B.Sc. (Hons.) in

Physics (Specialization in Electronics)

under the Framework of Honours School System

2021-2022

Applicable from academic session 2021-22 onwards

Also applicable for the students of B.Sc. 3rd and 4th Semester of 2021-2022 session

For 5th and 6th Semester of 2021-2022 session syllabus of 2020-2021 will be applicable

PANJAB UNIVERSITY, CHANDIGARH
OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR CHOICE BASED CREDIT SYSTEM B.Sc. (HONOURS) IN PHYSICS (SPECIALIZATION IN ELECTRONICS) UNDER THE FRAMEWORK OF HONOURS SCHOOL SYSTEM
(SEMESTER SYSTEM) EXAMINATION, 2021-22

OUTLINES OF TESTS

OBJECTIVE OF THE COURSE

To teach the fundamental concepts of Physics and Electronics and their applications. The syllabus will provide comprehensive theoretical and practical knowledge of Physics subject and other Science subjects opted by the student. The electronics courses will further improve the experimental skills of the student. The syllabus contents are in accordance with UGC module for CHOICE BASED CREDIT SYSTEM pertaining to B.Sc. (Hons.) in Physics (Specialization in Electronics).

Semester I

CORE COURSE (PHYSICS)

Theory Papers:

Core Course-1 (C1):	Mathematical Physics – I	100 Marks (4 credits)
Core Course-2 (C2):	Mechanics	100 Marks (4 credits)

Practicals:

Core Course-1 Practical (C1 Lab):	Mathematical Physics – I	50 Marks (2 credits)
Core Course-2 Practical (C2 Lab):	Mechanics	50 Marks (2 credits)

ABILITY ENHANCEMENT COMPULSORY COURSE

Ability Enhancement Compulsory Course-I (AECC1)	50 Marks (2 credits)
English/Environmental Science	50 Marks (2 credits)

GENERIC ELECTIVE

Each student may opt for any **two** of the generic electives offered by the other Departments of Panjab University out of following:

(i) Mathematics
(ii) Chemistry/Biochemistry/Biophysics
(iii) Economics
(iv) Computer Science
(v) Statistics
(vi) Geology

Generic Elective -1 (GE1)	150 Marks (6 credits)
Generic Elective -2 (GE-2)	150 Marks (6 credits)

Semester II

CORE COURSE (PHYSICS)

Theory Papers:

Core Course-3 (C3):	Electricity and Magnetism	100 Marks (4 credits)
Core Course-4 (C4):	Waves and Optics	100 Marks (4 credits)

Practicals:

Core Course-3 Practical (C3 Lab):	Electricity and Magnetism	50 Marks (2 credits)
Core Course-4 Practical (C4 Lab):	Waves and Optics	50 Marks (2 credits)

ABILITY ENHANCEMENT COMPULSORY COURSE

Ability Enhancement Compulsory Course-II (AECC2) 50 Marks (2 credits)
English/Environmental Science

GENERIC ELECTIVE

Each student may opt for any **two** of the generic electives offered by the other Departments of Panjab University out of following:

(i) Mathematics
(ii) Chemistry
(iii) Economics
(iv) Computer Science

Generic Elective -3 (GE3)	150 Marks (6 credits)
Generic Elective -4 (GE4)	150 Marks (6 credits)

Semester III

CORE COURSE (PHYSICS)

Theory Papers:

Core Course-5 (C5):	Mathematical Physics - II	100 Marks (4 credits)
Core Course-6 (C6):	Thermal Physics	100 Marks (4 credits)
Core Course-7 (C7):	Elements of Modern Physics	100 Marks (4 credits)

Practicals:

Core Course-5 (C5):	Mathematical Physics - II	50 Marks (2 credits)
Core Course-6 (C6):	Thermal Physics	50 Marks (2 credits)
Core Course-7 (C7):	Elements of Modern Physics	50 Marks (2 credits)

SKILL ENHANCEMENT COMPULSORY COURSE

Each student shall opt for any **one** of the skill enhancement courses offered out of following:

1. PHE-SEC1: Physics Enhancement Skills 50 Marks (2 credits)
2. PHE-SEC2: Computational Physics Skills 50 Marks (2 credits)
3. PHE-SEC3: Electrical Circuits and Network Skills 50 Marks (2 credits)
4. PHE-SEC4: Basic Instrumentation Skills 50 Marks (2 credits)
5. PHE-SEC5: Renewable energy and energy harvesting
50 Marks (2 credits)

GENERIC ELECTIVE

Each student may opt for any **one** of the generic electives studied in semesters I and II offered by the other Departments of Panjab University out of following:

(i) Mathematics
(ii) Chemistry/BioChemistry
(iii) Economics
(iv) Computer Science
(v) Statistics
(vi) Geology
(vii) Any of the subjects of Biomedical Sciences/Life Sciences provided the student has studied Biology at 10+2 level.

Generic Elective -5 (GE5) 150 Marks (6 credits)

Semester IV

CORE COURSE (PHYSICS)

Theory Papers:

Core Course-5 (C8):	Mathematical Physics - III	100 Marks (4 credits)
Core Course-6 (C9):	Quantum mechanics and Application	100 Marks (4 credits)
Core Course-7 (C10):	Analog Systems and Applications	100 Marks (4 credits)

Practicals:

Core Course-8 (C8):	Mathematical Physics - III	50 Marks (2 credits)
Core Course-9 (C9):	Quantum mechanics and Applications	50 Marks (2 credits)
Core Course-10 (C10):	Analog Systems and Applications	50 Marks (2 credits)

SKILL ENHANCEMENT COMPULSORY COURSE

Each student shall opt for any **one** of the skill enhancement courses (other than that taken during Semester III) offered out of following:

1. PHE-SEC1:	Physics Enhancement Skills	50 Marks (2 credits)
2. PHE-SEC2:	Computational Physics Skills	50 Marks (2 credits)
3. PHE-SEC3:	Electrical Circuits and Network Skills	50 Marks (2 credits)
4. PHE-SEC4:	Basic Instrumentation Skills	50 Marks (2 credits)
5. PHE-SEC5:	Renewable Energy and Energy Harvesting	50 Marks (2 credits)

GENERIC ELECTIVE

Each student may opt for any **one** of the generic electives studied in semesters I and II offered by the other Departments of Panjab University out of following:

(i) Mathematics
(ii) Chemistry/Biochemistry
(iii) Economics
(iv) Computer Science
(v) Statistics
(vi) Geology
(vii) Any of the subjects of Biomedical Sciences/Life Sciences provided the student has studied Biology at 10+2 level.

Generic Elective - 6 (GE6) — 150 Marks (6 credits)

EVALUATION

1. There shall be one Mid Term Examination of 20% Marks (20 marks) for theory papers in each semester. End-semester examination will be of 80% of total marks (80 marks).
2. **Evaluation of Practicals for Core and DSE Subjects** - The practical examination of all the core/DSE courses in a particular semester will be held together.
   There shall be internal assessment component for practicals of all the core/DSE courses having weightage of 20% of the allocated marks. It will be based on performance of the students in the laboratory, viva voice of each experiment, regularity (attendance) in the class and number of experiments performed.
   The final end-semester examination of all the core/DSE courses will be of 80% of the total marks and 4 (3+1) hours duration. The evaluation will be based on the following components for each of the the Core and DSE courses:
   (i) There will be written comprehensive test of 60 minutes duration containing short answer questions and covering all the experiments. It will be consisting of various sections corresponding to the core/DSE courses. The test will have a weightage of 20 % of the total allocated marks and will be jointly set by the teachers involved in the examination.
   (ii) Viva voce by the external examiner (weightage - 20%) related to the practicals core/DSE courses.
   (iii) Performance in the experiments done during the Practical examination (weightage - 40 %)

3. Evaluation of Practicals for Generic Elective Subjects - There shall be internal assessment for practicals having weightage of 20% marks of the total marks. It will be based on performance of the students in the laboratory, viva voice of each experiment, regularity (attendance) in the class and number of experiments performed. The final end-semester examination will be of 80% marks and 3 hours duration. The evaluation will be based on the following components with equal weightage:

(i) performance in the allotted Experiment and (ii) evaluation by the External examiner in the end-semester examination

3. **Evaluation in Skill Development Courses :** Projects/Jobs will be allocated to the students and will be evaluated by a Committee during (i) the midterm interaction with weightage 30 %, (ii) end-semester evaltion based on the presentation and project report, and innovation will be given extra credits.
4. To qualify a Course consisting of Theory and Practical parts, the student has to obtain minimum of 40% marks in each of the examinations held for the Theory and Practical parts. Failing in one component (Theory/Practical), the candidate has to reappear in that component only.

Pattern of end-semester question paper

(i) Nine questions in all with equal weightage. It will include one Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question.

The remaining eight questions will be placed in **Four Units** comprising two questions each, uniformly covering the whole syllabus. Students will attempt one question from each unit and the compulsory question. The candidate will be asked to attempt five questions.

The pattern of end term question paper should be 30% problem related, 10% thought provoking and 60% descriptive.

PREAMBLE

Physics is the science that involves the study of matter and its motion through space and time, along with related concepts. One of the most fundamental scientific disciplines, the main goal of physics is to understand how the universe evolved and behaves. New ideas in physics often explain the fundamental mechanisms of other sciences and the boundaries of physics are not rigidly defined. Physics also makes significant contributions through advances in new technologies that arise from theoretical breakthroughs. Specialization in Electronics subject along with studies in Physics plays an important role in progess of the Experimental Physics.

After partition of India, the Department of Physics was re-established in 1947, in Govt. College, Hoshiarpur (Punjab) and later, shifted to the present campus in August 1958. With the modest beginning of research in high-energy particle physics (nuclear emulsion) and optical UV spectroscopy, the research activities got a major filip with installation of cyclotron accelerator in late sixties. The department strengthened its research activities through UGC Special Assistance Programme (SAP) from 1980 to 1988 and College Science Improvement Programme from 1984 to 1991. In 1988, the department was accorded the status of Center of Advanced Study (CAS) by UGC with three major thrust areas, Particle physics, Nuclear physics and Solid-state physics, which is a unique feature in itself. The department is now in CAS fifth phase. The department participates in various national and international research initiatives in Accelerator-based reaserch in High Energy Physics, Nuclear Physics and Solid-State Physics. The department houses Cyclotron lab, EDXRF lab., Detector development lab., Experimental Solid-state Physics laboratories, Molecular Physics lab. and Advanced computation facilities for analyses of data from High Energy Physics, and Nuclear Spectroscopy and Reaction experiments. High Performance Computation facility is available for Condensed matter Physics and Nuclear Physics simulation calculations.

The Physics department is running undergraduate and postgraduate courses in Physics, and Physics (Specialization in Electronics) under the Honours School System. At present the department has strength of about 30 faculty members and Post-doctoral fellows, 50 non-teaching/administrative staff, 120 research students and 400 graduate and undergraduate students. The department has well equipped Practical and computing laboratories, Workshops and Library. The department has an 11-inch telescope to encourage/inculcate the scientific temper among public and with particular emphasis on college and school students. The department houses Indian Association of Physics Teachers (IAPT) office and actively leads in IAPT and Indian Physics Association (IPA) activities.

COURSE STRUCTURE

SEMESTER I		SEMESTER II	
C1	PHE-C1: Mathematical Physics - I	**C3**	PHE-C3: Electricity and Magnetism
C2	PHE-C2: Mechanics	**C4**	PHE-C4: Waves and Optics
AECC1	PHE-AECC1: English/ Environmental Science	**AECC2**	PHE: AECC2: English/ Environmental Science
GE1*		**GE3***	
GE2*		**GE4***	
SEMESTER III		**SEMESTER IV**	
C5	PHE-C5: Mathematical Physics - I	**C8**	PHE-C8: Mathematical Physics - III
C6	PHE-C6: Thermal Physics	**C9**	PHE-C9: Quantum mechanics and Applicat
C7	PHE-C7: Elements of Modern Physics	**C10**	PHE-C10: Analog systems and Applications
SEC1**		**SEC2****	
GE5*		**GE6***	
SEMESTER V		**SEMESTER VI**	
C11	PHE-C11: Digital Systems and applications	**C13**	PHE-C13:Electromagnetic Theory
C12	PHE-C12: Solid State Physics	**C14**	PHE-C14: Statistical Mechanics
DSE1#		**DSE3#**	
DSE2#		**DSE4#**	

C: Core Courses; GE: General Elective; AECC: Ability Enhancement Compulsory Courses; SEC: Skill Enhancement Courses; DSE: Discipline Specific Elective

***GE - General Elective courses are to be selected by the student from the pool of GE subjects - Mathematics, Chemistry, Economics and Computer Science offered by the other Departments of the University.**

****SEC - SKILL Enhancement Courses are to be selected by the student from the courses offered by the Physics Department in semesters III and IV.**

 # DSE - DISCIPLINE SPECIFIC ELECTIVE COURSES are to be selected by the student from the courses offered by the Physics Department in semesters V and VI.

***SKILL ENHANCEMENT COURSES (any one per semester in semesters III and IV)**

1. PHE-SEC1 Physics Workshop Skills
2. PHE-SEC2 Computational Physics Skills
3. PHE-SEC3 Electrical circuits and Network Skills
4. PHE-SEC4 Basic Instrumentation Skills
5. PHE-SEC5 Renewable Energy and Energy harvesting

#DISCIPLINE SPECIFIC ELECTIVE COURSES

(Any two per semester in semesters V and VI. Course under these will be offered only if a minimum of 10 students opt for the same.)

1. PHE-DSE1 Nuclear Physics
2. PHE-DSE2 Dissertation and Experimental Techniques Practicals
3. PHE-DSE3 Communication Systems
4. PHE-DSE4 Atomic and Molecular Physics
5. PHE-DSE5 Particle Physics
6. PHE-DSE6 Physics of Devices and Instruments

**Courses under these will be offered only if a minimum of 10 students opt for the same

Credits and Maximum Marks :

1. Core Courses (C1-C14)

   Credits = 06 (04 Theory + 02 Practicals) each

   Total marks 150 each

2. Discipline Specific Elective (DSE1-DSE4)

   Credits = 06 each

   Total marks = 150 each

3. Skill Enhancement Courses (SEC1-SEC2)

   Credits = 02 each

   Total marks = 50 each

4. Ability Enhancement (AECC1-AECC2)

   Credits = 02 each

   Total marks = 50 each

5. Generic Elective (GE1-GE6)

   Credits = 06 each

   Total marks = 150 each.

Semester I

PHE-C1: MATHEMATICAL PHYSICS-I

PHE-C1 (T): MATHEMATICAL PHYSICS-I
THEORY

Total Lectures: 60 **Credits: 4**

Max. Marks : 100

***Objective**: The emphasis of course is on applications in solving problems of interest to physicists. The objective of the course is to equip the student with the mathematical techniques that are required for understanding theoretical treatment in different Physics subjects being taught.*

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). **(2 Lectures)**

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. **(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. **(8 Lectures)**

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **(14 Lectures)**

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

Introduction to probability:

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance.

Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. **(4 Lectures)**

Dirac Delta function and its properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. **(2 Lectures)**

Suggested Reading

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

PHE-C1 (P) : MATHEMATICAL PHYSICS-I

PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

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

- *Highlights the use of computational methods to solve physical problems*
- *The course will consist of lectures (both theory and practical) in the Lab*
- *Evaluation done not on the programming but on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved*
- *Students can use any one operating system Linux or Microsoft Windows*

***Note:** The experiments listed in the Practical Part of the Core Papers, i.e., PHE-C1P: Mathematical Physics–I, PHE-C2P: Mechanics, PHE-C3P: Electricity and Magnetism and PHE-C4P: Waves and Optics, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. **15** experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

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. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects.
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (**π**)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$; $I = I_o \left[\frac{\sin\alpha}{\alpha}\right]^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ etc.*
Numerical differentiation (Forward and Backward difference 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
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler,	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source

modified Euler and Runge-Kutta (RK) second and fourth order methods	• Newton's law of cooling • Classical equations of motion Attempt following problems using RK 4 order method: Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3};\ \frac{dy}{dt} = -x$ for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$ The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -\sin\theta$. The pendulum is released from rest at an angular displacement α and θ'(0) = 0. Solve the equation for α = 0.1, 0.5 and 1.0 and plot θ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small θ (sin θ = θ)

Suggested Reading

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

PHE-C2: MECHANICS

PHE-C2 (T): MECHANICS

THEORY

Total Lectures: 60 **Credits: 4**

Max. Marks: 100

Objective: *The purpose of the course is to train the students in the Newtonian Mechanics and Special Theory of Relativity formalisms to an extent that they can use these in the modern branches of Physics.*

Fundamentals of Dynamics: Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field. Conservation of Energy, Conservative forces, Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Angular Momentum about the Centre of mass, Rotational invariance, Shape of Galaxy. **(6 Lectures)**

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

Elastic and Inelastic Scattering : Types of scattering and conservation laws, Laboratory and centre of mass systems, collision of particles which stick together, General elastic collision of particles of different mass, Cross-section of elastic scattering, Rutherford scattering. **(3 Lectures)**

Rotational Dynamics: Angular momentum of a particle and system of particles.
Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. Cylinder on an accelerated rough plane, Behaviour of angular momentum vector, Principal axes and Euler's equations, Elementary Gyroscope, Symmetrical Top. **(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 solid sphere. Force between a Point Mass and Spherical shell. Force between a Point Mass and Solid Sphere, Gravitational and Electrostatic self-energy. Gravitational energy of the Galaxy and of uniform sphere. **(3 Lectures)**

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). **(6 Lectures)**

Oscillations: SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **(5 Lectures)**

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

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum, Transformation of Force, Four vectors.
Problems of Relativistic Dynamics: Acceleration of charged particle by constant electric field, transverse Electric field. **(12 Lectures)**

Suggested Reading

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

Additional Suggested Reading

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

PHE-C2 (P): MECHANICS

PRACTICALS

Total Lectures: 60 **Credits: 2**

Max. Marks: 50

***Objective**: The laboratory exercises have been so designed that the students learn to verify some of the concepts learnt in the theory courses. They are trained in carrying out precise measurements and handling sensitive equipments.*

***Note:** The experiments listed in the Practical Part of the Core Papers, i.e., PHE-C1P: Mathematical Physics–I, PHE-C2P: Mechanics, PHE-C3P: Electricity and Magnetism and PHE-C4P: Waves and Optics, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. **15** experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

1. Use of Vernier callipers, Screw gauge, Spherometer, Barometer, Sphygmomanometer, Lightmeter, dry and wet thermometers, TDS/conductivity meter and other measuringinstruments based on applications of the experiments. Use of Plumb line and Spirit level.
2. To study the random error in observations.
3. Determination of height (of inaccessible structure) using 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 the value of g using Kater's Pendulum.
8. To study the variation of time period with distance between centre of suspension and centre of gravity for a bar pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.
9. Determination of coefficient of viscosity of a given liquid by Stoke's method. Study its temperature dependence.
10. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
11. To determine the Young's Modulus of a Wire by Optical Lever Method.
12. To determine the Young's modulus by (i) bending of beam using traveling microscope/laser, (ii) Flexural vibrations of a bar.
13. Determination of modulus of rigidity by (i) dynamic method Maxwell's needle/Torsional pendulum; (ii) Forced torsional oscillations excited using electromagnet.
14. To determine the elastic Constants of a wire by Searle's method.
15. To study one dimensional collision using two hanging spheres of different materials.

Suggested Reading

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

Semester II

PHE-C3: ELECTRICITY AND MAGNETISM

PHE-C3 (T): ELECTRICITY AND MAGNETISM
THEORY

Total Lectures : 60 **Credits: 4**

Max. Marks: 100

Objective *: The student is exposed to Electrostatics and Magnetostatics including Boundary value problems, Maxwell equations and their applications and analysis of Alternating current circuits.*

Electric Charges and Fields : Conservation and quantization of charge, Coulomb's Law, Energy of a system of charges. 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. Potential as line integral of field, potential difference, Gradient of a scalar function, Derivation of the field from the potential, potential of a charge distribution, Uniformly charged disc. Force on a surface charge, energy associated with an electric field, Gauss's theorem and differential form of Gauss's law, Laplacian and Laplace's equation, Poisson's equation. Force and Torque on a dipole.

(6 Lectures)

Electric Fields Around Conductors : Conductors and insulators, General electrostatic problem. Boundary conditions, Uniqueness theorem, 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: Plane Infinite Sheet and Sphere. **(10 Lectures)**

Dielectric Properties of Matter: Dielectrics, Moments of a charge distribution, Potential and field of a dipole, Atomic and molecular dipoles, Induced dipole moments, Permanent dipole moments, electric field caused by polarized matter, field of a polarized sphere, dielectric sphere in a uniform field, Gauss's law in a dielectric medium, Electrical susceptibility and atomic polarizability, Energy changes in polarization, Polarization in changing fields. Displacement vector **D**. Relations between **E**, **P** and **D**. **(8 Lectures)**

The Fields of Moving Charges : Magnetic forces, Measurement of a charge in motion, invariance of charge, Electric field measured in different frames of reference, Field of a point charge moving with constant velocity, Field of a charge that starts or stops, Force on a moving charge, Interaction between a moving charge and other moving charges. **(4 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. Change in **B** at a current sheet; Transformations of electric and magnetic fields. Rowland's experiment, Hall effect. **(9 Lectures)**

Magnetic Properties of Matter: Response of various substances to magnetic field, Force on a dipole in an external field, Electric currents in Atoms, Electron spin and Magnetic moment, types of magnetic materials, 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 : Universal law of induction, Mutual inductance, Reciprocity theorem, Self inductance, Energy stored in a Magnetic field. A circuit containing self inductance, Displacement current and Maxwell's equations. **(6 Lectures)**

Alternating Current Circuits: A resonance circuit, , Kirchhoff's laws for A.C. networks. Phasor, Complex Reactance and Impedance. Skin effect, Power and Energy in A.C. circuits, Anderson's Bridge, Instantaneous Power, Average Power, Reactive Power, Power Factor.

Sinusoidal Circuit Analysis for RL, RC and RLC Circuits. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

(4 Lectures)

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

Suggested Reading

1. Electricity and Magnetism (Berkley, Phys. Course 2), Edward M. Purcell, 1986 McGraw-Hill Education
2. Electricity and Magnetism: A.S. Mahajan & A.A. Rangwala (Tata- McGraw Hill), 1988.
3. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
4. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
5. Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
6. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
7. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

PHE-C3 (P): ELECTRICITY AND MAGNETISM (PRACTICALS)

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

Objective: *The aim of this course is to build an understanding about various components of an electrical circuit and to develop skill to measure the related physical quantities.*

Note: *The experiments listed in the Practical Part of the Core Papers, i.e., PHE-C1P: Mathematical Physics–I, PHE-C2P: Mechanics, PHE-C3P: Electricity and Magnetism and PHE-C4P: Waves and Optics, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***15*** *experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

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 determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
5. To determine the value of an air capacitance by de-Sauty Method and to find permittivity of air. Also to determine the dielectric constant of a liquid.
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine the mutual inductance of two coils by Absolute method.
15. Determination of E.C.E. of hydrogen and evaluation of Faraday and Avogadro constants.
16. To study the magnetic field produced by a current carrying solenoid using a pick-up coil/Hall sensor and to find the value of permeability of air.

17. To determine the frequency of A.C. mains using sonometer.
18. To determine the resistance of an electrolyte for A.C current and study its concentration dependence. Also to study temperature dependence.
19. Study of temperature dependence resistivity of Cu conductor, Manganin/constantin alloy and semiconductor (FET channel).
20. To measure thermo e.m.f. of a thermocouple as a function of temperature and find inversion temperature.
21. To study C.R.O. as display and measuring device by recording sines and square waves, output from a rectifier, verification (qualitative) of law of electromagnetic induction and frequency of A.C. mains.
22. To plot the Lissajous figures and determine the phase angle by C.R.O.
23. To study B-H curves for different ferromagnetic materials using C.R.O.
24. Determination of low inductance by Maxwell-Wein bridge.
25. Study of R.C. circuit with a low frequency a.c. source.
26. Studies based on LCR Board: Impedance of LCR circuit and the phase and between voltage and current.
27. To study the induced emf as a function of the velocity of magnet and to study the phenomenon of electromagnetic damping.
28. To study the variation of magnetic field with distance along axis of a circular coil – realization of Helmholtz's coils.

Suggested Reading

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

PHE-C4 : WAVES AND OPTICS

PHE-C4 (T) : WAVES AND OPTICS
THEORY

Total Lectures : 60 **Credits: 4**

Max. Marks : 100

Objective *: The course covers Harmonic oscillations and coupled oscillations, wave motion in damped, driven media. It also covers the Interference, diffraction and polarisation of light and their applications with emphasis on Holography.*

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

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(4 Lectures)**

Coupled oscillations : Stiffness coupled oscillations, normal coordinates and modes of vibrations. Normal frequencies, Forced vibrations and resonance of coupled oscillators, masses on string-coupled oscillators. **(3 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. **(6 Lectures)**

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. longitudinal waves on a rod, Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. Reflection and transmission of transverse waves on a string at the discontinuity. Impedance matching, eigen frequencies and eigen functions for stationary waves ona string. **(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. (Qualitative discussion only) **(2 Lectures)**

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

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

(7 Lectures)

Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

(3 Lectures)

Suggested Reading

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

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

PHE-C4 (P) : WAVES AND OPTICS
PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 100

Objective: *The course covers experiments related to damped, driven and forced oscillations, wave motion in media. Properties and Characteristics of light through experiments related to interference and diffraction phenomenon are high lighted.*

Note: *The experiments listed in the Practical Part of the Core Papers, i.e., PHE-C1P: Mathematical Physics–I, PHE-C2P: Mechanics, PHE-C3P: Electricity and Magnetism and PHE-C4P: Waves and Optics, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***15*** *experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material/liquid 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.
13. To study Malus's law of polarization.
14. To find the resolving power and magnification of a telescope.
15. To find the resolving power and magnification of a diffraction grating.
16. To study hydrogen/Neon gas discharge tube spectrum using diffraction grating.
17. To study temperature dependence of refractive index of organic liquid using Abbe's refractometer.
18. To study the variation of specific rotation of sugar solution with concentration.
19. To measure power distribution and divergence parameters of He-Ne and Semiconductor lasers.
20. To study Moire's fringe patterns and applications to measure small distance and angle.

Suggested Reading

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

Semester III

PHE-C5: MATHEMATICAL PHYSICS-II

PHE-C5 (T): MATHEMATICAL PHYSICS-II (THEORY)

Total Lectures : 60 **Credits: 4**

Max. Marks : 100

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

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. **(10 Lectures)**

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_0(x)$ and $J_1(x)$)and Orthogonality. **(24 Lectures)**

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

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line. **(6 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. Diffusion Equation. **(14 Lectures)**

Reference Books:

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

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PHE-C5 (P): MATHEMATICAL PHYSICS-II

PRACTICALS

Total Lectures : 30 **Credits: 2**

Max. Marks : 50

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

Note: *The experiments listed in the Practical Part of the Core Papers, i.e.,* ***PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE- C7 (P): Digital Systems and Applications, PHE- C8 (P): Mathematical Physics - III, PHE- C9 (P): Elements of Modern Physics, PHE- C10 (P): Analog Systems and Applications,*** *are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***20*** *experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

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

matrices, Inverse of a matrix, Eigen vectors, eigen values problems	
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function
Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion • Second order Differential Equation • Harmonic oscillator (no friction) • Damped Harmonic oscillator • Over damped • Critical damped • Oscillatory • Forced Harmonic oscillator • Transient and • Steady state solution • Apply above to LCR circuits also • Solve $$x^2\frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$$ with the boundary conditions at $x = 1, y = \frac{1}{2}e^2, \frac{dy}{dx} = e^2$- 0.5, In the range 1 ≤ x ≤ 3. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph.
Partial differential equations	Partial Differential Equation: • Wave equation • Heat equation

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

Reference Books:

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

PHE-C6: THERMAL PHYSICS

PHE-C6 (T) : THERMAL PHYSICS

THEORY

Total Lectures : 60 **Credits: 4**

Max. Marks : 100

Objective: *The covers laws of thermodynamics and applications, Thermodynamic Potentials, Maxwell's Thermodynamic Relations, Kinetic theory of gases, molecular collisions and real gas behaviour, Equation of State for Real Gases, Joule-Thomson Effect for Real and Van der Waal Gases.*

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: 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:

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

PHE-C6 (P) : THERMAL PHYSICS

PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

Objective: *The laboratory exercises have been so designed on measurements of thermal conductivity, Temperature Coefficient of Resistance,and use of various temperature transducers.*

Note: *The experiments listed in the Practical Part of the Core Papers, i.e.,* ***PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE- C7 (P): Digital Systems and Applications, PHE- C8 (P): Mathematical Physics - III, PHE- C9 (P): Elements of Modern Physics, PHE- C10 (P): Analog Systems and Applications,*** *are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***20*** *experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To measure the coefficient of linear expansion for different metals and alloys.
3. To determine the value of Stefan's Constant of radiation.
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 measure the thermal conductivity and thermal diffusivity of a conductor.
7. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
8. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
9. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions. To calibrate a thermocouple to measure temperature in a specified Range using (i) Null Method, (ii) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.
10. To determine thermal conductivity of a bad conductor disc using Advance kit involving constant current source for heating and thermocouples for temperature measurements.

Reference Books

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

PHE-C7: ELEMENTS OF MODERN PHYSICS

PHE-C7 (T): ELEMENTS OF MODERN PHYSICS

THEORY

Total Lectures : 60 **Credits: 4**

Max. Marks : 100

Objective : *The course content covers foundations of modern physics, experiments forming basis of quantum mechanics, Schrodinger equation and applications, uncertainty principle, nature of nuclear force, nuclear models, fission and fusion, nuclear reactors, stellar energy Spontaneous and Stimulated emissions and Lasers.*

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.
Gravitational Red-shift of photons. **(14 Lectures)**

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

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. **(10 Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier. **(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. Basic lasing. **(4 Lectures)**

Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
6. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan

Additional Books for Reference

7. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
8. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2^{nd} Edn, Tata McGraw-Hill Publishing Co. Ltd.

9. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
10. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
11. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

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PHE-C7 (P): ELEMENTS OF MODERN PHYSICS PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

Objective : *The laboratory experiments forming basis of quantum mechanics photoelectric effect – photoelectric effect, ionization potential, measurement of absorption and emission spectra, diffraction, diffraction of light, change on electron, and tunneling effect.*

Note: *The experiments listed in the Practical Part of the Core Papers, i.e.,* ***PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE- C7 (P): Digital Systems and Applications, PHE- C8 (P): Mathematical Physics - III, PHE- C9 (P): Elements of Modern Physics, PHE- C10 (P): Analog Systems and Applications,*** *are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***20*** *experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

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) Bar magnet.

9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine (i) wavelength and (ii) angular spread of He-Ne laser using plane diffraction grating
12. Dependence of scattering angle on kinetic energy and impact parameter in Rutherford scattering (mechanical analogue).

13. Measurement of the electrical and thermal conductivity of copper to determine its Lorentz number.
14. To determine energy band gap of a given semiconductor.
15. Verification of laws of probability and radioactivity (mechanical analogue).

Reference Books

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

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Semester IV

PHE-C8: MATHEMATICAL PHYSICS-III

PHE-C8 (T): MATHEMATICAL PHYSICS-III (THEORY)

Total Lectures : 60 **Credits: 4**

Max. Marks : 100

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

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. **(30 Lectures)**

Integrals Transforms:

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. **(15 Lectures)**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1^{st} and 2^{nd} order Derivatives and

Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2^{nd} order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1^{st} order. Solution of heat flow along infinite bar using Laplace transform. **(15 Lectures)**

Reference Books:

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

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PHE-C8 (P): MATHEMATICAL PHYSICS-III (PRACTICALS)

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

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

Note: *The experiments listed in the Practical Part of the Core Papers, i.e.,* ***PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE- C7 (P): Digital Systems and Applications, PHE- C8 (P): Mathematical Physics - III, PHE- C9 (P): Elements of Modern Physics, PHE- C10 (P): Analog Systems and Applications,*** *are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***20*** *experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

Scilab/C++ 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 $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)dx$, for σ = 1, 0.1, 0.01 and show it tends to 5.
3. Fourier Series:

Program to sum $\sum_{n=1}^{\infty}(0.2)^n$
Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:

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

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions 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.
8. Compute the n^{th} roots of unity for n = 2, 3, and 4.
9. Find the two square roots of −5+12*j*.
10. Integral transform: FFT of
11. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.

12. Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
13. Perform circuit analysis of a general LCR circuit using Laplace's transform.

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
- 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
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- 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
- https://web.stanford.edu/~boyd/ee102/**laplace**_ckts.pdf
- ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

PHE-C9: QUANTUM MECHANICS AND APPLICATIONS

PHE-C9 (T): QUANTUM MECHANICS AND APPLICATIONS

THEORY

Total Lectures: 60 **Credits: 4**

Max. Marks : 100

Objective : *The course content covers basis of quantum mechanics, Time dependent and time independent Schrodinger equations and their solutions with different potentials, applications of quantum mechanics for hydrogen-like and many electron atoms and atoms in electric and magnetic fields.*

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

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

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & 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 (Na etc.). **(10 Lectures)**

Reference Books:

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

Additional Books for Reference

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

PHE-C10: ANALOG SYSTEMS AND APPLICATIONS

PHE-C10 (T): ANALOG SYSTEMS AND APPLICATIONS
THEORY

Total Lectures : 60 **Credits: 4**

Max. Marks : 100

Objective: *The course content covers basic network theorems for circuit analysis, semiconductor physics and devices, diodes and applications, bipolar junction transistors, amplifiers, feedback concepts, Operation amplifiers and applications.*

Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. **(4 Lectures)**

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. Current Flow Mechanism in Forward and Reverse Biased Diode. **(10 Lectures)**

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

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

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(10 Lectures)**

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

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

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

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

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. **(9 Lectures)**

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

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6^{th} Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3^{rd} Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4^{th} edition, 2000, Prentice Hall
6. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6^{th} Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2^{nd} Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2^{nd} Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

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PHE-C10 (P): ANALOG SYSTEMS AND APPLICATIONS PRACTICALS

Total Lectures : 60 **Credits: 2**

Max. Marks : 50

Objective: *The laboratory exercises have been so designed that the students learn to study characteristics of various diodes, solar cells, and BJT and their biasing aspects, amplifiers, oscillators, ADC and DAC and OPAMP based application circuits*

Note: *The experiments listed in the Practical Part of the Core Papers, i.e.,* ***PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE- C7 (P): Digital Systems and Applications, PHE- C8 (P): Mathematical Physics - III, PHE- C9 (P): Elements of Modern Physics, PHE- C10 (P): Analog Systems and Applications,*** *are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II.* ***20*** *experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

1. To study I-V characteristics of different diodes - Ge, Si, LED and Zener. Use constant current source for Zener.
2. To study voltage regulation and ripple factor for a half-wave and a full-wave rectifier without and with different filters. Use of Zener diode and IC regulators.
3. To study common emitter characteristics of a given transistor and to determine various parameters.
4. Study of I-V & power curves of solar cells, and find maximum power point & efficiency.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
7. To design a Wien bridge oscillator for given frequency using an op-amp.
8. To design a phase shift oscillator of given specifications using BJT.
9. To study the Colpitt`s oscillator.
10. To design a digital to analog converter (DAC) of given specifications.
11. To study the analog to digital convertor (ADC) IC.
12. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
13. To design inverting amplifier using Op-amp (741,351) and study its frequency response
14. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
15. To study the zero-crossing detector and comparator
16. To add two dc voltages using Op-amp in inverting and non-inverting mode

17. To design a precision Differential amplifier of given I/O specification using Op-amp.
18. To investigate the use of an op-amp as an Integrator.
19. To investigate the use of an op-amp as a Differentiator.
20. To design a circuit to simulate the solution of a $1^{st}/2^{nd}$ order differential equation. \
21. To draw the characteristics of a given triode and to determine the tube parameters.
22. Calibration of a Si diode, a thermistor and thermocouple for temperature measurements.
23. To measure low resistance by Kelvin's double bridge/ Carey Foster's bridge.

Reference Books:

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

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Skill Enhancement Course (any four) (Credit: 02 each)

PHE-SEC1 to PHE-SEC5

PHE-SEC1: PHYSICS ENHANCEMENT SKILLS

Total Lectures : 30 **Credits: 2**

Max. Marks : 50

Objective: *The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode, and to improve the abilities of the students to frame and tackle problems in Physics.*

Note: *The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

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. **(4 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.

(10 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.

(10 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:

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

PHE-SEC2: COMPUTATIONAL PHYSICS

Total Lectures : 30 **Credits: 2**

Max. Marks : 50

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.*

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

Note: *The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

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

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

(5 Lectures)

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

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.

3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1 **(6 Lectures)**

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

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

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

Hands on exercises:

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

(9 Lectures)

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
3. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
5. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
6. Computational Physics: An Introduction, R. C. Verma et al. New Age International Publishers, New Delhi(1999)
7. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
8. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

PHE-SEC3: ELECTRICAL CIRCUITS AND NETWORK SKILLS

Total Lectures : 30 **Credits: 2**

Max. Marks : 50

Objective: *The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode*

Note: *The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

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. **(3 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. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(4 Lectures)**

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

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

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

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

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

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

Reference Books:

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

PHE-SEC4: BASIC INSTRUMENTATION SKILLS

Total Lectures : 30 **Credits: 2**

Max. Marks : 50

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

Note: *The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **(4 Lectures)**

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

AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter**,** specifications and their significance. **(4 Lectures)**

Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only-no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. **(6 Lectures)**

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **(3 Lectures)**

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

Impedance Bridges & 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. **(3 Lectures)**

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution. **(3 Lectures)**

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

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To 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:

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

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PHE-SEC5 RENEWABLE ENERGY AND ENERGY HARVESTING

Total Lectures : 30 **Credits: 2**

Max. Marks : 50

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

Note: *The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.*

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. **(3 Lectures)**

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems. **(6 Lectures)**

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

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

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

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

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

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

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

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

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

Demonstrations and Experiments

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

Reference Books:

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