University of Kalyani

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN

PHYSICS (GENERAL)

WITH EFFECT FROM THE ACADEMIC SESSION

2018-19

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN
PHYSICS (PROGRAMME/GENERAL)

INTRODUCTION:

The University Grants Commission (UGC) has taken various measures by means of formulating regulations and guidelines and updating them, in order to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions in India. The various steps that the UGC has initiated are all targeted towards bringing equity, efficiency and excellence in the Higher Education System of country. These steps include introduction of innovation and improvements in curriculum structure and content, the teaching-learning process, the examination and evaluation systems, along with governance and other matters. The introduction of Choice Based Credit System is one such attempt towards improvement and bringing in uniformity of system with diversity of courses across all higher education institutes in the country. The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising of core, elective, skill enhancement or ability enhancement courses. The courses shall be evaluated following the grading system, is considered to be better than conventional marks system. This will make it possible for the students to move across institutions within India to begin with and across countries for studying courses of their choice. The uniform grading system shall also prove to be helpful in assessment of the performance of the candidates in the context of employment.

Outline of the Choice Based Credit System being introduced:

1. **Core Course (CC):** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the student's proficiency/skill is termed as an Elective Course.

> 2.1 **Discipline Specific Elective Course (DSEC):** Elective courses that are offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

> 2.2 **Generic Elective Course (GEC):** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

3. **Ability Enhancement Courses/ Skill Enhancement Courses:**

> 3.1 **Ability Enhancement Compulsory Course (AECC):** Ability enhancement courses are the courses based upon the content that leads to Knowledge enhancement. They (i) Environmental Science, (ii) English Communication) are mandatory for all disciplines.

> 3.2 **Skill Enhancement Course (SEC):** These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN PHYSICS (PROGRAMME/GENERAL)

A. TOTAL Number of courses in UG-CBCS B.Sc. GENERAL:

Types of course	Core course (CC)	Elective course	Ability Enhncemnt Course		TOTAL
		Discipline specific elective course (DSE)	Ability Enhancmnt compulsory course(AECC)	Skill Enhancmnt course (SEC)	
No. of course	12	6	2	4	24
Credit/course	6	6	2	2	120

TABLE-1: DETAILS OF COURSES OF B.SC. (GENERAL) UNDER CBCS

S. No.	**Particulars of Course**	**Credit Point**	
		Theory + Practical	**Theory + Tutorial**
1.	**Core Course: 12 Papers**		
1.A.	Core Course: Theory (12 papers)	12x4 = 48	12x5 = 60
1.B.	Core Course (Practical/Tutorial)*(12 papers)	12x2 = 24	12x1 = 12
2.	**Elective Courses: (6 papers)**		
A.	DSE: Theory (6 papers)	6x4 = 24	6x5 = 30
B.	DSE(Pract./ Tutor.)* (6 papers)	6x2 = 12	6x1 = 6
#Optional Dissertation/ Project Work in place of one DSE paper (6 credits) in 6th semester			
3. Ability Enhancement Courses			
A.	Ability Enhancement compulsory course (AECC): (Theory)*(2 papers) (2 papers of 2 credits each)	2x2 = 4	2x2 = 4
B.	Skill Enhancement Course (SEC): (Theory)*(4 papers) (4 papers of 2 credits each)	4x2 = 8	4x2 = 8
	Total Credit:	**120**	**120**
## Wherever there is a practical, there will be no tutorial and vice- versa.			

TABLE-2: SEMESTER WISE DISTRIBUTION OF COURSES & CREDITS IN B.SC. GENERAL

Courses/ (Credits)	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Total No. of Courses	Total credit
CC-1,2,3 (6)	3 (1A,2A,3A)	3 (1B,2B,3B)	3 (1C,2C,3C)	3 1D,2D,3D)	-	-	12	72
DSE - 1,2,3 (6)	-	-	-	-	3 (1A,2A,3A)	3 (1B,2B,3B)	6	36
AECC (2)	1	1	-	-	-	-	2	04
SEC (2)	-	-	1	1	1	1	4	08
Total No. of Course/ Sem	4	4	4	4	4	4	24	--
Total Credit /Semester	20	20	20	20	20	20	--	120

TABLE-3: SEMESTER & COURSEWISE CREDIT DISTRIBUTION IN B.SC.(GENERAL)

(6 Credit: 75 Marks)

SEMESTER-I			
Course Code	**Course Title**	**Course wise Class (L+T+P)**	**Credit**
PHY-G-CC-T-01 PHY-G-CC-P-01	Mathematical Physics – I/Mechanics /Electricity and Magnetism	Core (60L+60P)	6 (4T+2P)
from other discipline	from other discipline	Core	6
from other discipline	from other discipline	Core	6
AECC-01	English Communication/ Environmental Science	AECC	2
Total	**4 courses**	**Total**	**20**
SEMESTER-II			
Course Code	**Course Title**	**Course Nature**	**Credit**
PHY-G-CC-T-02 PHY-G-CC-P-02	Waves and Optics/Mathematical Physics-II/Thermal Physics/Digital Systems and Applications	Core (60L+60P)	6 (4T+2P)
from other discipline	from other discipline	Core	6
from other discipline	from other discipline	Core	6
AECC-02	English Communication/ Environmental Science	AECC	2
Total	**4 courses**	**Total**	**20**
SEMESTER-III			
Course Code	**Course Title**	**Course Nature**	**Credit**
PHY-G-CC-T-03 PHY-G-CC-P-03	Mathematical Physics – III/Elements of Modern Physics/Analog Systems and Applications	Core (60L+60P)	6 (4T+2P)
from other discipline	from other discipline	Core	6
from other discipline	from other discipline	Core	6
PHY-G-SEC-T-01	Any one from **TABLE-4.2**	SEC (30L)	2
Total	**4 courses**	**Total**	**20**
SEMESTER-IV			
Course Code	**Course Title**	**Course Nature**	**Credit**
PHY-G-CC-T-04 PHY-G-CC-P-04	Quantum Mechanics and Applications/ Solid State Physics/ Electromagnetic Theory/ Statistical Mechanics	Core (60L+60P)	6 (4T+2P)
from other discipline	from other discipline	Core	6
from other discipline	from other discipline	Core	6
PHY-G-SEC-T-02	Any one from **TABLE-4.2 (not taken earlier)**	SEC (30L)	2
Total	**4 courses**	**Total**	**20**

SEMESTER-V			
Course Code	**Course Title**	**Course Nature**	**Credit**
PHY-G-DSE-T-01 PHY-G-DSE-P-01	Mechanics/Electricity and Magnetism/ Thermal Physics and Statistical Mechanics/Waves and Optics	DSE (60L+60P)	6 (4T+2P)
from other discipline	from other discipline	DSE	6
from other discipline	from other discipline	DSE	6
PHY-G-SEC-T-03	Any one from **TABLE-4.2 (not taken earlier)**	SEC (30L)	2
Total	**4 courses**	**Total**	**20**
SEMESTER-VI			
Course Code	**Course Title**	**Course Nature**	**Credit**
PHY-G-DSE-T-02 PHY-G-DSE-P-02	Digital, Analog Circuits and Instrumentation/Elements of Modern Physics/Solid State Physics/Quantum Mechanics/Nuclear And Particle Physics	DSE (60L+60P)	6 (4T+2P)
from other discipline	from other discipline	DSE	6
from other discipline	from other discipline	DSE	6
PHY-G-SEC-T-04	Any one from **TABLE-4.2 (not taken earlier)**	SEC (30L)	2
Total	**4 courses**	**Total**	**20**
Total (All semesters)	***24 courses***	***Total***	***120***

TABLE-4.1: Choices for Pass: Core Papers (Credit: 06 each)

Core Papers(Credit: 06 each) : 4 papers to be selected for Pass/General Students			
1. Mathematical Physics-I	5. Mathematical Physics-II	9. Elements of Modern Physics	13. Electromagnetic Theory
2. Mechanics)	6. Thermal Physics	10. Analog Systems and Applications	14. Statistical Mechanics
3. Electricity and Magnetism	7. Digital Systems and Applications	11. Quantum Mechanics and Applications	
4. Waves and Optics	8. Mathematical Physics III	12. Solid State Physics	

TABLE-4.2: Skill Enhancement Courses (Credit: 02 each)

For Pass COURSE (may be chosen) : 1 paper for Semester-III ; 1 paper for Semester-IV;1 paper for Semester-V and 1 paper for Semester-VI			
	Skill Enhancement Course-1 & Skill Enhancement Course-2		
1.Physics Workshop Skills	3.Electrical Circuits & Network Skills	5.Renewable Energy & Energy Harvesting	7.Radiation Safety
2.Computational Physics Skills	4. Basic Instrumentation Skills	6.Technical Drawing	8. Applied Optics
			9.Weather Forecasting

TABLE-4.3: Discipline specific elective course (DSE) (Pass/General course only): (Credit: 06 each)

For Pass/General COURSE:1 paper for Semester-V and 1 paper for Semester-VI			
1.Mechanics	3.Thermal Physics and Statistical Mechanics	5.Digital, Analog Circuits and Instrumentation	7.Solid State Physics
2.Electricity and Magnetism	4. Waves and Optics	6.Elements of Modern Physics	8. Quantum Mechanics
			9.Nuclear and Particle Physics

CORE COURSE (GENERAL/PASS IN PHYSICS)

PHY-G-CC-T-01: MATHEMATICAL PHYSICS-I (Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment: Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

Theory: 60 Lectures

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

Calculus:
Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order Differential Equations and Integrating Factor. (6 **Lectures**)

Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. (12 **Lectures**)

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

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

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates. (10 **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. (5 **Lectures**)

Dirac Delta function and its properties:
Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

(2   Lectures)

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

PHY-G-CC-P-01: MATHEMATICAL PHYSICS-I
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)
60 Lectures

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.
*   *Highlights the use of computational methods to solve physical problems*
*   *The course will consist of lectures (both theory and practical) in the Lab*
*   *Evaluation done not on the programming but on the basis of formulating the problem*
*   *Aim at teaching students to construct the computational problem to be solved*
*   *Students can use any one operating system Linux or Microsoft Windows*

Introduction and Overview

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.

Introduction to plotting graphs with Gnuplot/Origin/Excel

Basic 2D and 3D graph plotting - plotting functions and datafiles, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots

Introduction to programming in python/Fortran/Matlab/C,C^{++}:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object oriented programming.

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 $\alpha = tan\alpha$, $I = I_0\{sin\alpha/\alpha\}^2$, in optics

Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation

Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ, etc.

Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method

Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop.

Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods

First order differential equation

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

Attempt following problems using RK 4 order method

Also attempt some problems on differential
equation like:

1. Solve the coupled first order differential
    equations $dy/dx = y + x - x^2$, $dy/dx = -x$

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 < t < 15.

2.   The ordinary differential equation describing the motion of a pendulum is
$\theta'' = -sin\theta$.

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

Attempt following problems using RK 4 order method

Also attempt some problems on differential
equation like:

1. Solve the coupled first order differential
    equations $dy/dx = y + x - x^2$, $dy/dx = -x$

for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four
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small θ *(sin(θ))* =θ. 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 < t < 15.

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

OR, PHY-G-CC-T-01: MECHANICS

(Credits: Theory-04,
Practicals-02) Theory: 60
Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

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

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

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

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

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

Fluid Motion: Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.   (2 **Lectures**)
Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid 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). Physiological effects on astronauts. **(6 Lectures)**

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

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

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. Energy-Momentum Four Vector. **(10 Lectures)**

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

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

PHY-G-CC-P-01: MECHANICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)
60 Lectures

1. Measurements of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g
5. To determine the Moment of Inertia of a Flywheel/ a rigid body.

6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method
   (Poiseuille's method).
8. To determine the Young's Modulus of the material of a bar by flexure method
9. To determine the Modulus of Rigidity of a Wire by - Dynamic Method.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.
13. To draw the frequency – resonance length curve of a sonometer wire and to determine an unknown frequency of a tuning fork
14. Measurement of coefficient of viscosity by Stoke's method.

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

OR, PHY-G-CC-T-01: ELECTRICITY AND MAGNETISM (Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

Electric Field and Electric Potential:
Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

(6 Lectures)

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

(6 Lectures)

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

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

Magnetic Field:

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

(9 Lectures)

Magnetic Properties of Matter:

Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.   **(4 Lectures)**

Electromagnetic Induction:

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

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

(4 Lectures)

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

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

(3 Lectures)

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

PHY-G-CC-P-01: ELECTRICITY AND MAGNETISM
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)
 60 Lectures

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

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

PHY-G-CC-T-02: WAVES AND OPTICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

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

(5 Lectures)

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

(2 Lectures)

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

(4 **Lectures**)

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

Superposition of Two Harmonic Waves:

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

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

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

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

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

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

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.   (7 **Lectures**)

Reference Books
•   Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
•   Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
•   Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
•   Optics, Aj oy Ghatak, 2008, Tata McGraw Hill
•   The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
•   The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

PHY-G-CC-P-02: WAVES AND OPTICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify X^2 -T law.
2. To investigate the motion of coupled oscillators.

3. To study Lissaj ous Figures.
4. Familiarization with: Schuster's focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power 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 draw the deviation – wavelength of the material of a prism and to find the wavelength of an unknown line from its deviation.

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

OR, PHY-G-CC-T-02: MATHEMATICAL PHYSICS-II
(Credits: Theory-04, Practicals-02) Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

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.

(14 Lectures)

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

(24 Lectures)

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

(4 Lectures)

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

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

(14 Lectures)

Reference Books:
- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

PHY-G-CC-P-02: MATHEMATICAL PHYSICS-II
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures

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

Introduction to Numerical computation numpy, scipy/Matlab/Octave/ Scilab

Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg submodule. Introduction to on line graph plotting using matplotlib. Introduction to the scipy module. Uses in optimization and solution of differential equations.

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

Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems

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

Generation of Special functions using User defined functions

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

Partial differential equations
  ➢ Wave equation

  ➢ Heat equation

  ➢ Poisson equation

> ➤ Laplace equation

Reference Books:

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

OR, PHY-G-CC-T-02:
THERMAL PHYSICS

(Credits: Theory-04, Practicals-02) Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

(Include related problems for each topic)

Introduction to Thermodynamics
Zeroeth 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 CP and CV, 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, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. (10 **Lectures**)

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

(7 **Lectures**)

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

(7 **Lectures**)

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

(7 **Lectures**)

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

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

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

(10 Lectures)

Reference Books:
• Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.

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

OR, PHY-G-CC-P-02:
THERMAL PHYSICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's
   constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee
   and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance
   Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of
   Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature
8. Determination of the boiling point of a liquid by Platinum resistance thermometer
9. Determination of the melting point of a solid with a thermocouple.
10. Measurement of the coefficient of linear expansion of a solid using an optical lever

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

OR, PHY-G-CC-T-02: DIGITAL SYSTEMS AND APPLICATIONS

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment: Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

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

(3 Lectures)

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital LCs **(3 Lectures)**

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

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map **(6 Lectures)**

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

(4 Lectures)

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

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

(6 Lectures)

Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.
(3 Lectures)
Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).   **(2 Lectures)**
Counters(4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(4 Lectures)
Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM).
Computer memory. Memory organization & addressing. Memory Interfacing. MemoryMap   **(6 Lectures)**
Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI.   **(8 Lectures)**
Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions.
(4 Lectures)

Reference Books:
- Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed.,
  2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PHY-G-CC-P-02: DIGITAL SYSTEMS AND APPLICATIONS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures
1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT , XOR and ~~using~~ NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
    a) Addition and subtraction of numbers using direct addressing mode
    b) Addition and subtraction of numbers using indirect addressing mode
    c) Multiplication by repeated addition.
    d) Division by repeated subtraction.
    e) Handling of 16-bit Numbers.

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

OR, PHY-G-CC-T-03: MATHEMATICAL PHYSICS-III

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

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

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

PHY-G-CC-P-03: MATHEMATICAL PHYSICS-III
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)
60 Lectures
Numerical computation using Python/Matlab/Octave/Fortran:
  1. Solve differential equations:

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

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

$dy/dx + e^{-x} = x^2$
$\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + y = 0$

  2. Dirac Delta Function:

$\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(z-x)^2}{z\sigma^2}} (x+3)dx$, for σ=1,.1,.01 and show it tends to 5

3. Fourier Series:
Program to sum

$$\sum_{n=1}^{\infty} (.2)^n$$

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

1. Frobenius method and Special functions: $\int_{-1}^{1} P_n(\mu) P_m(\mu) d\mu = \delta_{n,m}$, Plot $P_n(x), J_n(x)$

   Show recursion relation

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

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

7. Evaluation of trigonometric functions e.g. *sin 6,* 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 nth roots of unity for n = 2, 3, and 4.

9. Find the two square roots of $-5+12j$.

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

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. Fernandez. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

OR, PHY-G-CC-T-03: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-04, Practicals-02) Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and

Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.   **(14 Lectures)**

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

(5 Lectures)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and 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.   **(4 Lectures)**

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

Additional Books for Reference
*   Modern Physics, J.R. Taylor, C.D. Zafiratos, M. A. Dubson, 2004, PHI Learning.
*   Theory and Problems of Modern Physics, Schauirf s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
*   Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
*   Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
*   Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

PHY-G-CC-P-03: ELEMENTS OF MODERN PHYSICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures
   1. Measurement of Planck's constant using black body radiation and photo-detector
   2. Photo-electric effect: photo current versus intensity and wavelength of light;
      maximum energy of photo-electrons versus frequency of light
   3. To determine work function of material of filament of directly heated vacuum
      diode.
   4. To determine the Planck's constant using LEDs of at least 4 different colours.
   5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
   6. To determine the 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 tunnelling effect in tunnel diode using I-V characteristics.
   11. To determine the slit width (a) using diffraction of single slit.
   12. To determine the slit width (a,b)   using diffraction of double slits.
13. To determine (1) wavelength and of He-Ne light /~~laser~~ using plane diffraction grating

14. To draw the I-V characteristics of a valve diode and to verify the laws of thermionic emission.

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

OR, PHY-G-CC-T-03: ANALOG SYSTEMS AND APPLICATIONS
(Credits: Theory-04, Practicals-02) Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction.   **(10 Lectures)**

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

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains a and P Relations between a and p. 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: 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:
- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

PHY-G-CC-P-03: ANALOG SYSTEMS AND APPLICATIONS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures
1. To study V-I characteristics of PN junction diode, and / Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.

6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage
   divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor
   amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using B JT.
10. To study the Colpitf s oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of
    given gain
14. To design inverting amplifier using Op-amp (741,351) and study its frequency
    response
15. To design non-inverting amplifier using Op-amp (741,351) & study its
    frequency response
16. To study the zero-crossing detector and comparator
17. To add two dc voltages using Op-amp in inverting and non-inverting mode
18. To design a precision Differential amplifier of given I/O specification using Op-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.
21. To design a circuit to simulate the solution of a $1^{st}/2^{nd}$ order differential equation.

22. To study the characteristics of a Bipolar Junction Transistor in CB
    configuration

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

PHY-G-CC-T-04: QUANTUM MECHANICS AND APPLICATIONS (Credits: Theory-04, Practicals-02) Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]
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 AlkaliAtoms (Na etc.). **(10 Lectures)**

Reference Books: A test book of
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

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

PHY-G-CC-P-04: QUANTUM MECHANICS AND APPLICATIONS

Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures

Use Fortan/Python/Matlab/Octave/ C/C++/Scilab for solving the following problems based on Quantum Mechanics like

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

$$\frac{d^2y}{dr^2} = \frac{2m}{h^2}\left(E - V(r)\right)y$$
where $V(r) = -\frac{e}{r}$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is « -13.6 eV. Take e = 3.795 (eVA)$^{1/2}$, he = 1973 (eVA) and m = 0.511×10^6eV/c^2.

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

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

$$\frac{d^2y(r)}{dr^2} + \frac{2m}{h^2}\left(E - V(r)\right)y(r) = 0,$$
where $V(r) = -\frac{e}{r}e^{-r/a}$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVA)$^{1/2}$, m = 0.51 1x10^6 eV/c^2, and a = 3 A, 5 A, 7 A. In these units he = 1973 (eVA). The ground state energy is expected to be above -12 eV in all three cases.

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

$$\frac{d^2y(r)}{dr^2} + \frac{2m}{h^2}\left(E - V(r)\right)y(r) = 0,$$
where $V(r) = -\frac{e}{r}e^{-r/a}$

For the anharmonic oscillator potential

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

for the ground state energy (in MeV) of particle to an accuracy of three significant

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

3. Solve the s-wave radial Schrodinger equation for the vibration of hydrogen molecule:

$$\frac{d^2 y(r)}{dr^2} + \frac{2m}{\hbar^2}\left(E - V(r)\right)y(r) = 0, \quad \text{where } V(r) = D\left(e^{-2\alpha r'} - e^{-2\alpha r'}\right), r' = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take m=940x106eV/c, D=0.755501 eV, α=1.44, r_0=0.131349A

Laboratory based experiments:
5. Study of Electron spin resonance- determine magnetic field as a function of the

   resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of C CD s

Reference Books:
- Schaum's outline of Programming with C++. J.Hubbard, 2 0 0 0, McGraw-Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274

OR, PHY-G-CC-T-04: SOLID STATE PHYSICS
(Credits: Theory-04, Practicals-02) Theory: 60 Lectures
 F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
 Practical (Sessional Viva-voce) - 05]

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis - Central and Non-Central

Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

(12 Lectures)

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

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

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

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

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

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

Reference Books:
- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill

- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PHY-G-CC-P-04: **SOLID STATE PHYSICS**
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures
1. Measurement of susceptibility of paramagnetic solution (Quinckf s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using

   Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe

   method (room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

11. To measure the mutual inductance of two coaxial coils at various relative orientations using a ballistic galvanometer.

12. Verification of the inverse cube law for magnetic dipoles (study of the dependence of

the field of a magnetic dipole on distance) and determination of the horizontal

component of the earth's magnetic field by deflection and oscillation magnetometers.

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

OR, PHY-G-CC-T-04: ELECTROMAGNETIC THEORY
(Credits: Theory-04, Practicals-02) Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]

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

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

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

(10 Lectures)

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

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

(5 Lectures)

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

(8 Lectures)

Optical Fibres:- Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

(3 Lectures)

Reference Books:
•   Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
•   Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
•   Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference
- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004,
  Cambridge University Press

PHY-G-CC-P-04: ELECTROMAGNETIC THEORY
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures

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

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

Springer

OR, PHY-G-CC-T-04: STATISTICAL MECHANICS
(Credits: Theory-04, Practicals-02) Theory: 60 Lectures
F.M. = 75(Theory - 40, Internal Assessment – 15)
Internal Assessment : Class Attendance (Theory) – 05,
Theory (Class Test/ Assignment/ Tutorial) – 05,
Practical (Sessional Viva-voce) - 05]
Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase
Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) - Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

(18 Lectures)

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

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

(5 Lectures)

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.
(13 Lectures)
Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

(15 Lectures)

Reference Books:
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

PHY-G-CC-P-04: STATISTICAL MECHANICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures
Use C/C+$^+$/Scilab for solving the problems based on Statistical Mechanics like
1. Plot Planck's law for Black Body radiation and compare it with Wein's Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein
   distribution function, (c) Debye distribution function for high temperature (room
   temperature) and low temperature and compare them for these two cases
3. Plot Maxwell-Boltzmann distribution function versus temperature.
4. Plot Fermi-Dirac distribution function versus temperature.
5. Plot Bose-Einstein distribution function versus temperature.

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

Skill Enhancement Course [any four (PHY-G- SEC-T-(01-04)) may be chosen for GENERAL/PASS course] (Credit: 02 each)

1. PHYSICS WORKSHOP SKILL (Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]
30 Lectures
The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode

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

2.COMPUTATIONAL PHYSICS SKILLS

(Credits: 02)
 F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]
Theory: 30 Lectures

*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.*

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:
• Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
• Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
• LaTeX-A Document Preparation System", Leslie Lamport (Second Edition,
   Addison-Wesley, 1994).
• Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
• Schaum's Outline of Theory and Problems of Programming with Fortran, S
   Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.

- Computational Physics: An Introduction, R. C. Verma, et al. New Age International
  Publishers, New Delhi(1999)
- A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn., 2007, Wiley India Edition.

3. ELECTRICAL CIRCUITS & NETWORK SKILLS (Credits: 02)

F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]

Theory: 30 Lectures

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

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

4. BASIC INSTRUMENTATION SKILLS
(Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]
Theory: 30 Lectures
This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.

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

5. RENEWABLE ENERGY AND ENERGY HARVESTING (Credits: 02)

F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]

Theory: 30 Lectures

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

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

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

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

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

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

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

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

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

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

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

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

6. TECHNICAL DRAWING

(Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]
Theory: 30Lectures

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

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

Object Projections: Orthographic projection. Interpenetration and intersection of solids. Isometric and oblique parallel projection of solids.   **(4 Lectures)**

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

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

7. RADIATION SAFETY

(Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]
Theory: 30 Lectures
The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

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

(6 Lectures)

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources,

Interaction of Photons - Photo electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients,

Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), **Interaction of Neutrons-** Collision, slowing down and Moderation.   (7 **Lectures)**

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

Radiation detection: Basic concept and working principle of *gas detectors* (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters

(MWPC) and Gieger Muller Counter), *Scintillation Detectors* (Inorganic and

Organic Scintillators), *Solid States Detectors* and *Neutron Detectors, Thermo luminescent Dosimetry.* (7 **Lectures**)

Radiation safety management: *Biological effects of ionizing radiation,* Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management. **(5 Lectures)**

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. *Industrial Uses:* Tracing, Gauging, Material Modification, Sterization, Food preservation. **(5 Lectures)**

Experiments:
1. Study the background radiation levels using Radiation meter

Characteristics of Geiger Muller (GM) Counter:
2) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
3) Study of counting statistics using background radiation using GM counter.
4) Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
5) Study of absorption of beta particles in Aluminum using GM counter.
6) Detection of a particles using reference source & determining its half life using spark counter.
7) Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books:
1. W.E. Burcham and M. Jobes - Nuclear and Particle Physics - Longman (1995)
2. G.F.Knoll, Radiation detection and measurements
3. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
4. W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.
5. J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
6. Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
7. A. Martin and S. A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
8. NCRP, ICRP, ICRU, IAEA, AERB Publications.
9. W.R. Hendee, "Medical Radiation Physics", Year Book - Medical Publishers Inc. London, 1981

8. APPLIED OPTICS
(Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]

THEORY: 30 Lectures

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

Sources and Detectors (No. of Lectures:7)

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

Experiments on Lasers:

1. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
2. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
3. To find the polarization angle of laser light using polarizer and analyzer
4. Thermal expansion of quartz using

laser Experiments on Semiconductor

Sources and Detectors

1. V-I characteristics of LED
2. Study the characteristics of solid state laser
3. Study the characteristics of LDR
4. Photovoltaic Cell
   Characteristics of IR sensor

Fourier Optics (No. of Lectures:7)

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

lens.

Experiments on Fourier Optics:

1. Fourier optic and image processing
   a. Optical image addition/subtraction
   b. Optical image differentiation
   c. Fourier optical filtering
   d. Construction of an optical 4fsystem

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

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

Holography (No. of Lectures:6)

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

Experiments on Holography and interferometry

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

White light Hologram

Photonics: Fibre Optics (No. of Lectures:10)

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

Experiments on Photonics: Fibre Optics

1. To measure the numerical aperture of an optical fibre
2. To study the variation of the bending loss in a multimode fibre
3. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
4. To measure the near field intensity profile of a fibre and study its refractive index profile
   To determine the power loss at a splice between two multimode fibre

Reference Books
➢ Fundamental of optics, F.A. Jenkins & H.E.White,1981,Tata McGrawhill.
➢ LASERS: Fundamentals & applications, K. Thyagrajan & A.K. Ghatak, 2010,Tata McGrawHill

- Fibre optics through experiments, M.R. Shenoy, S.K. Khijwania, et.al. 2009, Viva Books
- Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008,Elsevier.
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007,Springer.
- Optical Systems and Processes, JosephShamir,2009, PHI Learning Pvt. Ltd.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
- Optical Physics, A. Lipson, S.G. Lipson, H. Lipson, 4th Edn., 1996, Cambridge Univ. Press

9. WEATHER FORECASTING
(Credits: 02)
F.M. = 50 (Theory - 40, Internal Assessment – 10)
Internal Assessment [Class Attendance (Theory) – 05, Theory
(Class Test/ Assignment/ Tutorial) – 05]
Theory: 30 Lectures
The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics. **(9 Periods)**

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws. **(4 Periods)**

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes. **(3 Periods)**

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate. **(6 Periods)**

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

(8 Periods)

Demonstrations and Experiments:

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

Reference books:

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

Discipline specific elective course (DSE) (any two for Pass/General course only): (Credit: 06 each)

PHY-G-DSE-T-01: MECHANICS
(Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]
Theory: 60 Lectures

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

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

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

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

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

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

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

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

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

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

Reference Books:
- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addi son-Wesley
- Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
- Physics - Resnick, Halliday & Walker 9/e, 2010, Wiley
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
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PHY-G-DSE-P-01: MECHANICS

Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures

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

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

OR, PHY-G-DSE-T-01: ELECTRICITY AND MAGNETISM

(Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]
Theory: 60 Lectures

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

(12 Lectures)

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

conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

(22 Lectures)

Magnetism:
Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.
Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro magnetic materials. **(10 Lectures)**

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

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

(10 Lectures)

Reference Books:
- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
- Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press
- Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.
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PHY-G-DSE-P-01: ELECTRICITY AND MAGNETISM
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

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

9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

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

OR, PHY-G-DSE-T-01: THERMAL PHYSICS AND STATISTICAL MECHANICS (Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

Theory: 60 Lectures

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

(22 Lectures)

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

(10 Lectures)

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

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

(6 Lectures)

Statistical Mechanics: Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein

distribution law - photon gas - comparison of three statistics.   **(12 Lectures)**

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

PHY-G-DSE-P-01: THERMAL PHYSICS AND STATISTICAL MECHANICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures
1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo e.m.f across two junctions of a thermocouple with temperature.

9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

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

OR, PHY-G-DSE-T-01: WAVES AND OPTICS
(Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

Theory: 60 Lectures

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

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

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

Fluids: Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature- lubrication. **(6 Lectures)**

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

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

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

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

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

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

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

PHY-G-DSE-P-01: WAVES AND OPTICS

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

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

PHY-G-DSE-T-02: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION
(Credits: Theory-04, Practicals-02)
 F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]
Theory: 60 Lectures

UNIT-1: Digital Circuits
Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR

Gates. (4 **Lectures**)

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. (5 **Lectures**)

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

UNIT-2: Semiconductor Devices and Amplifiers:
Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. (5 **Lectures**)

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains a and p. Relations between a and p. Load Line analysis of Transistors. DC Load line & Q-point. Active, Cutoff & Saturation regions. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers. **(12 Lectures)**

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

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

UNIT-4: Instrumentations: Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. (3 **Lectures**)

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation. (6 **Lectures**)

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

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

Learning Pvt. Ltd.
- OP-AMP & Linear Digital Circuits, R. A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

PHY-G-DSE-P-02: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05, Experiment -10)

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

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

OR, PHY-G-DSE-T-02: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

Theory: 60 Lectures

Planck's quantum, Planck's constant and light as a collection of photons; Photo electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.   **(8 Lectures)**

Problems with Rutherford model- instability of atoms and observation of discrete

atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. **(4 Lectures)**

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. **(4 Lectures)**

Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension. **(11 Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier. **(12 Lectures)**

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

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life; a decay; (3 decay - energy released, spectrum and Pauli's prediction of neutrino; y-ray emission. **(11 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.**(4 Lectures)**

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

PHY-G-DSE-P-02: ELEMENTS OF MODERN PHYSICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

Theory: 60 Lectures
1. To determine value of Boltzmann constant using V-I characteristic of PN diode.

2. To determine work function of material of filament of directly heated vacuum diode.

3. To determine the ionization potential of mercury.

4. To determine value of Planck's constant using LEDs of at least 4 different colors.

5. To determine the wavelength of H-alpha emission line of Hydrogen atom.

6. TodeterminetheabsorptionlinesintherotationalspectrumofIodinevapour.

7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photo sensor & compare with incoherent source –Na.

8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light

9. To determine the value of e/m by(a)Magnetic focusing or (b) Bar magnet.

10. TosetuptheMillikanoildropapparatusanddeterminethechargeofanelectron.

11. To determine the slit width(a) the wavelength of monochromatic/ laser a source using diffraction of single slit.

12. To determine the slit width (a,b) the wavelength of monochromatic/ laser a source using diffraction of double slits.

13. To determine (1) wavelength of He-Ne light /laser using plane diffraction grating

14. To draw the I-V characteristics of a valve diode and to verify the laws of thermionic emission.

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

OR, PHY-G-DSE-T-02: SOLID STATE PHYSICS

(Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

Theory: 60 Lectures
Prerequisites: Knowledge of "Elements of Modern Physics"

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

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

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

(12 Lectures)

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons. **(10 Lectures)**

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

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

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

PHY-G-DSE-P-02: SOLID STATE PHYSICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

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

8.   To study the BH curve of iron using a Solenoid and determine the energy loss.
9.   To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap.
10.   To determine the Hall coefficient of a semiconductor sample.
11.   To measure the mutual inductance of two coaxial coils at various relative orientations using a ballistic galvanometer.
12.   Verification of the inverse cube law for magnetic dipoles (study of the dependence of the field of a magnetic dipole on distance) and determination of the horizontal component of the earth's magnetic field by deflection and oscillation magnetometers.

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

OR, PHY-G-DSE-T-02: QUANTUM MECHANICS
(Credits: Theory-04, Practicals-02)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)
Internal Assessment [Class Attendance (Theory) – 05, Theory (Class Test/ Assignment/ Tutorial) – 05, Practical (Sessional Viva-voce) - 05]

Theory: 60 Lectures
Prerequisites: Knowledge of (1) "Mathematical Physics" and (2) "Elements of Modern Physics "

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

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

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

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers 1 and m; s, p, d,.. shells (idea only) **(10 Lectures)**

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

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

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

Reference Books:
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics for Scientists and Engineers, D.A.B. Miller, 2008, Cambridge University Press

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

PHY-G-DSE-P-02: QUANTUM MECHANICS
Practical – 20 marks (Lab. Note Book – 05, Viva-Voce-05,Experiment -10)

60 Lectures
Use Fortan/Python/Matlab/Octave/ C/C++/Scilab for solving the following problems based on Quantum Mechanics like

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

$$\frac{d^2 y(r)}{dr^2} + \frac{2m}{\hbar^2}\left(E - V(r)\right)y(r) = 0, \text{ where } V(r) = -\frac{e}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is « -13.6 eV. Take e = 3.795 (eVA)$^{1/2}$, he = 1973 (eVA) and m = 0.511x10^{6}eV/c^2.

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

where m is the reduced mass of the system (which can be chosen to be the mass of an

electron), for the screened coulomb potential

$$\frac{d^2 y(r)}{dr^2} + \frac{2m}{\hbar^2}\left(E - V(r)\right)y(r) = 0, \text{ where } V(r) = -\frac{e}{r}e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVA)^{1/2}$, m = 0.51 1x10^6 eV/c^2, and a = 3 A, 5 A, 7 A. In these units he = 1973 (eVA). The ground state energy is expected to be above -12 eV in all three cases.

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

$$\frac{d^2 y(r)}{dr^2} + \frac{2m}{\hbar^2}\left(E - V(r)\right)y(r) = 0, \text{ where } V(r) = -\frac{e}{r}e^{-r/a}$$

For the anharmonic oscillator potential

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

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

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

$$\frac{d^2 y(r)}{dr^2} + \frac{2m}{\hbar^2}\left(E - V(r)\right)y(r) = 0, \text{ where } V(r) = D\left(e^{-2\alpha r'} - e^{-2\alpha r'}\right), r' = \frac{r-r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take m=940x106eV/c, D=0.755501 eV, α=1.44, r_0=0.131349A

Laboratory based experiments:
8.   Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
9.   Study of Zeeman effect: with external magnetic field; Hyperfine splitting
10. To show the tunnelling effect in tunnel diode using I-V characteristics.
8.   Quantum efficiency of CCD s

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

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

OR, PHY-G-DSE-T-02: NUCLEAR AND PARTICLE PHYSICS
(Credits: Theory-05, Tutorials-01)
F.M. = 75 (Theory - 60, Internal Assessment – 15)

Internal Assessment [Class Attendance – 05,
Class Test/ Assignment/ Tutorial – 10]

Theory: 75 Lectures
Prerequisites: Knowledge of "Elements of Modern Physics"

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

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. (12 **Lectures)**

Radioactivity decay:(a) Alpha decay: basics of a-decay processes, theory of a-emission, Gamow factor, Geiger Nuttall law, a-decay spectroscopy. (b) (3-decay: energy kinematics for (3-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **(9 Lectures)**

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

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

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. (6 **Lectures)**
Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. **(6 Lectures)**

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

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular

momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. **(14 Lectures)**

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