
9. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
10. To design and study the Sample and Hold Circuit.
11. Design and analyze the Clippers and Clampers circuits using junction diode
12. To plot the frequency response of a microphone.
13. To measure Q of a coil and influence of frequency, using a Q-meter

Reference Books:

- Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008,Springer
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
- Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

Course Learning Outcome:

At the end of the course, the student should be conversant with the following:

1. About accuracy and precision, different types of errors and statistical analysis of data.
2. About Noise and signal, signal to noise ratio, different types of noises and their identification.
3. Concept of electromagnetic interference and necessity of grounding.
4. Working of a digital multimeter.
5. Vacuum systems including ultrahigh vacuum systems.
6. Conduct Experiments using different transducers including LVDT and gain hands

on experience and verify the theory.

EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

L	T	P	Cr
4	0	2	6

Course Objective:

Through this course, the student will able to

1. Understand about embedded systems, their classification and applications.
2. Understand about the 8085 microprocessors.
3. Understand about 8051 microcontrollers.
4. Understand about the timer and counter programming.

Course Content:

Embedded system introduction: Introduction to embedded systems and general-purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embeddedsystems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers. **(6 Lectures)**

Review of microprocessors: Organization of Microprocessor based system, 8085µp pin diagram and architecture, concept of data bus and address bus, 8085programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts. **(6 Lectures)**

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. **(6 Lectures)**

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation. **(6 Lectures)**

Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions. **(9 Lectures)**

Timer and counter programming: Programming 8051 timers,counter programming. **(3 Lectures)**

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority inthe8051. **(6 Lectures)**

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing. **(4 Lectures)**

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. **(4 Lectures)**

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. **(10 Lectures)**

Reference Books:

- Embedded Systems: Architecture, Programming & Design, R.Kamal, 2008,Tata McGrawHill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson EducationIndia.
- Embedded microcomputor system: Real time interfacing, J.W.Valvano, 2000,Brooks/Cole
- Microcontrollers in practice, I. Susnea and M. Mitescu, 2005,Springer.
- Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson EducationIndia
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

DSE LAB: Embedded System: Introduction to Microcontrollers

List of Experiments

Following experiments using 8051:

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

Reference Books:

- Embedded Systems: Architecture, Programming& Design, R.Kamal] 2008,Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
- Embedded Microcomputor System: Real Time Interfacing, J.W.Valvano, 2000,Brooks/Cole

- Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

Course Learning Outcome:

At the successful completion of the course the student is expected to master the following:

1. Embedded systems including its generic architecture, design and classifications.
2. Embedded processors and microcontrollers.
3. Organization of Intel 8051 microcontroller, its architecture, programming and its memory organization.
4. Organization of intel microprocessor 8085, its architecture, pin diagram, timing diagram, and programming in assembly language
5. Programming with and without interrupt service request.
6. Interfacing parallel and serial ADC and DAC.
7. Basics of embedded system development and product development with a brief introduction to Arduino.
8. Student shall be able to design, fabricate, test and run the programs.

PHYSICS OF DEVICES AND INSTRUMENTS

L	T	P	Cr
4	0	2	6

Course Objective:

This course will build up understanding about devices and instruments to bachelor students. The objective of the course is:

1. To understand about device characteristics and metal-semiconductor junctions.
2. To enhance their knowledge about power supplies and filters.
3. To know about multivibrators using transistors.
4. To acquaint with processing of the device and their fabrication techniques.
5. To understand about electronic communication systems.

Course Content:

Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO_2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode. **(9 Lectures)**

Power supply and Filters: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection .Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. **(6 Lectures)**

Multivibrators: Astable and Monostable Multivibrators using transistors. **(2 Lectures)**

Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565or4046). **(8 Lectures)**

Processing of Devices: Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation. **(10 Lectures)**

Digital Data Communication Standards:
Serial Communications: RS232, Handshaking, Implementation of RS232 on PC. **(4 Lectures)**

Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART). **(4 Lectures)**

Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.
(4 Lectures)

Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK. **(10 Lectures)**

Reference Books:

- Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley &Sons
- Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
- Op-Amps & Linear Integrated Circuits, R.A. Gayakwad,4 Ed. 2000, PHI Learning Pvt. Ltd
- Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
- Electronic Communication systems, G. Kennedy, 1999, Tata McGrawHill.
- Introduction to Measurements & Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt.Ltd.
- PC based instrumentation; Concepts & Practice, N. Mathivanan, 2007, Prentice-Hall of India

DSE LAB: PHYSICS OF DEVICES ANDINSTRUMENTS

List of Experiments:

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.

6. To study the output characteristics of a MOSFET.

7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.
11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

SPICE/MULTISIM simulations for electrical networks and electronic circuits

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1st order active low pass and high pass filters of given cutoff frequency
6. Design a Wein`s Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flop`s using NAND Gates
8. Design 4-bit asynchronous counter using Flip-Flop ICs
9. Design the CE amplifier of a given gain and its frequency response.
10. Design an Astable multivibrator using IC555 of given duty cycle.

Reference Books:

- Basic Electronics:A text lab manual, P.B. Zbar, A.P. Malvino, M.A.Miller,1994, Mc-Graw Hill
- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-GrawHill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, PrenticeHall.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., 2000, PrenticeHall.
- Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
- PC based instrumentation; Concepts & Practice, N. Mathivanan, 2007, Prentice-Hall of India

Course Learning Outcome:

After successful completion of the course students will be able to:

1. Understand metal- semiconductor junctions, MOSFET, JFET, tunneling diodes, their working and device characteristics.
2. Learn about CMOS and charged couple devices.
3. Get a qualitative idea of C and L Filters. IC Regulators, line and load regulation, active and passive Filters, low pass, high pass, band pass and band reject filters.
4. Understand the basics about astable and monostable multivibrators using transistors.
5. Know about basic process flow for IC fabrication, crystal plane and orientation, defects in the lattice.
6. Understand the basic concepts of lithography for device processing.

7. Understand about the electronic communication system and have an idea about modulation of waves for communication.
8. Apply the learned concept for experiments in the lab.

APPLIED DYNAMICS

L	T	P	Cr
4	0	2	6

Course Objective:

The objective of this course is to provide

1. knowledge of dynamical systems in various branches of physics.
2. chaos and fractals with examples and elements of fluid dynamics.

Course Content

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems : the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

Other examples of dynamical systems –
In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits
In Chemistry: Rate equations for chemical reactions e.g. auto catalysis, bistability
In Economics: Examples from game theory.
Illustrative examples from other disciplines.

Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples.

Computing and visualizing trajectories on the computer using a software packages. Discrete dynamical systems. The logistic map as an example. **(20 Lectures)**

Introduction to Chaos and Fractals: Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer.

Self similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Serpinski gasket and DLA. Chaos in nonlinear finite-difference equations- Logistic map: Dynamics from time series. Parameter dependence- steady, periodic and chaos states. Cobweb iteration. Fixedpoints. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on

initial conditions. Period- Doubling route tochaos.
Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension.

(25 Lectures)

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis- concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows,separated & unseparated flows. Flow visualization - streamlines, pathlines, Streaklines. **(15 Lectures)**

Reference Books

- Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata,2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass,Springer.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press,2002
- Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

DSE LAB: APPLIED DYNAMICS

Laboratory/Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
8. Computational visualization of trajectories Electron motion in mesoscopic conductors as a chaotic billiard problem.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

Reference Books

- Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata,2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press,2002
- Fluid Mechanics, 2nd Edn, L.D. Landau & E.M. Lifshitz, Pergamon Press, Oxford,1987

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

Course Learning Outcome:

Students would achieve the ability to:

1. Develop the concept of phase space to define and formulate the dynamical systems.
2. Identify the dynamical systems in Biology, Chemistry, Economics and computing and visualizing trajectories using computer software.
3. Learn computer software skills to do qualitative analysis of dynamical systems.
4. To generate computer simulation of trajectories in phase space for simple systems demonstrating chaotic systems.
5. To simulate onset of chaos in simple dynamical systems in various conditions.
6. Formulate the basic equations

ASTRONOMY & ASTROPHYSICS

L	T	P	Cr
5	1	0	6

Course Objective:

1. To understand basic astrophysical processes and systems, ranging from sun to stars, galaxies and the whole universe
2. To learn large numerical simulations and analysis of observational data and interpretation of the results obtained

Course Content:

Astronomical Scales: Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. **(5 Lectures)**

Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equationof Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram. **(10 Lectures)**

Astronomical techniques: Basic Optical Definitions for Astronomy (MagnificationLight Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes). **(6 Lectures)**

Physical principles: Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium, Theory of Radiative Transfer (Radiation Field, Radiative Transfer Equation), Optical Depth; Solution of Radiative Transfer Equation, Local Thermodynamic Equilibrium. **(6 Lectures)**

The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magnetohydrodynamics. Helioseismology). **The solar family** (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. **(4 Lectures)**

Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification). **(4 Lectures)**

Stellar structure: Hydrostatic Equilibrium of a Star, Some Insight into a Star: Virial Theorem, Sources of Stellar Energy, Modes of Energy Transport, Simple Stellar Model, Polytropic Stellar Model. **Star formation: B**asic composition of Interstellar medium, Interstellar Gas, Interstellar Dust, Formation of Protostar, Jeans criterion, Fragmentation of collapsing clouds, From protostar to Pre-Main Sequence, Hayashi Line. **(6 Lectures)**

Nucleosynthesis and stellar evolution: Cosmic Abundances, Stellar Nucleosynthesis, Evolution of Stars (Evolution on the Main Sequence, Evolution beyond the Main Sequence), Supernovae. **Compact stars:** Basic Familiarity with Compact Stars, Equation of State and Degenerate Gas of Fermions, Theory of White Dwarf, Chandrasekhar Limit, Neutron Star (Gravitational Red-shift of Neutron Star, Detection of Neutron Star: Pulsars), Black Hole. **The milky way**: Basic Structure and Properties ofthe Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around theGalactic Nucleus. **(10 Lectures)**

Galaxies: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms, Active Galaxies **(4 Lectures)**

Active galaxies: 'Activities' of Active Galaxies, How 'Active' are the Active Galaxies? Classification of the Active Galaxies, Some Emission Mechanisms Related to the Study of Active Galaxies, Behaviour of Active Galaxies (Quasars and Radio Galaxies, Seyferts, BL Lac Objects and Optically Violent Variables), The Nature of the Central Engine, Unified Model of the Various Active Galaxies. **(10 Lectures)**

Large scale structure & expanding universe: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter), Friedmann Equation and its Solutions, Early Universe and Nucleosynthesis (Cosmic Background Radiation, Evolving vs. SteadyStateUniverse). **(10 Lectures)**

Reference Books:

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley PublishingCo.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4^{th} Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, NewDelhi,2002.
- Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi, 2001.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

Course Learning Outcome:

After the completion of the course, student should be able to:

1. Explain and use various scales, units used in Astronomy. Use the concepts of positional astronomy to determine diurnal motion of the stars, estimate the equation of time, stat distance using parallax, and other parameters associated with stars.
2. Explain the construction and working of astronomical telescopes, describes physical principles controlling astronomical systems. Explain the structure of the sun and associated solar activity.
3. Describe the process of staller evolution and star formation, life cycle of stars, explain the structure and properties of Milky way galaxy. Explain the types of galaxies and their basic properties.
4. Elucidate the theory of expanding universe, Hubble's law.

ATMOSPHERIC PHYSICS

L	T	P	Cr
4	**0**	**2**	**6**

Course Objective:

1. To learn basic concepts of Earth's atmosphere, dynamical process.
2. To understand simple principles for remote sensing, elementary aerosol and cloud physics.
3. To learn atmospheric wave and their type and properties.

Course Content:

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, 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. **(10 Lectures)**

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, Mesoscale circulations, The general circulations, Tropical dynamics. **(11 Lectures)**

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. **(14 Lectures)**

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. **(10 Lectures)**

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. **(15 Lectures)**

Reference Books:

- Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61,1996
- The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd edn.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,2014

DSE LAB: Atmospheric Physics

List of Experiments:

1. Numerical Simulation for atmospheric waves using dispersion relations
2. Atmospheric gravity waves
   (b) Kelvin waves
   (c) Ross by waves, and mountain waves
3. Offline and online processing of radar data
   (a) VHF radar,
   (b) X-band radar, and
   (c) UHF radar
4. Offline and online processing of LIDAR data
5. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
6. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique

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

Reference Books:

- Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61,1996
- The Physics of Atmosphere – J.T. Houghton; Cambridge Univ. Press; 3rd edn.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,2014

Course Learning Outcome:

Student should be able to

1. Describe the general features of Earth's atmosphere, derive the hydrostatic equations and explain techniques for meteorological observations.
2. Describe features of atmospheric dynamics, basic conservation laws, derive momentum equation use them to explain atmospheric circulations and dynamics.
3. Explain the types of atmospheric waves and their properties, propagation mechanism and effect in atmospheric circulation.
4. Explain construction and working of atmospheric measurement techniques such as Radar, Lidar, etc., Describe the sources and effect of atmospheric aerosols.

NANO MATERIALS AND APPLICATIONS

L	T	P	Cr
4	0	2	6

Course Objective:

This course will develop basic understanding of the nanosystems and their applications. The objectives of the course are:

1. To acquaint the students with nanoscale systems, 1D, 2D and 3D systems.
2. To understand about the synthesis of nanostructure materials by various deposition processes.
3. To familiarize about various characterization techniques such as XRD, electron microscopy, atomic force microscopy etc.
4. To understand about various optical properties in nanoscale systems.
5. To learn about electron transport in nanomaterials.
6. To understand about the applications of nanomaterials.

Course Content:

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

(12 Lectures)

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. **(8 Lectures)**

CHARACTERIZATION: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **(6 Lectures)**

OPTICAL PROPERTIES: Coulomb interaction in nanostructures. Concept ofdielectric 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 heterostrctures and nanostructures. **(14 Lectures)**

ELECTRON TRANSPORT: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **(5 Lectures)**

APPLICATIONS: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron 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). **(15 Lectures)**

Reference books:

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. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin,2004).

DSE LAB: Nano Materials and Applications

List of Experiments:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.

6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route)and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

Reference Books:

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).

Course Learning Outcome:

At the end of the course the student is expected understand the following:

1. In the Nano systems and its implications in modifying the properties of materials at the nanoscale.
2. Concept of Quantum confinement, 3D, 2D, 1D and 0D nanostructure with examples.
3. Different synthesis techniques including top down and bottom-up approaches.
4. Characterization of nanostructured materials using X-ray diffraction, electron microscopy, Atomic Force Microscopy and Scanning Tunneling Microscopy.
5. Optical properties of nanostructured materials, modification of band gap, excitonic confinement.
6. Applications of nanostructured materials in making devices namely MEMS, NEMS and other heterostructures for solar cell and LEDs.
7. The student will synthesize nanoparticles by different chemical routs and characterize them in the laboratory using the different techniques he has learnt in the theory.

EARTH SCIENCE

L	T	P	Cr
5	1	0	6

Course Objective:

1. To learn basics of evolution of Universe, galaxy, solar system, planets and earth.
2. To learn about the internal and external structure of the earth.
3. To have better understanding of the climate and other challenging process our earth currently facing.

Course Content:

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 Lectures)**

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 and land organisms. **(15 Lectures)**

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 erosion and beach processes. Tides. Tsunamis.
   (c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones.

   Climate:
   i. Earth's temperature and greenhouse effect.
   ii. Paleo climate 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. **(20 Lectures)**

4. **Evolution:**

Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts 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 theEarth. **(15 Lectures)**

5. Disturbing the Earth –Contemporary dilemmas

(a) Human population growth.
(b) Atmosphere: Greenhouse gas emissions, climate change, air pollution.
(c) Hydrosphere: Fresh water depletion.
(d) Geosphere: Chemical effluents, nuclear waste.
(e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems. **(10 Lectures)**

Reference Books:

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

Course Learning Outcome:

Student should be able to

1. Explain origin of the Universe, evolution of galaxy, solar system, planets and earth.
2. Describe structures of earth: Internal, hydrosphere, atmosphere, cryosphere and Biosphere.
3. Explain various dynamical process controlling earth and its dynamics, and climate.
4. Explain various process of geological study, application of geochronology, origin and evolution of earth.
5. Understand and explain various contemporary problem the Earth facing such as population growth, climate change, pollutions, loss of biodiversity.

MEDICAL PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

The objective of this course is to build-up basic understanding of:

1. Application of Physics to clinical medicine.
2. Physics of Diagnostic and Therapeutic Systems
3. Radiation Physics
4. Medical Imaging Physics UGC Document on LOCF Physics.
5. Essential physics of Medical Imaging, Radiological Physics, Therapeutic Systems and Radiation Therapy is acquired.

Course Content:

PHYSICS OF THE BODY-I

Mechanics of the body: Skeleton, forces, and body stability. Muscles and the dynamics of body movement, Physics of body crashing. **Energy household of the body:** Energy balance in the body, Energy consumption of the body, Heat losses of the body, **Pressure system of the body:** Physics of breathing, Physics of cardiovascular system. **(7 Lectures)**

PHYSICS OF THE BODY-II

Acoustics of the body: Nature and characteristics of sound, Production ofspeech, Physics of the ear, Diagnostics with sound and ultrasound. **Optical system of the body:** Physics of the eye. **Electrical system of the body:** Physics of the nervous system, Electrical signals and information transfer. **(7 Lectures)**

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I

X-RAYS: Electromagnetic spectrum – production of x-rays – x-ray spectra-Brehmsstrahlung- Characteristic x-ray – X-ray tubes – Coolidge tube – x-ray tube design – tube cooling stationary mode – Rotating anode x-ray tube – Tube rating – quality and intensity of x-ray. X-ray generator circuits – half wave and full wave rectification – filament circuit – kilo voltage circuit – high frequency generator – exposure timer – HT cables. **(8 Lectures)**

RADIATION PHYSICS: Radiation units - exposure - absorbed dose – units: rad, gray-relative biological effectiveness - effective dose - inverse square law - interaction of radiation with matter - linear attenuation coefficient. Radiation Detectors -Thimble chamber- condenser chambers – Geiger counter – Scintillation counter – ionization chamber – Dosimeters – survey methods – area monitors – TLD and semiconductor detectors. **(8 Lectures)**

MEDICAL IMAGING PHYSICS: X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR) – NMR imaging – MRI Radiological imaging – Radiography – Filters – grids – cassette – X-ray film – film processing – fluoroscopy – computed tomography scanner – principle function – display – generations– mammography. Ultrasound imaging – magnetic resonance imaging – thyroid uptake system – Gamma camera (Only Principle, function anddisplay). **(10 Lectures)**

RADIATION THERAPY PHYSICS: Radiotherapy – kilo voltage machines – deep therapy machines – Telecobalt machines – Medical linear accelerator. Basics of Teletherapy units – deep x-ray, Telecobalt units, medical linear accelerator – Radiation protection – external beam characteristics – phantom – dose maximum and build up – bolus – percentage depth dose – tissue – air ratio – back scatter factor. **(10 Lectures)**

RADIATIONANDRADIATIONPROTECTION: Principles of radiation protection – protective materials-radiation effects – somatic, genetic stochastic & deterministic effect, Personal monitoring devices – TLD film badge – pocket dosimeter. Radiation dosimetry, Natural radioactivity, Biological effects of radiation, Radiation monitors**.**

(10- Lectures)

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II

Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography.
Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose inradiation treatment. **(10 Lectures)**

Reference Books:

- Medical Physics, J.R. Cameron and J.G.S kofronick, Wiley(1978)
- Basic Radiological Physics Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi(2003)
- Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins(1990)
- Physics of the human body, Irving P. Herman, Springer(2007).
- Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rd edition(2003)
- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition(2002)
- The Physics of Radiology-H E Johns and Cunningham.

DSE LAB: Medical Physics

List of Experiments:

1. Understanding the working of a manual Hg Blood Pressure monitor and measurethe Blood Pressure.
2. Understanding the working of a manual optical eye-testing machine and to learneye-testing procedure.
3. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
4. Correction of Hypermetropia/Hyperopia (long sightedness) using a combinationof lenses on an optical bench/breadboard.
5. To learn working of thermoluminescent dosimeter (TLD) badges and measurethe background radiation.
6. Familiarization with Geiger-Muller (GM) Counter and to measure background radiation.
7. Familiarization with Radiation meter and to measure background radiation.
8. Familiarization with the construction of speaker-receiver system and to design a speaker-receiver system of given specification.

Reference Books:

- Basic Radiological Physics, Dr. K. Thayalan - Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi(2003)
- Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins(1990)
- Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rd edition(2003)
- The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition(2002)
- The Physics of Radiology-H E Johns and Cunningham.

Course Learning Outcome:

This course will enable the student to

1. Gain a broad and fundamental understanding of Physics while developing particular expertise in medical applications.
2. Learn about the human body, its anatomy, physiology and bioPhysics, exploring its performance as a physical machine. Other topics include the Physics of the senses.

3. study diagnostic and therapeutic applications like the ECG, radiation Physics, X-ray technology, ultrasound and magnetic resonance imaging.
4. Gain knowledge with reference to working of various diagnostic tools, medical imaging techniques, how ionizing radiation interacts with matter, how it affects living organisms and how it is used as a therapeutic technique and radiation safety practices.
5. Imparts functional knowledge regarding need for radiological protection and the sources of an approximate level of radiation exposure for treatment purposes.

DISSERTATION

Course Objective:

1. This course is focused to facilitate student to carry out extensive research and development project or technical project through problem and gap identification.
2. Development of methodology for problem solving, interpretation of findings, presentation of results and discussion of findings.
3. To expose the students to advances in the various research areas worldwide.

Course Learning Outcome:

1. Students will be able to gain in depth knowledge of the area of research.
2. Learn experimental synthesis of various materials for certain applications.
3. Learn various mathematical/ computational tools for theoretical studies.
4. Understand and learn the working of various characterization tools.
5. Analyze and critically evaluate different technical/research solutions
6. Students will learn to discuss present their research work in a systematic manner.
7. Identify the issues that must be addressed within the framework of the specific dissertation in order to take into consideration

SKILL ENHANCEMENT COURSE
(any four)
PHYSICS WORKSHOP SKILL

L	T	P	Cr
2	0	0	2

Course Objective:

The aim of this course is to enable the students

1. To familiar and experience with various machine tools, lathes, shapers, drilling machines, cutting tools, welding sets and also in different gear systems, pulleys etc.
2. He /she will also acquire skills in the usage of multimeters, soldering iron, oscilloscopes, power supplies and relays.

Course Content:

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, 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. **(3 Lectures)**

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 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. **(8 Lectures)**

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. **(8 Lectures)**

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. **(6 Lectures)**

Reference Books:

- 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, 3rd Edn., Editor Newnes [ISBN:0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN:0861674480]

Course Learning Outcome:

Students would achieve:

1. The ability to make simple length, height, time, area, volume measurements.
2. Mechanical skills needed to the workshop practice.
3. Hand on experience of workshop practice by doing casting, foundry, machining, welding and learn to use various machine tool like lathe shaper, milling and drilling machines etc. and working with wooden and metal blocks.
4. Electrical and electronics skills related to the measurement of various electrical and electronics quantities.
5. Knowledge of prime movers.

COMPUTATIONAL PHYSICS

L	T	P	Cr
2	**0**	**0**	**2**

Course Objective:

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

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

Course Content:

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Rootsof Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. **(5 Lectures)**

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems. **(6 Lectures)**

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

(6 Lectures)

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluate datx=1

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

(2 Lectures)

Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. **(2 Lectures)**

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

(4 Lectures)

Hands on exercises:

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

12. Motion of particle in a central force field and plot the output for visualization.

Reference Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5^{th} Edn., 2012, PHI Learning Pvt.Ltd.
- Computer Programming in Fortran 77”. V. Rajaraman (Publisher:PHI).

- LaTeX–A Document Preparation System”, Leslie Lamport (Second Edition, Addison-Wesley,1994).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning2010)
- Schaum’s Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill BookCo.
- Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, NewDelhi(1999)
- A first course in Numerical Methods, U.M.AscherandC.Greif, 2012,PHILearning
- Elementary Numerical Analysis, K.E. Atkinson, 3^{rd}Edn.,2007, Wiley IndiaEdition.

Course Learning Outcome:

This course will enable the students to

1. Learn, write and run FORTRAN programs in the Linux system. In particular, they will attempt the following exercises: (i) Exercises on syntax on usage of FORTRAN. (ii) Usage of GUI windows, Linux commands, familiarity with DOS.
2. Learn the skills for writing a flow chart and then writing the corresponding program for a specific problem using the C/ C++/FORTRAN language
3. Attempt the following exercises: (i) Exercises on syntax on usage of FORTRAN. (ii) Usage of GUI windows, Linux commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN. (iii) To print out all natural even/ odd numbers between given limits. (iv) To find maximum, minimum and range of a given set of numbers.
4. Learn “Scientific Word Processing”, particularly, how to use the LaTeX software in writing articles and papers which include mathematical equations and diagrams. Similarly, students should learn the basics of Gnuplot.

ELECTRICAL CIRCUIT NETWORK SKILLS

L	T	P	Cr
2	0	0	2

Course Objective:

The aim of this course is to enable the students:

1. To design and trouble shoots the electrical circuits, networks and appliances through hands-on mode.
2. To design various types of DC and AC circuits.
3. To understand and operate generators, transformers and electric motors and to do electrical wiring with assured electrical protection devices

Course Content:

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law.Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. **(2 Lectures)**

Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. **(2 Lectures)**

Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(2 Lectures)**

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **(2 Lectures)**

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

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor. **(3 Lectures)**

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources. **(4 Lectures)**

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

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drops and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wire nuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board. **(3 Lectures)**

Reference Books:

- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja
- Performance and design of AC machines - M G Say ELBSEdn.

Course Learning Outcome:

Students would achieve the ability to:

1. Explain and apply the basic principles of electricity, electrical circuits and electrical drawings.
2. Understand the physics of generators, transformers, electric motors.
3. Learn about electrical wiring with assured electrical protection devices.
4. Understand the physics of solid state devices and their applications.

BASIC INSTRUMENTATION SKILLS

L	T	P	Cr
2	0	0	2

Course Objective:

The aim of this course is

1. To get exposure with various aspects of instruments and their usage through hands-on mode.
2. To learn about various electrical measurement techniques.

Course Content:

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **(2 Lectures)**
Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **(2 Lectures)**

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter. **(3 Lectures)**

AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier-amplifier. Block diagram ac millivoltmeter**,** specifications and their significance. **(3 Lectures)**

Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. **(3 Lectures)**

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **(2 Lectures)**

Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **(3 Lectures)**

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

Digital Instruments: Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **(2 Lectures)**

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/

frequency counter, time- base stability, accuracy and resolution. **(2 Lectures)**

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

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

7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q-meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Reference Books:

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

Course Learning Outcome:

Students would achieve the ability to:

1. To analyze and fit the experimental data.
2. To estimate different kind of errors coming in data.
3. To explain principle, theory and application of various sensors and transducers.
4. To explain the basic principle and importance of the different AC and DC measurement techniques.
5. To explain the concepts of signal conditioning and noise analysis.

RENEWABLE ENERGY AND ENERGY HARVESTING

L	T	P	Cr
2	0	0	2

Course Objective:

The objective of this course is to learn not only the theories of the renewable sources of energy, but also to have hands-on experiences on them wherever possible.

Some of the renewable sources of energy which students will study are:

1. off-shore wind energy
2. tidal energy
3. solar energy
4. biogas energy and
5. hydroelectricity
6. In this course student will also study non-conventional energy sources and their practical applications.

Course Content:

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. **(4 Lectures)**

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems. **(5 Lectures)**

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid inter connection topologies. **(4 Lectures)**

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. **(2 Lectures)**

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

Geothermal Energy: Geothermal Resources, Geothermal Technologies. **(1 Lectures)**

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydropower sources. **(1 Lectures)**

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

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications, Carbon captured technologies, cell, batteries, power consumption Environmental issues and Renewable sources of energy, sustainability.

(2 Lectures)

Demonstrations and Experiments

1. Demonstration of Training modules on Solar energy, wind energy, etc.

2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Reference Books:

- Non-conventional energy sources - G.D Rai - Khanna Publishers, NewDelhi
- Solar energy - M P Agarwal - S Chand and Co.Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook,2009
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich(USA).
- http://en.wikipedia.org/wiki/Renewable_energy

Course Learning outcome:

This course will enable the students to:

1. **1.** Learn about piezoelectricity, carbon- captured technologies like cells, batteries.
2. **2.** Observe practical demonstrations of (i) training modules of solar energy, wind energy etc., (ii) Conversion of vibration into voltage using piezoelectric materials, (iv) conversion of thermal energy into voltage using thermoelectric modules.
3. **3.** Understand about fossil fuels and Alternate Sources of Energy e.g. Solar energy, Wind Energy harvesting, Ocean Energy, Geothermal Energy, Hydro Energy, Piezoelectric Energy Harvesting, Electromagnetic Energy Harvesting.

MECHANICAL DRAWING

L	T	P	Cr
2	0	0	2

Course Objective:

The objective of this course is to introduce basic sketching techniques to students.

1. Students will be able to draw orthographic projections and sections.
2. Learn to take data and transform it into graphic drawings.
3. Students are able to use the drafting instruments properly and improve their lettering and dimensioning skills.
4. Students learn how to operate Auto Cad and transform sketches and technical data into electronic drawings.

Course Content:

Introduction: Drafting Instruments and their uses. lettering: construction and uses of various scales: dimensioning as per I.S.I. 696-1972. Engineering Curves: Parabola: hyperbola: ellipse: cycloids, involute: spiral: helix and loci of points of simple moving mechanism.2D geometrical construction. Representation of 3D objects. Principles of projections. **(4Lectures)**

Projections: Straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids. **(6Lectures)**

Object Projections: Orthographic projection. Interpenetration and intersection of solids.

Isometric and oblique parallel projection of solids. **(4Lectures)**

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD- specific skills (graphical user interface. Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extract drawing data). Control entity properties. Demonstrating basic skills to produce 2-D and 3-Ddrawings. 3D modeling with Auto CAD (surfaces and solids), 3D modeling with sketch up, annotating in Auto CAD with text and hatching, layers, templates & design center, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale. **(16Lectures)**

Reference Books:

- K. Venugopal, and V. Raja Prabhu. Engineering Graphic, New Age International
- AutoCAD 2014 & AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
- Architectural Design with Sketchup/Alexander Schreyer/John Wiley &Sons/ISBN:978-1-118-12309-6

Course Learning Outcome:

After the successful completion of the course students will

1. Understand Parametric Modelling Fundamentals, Procedure, and "Shape before Size" approach.
2. Develop an ability to Create Parametric 2-D Sketches, and Create and Edit Parametric dimensions.
3. Become able to draw multiview orthographic and other projections including isometric, sectional, and perspective.
4. Be able to interpret and comprehend a sketch.
5. Be able to convert sketches into engineered drawings.

RADIATION SAFETY

L	T	P	Cr
2	0	0	2

Course Objective:

The aim of this course is for awareness and understanding regarding radiation hazards and safety.

1. To increase the awareness and understanding of the students regarding the radiation hazards and safety.
2. To introduce the basic and advance idea of harmful radiation from various sources.
3. To introduce various detection and monitoring techniques and method of safe management of radiative sources.
4. To enhance students' skills in various applications of nuclear techniques

Course Content:

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. **(5 Lectures)**

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. **(5 Lectures)**

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, Thermo luminescent Dosimetry. **(6 Lectures)**

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. **(6 Lectures)**

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. **(3 Lectures)**

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)

Reference Books:

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 Handbook5)
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., Bristol1981.
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

Course Learning outcome:

Student should be able to

1. Explain basic concepts of atomic and nuclear physics focused on harmful radiation. Describes concepts of radio activity.
2. Describes interaction of various types of radiation (photon, neutron, charge particles etc.) with matter.
3. Use radiation detection and monitoring devices, effectively implement radiation safety management technique.

APPLIED OPTICS

L	T	P	Cr
2	0	0	2

Course Objective:

1. To introduces basic and advance concepts of optical sources such as LASER, LED
2. To develop advance understanding on optical image processing techniques.
3. To trained students about the concepts of Holography and Fiber optics.

Course Content:

i. Source and Detector:

Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers.

Experiments on Lasers:

a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.

b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid-state laser.
c. To find the polarization angle of laser light using polarizer and analyzer
d. Thermal expansion of quartz using laser

Experiments on Semiconductor Sources and Detectors:

a. V-I characteristics of LED
b. Study the characteristics of solid state laser
c. Study the characteristics of LDR
d. Photovoltaic Cell
e. Characteristics of IR sensor

ii. Fourier Optics:

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

Experiments on Fourier Optics:

a. Fourier optic and image processing

1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system

b. Fourier Transform Spectroscopy

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

Experiment:

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

iii. Holography

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

Experiments on Holography and interferometry:

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

iv. Photonics: Fiber Optics

Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating

Experiments on Photonics: Fibre Optics

a. To measure the numerical aperture of an optical fibre
b. To study the variation of the bending loss in a multimode fibre

c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
d. To measure the near field intensity profile of a fibre and study its refractive index profile
e. To determine the power loss at a splice between two multimode fibre.

Reference Books:

- Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGrawhill.
- LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGrawHill
- Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, VivaBooks
- Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
- Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt.Ltd.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt.Ltd.
- Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ.Press.

Course Learning Outcome:

Student should be able to

1. Explain basic physical concepts associated with LASER and LEDs.
2. Use various optical image processing techniques, Fourier transform spectroscopy, NMR spectroscopy techniques.
3. Explain concepts of holography, its types, use of white light holography.
4. Describe basic principle of optical fiber, its types and their application in data transfer.

WEATHER FORECASTING

L	T	P	Cr
2	**0**	**0**	**2**

Course Objective:

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques.

1. To introduce basics physical laws governing atmospheric systems: circulation, dynamics, connections of global weather to small scale local weather.
2. To create awareness about the climate change and its overlying effect on the weather.
3. To teach various techniques to obtained weather data and its analysis methods for forecasting

Course Content:

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics. **(6 Lectures)**

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

(4 Lectures)

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

(3 Lectures)

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.

(4 Lectures)

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts. **(8 Lectures)**

Demonstrations and Experiments:

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
   (a) To calculate the sunniest time of the year.
   (b) To study the variation of rainfall amount and intensity by wind direction.
   (c) To observe the sunniest/driest day of the week.
   (d) To examine the maximum and minimum temperature throughout the year.
   (e) To evaluate the relative humidity of the day.
   (f) To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and nonaviation)

Reference books:

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers,Nagpur.
4. Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
5. Why the weather, Charls Franklin Brooks, 1924, Chpraman & Hall,London.
6. Atmosphere and Ocean, John G. Harvey, 1995, The ArtemisPress.

Course Learning outcome:

Student should be able to

1. Explain the basics idea of atmosphere, its structure, and variation of parameters like

pressure, temperature etc.

2. Measure weather parameters such as wind speed, direction, humidity, cloud, rainfall etc., necessary for forecasting.

GENERIC ELECTIVE COURSES (GE)

(any four for other Departments/Disciplines)

PHG-102: MECHANICS

L	T	P	Cr
4	0	2	6

Course Objective:

This is a basic course in Physics which deals with

1. Vector algebra, first and second differential equations.
2. The students will also be introduced about the Newton's laws of motion, forces, angular momentum and knowledge about the center of mass and moment of Inertia.
3. To understand the concepts of gravitation, oscillations and elasticity.
4. To introduce the concept of special relativity and its applications to Physical Sciences.
5. Experimental demonstration of above discussed topics will help them to develop understanding of basic physics in their daily life.

Course Content:

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

(4 Lectures)

Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

(5 Lectures)

Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of asystem of particles. Centre of Mass.

(5 Lectures)

Momentum and Energy: Conservation of momentum. Work and energy.Conservation of energy. Motion of rockets.

(6 Lectures)

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.

(5 Lectures)

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant).

Kepler’s Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.

(12 Lectures)

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages.

(8 Lectures)

Damped oscillations.

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.

(10 Lectures)

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

(5 Lectures)

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

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Reference Books:

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

GE LAB: MECHANICS

List of Experiments:

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
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.

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4^{th} Edition, reprinted 1985, Heinemann EducationalPublishers.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11^{th} Edition, 2011, Kitab Mahal, NewDelhi.

Course Learning Outcome:

On successful completion of the course

1. students would have grasped the fundamentals of different types of frames of references and transformation laws.

2. Learned conservation laws of energy and linear and angular momentum and apply them to solve problems.
3. Students develop understanding about fundamental ideas of special theory of relativity such as length contraction and time dilation and mass –energy invariance.
4. Students develop ability to perform experiments and develop understanding about gravity, angular momentum, Moment of Inertia, oscillations and elastic property.

PHG 151: ELECTRICITY AND MAGNETISM

L	T	P	Cr
4	0	2	6

Course Objective:

1. To learn the concept of vector analysis.
2. To learn the concepts of charge, fields and potentials and how do they interact with each other.
3. To be able to use the basic laws of Laplace's and Poisson's equations.
4. To learn concepts of magnetic fields and use them to estimate field due to various structure like solenoid, toroid.
5. To learn the concepts of electromagnetic induction and its applications.

Course Content:

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

(5 Lectures)

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet,charged conductor. Electric potential as line integral of electric field, potential due toa point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarization, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(25 Lectures)**

Magnetism:

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. **(8 Lectures)**

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.

(6 Lectures)

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **(6 Lectures)**

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

(10 Lectures)

Reference Books:

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-HillEducation
- Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ.Press
- Electricity and Magnetism, D C Tayal, 1988, Himalaya PublishingHouse.
- University Physics, Ronald Lane Reese, 2003, ThomsonBrooks/Cole.
- D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.
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GE LAB: ELECTRICITY AND MAGNETISM

List of Experiments:

1. Tousea 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 (Determined B/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 determineits(a)Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster’s Bridge.
9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

Reference Books

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

Course Learning Outcome:

After successful completion of the course, student should be able to

1. Explain scalar and vector product, curl and divergence and the related theorems.
2. Explain and determine electric field and potential due various charge configuration.
3. Explain gauss's law and use it to determine electric filed.
4. Describe the concepts of Laplace's and Poisson's equations and Uniqueness theorem.
5. Explain the concept of Capacitor's and use the method of images and determine potential due to various charge distributions.
6. Explain the concept of electromagnetic introduction and its application in various electric instruments, describe various electric circuit and determine their reactance and impedance. Explain the concept and use of ballistic galvanometer.

GE: THERMAL PHYSICS AND STATISTICAL MECHANICS

L	T	P	Cr
4	0	2	6

Course Objective:

The objective of this course is to build-up basic understanding of

1. Laws of thermodynamics, thermo dynamical potentials and kinetic theory of gases.
2. To learn the application of classical statistics to theory of radiation, to comprehend the failure of classical statistics and need for quantum statistics.

Course Content:

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(12 Lectures)**

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

(8 Lectures)

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases. **(10 Lectures)**

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

(8 Lectures)

Statistical Mechanics: Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(6 Lectures)**

Reference Books:

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

GE LAB: THERMAL PHYSICS AND STATISTICAL MECHANICS

List of Experiments:

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

Reference Books:

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

Course Learning Outcome:

After successful completion of the course, the student will

1. Familiarize with various thermodynamic process and work done in each of these processes.

2. Have a clear understanding about reversible and irreversible process and also working of a Carnot engine, and knowledge of calculating change in entropy for various process.
3. Get familiar with kinetic theory of Gasses (behaviour of real gas).
4. Find the connection between statistics and thermodynamics.
5. Differentiate between different ensemble theories used to explain the behavior of the systems.

GE: WAVES AND OPTICS

L	T	P	Cr
4	0	2	6

Course Objective:

The objectives of the course are:

1. To introduce basic concepts of wave motion and principle of superposition.
2. To able to use the concepts of Interference, diffraction and polarization in wave optical applications.

Course Content:

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

(6 Lectures)

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

(3 Lectures)

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

(4 Lectures)

Fluids: Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - 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.

(6 Lectures)

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

(7 Lectures)

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

(3 Lectures)

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

(Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

(9 Lectures)

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

(4 Lectures)

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

(10 Lectures)

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

(8 Lectures)

Reference Books:

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

GE LAB: WAVES AND OPTICS

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify 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 SingleSlit.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Reference Books:

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

Course Learning Outcome:

Students should be able to

1. Describe examples of oscillating systems, describe superposition principle and its application in explaining beats and concepts of phase and group velocities.
2. Explain wave motions, its components, its type, and able to write wave equation.
3. Explain electromagnetic waves, principle of interference, diffraction and difference between them.
4. Describe working principle of Michelson Interferometer, Newton's ring and by using them able to determine wavelength of light, refractive index of the medium.

GE: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION

L	T	P	Cr
4	0	2	6

Course Objective:

The course will lead to understand about:

1. Difference between analog and digital circuits.
2. Binary numbers, logic gates and Boolean algebra
3. Concepts of semiconductor devices and amplifiers.
4. Basic understanding of operational amplifiers.
5. Understand about the instrumentation various systems.

Course Content:

Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

(5 Lectures)

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) KarnaughMap.

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and

Full Adders and Subtractors, 4-bitbinaryAdder-Subtractor.

(10 Lectures)

Semiconductor Devices and Amplifiers:

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Active, Cutoff & Saturation regions. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B &C Amplifiers.

(20 Lectures)

UNIT-3: Operational Amplifiers (Black Box approach):

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

(10 Lectures)

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

(3 Lectures)

Instrumentations: Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation.

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator.

(12 Lectures)

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-GrawHill.
- Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
- Microelectronic Circuits, M.H. Rashid, 2^{nd} Edn., 2011, Cengage Learning.
- Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7^{th} Ed., 2011, Tata McGrawHill
- Fundamentals of Digital Circuits, A. Anand Kumar, 2^{nd} Edition, 2009, PHI

Learning Pvt. Ltd.

LAB: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTS

List of Experiments:

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

Reference Books:

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, PrenticeHall.
- OP-Amps & Linear Integrated Circuit, R.A. Gayakwad, 4th Edn, 2000, PrenticeHall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-GrawHill.

Course Learning Outcome:

After successful completion of the course, the student should be able to:

1. Learn the difference between analog and digital systems.
2. Learn about digital circuits, logic gates, Boolean algebra and various operation of digital systems
3. Explain about semiconductor devices like PN junctions, transistors and amplifiers.
4. Understand about operational amplifiers and oscillators.
5. Describe about CRO and its working, various power supplies and, timer IC’s.

GE: ELEMENTS OF MODERN PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

The objectives of the course are:

1. To describe the concept of plank hypothesis of photons, Black body radiation of matter.
2. To determine the uncertainty in position and momentum by Heisenberg uncertainty principle.
3. To understand the size and structure of atomic nucleus and its relation with atomic weight.

Course Content:

Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson- Germer experiment.

(8 Lectures)

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.

(8 Lectures)

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.

(10 Lectures)

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

(10 Lectures)

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

(6 Lectures)

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

(8 Lectures)

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.

(6 Lectures)

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

(4 Lectures)

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2009,McGraw-Hill
- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning
- Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
- Quantum Physics, Berkeley Physics,Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
- Modern Physics, R.A. Serway, C.J. Moses, and C.A. Moyer, 2005, Cengage Learning

LAB: ELEMENTS OF MODERN PHYSICS

List of Experiments

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine 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 Photosensor & compare with incoherent source –Na.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

Reference Books:

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

Course Learning Outcome:

Upon successful completion of this course, it is intended that a student will be able to:

1. Calculate the Wave amplitude and wave functions.
2. Understand the concept of alpha decay and beta decay.
3. Estimating semi-empirical mass formula and binding energy by liquid drop model.

GE: MATHEMATICAL PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

This is a basic course in Physics which will lead to:

1. Developing skill to solve problems of differential equations and vector calculus.
2. Emphasize in solving problems in Physics.

Course Content:

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(8 Lectures)**

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. **(12 Lectures)**

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite & Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations. **(11 Lectures)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **(7 Lectures)**

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. **(8 Lectures)**

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's

Inequality. Cauchy's Integral formula. **(14 Lectures)**

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, TataMcGraw-Hill.

- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- An Introduction to Ordinary Differential Equations, E.A Coddington, 1961, PHI Learning
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Publications.
- Mathematical methods for Scientists & Engineers, D.A. Mc Quarrie, 2003, Viva Books.

LAB: MATHEMATICAL PHYSICS

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. TernaryOperator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of π
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha=\tan\alpha; I=I_O[(\sin\alpha)/\alpha]^2$ in optics

Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop

Referred Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt.Ltd.
- Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-HillPub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge UniversityPress.
- AfirstcourseinNumericalMethods,U.M.Ascher&C.Greif,2012,PHILearning.
- Elementary Numerical Analysis, K.E. Atkinson,3rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier DoverPub.
- An Introduction to computational Physics, T.Pang, 2ndEdn., 2006,Cambridge Univ. Press

Course Learning outcome:

Student should be able to

1. Solve first order differential equations and second order differential equations with constant coefficients, and partial derivatives.
2. Learn about solving Fourier series.
3. Understand Complex representation of Fourier series.
4. Expansion of functions with arbitrary period.
5. Understand about complex analysis.

GE: SOLID STATE PHYSICS

L	T	P	Cr
4	0	2	6

Course Objective:

This course will build up basic understanding about solid state Physics to bachelor students. The objectives of the course are:

1. To understand about the crystal structure, lattice, unit cell and miller indices.
2. To know the difference between amorphous and crystalline materials.
3. To understand about the elementary concepts of lattice vibrations and various theories related to that.
4. To understand about the magnetism in materials and various concepts related to that.
5. To learn about the dielectric and ferroelectric properties in materials.
6. To understand about the concepts of band theory and basics of superconductivity.

Course Content:

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

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

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

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons. **(6 Lectures)**

Elementary band theory: Kronig Penny model. Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. **(6 Lectures)**

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-GrawHill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009,Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

LAB: SOLID STATE PHYSICS

List of Experiments:

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 study the BH curve of iron using a Solenoid and determine the energy loss.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books

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

Course Learning Outcome:

1. A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays by crystalline materials.
2. Understanding of lattice vibrations, phonons and learning of Einstein and Debye theory of specific heat of solids.
3. Better understanding of magnetism (dia, para, ferro) and theories related to that.
4. Secured an understanding about the dielectric and ferroelectric properties of materials.
5. Understand the basic idea about superconductors and their classifications.
6. To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop.

GE: QUANTUM MECHANICS

L	T	P	Cr
4	0	2	6

Prerequisites: Knowledge of (1) "Mathematical Physics" and (2) "Elements of Modern Physics"

Course Objective:

This course will build up basic understanding about quantum mechanics to bachelor students. The objective of the course is:

1. To study the basic principles of quantum mechanics.
2. Explain the operator formulation of quantum mechanics.
3. Student will learn the concept of wave function, Schrodinger equation and their applications.
4. To study role of uncertainty in quantum physics.
5. To describe the structure of the hydrogen atom and show an understanding of quantization of angular momentum

Course Content:

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. Eigen values and Eigen functions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures)**

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

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem- square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigen functions using Frobenius method.
(12 Lectures)

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wave functions from Frobenius method; Orbital angular momentum quantum numbers l and m;s, p, d, shells (idea only) **(10 Lectures)**

Atoms in Electric and 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 & Magnetic Energy, Gyromagnetic Ratio & Bohr Magneton. **(8Lectures)**

Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. **(4Lectures)**

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total Angular Momentum. Vector Model. Spin-orbit coupling in atoms L-S and J-J couplings. **(10Lectures)**

Reference Books:

- A Text book of Quantum Mechanics, P.M. Mathews & K.Venkatesan, 2nd Ed., 2010, McGrawHill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002,Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics for Scientists and Engineers, D.A.B. Miller, 2008,Cambridge University Press

Additional Books for Reference

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

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GE LAB: QUANTUM MECHANICS

60 Lectures

Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like

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

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

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

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

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

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

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511×10^6 eV/c^2 , and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

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

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

For the anharmonic oscillator potential

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

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

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

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

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

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

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: $m = 940\text{x}10^6 eV/C^2$, $D = 0.755501$ eV, $\alpha = 1.44$, $r_o = 0.131349$ Å

Some laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To study the quantum tunnelling effect with solid state device, e.g. tunnelling current in backward diode or tunnel diode.

Reference Books:

- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-HillPub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Presseta l.,3rd Edn., 2007, Cambridge University Press.
- Elementary Numerical Analysis, K.E. Atkinson, 3 rdEd. 2007, Wiley IndiaEdition
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014Springer
- Scilab by example: M. Affouf, 2012, ISBN:978-1479203444
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGrawHill.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and BartlettLearning.

Course Learning Outcome:

On successful completion of the course students will be able to understand

1. How to apply principles of quantum mechanics to calculate observables on known wave functions.
2. How to solve time-dependent and time-independent Schrödinger equation for simple potentials.
3. The structure and dynamics of atoms and simple molecules.
4. Quantum mechanics formulation for Hydrogen atom.

GE: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

L	T	P	Cr
4	0	2	6

Course Objective:

Through this course, the student will able to

1. Understand about embedded systems, their classification and applications.
2. Understand about the 8085 microprocessors.
3. Understand about 8051 microcontrollers.
4. Understand about the timer and counter programming.

Course Content:

Embedded system introduction: Introduction to embedded systems and general

purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges and design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.
(6Lectures)

Review of microprocessors: Organization of Microprocessor based system, 8085µp pin diagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts. **(4Lectures)**

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and callinstructions.
(12Lectures)

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of8051 microcontroller, I/O port pins description and their functions, I/O port programming in 8051, (Using Assembly Language), I/O programming: Bit manipulation. **(4Lectures)**

Programming of 8051: 8051addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic & logic instructions, 8051 programming in C:- for time delay and I/O operations and manipulation, for arithmetic & logic operations, for ASCII and BCD conversions. **(12Lectures)**

Timer & counter programming: Programming 8051 timers, counter programming.
(3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority inthe8051. **(6Lectures)**

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing,LCDinterfacing. **(2Lectures)**

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. **(3Lectures)**

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. **(8Lectures)**

Reference Books:

- Embedded Systems: Architecture, Programming & Design, R. Kamal, 2008,Tata McGrawHill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson EducationIndia.
- Embedded microcomputor system: Real time interfacing, J.W.Valvano, 2000,

Brooks/Cole

- Microcontrollers in practice, I. Susnea and M. Mitescu, 2005,Springer.
- Embedded Systems: Design & applications, S.F. Barrett, 2008, PearsonEducation
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

PRACTICALS-DSE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

60 Lectures

Following experiments using 8051:

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

Reference Books:

- Embedded Systems: Architecture, Programming & Design, R. Kamal, 2008, Tata McGrawHill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education
- Embedded Microcomputor System: Real Time Interfacing, J.W. Valvano, 2000, Brooks/Cole
- Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, CengageLearning

Course Learning Outcome:

At the successful completion of the course the student is expected to master the following:

1. Embedded systems including its generic architecture, design and classifications.
2. Embedded processors and microcontrollers.
3. Organization of Intel 8051 microcontroller, its architecture, programming and its memory organization.
4. Organization of intel microprocessor 8085, its architecture, pin diagram, timing diagram, and programming in assembly language
5. Programming with and without interrupt service request.

6. Interfacing parallel and serial ADC and DAC.
7. Basics of embedded system development and product development with a brief introduction to Arduino.
8. Student shall be able to design, fabricate, test and run the programs.

GE: NUCLEAR AND PARTICLE PHYSICS

L	T	P	Cr
5	1	0	6

Prerequisites: Knowledge of "Elements of Modern Physics"

Course Objective:

This is a basic course in Physics which deals with

1. the phenomena taking place in the nuclear domain.
2. an insight into the dimensions of a nucleus.
3. the detailed study about the stability of nucleus and various other properties.
4. various types of radiations and their interaction with matter.
5. various types of nuclear model, Radioactivity decay**,** nuclear reactions and their energetics.
6. A brief introduction of elementary particles and their classification will also be taught to the students.

Course Content:

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(15Lectures)**

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 fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. **(14Lectures)**

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. **(10Lectures)**

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). **(8Lectures)**

Nuclear Astrophysics: Early universe, primordial nucleo synthesis (particle nuclear interactions), stellar nucleo synthesis, concept of gamow window, heavy element production: r- and s-process path. **(5Lectures)**

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

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. **(6Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(2Lectures)**

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. **(8Lectures)**

Reference Books:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R. A. Dunlap. (Thomson Asia,2004)
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics-An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Theoretical Nuclear Physics, J.M. Blatt & V.F. Weisskopf (Dover Pub.Inc.,1991)

Course Learning Outcome:

On successful completion of the course students will be able to understand about

1. The nuclear forces, size, shape, density and constituent of nucleus and all its properties.
2. Interaction of various types of radiation with matter which they observe in their daily life.
3. Detecting methods, and instruments for different types of charged and neutral particle.
4. Bosonic, Fermionic and Elementary particles, their interactions and various decays.

GE: FUNDAMENTALS OF ELECTRONIC MATERIALS AND DEVICES

L	T	P	Cr
5	1	0	6

Course Objective:

1. Discuss about the characteristics, working of diodes, semiconductors and transistors.
2. Use Information Communication Technology to gather knowledge at will.
3. Provide knowledge of various Power electronic circuits and its application as operational amplifiers, multivibrators etc.

Course Content:

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.
De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.)
Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor. **(20 Lectures)**

Semiconductor Devices and Amplifiers: Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.
Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. DC Load line & Q-point. Active, Cutoff & Saturation regions. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Current gains α and β. Relations between α and β Voltage Divider Bias Circuit for CE Amplifier Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers. **(25 Lectures)**

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed loop Gain. CMRR, concept of Virtual ground. Applications of Op- Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator,(5) Integrator, (6) Zero crossing detector Sinusoidal Oscillators, Determination of Frequency of RC Oscillator. **(13 Lectures)**

Instrumentations: Introduction to CRO: Block Diagram of CRO: Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Basic idea about capacitor filter, Zener Diode and Voltage Regulation. Timer IC: IC 555 Pin diagram and its application as Astable and Monostable multivibrator. **(15 Lectures)**

Course Learning Outcomes:

1. Students will be able to Perform experiments and interpret the results of observation, including making an assessment of experimental uncertainties.

2. Students would have developed skills and enthusiasms to the best of their potential.
3. They will be able to use Information Communication Technology to gather knowledge

GE: MECHANICS, HEAT, OSCILLATIONS AND WAVES

L	T	P	Cr
5	1	0	6

Course Objective:

1. The course will deal, respectively, with a limited selection of specific topics included in the CBSE Std. XI and Std. XII physics curricula. The topics to be discussed are those which involve basic concepts and fundamental principles, and which therefore have wide applicability.
2. They are also the topics that are conceptually the deepest, and must therefore be understood as clearly as possible.

Course Content:

The nature of physical laws, Fundamental constants & dimensional analysis, dimensional analysis and scaling, the fundamental force of nature. **(9 Lectures)**
Scalar, vectors, plane polar coordinates, vectors in a plane, scalars, and pseudo scalars, kinematics in a plane, vectors in a 3-dimensional space, the finite rotation formula **(8 Lectures)**

Polar coordinates in 3-dimensions, cylindrical and spherical polar coordinates, motion in a circle, Newton's laws of motion **(9 Lectures)**

Conservation laws and Newton's equations, conservation of angular momentum, two-body scattering, two body collision kinematic, conservative forces-the concept of a potential **(10 Lectures)**

Central potential and central force, central force problem, Keplers laws of planetary motion, Non-Inertial forces, Kepler problem, satellite motion. **(9 Lectures)**

Linear Elasticity of solids, simple harmonic motion, examples of simple harmonic motion, damped simple harmonic motion **(10 Lectures)**.

Wave motion, Fluid dynamics, fluid flow. **(5 Lectures)**

Circulation and vorticity, What is thermodynamics, the classical ideal gas, the laws of thermodynamics, specific heat of an ideal gas, Van der Waals equation, phase transition, summary **(12 Lectures)**

Course Learning Outcome:

On successful completion of the course students will be able to

1. Learn about dimensional analysis.
2. Plot various functions.
3. Learn conservation laws of energy and linear and angular momentum and apply them to solve problems.
4. Develop understanding about gravity, angular momentum, Moment of Inertia and elastic property. First and second laws of thermodynamics, perfect gas law, properties of real gases, and the general energy equation for closed systems.

5. Learn the fundamentals of harmonic oscillator model, including damped and forced oscillators and grasp the significance of terms like quality factor and damping coefficient

GE: INTRODUCTION TO ELECTROMAGNETIC THEORY

L	T	P	Cr
5	1	0	6

Course Objective:

This course introduces students to handling electromagnetic theory using vector calculus. The main objectives of the course is:

1. To introduce the basic mathematical concepts related to electromagnetic vector fields.
2. To impart knowledge on the concepts of electrostatics, electric potential, energy density and their applications.
3. Describe the concepts of Laplace's and Poisson's equations and Uniqueness theorem
4. To impart knowledge on the concepts of magnetostatics, magnetic flux density, scalar and vector potential and its applications.
5. To impart knowledge on the concepts of Faraday's law, induced emf and Maxwell's equations.
6. To impart knowledge on the concepts of Concepts of electromagnetic waves.

Course Content:

Electric Field, Electric Potential and Electric Potential Energy
Coulomb's law Divergence of electric field Gauss' law Curl of electric field Stokes' theorem Electrostatic potential. Laplace's equation for electrostatic potential Laplace's equation in other fields Uniqueness of solution of Laplace's equation Poisson equation and uniqueness of its solution Method ofimages for planar surfaces Work and energy in electrostatics. **(20 Lectures)**

Dielectric Properties of Matter:
Conductors and capacitors Reciprocity theorem Polarization and bound charges Linear dielectrics Electric displacement Fields in dielectrics. **(15 Lectures)**

Magnetic Field:
Magnetic field due to a magnet Magnetic field due to a steady current Divergence and curl of magnetic field Ampere's law. The vector potential Magnetization and bound currents. Magnetic fields in matter. **(15 Lectures)**

Electromagnetic Induction and Electromagnetic waves:
Maxwell's equations Work done by electromagnetic field Poynting's theorem Momentum in electromagnetic field Angular momentum in electromagnetic field Electromagnetic waves: the wave equation. Wave equation Plane electromagnetic waves Energy carried by electromagnetic waves Pressure due to electromagnetic waves Refection and transmission of electromagnetic waves Reflection and transmission of electromagnetic waves. **(25 Lectures)**

Course Learning Outcome:
Student should be able to

1. Handle problems that are more complicated (electric field and potential due various charge configuration).
2. Understand and describe the concepts of Laplace's and Poisson's equations and Uniqueness theorem.

3. Explain the concept of Capacitor's and use the method of images and determine potential due to various charge distributions
4. Explain the concept of magnetic fields, and determine field due to solenoid and toroid.
5. Explain the concept of electromagnetic induction, and its applications.
6. learn here mathematics will help them in their future courses like fluid dynamics that use similar mathematics.

SEMESTER VII

PHC411: CLASSICAL MECHANICS

L	T	P	Cr
3	0	0	3

Course Objective:

1. To develop the idea of theoretical understanding of motion of a group of particles involving a wide range of length and energy scales.
2. To develop an understanding of Lagrangian and Hamiltonian formulation which allow for simplified treatments of many complex problems in classical mechanics and provides the foundation for the modern understanding of dynamics.

Course Content:

Lagrangian and Hamiltonian Formulations of Mechanics:
Calculus of variations, Hamilton's principle of least action, Lagrange's equations of motion, conservation laws, systems with a single degree of freedom, rigid body dynamics, symmetrical top, Hamilton's equations of motion, phase plots, fixed points and their stabilities. **(18 Lectures)**

Two-Body Central Force Problem:
Equation of motion and first integrals, classification of orbits, Kepler problem, scattering in central force field. **(8 Lectures)**

Small Oscillations:
Linearization of equations of motion, free vibrations and normal coordinates, forced oscillations. **(6 Lectures)**

Hamiltonian Mechanics and Chaos:
Canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action-angle variables, perturbation theory, integrable systems, introduction to chaotic dynamics. **(13 Lectures)**

Reference Books:

- H. Goldstein, Classical Mechanics.
- L.D. Landau and E.M. Lifshitz, *Mechanics.*
- I.C. Percival and D. Richards, *Introduction to Dynamics*.
- J.V. Jose and E.J. Saletan, Classical Dynamics: A Contemporary Approach.
- E.T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies.
- N.C. Rana and P.S. Joag, *Classical Mechanics*.
- CLASSICAL MECHANICS published by New Age International (2018).

Course Learning Outcome:

1. Students will be able to try finding solution of a time evolution of state of a system employing Lagrangian and Hamiltonian approaches. Further, the two-body central force problem and small oscillations problem is discussed in details considering the direct applications in many systems at atomic to stellar scale.
2. The special relativistic aspect has been covered in the Special Theory of Relativity part.

Methods of Canonical transforms helps developing the skills of solving the classical mechanics problem more profoundly.

3. An introduction to chaotic dynamics introduces more complex and sometimes real-life classical approach challenges in chaotic regime.

PHC412: CLASSICAL ELECTRODYNAMICS

L	T	P	Cr
3	0	0	3

Course Objective:

1. To make students understand the basic laws and applications of electromagnetic theory.
2. To evaluate fields and forces in using basic scientific method.
3. To provide concepts of relativistic electromagnetic theory and its applications in branches of Physical Sciences.

Course Content:

Maxwell's Equations:

Review (Displacement current, Maxwell's equations, vector and scalar potentials, gauge symmetry, Coulomb and Lorentz gauges, electromagnetic energy and momentum, conservation laws**),** inhomogeneous wave equation and Green's function solution.

(10 Lectures)

Electromagnetic Waves:

Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities. **(15 Lectures)**

Radiation:

Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, antenna, radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, radiation emitted by a charge in arbitrary extremely relativistic motion, Cherenkov radiation.

(15 Lectures)

Covariant Formulation of Electrodynamics: Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles. **(5 Lectures)**

References:

- **J.D. Jackson,** Classical Electrodynamics.
- **D.J. Griffiths,** Introduction to Electrodynamics.
- **J.R. Reitz, F.J. Milford and R.W. Christy,** *Foundations of Electromagnetic Theory.*
- **W.K.H. Panofsky and M. Phillips,** Classical Electricity and Magnetism.
- **F.F. Chen,** Introduction to Plasma Physics and Controlled Fusion.
- **Landau and Lifshitz,** Classical Theory of Field

Course Learning Outcome:

1. Students should be able to solve the problems of electrostatics and magnetism.
2. They should be able to learn and use the maxwell's equations in possible applications.
3. The properties of radiation and its interaction with the matter and the special theoretical effects have been covered in this course.

PHC413 ELECTRONICS AND COMMUNICATION

L	T	P	Cr
3	0	0	3

Course Objectives:

1. To understand operation of semiconductor devices.
2. To apply concepts for the design of Regulators and Amplifiers
3. To understand DC analysis and AC models of semiconductor devices.

Course Content:

Analog Electronics:
Power amplifiers, JFET and MOSFET circuits. Operational amplifiers DC coupled pairs, Differential amplifiers, its parameter, Introduction to Lock-in Amplifier, basic applications, Sinusoidal oscillators, Multi vibrators, Schmitt trigger, 555 IC timer, Clipping and clamping circuit, Sample and hold circuit, Active RC filter Power supplies and regulators, Power electronic circuits. **(20 Lectures)**

Communication System:
Basic principles of amplitude, frequency and phase modulation, Demodulation, Spectral analysis and signal transmission through linear systems, Random signals and noise, Digital modulation and Demodulation; Basics of RF and Microwave communication. **(15 Lectures)**

Digital Electronics:
Basic logic gates, Boolean algebra, combinational logic gates, digital comparators, Flip flops, shift registers, counters, Analog to digital converters and Digital to analog converters. Microprocessor and microcontroller basics. **(10 Lectures)**

Reference Books:

- P. Horowitz and W. Hill, The Art of Electronics.
- J. Millman and A. Grabel, Microelectronics.
- J.J. Cathey, Schaum's Outline of Electronic Devices and Circuits.
- M. Forrest, Electronic Sensor Circuits and Projects.
- W. Kleitz, Digital Electronics: A Practical Approach.
- J.H. Moore, C.C. Davis and M.A. Coplan, Building Scientific Apparatus.

Course Learning Outcome:

After the successful completion of the course, the student should be able to learn

1. The concepts of microelectronics, introduction to the field effect transistors, identify its major

properties and main types of FET and op-amps circuits.
2. The basics of digital circuits and the Boolean algebra involved.
3. Basics knowledge of microprocessors and microcontrollers.

PHC414: COMPUTATIONAL PHYSICS

L	T	P	Cr
3	0	0	3

Course Objective:

1. To enable students, learn the essentials of computational methods and techniques used tosolve physics problems numerically.

Course Content:

Introduction to programming language: Overview of computer organization, hardware, software, scientific programming in FORTRAN and/or C, C++. **(15 Lectures)**

Numerical techniques: Interpolation, extrapolation, regression, numerical integration, quadrature, random number generation, linear algebra and matrix manipulations, inversion, diagonalization, eigenvectors and eigenvalues, integration of initial-value problems, Euler, Runge-Kutta, and Verlet schemes, root searching, optimization, fast Fourier transforms, Curve Fitting. **(30 Lectures)**

One Computational project.

Reference Books:

1. V. Rajaraman, Computer Programming in Fortran 77.
2. W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, *Numerical Recipes in FORTRAN 77: The Art of Scientific Computing*. (Similar volumes in C, C++.)
3. H.M. Antia, Numerical Methods for Scientists and Engineers.
4. D.W. Heermann, Computer Simulation Methods in Theoretical Physics.
5. H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods.
6. J.M. Thijssen, Computational Physics.

Course Learning Outcome:

1. Students shall be able to learn a computer programming language and basics of computational methods in interpolation, root finding, differentiation, integration, eigenvalue determination, FFT, solution of differential equation etc.

PHP415 LAB I

L	T	P	Cr

6 0 0 6

Course Objective:

1. To provide the practical knowledge of experimental electronics.
2. Learn to acquire data in various experimental systems and to understand the use of various electronic systems.
3. To design a circuit on the bread-board for a particular experiment.
4. To keep the record of the experiments, performed in the laboratory.

List of Experiments

1. To study the various digital analog circuits:
(a). 4-bit discrete binary adder network,
(b). 8-bit DAC using 0808 IC without OP-amp.
2. To draw transfer characteristics of
(a) An OP-amp (741IC) in inverting mode in close loop.
(b) To determine offset voltage
(c) To determine CMRR of the OP-amp
3. To determine the band gap of a semiconductor (Ge)
4. To study the amplitude modulation with the help of CRO
(a) With I/O frequency at constant I/O voltage
(b) To study variation of percentage of modulation with I/O voltage at constant I/O frequency.
(c) Plotting modulated and demodulated wave
(d) To determine carrier frequency
5. To study the frequency response of RC coupled amplifier
(b) With feedback
(c) Without feedback

Course Learning Outcome:

1. Students will be able to design the adder circuit and analyze it.
2. Students will be able to design the Op-Amp circuit on the bread board by themselves and learn the characteristics of Op-Amp along with CMRR.
3. Students will gain the knowledge of CRO for various applications.
4. Students will be able to perform logical operations using microprocessor.

SEMESTER VIII

PHC461: THERMODYNAMICS AND STATISTICAL MECHANICS

L	T	P	Cr
3	0	0	3

Course Objective:

1. To build the theoretical understanding towards the thermodynamics on the basis of underlying statistical formulation.
2. To have an understanding for the various aspects of equilibrium and non-equilibrium statistical physics.
3. To describe the features and examples of Maxwell-Boltzmann, Bose-Einstein and Fermi Dirac statistics

Course Content:

Review of thermodynamics: Laws of thermodynamics, thermodynamics potentials, Maxwell's relations, stability conditions. **(10 Lectures)**

Probability: Random variable (continuous), probability density function (PDF), moments and cumulants of a distribution, one variable distributions: Guassian, binomial and Poisson, many random variables, joint Gaussian distribution, central limit theorem. **(13 Lectures)**

Classical statistics: Microstates and macrostates, microcanonical, canonical and grand canonical ensembles, connection to thermodynamics, classical ideal gas. **(8 Lectures)**

Quantum statistics: Microstates and macrostates, microcanonical, canonical and grand canonical ensembles, Bose-Einestein and Fermi-Dirac statistics, ideal quantum gases.
Diamagnetism, paramagnetism, ferromagnetism and Ising model.
Diffusion equation, random walk and Brownian model.

(14 Lectures)

Reference Books:

1. Statistical Physics of Particles by Mehran Kardar, Cambridge.
2. An Introductory Course of Statistical Mechanics by Palash B. Pal, Narosa.
3. Statistical Mechanics by R. K. Pathria, Butterworth-Heinemann.
4. Thermodynamics and Statistical Mechanics by W. Greiner, L. Neise, H. Stocker, and D. Rischke, Springer.
5. Statistical Mechanics by K. Huang, Wiley.

Course Learning Outcome:

1. Students shall be able to learn the basics of thermodynamics and the required mathematical tools.
2. A treatise to the derivation of such phenomenon is presented on the basis of statistical mechanical analysis employing classical and quantum mechanics based approaches.

PHC462: Quantum Mechanics II

L	T	P	Cr
3	0	0	3

Course Objective:

1. To grow the understanding of Quantum mechanics for more application point of view on the foundations of basics learned in the previous quantum mechanics course.
2. To understand the concepts of the time-dependent perturbation theory and their applications to physical situations.
3. To understand the basics of scattering theory.

Course Content:

Time independent Perturbation Theory: Time independent perturbation theory for non-degenerate and degenerate systems upto second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman effect with electron spin. Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules. **(15 Lectures)**

Time Dependent Perturbation Theory: Time dependent perturbation theory, constant perturbation, Fermi Golden rule, coulomb excitation, sudden and adiabatic approximation, Harmonic perturbation, radiative transition in atoms, Semi-classical treatment of radiation, Einstein's A and B coefficients and spontaneous emission of radiation. **(10 Lectures)**

Relativistic Wave Equations: Generalization of the Schrödinger equation; Klein-Gordon equation and its drawbacks, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Dirac's equation for a free particle, relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices, and their properties, non-relativistic limit of Dirac equation, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, Non conservation of orbital angular momentum and idea of spin, interpretation of negative energy and theory of positron. **(20 Lectures)**

Reference Books:

6. D. J. Griffiths, Introduction to Quantum Mechanics (Pearson).
7. J. J. Sakurai, Advanced Quantum Mechanics (Wesley).
8. N. Zettili, Quantum Mechanics Concepts and Applications (Wiley).
9. K. Ghatakh and S. Lokanathan, Quantum Mechanics 3rded. (MacMillan).
10. L. I. Schiff, Quantum Mechanics (McGraw Hill).
11. C. Cohen-Tannoudji, Quantum Mechanics (Volume I and II).

Course Learning Outcome:

1. Students shall be able to apply the quantum mechanical treatment to the more complex problems such as Perturbation theory, Scattering theory and its applications to various possible simple potentials including relativistic effect in quantum mechanical treatment of a system.
2. The students will be familiar with various approximation methods applied to atomic, nuclear

and solid-state physics.

PHC463 Condensed Matter Physics I

L	T	P	Cr
3	0	0	3

Course Objective:

1. To impart the knowledge of basics of condensed matter physics at the masters' level.
2. To understand the concept of structure in reference to properties of materials.

Course Content:

Crystalline and amorphous solids, The crystal lattice, Basis vectors, Unit cell, Symmetry operations, Point groups and space groups, Plane lattices, and their symmetries. Three dimensional crystal systems, Miller indices, Directions and planes in crystals. Interplanar spacings, Crystal structures: SC, FCC, BCC, HCP, Nacl, CsCl, Diamond and ZnS structure, Closed packed structures. **(9 Lectures)**

X-ray diffraction by crystals, Laue theory, Interpretation of Laue equations, Bragg's law, Atomic scattering factor, Experimental methods of X-ray diffraction, Neutron and electron diffraction. Reciprocal lattice, Brillouin zones. Bragg's law in Reciprocal Space, Ewald construction. **(8 Lectures)**

Interatomic Forces and types of bonding. Ionic Bonds, Covalent bonds, Metallic bonds, Van der Waals' bonds, Hydrogen Bonds, Binding Energy of Ionic crystals, Cohesive energy of inert gas solids. Cohesive energy and bulk modulus of ionic crystals. Madelung constant, Lennard - Jones Potential. **(4 Lectures)**

Vibrations of one-dimensional monatomic and diatomic lattices. Infrared absorption inionic crystals (one-dimensional model). Normal modes and phonons. Normal and Umclapp Process, Frequency distribution function, Specific Heat, Classical Theory and Einstein's Theory Lattice Specific Heat, Debye's theory of lattice specific heat. Anharmonic effects, Thermal Conductivity. **(7 Lectures)**

Drude-Lorentz's Classical Theory (Free electron Gas Model), Quantized free electron theory (Sommerfeld's Quantum Theory), Fermi energy, wave vector, velocity and temperature, Density of states. Electronic specific heats. Sommerfeld's model for metallic conduction. **(7 Lectures)**.

Energy bands in solids, The Bloch theorem, Bloch functions, Kroning-Penney model, Number of states in the band, Band gap in the nearly free electron model, The tight binding model, The fermi surface, Electron dynamics in an electric field, The effective mass, Concept of hole. **(10 Lectures)**

Reference Books:

1. F.C. Phillips: An introduction to crystallography (wiley) (3rd edition)
2. Introduction of Solids: L.V. Azaroff
3. Solid State Physics-Structure and Properties of Materials: M.A. Wahab
4. Solid State Physics: N.W. Ashcroft and N.D. Mermin
5. C. Kittel: Solid-state physics (Wiley eastern)(5th edition).
6. Charles A Wert and Robb M Thonson: Physics of Solids
7. J. P. Srivastava: Elements of solid state physics (Prentice Hall India; 2nd edition)
8. Christmaan-solid state physics (academic press)

Course Learning Outcome:

1. The students shall be able to learn the concepts of lattice and crystals, long range forces, X-ray diffraction, Vibrational analysis and concepts of phonons.
2. The quantum mechanical treatment of solids particularly focusing upon the study of the energy (states) as a function of spatial configuration of atoms.
3. The students will be able to formulate basic models for electrons and lattice vibrations for describing the physics of crystalline materials; and develop an understanding of relation between band structure and properties of a material.

PHC464 Atomic and Molecular Physics

L	T	P	Cr
3	0	0	3

Course Objective:

1. To make students understand the basic theory of spectroscopic techniques.
2. To understand the basic aspects of atomic and molecular physics.
3. To study spectroscopy of the multi-electron atoms and diatomic molecules.

Course Content:

Atomic Spectroscopy: Fine structure of Hydrogen lines, magnetic dipole moments, electron spin and vector atom model, identical particles, Pauli's exclusion principle, multielectron atoms-Hartreesself consistent field theory, L-S and j-j coupling schemes, alkali atom spectra, equivalent and non-equivalent electrons, normal and anomalousZeeman effect, Paschen Back Effect, hyper fine structure, Stark effect, width of spectral lines, X-ray spectra. **(22 Lectures)**

Molecular Spectroscopy: Born-Openheimer approximation, molecular orbital theory, rotational spectra of diatomic molecules, non-rigid rotator, vibrational spectra, anharmonic oscillator, explanation of rotational vibrational spectra in infrared, Raman effect and intensity alternation of the rotational bands, applications of infrared and Raman spectroscopy, electronic spectra of molecules, Fortrait Parabola, vibrational structure of electronic bands, Intensities of electronic transitions, Franck Condon principle, Condon parabola. **(23 Lectures)**

References:

1. Atomic Spectra- H.E white, Cambridge University Press, Newyork, (1935).

2. Atomic and molecular spectra: Laser- R. Kumar
3. Fundamentals of Molecular Spectroscopy- C.B. Banewell
4. Molecular Spectroscopy– A. Das
5. Spectra of atoms and molecules- P. F. Bemath

Course Learning Outcome:

1. Students shall be able to understand the basics of atomic spectroscopy such as quantum mechanical hypothesis of atomic spectra, L-S and J-J coupling schemes, Zeeman effect, Stark effect, X-ray spectra etc.
2. Student will learn the quantum behavior of atoms in external electric and magnetic fields; and become familiar with the working principle of laser.

LAB II

L	T	P	Cr
0	0	0	6

Course Objective:

1. To make students learn the basics of physics through experimental methods.
2. To relate the theory through experiments of electronics and solid-state physics.
3. To analyze the data obtained through the experiments and keep the record of the experiments.
4. To expose the students to handle the experiments with confidence and ease.

List of Experiments

1. To study a RC circuit as a low pass and high pass filter and study the RC circuit as a differentiator and an integrator.
2. To determine the refractive index of a material of the given prism using a spectrometer.
3. To convert a micro ammeter into an ohm meter of different range and used to measure unknown resistance.
4. To study the variation of resistivity of Ge crystal with temperature by four probe methodand hence to determine the band gap for it.
5. Determination of Plank's constant using LED.
6. To study the Hall Effect and hence to determine the Hall coefficient and Carrier concentration

Course Learning Outcome:

1. Students will be able to study and understand the concept of low pass and high pass filters through RC circuits.
2. Students will be able to understand the concept of band gap through experiment and analyze it.
3. Students will learn and calculate the Hall coefficient, Hall angle, carrier concentration of Ge through Hall effect experiment.

4. Design and learn the circuit designing in the experimental lab through these experiments.
5. Learn to analyze the data.

SEMESTER IX

PHC 511 Condensed Matter Physics II

L	T	P	Cr
4	0	0	4

Course Objective:

1. To make students learn more about the theoretical models for studying condensed matter.
2. To enable the students to develop an understanding of relation between band structureand the electrical/optical properties of a material.
3. To introduce the concept of defects in materials with respect to structures.

Course Contents:

Semiconductors: Intrinsic and extrinsic semiconductors. Carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors. Band-gap. Direct and indirect gap semiconductors. Hydrogenic model of impurity levels. **(8 Lectures)**

Band Theory (Advanced form Condensed matter Physics I), Tight Binding, Pseudo potential methods, De Haas von Alfen Effect, AC conductivity and optical properties, plasma oscillations. **(6 Lectures)**

Defects in Crystals: Vacancy formation, Mechanism of Plastic deformation in solids, Stress Imperfections in crystals: Lattice defects & configurational entropy, vacancies, Schottky& Frankel pairs, Edge & screw dislocations (qualitative ideas), Frank-Read Sources, Dislocations in FCC, BCC and HCP structures Experimental methods of detecting defects. **(8 Lectures)**

Magnetism in solids: Magnetic properties of solids. Diamagnetism, Langevin equation. Quantum theory of paramagnetism. Curie law. Hund's rules. Exchange interaction.Paramagnetism in rare earth and iron groupions. Elementary idea of crystal field effects. Ferromagnetism. Curie-Weiss law. Heisenberg exchange interaction. Mean field theory. Antiferromagnetism. Neel point. Nuclear magnetic resonance. Hall effects. Elementary ideas of Quantum Hall effect. Cyclotron resonance and magneto resistance. **(10 Lectures)**

Superconductivity: Survey of important experimental results. Critical temperature. Meissner effect. Type I and type II superconductors. Thermodynamics of superconducting transition. London's equation. London penetration depth. BCS theory with derivation. High-T_c superconductors. Josephson junctions. **(10 Lectures)**

Superfluidity. Ordered phases of matter: translational and orientational order, kinds ofliquid crystalline order, liquid crystals. Quasi crystals. Nanostructures, buckyballs. **(2 Lectures)**

Principle and applications of characterization techniques: Electron Microscopy. **(1 Lectures)**

Reference Book:

1. John Singleton: Band theory and Electronic properties of Solids (Oxford University Press; Oxford Master Series in Condensed Matter Physics).
2. Ibach&Luth: Solid State Physics
3. Elementary Dislocation Theory: Weertman and Weertman
4. M. Ali Omar: Elementary solid state physics (Addison-wesley)
5. C. Kittel: Solid-state physics (Wiley eastern) (5th edition)
6. Solid State Physics, A.J.Dekker, Macmillan India Ltd
7. Material Science & Engineering, V.Raghavan, Prentice –Hall of India, New Delhi (2001)

Course Learning Outcome:

1. Students shall be able to grow their understanding about the quantitative hypotheses of energy levels, band gap computation based upon different approaches,
2. Defects in crystals,
3. The students will learn the magnetic properties, superconductivity and superfluidity with reference to the structure of a material.

PHC512: Nuclear and Particle Physics

L	T	P	Cr
4	0	0	4

Course Objective:

1. To understand the basics of nuclear physics and particle physics.
2. To provide an understanding of static properties of nuclei, nuclear decay modes, nuclear force and nuclear models.
3. To provide the understanding of basics of particle physics.

Course Content:

Introduction: Historical overview, weak and strong interactions, units: length, mass and energy, review of special relativity, radioactive decay. **(9 Lectures)**

Nuclear Force: Deuteron problem, nucleon-nucleon scattering.
Structure of Nuclei: distribution of mass within nucleus, liquid drop model, nuclear binding energy, semi-empirical mass formula, beta stability, ground state properties: the shell model, magic numbers.
Nuclear reactions: excited states of nuclei, beta decay, alpha decay, gamma decay, nuclear fission and fusion. **(12 Lectures)**

Experimental Methods: Accelerators, beams, interaction of particles with matter, particle detectors 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 Lectures)**

Elementary Particles: leptons and the weak interaction, baryons, nutrinos, conserved quantities, nutrino oscillations, evidence for quarks, hadrons, Feynman diagrams. **(9 Lectures)**

Reference Books:

1. An Introduction to Nuclear Physics by W.N. Cottingham, Cambridge.
2. Particle Physics by B.R. Martin and G. Shaw, Wiley.
3. NUCLEAR PHYSICS: Problem-based Approach including Matlab, published by PHI (2016)

Course Learning Outcome:

1. Students shall be able to learn the basics theories and phenomenon of nuclear physics and particle physics involving relativistic quantum theory, mesons and strange particles, basic quantum numbers, weak and strong interactions.
2. The students will have an understanding of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of nuclear radiation with matter.

PHD513 Optoelectronics I (Laser and Detectors)

L	T	P	Cr
4	0	0	4

Course Objective:

1. To make students learn the basic theories of optoelectronics particularly applied in Lasers and detectors
2. To understand the concepts semiconductor laser sources.
3. To make the students understand about photo detectors.

Course Content:

Unit I

Physics of interaction between Radiation and Atomic systems-stimulated emissions, lineshape functions, Einstein Coefficients, Light Amplification, threshold condition, Laser Rate Equations, Two, three and four level systems. Line Broadening Mechanisms –Natural, Collision and Doppler, Theory of optical resonators – Fabry Perot Resonator, Modes of a Confocal resonator system, Planar resonator, General Spherical resonator, Gaussian Beam Propagation and ABCD law, Optical cavity stability criteria. **(7 Lectures)**

Unit II

Losses in the cavity – quality factor, line width of the Laser, Mode selection – Transverse and longitudinal, Q – Switching – Peak Power, Total Energy, Pulse duration, Techniques for the control of laser output employing Q-switching, mode-locking and mode-dumping, **Laser Systems** – Ruby Laser, He-Ne Laser, Nd:YAG, Nd: Glass, CO_2 Laser, Excimer

Laser, Fiber lasers, Properties of Lasers – Directionality, Coherence etc. **(15 Lectures)**

Unit III **Semiconductor Optical sources**:
Direct and Indirect Band Gap semiconductors, Light source Material Heterojunction structure. Light Emitting Diode (LED) Laser Diodes (LD), Basics of Quantum dots, Quantum wire Laser and VCSELs, Distributed feedback laser (DFB), Distributed feedback reflector (DBR) laser. **(20 Lectures)**

Unit IV **Photo Detectors:**
Principle of operation, Performance parameters, Quantum efficiency, Responsibility, Cut off wave length, Photo detector Material. Frequency Response, Thermal Noise, Shot- Noise Signal to noise ratio, Noise Equivalent Power (NEP) structure of PIN and APD, CCD, LED and LCD display. **(18 Lectures)**

Reference Books:

1. M. Born and E. Wolf, Principles of Optics, Macmillan, New York.
2. A.K. Ghatak and K. Thyagarajan, Optical Electronics (Cambridge University Press)
3. A Yariv, Quantum Electronics (John Wiley).
4. K. Thyagarajan and A.K.Ghatak, Laser: Theory and Applications. (McMillan India. New Delhi)
5. W.T. Silfvast, Laser Fundamentals, (Cambridge University Press).
6. G.H.P. Thompson, Physics of Semiconductor Laser Devices, (John Wiley & Sons)
7. J. M. Senior, Optical fiber Communications, Principles & Practice, (Prentice Hall of India).
8. G. Kaiser, Optical fiber Communications, McGraw Hill Book Company.
9. AjoyGhatak, K. Thyagarajan, Introduction to Fiber optics.
10. A. E. Siegman, Lasers, Baa E Saleh, Fundamentals of Photonics

Course Learning Outcome:

1. Students will be able to study the matter-radiation interaction, basics of Lasers, and optical resonance, properties of electromagnetic waves in cavity, LED, LD, Quantum dots, DBR lasers, different displays etc.
2. To understand in detail about direct/indirect band gap in reference to optoelectronic applications

PHE511: RESEARCH METHODOLOGY

L	T	P	Cr
3	0	0	3

Course Objective:

1. To familiarize participants with basic of research and the research process and ethics in research.
2. To enable the students to choose right problem and methodology.
3. To explain the students about conducting research work and formulating research synopsis and report.
4. To familiarize participants national and international journals.
5. To impart knowledge about scientific writing.

Course Content:

Unit I: Introduction

Philosophy of research, Introduction to research methods, Relevance and ambiguity in applied research, Ethics in research, Scientific explanation and understanding in science, characteristics of scientific research and logic of scientific enquiry, Introduction to different perspectives and types of research.

Designing Research: Meaning, Elements and Need of research design, Features of a good design, Different types of research design, Developing a research plan, Defining the research problem and hypothesis, selecting a problem, Necessity of defining the problem, Techniques involved in defininga problem; Hypothesis – Types of hypothesis, Differences between hypothesis and research problem.

Priority Setting in Research: Introduction to setting research priorities - Process – Links with planning, participation, time and information, Steps – choosing the right problem, Defining objectives and Options, Choosing and evaluating, Preparing for implementation, Type of research, Choosing a Methodology, Methods of setting research priorities. **(20 Lectures)**

Unit II: Review of Published Research

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introductionto subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and Wiki- Databases, Academic databases and search engines: Science Direct, SciFinder, Scopus, Web of knowledge. Finding and citing published information. **(7 Lectures)**

Unit III: Methods of Scientific Writing:

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism. Introduction to LaTex. **(8 Lectures)**

Unit IV: Communicating Results for Application

Identifying users and their needs, Channels of communication with users, Type of research – user linkages, Management options for strengthening researcher-user communication; Communicating Scientific Results: Importance of research communication in science, Overview of research communication process in science, Role of scientific journals – quality of journals, citation index, Other options for communicating results. **(10 Lectures)**

References:

- Research Methodology in Chemical Sciences: Experimental and Theoretical Approach TanmoyChakraborty, Lalita Ledwani, CRC Publishers.
- Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills inchemistry. 2nd Ed. Prentice-Hall, Harlow.
- Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press. 4.Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
- Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
- Date, C. J. An Introduction to Database System, Addision Wesley, U.K (1986).
- Caulcutt R, R Boddy, Statistics for Analytical Chemists, First Ed. 1983, By, Chapman & Hall.
- Medhi, J. Statistical Methods. Wiley Eastern, New Delhi (1992).

Course Learning Outcome:

After the successful completion of the course, the students are expected to

1. Develop understanding on various kinds of research, objectives of doing research, research process,research designs and sampling.
2. Understanding of research ethics.
3. Have basic knowledge on qualitative research techniques.
4. Ability to define problems and select the journals for publishing research work.

PHC514: LABIII

L	T	P	Cr
0	0	0	6

Course Objective:

1. To provide the practical knowledge of experimental electronics and optoelectronics.
2. Learn to acquire data in various experimental systems and to understand the use ofvarious electronic systems.
3. To design a circuit on the bread-board for a particular experiment.
4. To keep the record of the experiments, performed in the laboratory.
5. To Interpret the results using the correct physical scientific framework and tools.

Course Content:

- To verify the arithmetic and logic function of ALU.

- To study the time period of (555 timer) astable 555 and monostable 555.
- To determine the wavelength of laser using diffraction grating.
- To determine the numerical aperture of optical fiber.
- To determine the wavelength of laser using Michelson interferometer.

Course Learning Outcome:

1. Students will be able to learn the various mathematical operations using Boolean functions usingALU.
2. The students will learn the designing of circuit using 555timer.
3. The students will understand the diffraction through grating, experimental determination of aperture of optical fiber.
4. Students will learn to operate a GM counter and relate it with the theory.
5. Students will relate the concept of magnetic susceptibility for paramagnetic and diamagnetic materials by performing the experiment and analyzing it.
6. The student will relate the concepts of longitudinal, transverse and standing waves using Melde'sexperiment.

SEMESTER X

PHP563: PROJECT

Credits 15

Course Objective:

1. This course is focused to facilitate student to carry out extensive research and developmentproject or technical project through problem and gap identification,
2. Development of methodology for problem solving, interpretation of findings, presentation ofresults and discussion of findings.
3. To expose the students to advances in the various research areas worldwide.

Course Learning Outcome:

1. Students will be able to gain in depth knowledge of the area of research.
2. Learn experimental synthesis of various materials for certain applications.
3. Learn various mathematical/ computational tools for theoretical studies.
4. Understand and learn the working of various characterization tools.
5. Analyze and critically evaluate different technical/research solutions
6. Students will learn to discuss present their research work in a systematic manner.
7. Identify the issues that must be addressed within the framework of the specific dissertation in order totake into consideration.