University of Kalyani

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN
PHYSICS (HONOURS)

WITH EFFECT FROM THE ACADEMIC SESSION

2022-2023

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN PHYSICS (HONOURS)

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 Set of two 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):** SEC must be opted in 3rd, 4th Semester only. SEC-01 is meant for 3rd Semesters and SEC-02 is meant for 4th Semesters. Student of Physics Honours will take SEC course from Physics.

CBCS CURRICULUM FOR SEMESTARIZED UNDER-GRADUATE
COURSE IN PHYSICS (HONOURS)

A. TOTAL Number of courses in UG-CBCS (B.Sc. PHYSICS Hons.):

Types of course	Core course (CC)	Elective course		Ability enhancement course		TOTAL
		Discipline specific elective course (DSE)	Generic elective course(GE)	Ability Enhancement compulsory course (AECC)	Skill Enhancement course (SEC)	
No. of course	14	4	4	2	2	26
Credit/course	6	6	6	2	2	140

Structure of B.Sc. Honours in PHYSICS under CBCS

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

Discipline Specific Elective Courses (DSE) -to be opted for in Semesters V and VI

Semesters V	Semesters VI
Advanced Mathematical Physics / Classical Dynamics	Nano Materials and Applications / Communication Electronics
Nuclear and Particle Physics /Astronomy and Astrophysics	Biophysics / Dissertation

Generic Elective Courses (GE) - Courses offered to students of other Departments
1. Mechanics/ Thermal Physics and Statistical Mechanics (Semester-I)
2. Electricity and Magnetism/ Waves and Optics (Semester-II)
3. Thermal Physics and Statistical Mechanics/ Mechanics (Semester-III)
4. Waves and Optics/ Electricity and Magnetism (Semester-IV)

Ability Enhancement Compulsory Courses (AECC) - Two compulsory courses in Semesters I & II
1. Environmental Science
2. Bengali / English communication

Skill Enhancement Courses (SEC): Two courses in Semesters III and IV
1. Electrical circuits & Network Skills/ Basic Instrumentation Skills (Semester III)
2. Renewable Energy & Energy harvesting/ Weather Forecasting (Semester-IV)

TABLE-1: DETAILS OF COURSES & CREDIT OF B.SC. PHYSICS (HONOURS) UNDER CBCS

S. No.	Particulars of Course	Credit Point	
		Theory + Practical	Theory + Tutorial
1.	**Core Course: 14 Papers**		
1.A.	Core Course: Theory (14 papers)	14x4 = 56	14x5 = 70
1.B.	Core Course (Practical/Tutorial)*(14 papers)	14x2 = 28	14x1= 14
2.	**Elective Courses: (8 papers)**		
2.A.	A. Discipline specific Elective(DSE)(4 papers)		4x5 = 20
2.B.	DSE (Tutorial)* (4 papers)		4x1 =4
2C.	General Elective(GE) (Interdisciplinary) (4 papers)	4x4 = 16	4x5 = 20
2.D.	GE (Practical / Tutorial)* (4 papers)	4x2 =8	4x1 =4
	#Optional Dissertation/ Project Work in place of **one** *DSE paper (6 credits) in 6ᵗʰ semester*		
3. Ability Enhancement Courses			
A.	AECC(2 papers of 2 credits each) ENVS, English Communication/ MIL	2x2 = 4	2x2 = 4
B.	Skill Enhancement Course(SEC) (2 papers of 2 credits each)	2x2 = 4	2x2 = 4
	Total Credit:	**140**	**140**

Wherever there is a practical, there will be no tutorial and vice- versa.
*DSE courses do not have any practical module. In these courses the students will appear in tutorial instead of practical examination.
**Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

TABLE-2: SEMESTERWISE DISTRIBUTION OF COURSE & CREDITS IN B.SC. PHYSICS (HONOURS) UNDER CBCS

Courses/ (Credits)	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-Vi	Total No. of Courses	Total credit
CC (6)	2	2	3	3	2	2	14	84
DSE (6)	--	--	--	--	2	2	04	24
GE (6)	1	1	1	1	--	--	04	24
AECC (2)	1	1			--	--	02	04
SEC (2)	--	--	1	1	--	--	02	04
Total No. of Course/ Sem.	4	4	5	5	4	4	26	
Total Credit /Semester	20	20	26	26	24	24		140

❖ **COURSE CODE & COURSE TITLE:**

❖ *Each paper of any course denoted by-(2-4 letters Subject Code--Honours/General (H/G)--Course Type(CC/GE/DSE)-(Theory/Tutorial/Practical)-Number of course. Ex.-Physics-PHY-H-CC-T-1)*

A. Core courses (CC)

1. PHY-H-CC-T/P-01: Mathematical Physics-I
2. PHY-H-CC-T/P-02: Mechanics
3. PHY-H-CC-T/P-03: Electricity and Magnetism
4. PHY-H-CC-T/P-04: Waves and Optics
5. PHY-H-CC-T/P-05: Mathematical Physics-II
6. PHY-H-CC-T/P-06: Thermal Physics
7. PHY-H-CC-T/P-07: Analog Systems and Applications
8. PHY-H-CC-T/P-08: Mathematical Physics III
9. PHY-H-CC-T/P-09: Elements of Modern Physics
10. PHY-H-CC-T/P-10: Digital Systems and Applications
11. PHY-H-CC-T/P-11: Quantum Mechanics and Applications
12. PHY-H-CC-T/P-12: Statistical Mechanics
13. PHY-H-CC-T/P-13: Electromagnetic Theory
14. PHY-H-CC-T/P-14: Solid State Physics

B. Discipline specific elective courses (DSE)
1. PHY—H-DSE-T-01: Advanced Mathematical Physics /Classical Dynamics

2. PHY—H-DSE-T-02: Nuclear and Particle Physics/Astronomy and Astrophysics

3.   PHY—H-DSE-T-03: Nano Materials and Applications/Communication Electronics
4.   PHY—H-DSE-T-04: Bio Physics/Dissertation

C. Generic elective courses (GE):
1. PHY—H-GE-T/P-01:- Mechanics/ Thermal Physics and Statistical Mechanics (Semester-I)
2. PHY—H-GE-T/P-02:- Electricity and Magnetism/ Waves and Optics (Semester-II)
3. PHY—H-GE-T/P-03:- Thermal Physics and Statistical Mechanics/ Mechanics (Semester-III)
4. PHY—H-GE-T/P-04:- Waves and Optics/ Electricity and Magnetism (Semester-IV)

D. Ability enhancement compulsory courses (AECC)
1. AECC-01: Environmental Science
2. AECC-02: Bengali/English Communication

E. Skill enhancement courses (SEC)
1. PHY—H-SEC-T/P-01: Electrical circuits & Network Skills/ Basic Instrumentation Skills (Semester III)
2. PHY—H-SEC-T/P-02: Renewable Energy & Energy Harvesting/ Weather Forecasting (Semester-IV)

TABLE-3: SEMESTER & COURSEWISE CREDIT DISTRIBUTION IN B.SC. PHYSICS (HONOURS) UNDER CBCS (6 Credit: 75 Marks)

	Course Code	Course Title	Course wise Class (L+T+P)	Credit
Semester I	PHY-H-CC-T- 01	Mathematical Physics-I	Core (60L)	4
	PHY-H-CC-P- 01		Core (60P)	2
	PHY-H-CC-T-02	Mechanics	Core (60L)	4
	PHY-H-CC-P-02		Core (60P)	2
	PHY-H-GE-T- 01	Mechanics/ Thermal Physics and Statistical Mechanics	Generic Elective (60L)	4
	PHY-H-GE-P- 01		Generic Elective (60P)	2
	AECC-01	Environmental Science	Ability Enhancement Compulsory (30L)	2
	Total	**4 courses**	**Total**	**20**
Semester II	PHY-H-CC-T-03	Electricity and Magnetism	Core (60L)	4
	PHY-H-CC-P-03		Core (60P)	2
	PHY-H-CC-T- 04	Waves and Optics	Core (60L)	4
	PHY-H-CC-P- 04		Core (60P)	2
	PHY-H-GE-T-02	Electricity and Magnetism/ Waves and Optics	Generic Elective (60L)	4
	PHY-H-GE-P- 02		Generic Elective (60P)	2
	AECC-2	Bengali / English communication	Ability Enhancement Compulsory (30L)	2
	Total	**4 courses**	**Total**	**20**
Semester III	PHY-H-CC-T- 05	Mathematical Physics-II	Core (60L)	4
	PHY-H-CC-P-05		Core (60P)	2
	PHY-H-CC-T-06	Thermal Physics	Core (60L)	4
	PHY-H-CC-P-06		Core (60P)	2
	PHY-H-CC-T-07	Analog Systems and Applications	Core (60L)	4
	PHY-H-CC-P-07		Core (60P)	2
	PHY-H-GE-T-03	Thermal Physics and Statistical Mechanics/ Mechanics	Generic Elective (60L)	4
	PHY-H-GE-P-03		Generic Elective (60P)	2
	PHY-H-SEC-T-01	Electrical Circuits & Network Skills/ Basic Instrumentation Skills	Skill Enhancement (30L)	2
	Total	**5 courses**	**Total**	**26**
Semester IV	PHY-H-CC-T- 08	Mathematical Physics III	Core (60L)	4
	PHY-H-CC-P- 08		Core (60P)	2
	PHY-H-CC-T-09	Elements of Modern Physics	Core (60L)	4
	PHY-H-CC-P-09		Core (60P)	2
	PHY-H-CC-T-10	Digital Systems and Applications	Core (60L)	4
	PHY-H-CC-P-10		Core (60P)	2
	PHY-H-GE-T-04	Waves and Optics/ Electricity and Magnetism	Generic Elective (60L)	4
	PHY-H-GE-P-04		Generic Elective (60P)	2
	PHY-H-SEC-T-02	Renewable Energy & Energy harvesting/Weather Forecasting	Skill Enhancement (30L)	2
	Total	**5 courses**	**Total**	**26**
Semester V	PHY-H-CC-T-11	Quantum Mechanics & Applications	Core (60L)	4
	PHY-H-CC-P-11		Core (60P)	2
	PHY-H-CC-T-12	Statistical Mechanics	Core (60L)	4
	PHY-H-CC-P-12		Core (60P)	2
	PHY-H-DSE-T-01	Advanced Mathematical Physics /Classical Dynamics	Discipline Specific Elective (75L+15T)	5+1
	PHY-H-DSE-T-02	Nuclear and Particle Physics /Astronomy and Astrophysics	Discipline Specific Elective (75L+15T)	5+1
	Total	**4 courses**	**Total**	**24**

	PHY-H-CC-T-13	Electro-magnetic Theory	Core (60L)	4
	PHY-H-CC-P-13		Core (60P)	2
	PHY-H-CC-T-14	Solid State Physics	Core (60L)	4
	PHY-H-CC-P-14		Core (60P)	2
Semester VI	PHY-H-DSE-T -03	Nano Materials and Applications / Communication Electronics	Discipline Specific Elective (75L+15T)	5+1
	PHY-H-DSE-T-04	Biophysics / Dissertation (Follow Guidelines of Dissertation)	Discipline Specific Elective (75L+15T)	5+1
	Total	**4 courses**	**Total**	**24**

Class Assignments
The class assignment for different course segments (theory, practical, tutorial) are as follows:
- ➢ Theory: 1 credit = 1 hour/week
- ➢ Practical: 1 credit = 2 hours/week
- ➢ Tutorial: 1 credit = 1 hour/week
- ➢ Project: 1 credit = 1 hour/week

CORE COURSE (HONOURS IN PHYSICS)

PHY-H-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.

(5 **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. (10 **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.

(5 **Lectures**)

Vector Calculus:
Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. (6 **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. **(7Lectures)**

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 proof)
(10 Lectures)

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

Matrices: Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Eigen-values and Eigenvectors (Degenerate and non-degenerate). Cayley-Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary homogeneous Differential Equations. Functions of a Matrix. (6 **Lectures**)

Introduction to probability:
Independent random variables: Sample space and Probability distribution functions. Binomial, Gaussian, and Poisson distribution with examples. Mean and variance. **(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.
- Vector Analysis, S. Lipschutz, D. Spellman, M. R. Spiegel, Schaum's Outlines Series
- Fundamentals of Mathematical Physics, A.B. Gupta, Books & Allied Ltd; 5th edition
- Mathematical Physics, Goswami, 1st edition, Cengage Learning
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Higher Enginering Mathematics, B. S. Grewal, Khanna Publisher
- Play with Graphs, Amit M. Agarwal, Arihant Publisher
- 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
- Undergraduate Physics Companion (Vol-1), S. Pal, 1st edition, Suhrid Prakashani, Kolkata

PHY-H-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*

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 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.

Introduction to plotting graphs with Matplotlib/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

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, Factorial of a number, sum of a power series e.g. sin, cosine, exponential series etc.

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

Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation
Evaluation of trigonometric functions e.g. *sinθ*, *cosθ*, *tanθ* 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. Monte-Carlo integration

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

Referred Books:
• Introduction to Numerical Analysis, S.S. Sastry, 5 th Edn. , 2012, PHI Learning Pvt. Ltd.

- Numerical Methods, Arun Kr Jalan, Utpal Sarkar, University Press
- Python Programming, Satyanarayana, Radhika Mani, Jagdesh, University Press
- Scientific Computing in Python, Abhijit Kar Gupta, Techno World
- 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, 3 rd Edn. , 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006, Cambridge Univ. Press

PHY-H-CC-T-02: 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. Euler's Equation. Bernoulli's Theorem.
(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 effectson 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. Four Vectors (definition and examples only). **(10 Lectures)**

Reference Books:
• Mechanics and general properties of matter, Satyendra Nath Maiti and Debiprasad Roychoudhury, New age international.
• Mechanics through Problems, Dhiranjan Roy, Ananda Dasgupta, 2022, Techno World.
• Problems in General Physics, I E Irodov, Arihant Publications.
• Mechanics, Berkeley Physics, vol. 1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
• Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
• 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.
• Undergraduate Physics Companion (Vol-1), S. Pal, 1st edition, Suhrid Prakashani, Kolkata
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
• Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PHY-H-CC-P-02: **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 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
- Practical Physics Vol 1, Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
- 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

PHY-H-CC-T-03: 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 Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.
                                  (9 Lectures)

Magnetic Properties of Matter:
Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability. Relation between B, H, M. B-H curve and hysteresis. **(3 Lectures)**

Electromagnetic Induction:
Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. **(5 Lectures)**

Transients: Growth and decay of currents and voltages in L-R, C-R and L-C-R circuits; electrical oscillations in L-C circuits. **(2 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
- 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
- Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

- Undergraduate Physics Companion (Vol-2), S. Pal, 1st edition, Suhrid Prakashani, Kolkata.

PHY-H-CC-P-03: 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
• Practical Physics Vol 1, Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
• 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-H-CC-T-04: **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 equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and equal frequency differences.
(5 Lectures)

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

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

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

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

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

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

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

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

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

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

Reference Books
- A Text Book on Light, B. Ghosh, K.G. Mazumder, Sreedhar Publisher.
- Advanced Acoustics, D. P. Roychowdhury, Chayan Publisher
- 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
- Optics, Ajoy 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

- Undergraduate Physics Companion (Vol-2), S. Pal, 1st edition, Suhrid Prakashani, Kolkata

PHY-H-CC-P-04: 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 Lissajous Figures.

4. Familiarization with: Schuster's focusing; determination of angle of prism.

5. To determine refractive index of the Material of a prism using sodium source.

6. To determine the dispersive power 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
- B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited.
- Advanced Practical Physics, Vol 1, B. Ghosh, K.G.Majumdar, Shreedhar Publishers.
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
- 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-H-CC-T-05: 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 Physics, H.K. Dass, S Chand Publishing
*   Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
*   Mathematical Physics, P.K. Chattopadhyay, 2014, New Academic Science
*   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-H-CC-P-05: 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/Fortan/C/ C++
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.

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

Solve Ordinary Differential Equations (ODE) (1st and 2nd order Differential equation) by Euler, modified Euler and Runge-Kutta (RK) 2nd and 4th order methods
✓   Radioactive decay
✓   Current in LCR, RC, LC circuits with DC source and AC source.
✓   Newton's law of cooling
✓   Classical equations of motion (1st and 2nd order Differential Equations)
✓   Simple harmonic oscillator
✓   Damped, overdamped, critically damped harmonic oscillator.
✓   Undamped and damped forced harmonic oscillator

✓ Transient and Steady state solution of a forced harmonic oscillator

Also attempt some problems on differential equations like:

(i)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.

(ii)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. $\theta(0) = a$, $\theta'(0) = 0$. Use the RK4 method to solve the equation for a = 0.1, 0.5 and 1.0 and plot θ as a function of time in the range $0 < t < 8\pi$. Also, plot the analytic solution valid in the small θ $(\sin(\theta) = \theta)$.

Solve Partial Differential Equations (PDE) by Fixed difference method

a) Wave equation
b) Heat equation
c) Poisson equation
d) Laplace equation

Reference Books:

- Physics in Laboratory including python Programming (Semester III), Mandal, Chowdhuri, Das, Das, Santra Publication
- 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. Fernandez. 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

PHY-H-CC-T-06: 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
Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroeth 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:
- Thermal Physics, A. B. Gupta, Haripada Roy, Books & Allied Ltd
- 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, Blundell and Blundell, 2nd Ed., 2012, Oxford University Press

PHY-H-CC-P-06: **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
- Advanced Practical Physics, Vol 1, B. Ghosh, K. G. Majumder, Sreedhar Publication
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd
- 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-H-CC-T-07: **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: Halfwave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.
(6 Lectures)
Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC

Configurations. Current gains α and β, Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

(6 Lectures)

Amplifiers: Transistor Biasing and 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.
- Fundamental Principles of Electronics, B Ghosh, 2nd ed, 2008, Books & Allied (P) Ltd.
- 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-H-CC-P-07: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 Colpitt's oscillator.

11. To design a digital to analog converter (DAC) of given specifications.

12. To study the analog to digital convertor (ADC) IC.

13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain

14. To design inverting amplifier using Op-amp (741,351) and study its frequency response

15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response

16. To study the zero-crossing detector and comparator

17. To add two dc voltages using Op-amp in inverting and non-inverting mode

18. To design a precision Differential amplifier of given I/O specification using Opamp.

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.
• Advanced Practical Physics (volume II), B. Ghosh , Shreedhar Publication
• An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd
• Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
• Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

PHY-H-CC-T-08: 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-H-CC-P-08: **MATHEMATICAL PHYSICS-III**
Practical - 20 marks (Lab. Note Book - 05, Viva-Voce-05,Experiment -10) **60 Lectures**

Numerical computation using Python/MATLAB/Octave/Fortran/C/C++:

1. Dirac delta function: Calculate the integration $\int e^{\frac{-(2-x)^2}{2\sigma^2}} (x+3)dx$ for σ=1, .1, .01 and show it tends to 5.
2. Write a program to calculate the sum $\sum_{n=1}^{\infty} 0.2^n$
3. Evaluate the Fourier coefficients of a given periodic function (square wave).
4. Frobenius method and special functions: Verify the relation $\int_{-1}^{1} P_n(\mu)P_m(\mu) = \delta_{n,m}$. Plot $P_n(x)$, $J_n(x)$.
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*.
8. Given Bessel's function at N points find its value at an intermediate point.
9. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
10. Compute the nth roots of unity for n = 2, 3, and 4.
11. Find the two square roots of -5+12j.
12. Integral transform: FFT of *exp(-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

PHY-H-CC-T-09: 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 hypothesis, 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; Waveparticle 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.

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.
- Quantum Mechanics, Bransden and Joachain, Pearson Education Ltd.
- 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 Atomic and Nuclear Physics, A. B. Gupta, Books & Allied Ltd; 2nd Revised edition.
- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill
- 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.
- Quantum Mechanics, Volume 1: Basic Concepts, Tools, and Applications, Claude Cohen-Tannoudji, Bernard Diu , Franck Laloë, Wiley-VCH; 2nd edition (9 October 2019)
- 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-H-CC-P-09: 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

PHY-H-CC-T-10: 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 ICs. **(3 Lectures)**

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (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.

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.   **(6 Lectures)**

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & 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:
- Electronics: Fundamentals and Applications, D. Chattopadhyay, P.C. Rakshit, New Age Publication
- Fundamental Principles of Electronics, B Ghosh, 2nd ed, 2008, Books & Allied (P) Ltd.
- Fundamentals of Microprocessor and Microcontrollers, B. Ram, Dhanpat Rai Publications.
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- 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. Gaonkar, Prentice Hall.

PHY-H-CC-P-10: 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.
- Advanced Practical Physics (volume II), B. Ghosh , Shreedhar Publication
- 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.

PHY-H-CC-T-11: 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. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Hermitian Operators, Expectation values of position and momentum. Wave Function of a Free Particle. (8 **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. (5 **Lectures**)

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle. **(10 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. **(11 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. **(11 Lectures)**

Atoms in External Magnetic Fields:- Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). **(5 Lectures)**

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

Reference Books:
- Foundation Of Quantum Mechanics, AB Gupta, Books & Allied (P) Ltd.
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Wiley india Pvt. Ltd; 2nd edition
- Problems And Solutions On Quantum Mechanics, Y. K. Lim, Sarat Book Distributors.
- Atomic & Molecular Spectra: Laser, Raj Kumar, Kedar Nath, Ram Nath.
- 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-H-CC-P-11: 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: $\frac{d^2y}{dr^2} = \frac{2m}{\hbar^2}(E - V(r))y$

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

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

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

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

   Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVA)$^{1/2}$, $m = 0.511 \times 10^6 eV/c^2$, 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: $\frac{d^2y}{dr^2} = \frac{2m}{\hbar^2}(E - V(r))y$,

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

   Convert to dimensionless variables. Plot the Ground and first exited state wave functions.

4. Solve the s-wave radial Schrodinger equation for the vibration of hydrogen molecule:
   $\frac{d^2y}{dr^2} = \frac{2m}{\hbar^2}(E - V(r))y$, where V(r) = $D(e^{-2\alpha r'} - e^{-\alpha r'})$, $r'=(r-r_0)/r$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take m =940×106eV/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 CCD'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., 3 rd 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. Fernandez.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

PHY-H-CC-T-12: 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:
- An Introductory Course of Statistical Mechanics, Palash Baran Pal, Narosa.
- Introduction to Statistical Mechanics, S. K. Sinha, Narosa.
- Statistical Mechanics, Upendranath Nandi, Techno World.
- Statistical Mechanics, 2ed, (An Indian Adaptation), K. Huang Wiley India Pvt Ltd.
- 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-H-CC-P-12: STATISTICAL MECHANICS
Practical - 20 marks (Lab. Note Book - 05, Viva-Voce-05,Experiment -10)

60 Lectures
Use C/C+$^+$/Scilab/Fortan/Python/Matlab 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.

6. Write a program to flip a coin for n times and count heads and tails.

7. Write a program for roll a dice and display the number.

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. Fernandez. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub.

PHY-H-CC-T-13: **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.
- A Text Book on Light, B Ghosh, K G Mazumder, Sreedhar Publisher.
- 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 for Engineers & Physicists, G. Lehner, 2010, Springer
- Problems And Solutions In Electromagnetics, Ajoy Ghatak K. Thyagarajan R. K. Varshney,

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.

PHY-H-CC-P-13: 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 (Vol 1 & Vol 2), B. Ghosh, K. G. Majumder, Sreedhar Publication
- 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

PHY-H-CC-T-14: **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.
- Solid State Physics, S O Pillai, New Age International Private Limited.
- 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, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications
- Solid State Physics, A J Dekker, Laxmi Publication

PHY-H-CC-P-14: 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.

PHYSICS-DSE 1-4 (ELECTIVES)

PHY-H-DSE-T-01: ADVANCED MATHEMATICAL PHYSICS
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures
F.M. = 75 (Theory - 60, Internal Assessment - 15)
Internal Assessment [Class Attendance -05,Class Test/ Assignment/ Tutorial - 10]
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.

Laplace Transform (No. of Lectures:15)

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Linear Vector Spaces (No. of Lectures:15)
Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of

Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. Inner products. Gram-Schmidt orthogonalization. Orthogonal and unitary transformations and their matrix representations.

Cartesian Tensors (No. of Lectures:15)

Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line.Condition for Two Lines to be Coplanar. Foot Perpendicular from a Point on a Line.Rotation Tensor(NoDerivation).IsotropicTensors.Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

General Tensors (No. of Lectures:15)

Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. MetricTensor.

Reference Books
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- MathematicalMethodsforPhysicists,G.B.Arfken,H.J.Weber,andF.E.Harris,19 70,Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011,Cambridge University Press
- Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, DoverPub.
- Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole

OR, PHY-H-DSE-T-01: CLASSICAL DYNAMICS
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures
F.M. = 75 (Theory - 60, Internal Assessment - 15)
Internal Assessment [Class Attendance -05, Class Test/ Assignment/ Tutorial - 10]
The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

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

(22 Lectures)

Special Theory of Relativity: Geometrical interpretation of Space-time:Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Intervals: space-like, time-like & light-like. Four-

velocity and acceleration. Elementary idea of tensors: Covariant and contravariant tensors, Metric and alternating tensors. Four-momentum and energymomentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle. The Electromagnetic field tensor and its transformation under Lorentz transformations: relation to known transformation properties of E and B. Electric and magnetic fields due to a uniformly moving charge. Equation of motion of charged particle & Maxwell's equations in tensor form. Motion of charged particles in external electric and magnetic fields. **(38 Lectures)**

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

Reference Books:
- Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
- The special theory of relativity, Sriranjan Banerji, Asit Banerjee, PHI.
- Fundamentals of Special and General Relativity, K D Krori, PHI.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
- The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
- Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
- An Introduction to Classical Electromagnetic Radiation, G. S. Smith, Cambridge University Press

PHY-H-DSE-T-02: NUCLEAR AND PARTICLE PHYSICS
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures
F.M. = 75 (Theory - 60, Internal Assessment - 15)
Internal Assessment [Class Attendance -05, Class Test/ Assignment/ Tutorial - 10]
General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(10 Lectures)**

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

Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of a-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) (β- decay: energy kinematics for (β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **(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:
• Problems And Solutions On Atomic, Nuclear And Particle Physics, Lim Yung-Kou, Sarat Book Distributors.
• Nuclear Physics, S N Ghosal, S Chand Publishing.
• Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
• Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
• Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
• Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
• Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).

OR, PHY-H-DSE-T-02: ASTRONOMY & ASTROPHYSICS

(Credits: Theory-05, Tutorials-01) Theory: 75 Lectures

F.M. = 75 (Theory - 60, Internal Assessment - 15)
Internal Assessment [Class Attendance -05, Class Test/ Assignment/ Tutorial - 10]

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

Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars:

Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

(25 Lectures)

Astronomical techniques: Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of

Detectors, detection Limits with Telescopes).

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

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

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

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

Nucleosynthesis and stellar evolution: Cosmic Abundances, Stellar Nucleosynthesis, Evolution of Stars (Evolution on the Main Sequence, Evolution beyond the Main Sequence), Supernovae. **Compact stars:** Basic Familiarity with Compact Stars, Equation of State and Degenerate Gas of Fermions, Theory of White Dwarf, Chandrasekhar Limit, Neutron Star (Gravitational Red-shift, Neutron Star, Detection of Neutron Star: Pulsars), Black Hole. The milky way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and round the Galactic Nucleus. **(11 Lectures)**

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

Active galaxies: 'Activities' of Active Galaxies, How 'Active' are the Active Galaxies? Classification of the Active Galaxies, Some Emission Mechanisms Related to the Study of Active Galaxies, Behaviour of Active Galaxies (Quasars and Radio Galaxies, Seyferts, BL Lac Objects and Optically Violent Variables), The Nature of the Central Engine, Unified Model of the Various Active Galaxies. **(8 Lectures)**

Large scale structure & expanding universe: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter), Friedmann Equation and its Solutions, Early Universe and Nucleosynthesis (Cosmic Background Radiation, Evolving vs. Steady State Universe) **(8 Lectures)**

Reference Books:
- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.

- Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

PHY-H-DSE-T-03: NANO MATERIALS AND APPLICATIONS
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures
F.M. = 75 (Theory - 60, Internal Assessment - 15)
Internal Assessment [Class Attendance -05, Class Test/ Assignment/ Tutorial - 10]

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

SYNTHESIS OF NANOSTRUCTURE MATERIALS: Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, Ebeam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spraypyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.   **(10 Lectures)**

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

OPTICAL PROPERTIES: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalizationabsorption, emission and luminescence. Optical properties of heterostrctures and nanostructures.   **(16 Lectures)**

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

APPLICATIONS: Applications of nanoparticles, quantum dots, nano wires and thin films for photonic devices (LED, solar cells). Single electron devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).   **(18 Lectures)**

Reference books:
- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- Nanomaterials Theory Problems and Solutions, Upendranath Nandi, Debnarayan Jana, Techno World.
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).

- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
- M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
- Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

OR, PHY-H-DSE-T-03: COMMUNICATION ELECTRONICS
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures
F.M. = 75 (Theory - 60, Internal Assessment - 15)
Internal Assessment [Class Attendance -05, Class Test/ Assignment/ Tutorial - 10]

Electronic communication (No. of Lectures:11)
Introduction to communication - means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

Analog Modulation (No. of Lectures:15)
Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

Analog Pulse Modulation (No. of Lectures:12)
Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

Digital Pulse Modulation (No. of Lectures:12)
Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

Introduction to Communication and Navigation systems: (No. of Lectures: 25)
Satellite Communication- Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. Mobile Telephony System - Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only)

Reference Books
- Electronic Communications, D. Roddy and J. Coolen, Pearson EducationIndia.
- Advanced Electronics Communication Systems- Tomasi, 6th edition, PrenticeHall.
- Communication System by Sanjay Sharma, S.K. Kataria and Sons
- Electronic Communication: Modulation and Transmission by Schoenbeck, Prentice Hall India Learning Private Ltd.

- Electronic Communication systems, G. Kennedy, 3rd Edn, 1999, Tata McGraw Hill.
- Principles of Electronic communication systems- Frenzel, 3rdedition, McGrawHill
- Communication Systems, S. Haykin, 2006, Wiley India
- Electronic Communication system, Blake, Cengage, 5th edition.
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

PHY-H-DSE-T-04: Bio-Physics

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

F.M. = 75 (Theory - 60, Internal Assessment - 15)
Internal Assessment [Class Attendance - 05, Class Test/ Assignment/ Tutorial - 10]

Building Blocks & Structure of Living State: Atoms and ions, molecules essential for life, what is life. **Living state interactions:** Forces and molecular bonds, electric & thermal interactions, electric dipoles, casimir interactions, domains of physics in biology. **(18 Lectures)**

Heat Transfer in biomaterials: Heat Transfer Mechanism, The Heat equation, Joule heating of tissue. **Living State Thermodynamics:** Thermodynamic equilibrium, first law of thermodynamics and conservation of energy. Entropy and second law of thermodynamics, Physics of many particle systems, Two state systems, continuous energy distribution, Composite systems, Casimir contribution of free energy, Protein folding and unfolding. **(19 Lectures)**

Open systems and chemical thermodynamics: Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis & synthesis, Entropy of mixing, The grand canonical ensemble, Haemoglobin.
Diffusion and transport Maxwell-Boltzmann statistics, Fick's law of diffusion, sedimentation of Cell Cultures, diffusion in a centrifuge, diffusion in an electric field, Lateral diffusion in membranes, Navier stokes equation, low Reynold's Number, Transport, Active and passive membrane transport.
(19 Lectures)

Fluids: Laminar and turbulent fluid flow, Bernoulli's equation, equation of continuity, venture effect, Fluid dynamics of circulatory systems, capillary action.

Bioenergetics and Molecular motors: Kinesins, Dyneins, and microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in biomolecules, vibrational spectra of biobiomolecules. **(19 Lectures)**

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

OR, PHY-H-DSE-04: DISSERTATION/ PROJECT WORK:

Guidelines to Dissertation/ Project Work: A Dissertation/ Project Work is an optional course and may be opted in lieu of a DSE-04 Course in the 6th semester and its evaluation shall be done in the 6th End Semester Examination (ESE).

- Students shall undertake the project work related to the concerned subject only under the guidance of the teacher(s) as supervisor from the department. A teacher can guide more than one group, if necessary.
- Dissertation/ Project Work can be experimental, theoretical, or both. No two groups in the same institution are permitted to do the same problem.
- After the completion of Dissertation/ Project Work but before "Report Writing", an abstract/ synopsis of Dissertation/ Project Work shall have to be submitted to the Supervisor for his/ her recommendation to write the Report.
- The Dissertation/ Project Work is a group activity; the maximum number of students is limited to 5 (five). However, each student shall prepare and submit the Abstract/ Synopsis and Report separately and, each student must present the Report before the Examiners at the ESE during evaluation. The report may be written as per the format shown in APPENDIX – A.

Assessment of Dissertation/ Project Work:

Report of Dissertation/ Project Work be submitted during the End Semester Examination (ESE) and presentation of the same be done in front of both Internal and External Practical Examiners. Both the examiners shall assess the report and award marks. Marks be awarded on the basis of the following items (The following table):

Table for Method of Evaluation
(Assessment of Dissertation/ Project Work)

Evaluator	Items	Maximum Marks
I. Internal Examiner: (max. marks = 35)	1. Timely completion of work	10
	2. Timely submission of the abstract/synopsis	10
	3. Contents of abstract/synopsis	15
II. Internal Examiner and External Examiner: (max. marks = 40)	1. Contents of the Report	20
	2. Presentation of the Report	10
	3. *Viva-voce* on the Work and Report	10

APPENDIX – A
Format of Report Writing under Dissertation/Project Work

A Dissertation/ Project Work is an optional course and may be opted in lieu of a DSE-04 Course in the 6th semester. Under such course, each student shall prepare and submit a Report of the work, and the Report shall be as per the format mentioned below:

- ❖ Title page.
- ❖ Table of Contents.
- ❖ Bonafide CERTIFICATE (*Format prescribed below*)- with signatures of Supervisor & Head of the Department (HOD).
- ❖ DECLARATION (*Format prescribed below*) by student-to declare that the Work has been done by the student (individually/ as a member of a group) and the Report has been written by him/ her.
- ❖ Acknowledgements.
- ❖ Symbols, Abbreviations, Acronyms, Nomenclature, Notation Table and List of Figure Captions- if

necessary.

- ❖ Abstract/ Synopsis:
- ✓ Chapter I: Introduction
- ✓ Chapter II: Review of literature
- ✓ Chapter III: Materials and methods
- ✓ Chapter IV: Results and discussion
- ✓ Chapter V: Conclusion and suggestions (*if any*)
- ✓ Chapter VI: Bibliography.

The report-writing should be limited to a maximum total number of pages of 20 (A4 format). Use a standard, 12pt, font, such as Times New Roman, for the main text. Use different font sizes, bold, italic and underline where appropriate.

<div align="center">

NAME OF THE COLLEGE / INSTITUTION

Address with pin code

Department of Physics

CERTIFICATE

</div>

Certified that the Dissertation/ Project Work entitled ……………………………… carried out by ……………………………………………………………………………., Registration No. ..……Year ……. and Roll …….No..……**,** during the Academic session: ……………in partial fulfilment for the award of BSc Physics (Honours) Degree of University of Kalyani, Kalyani**.** The REPORT has been approved as it satisfies the academic requirements in respect of Dissertation/ Project Work prescribed for the said Degree.

<div align="center">

DECLARATION

</div>

I hereby declare that the Dissertation/ Project work entitled ……..……………………………….………presented in this REPORT is my own work and has been carried out during the Academic session**:** ……………….**,** under the supervision of ………….………………………….**,** Assistant-Professor/Associate-Professor/SACT, Department of Physics**,** ……..…………… College in partial fulfilment for the award of BSc (Honours) Degree of University of Kalyani**,** Kalyani and, that the REPORT has been prepared by me**.**

Further**,** I solemnly declare that**,** to the best of my knowledge**,** neither the whole nor a part of this REPORT has been previously submitted to any University for any examination**.**

<div align="right">

…………………………………

(Signature of student)

</div>

Date: Name of student**:** …………………………...……………

Place: 6th semester BSc Physics (Honours)

Registration No**.** …………….…… Year**:** …………...……

Skill Enhancement Courses (Credit: 02 each)

PHY—H-SEC-T-01: 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 digital multimeter (name of the circuit elements and their ranges), Analog voltmeter and analog ammeter.   **(6 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 (principle of generation, output wave form, advantage of using three-phase). Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.   **(8Lectures)**

Generators and Transformers: DC Power sources (basic idea). AC and DC generators (basic principle of action). Inductance, capacitance, and impedance. Operation of transformers (Step-up and step-down).
                                                         (4 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Speed & power of ac motor.
                                                         (3 Lectures)

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers (half wave and full wave rectifier with L, C, L-C filter arrangement, regulation). Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources. **(4 Lectures)**

Electrical Protection: Relays, Fuses and disconnect switches, Working principle of Circuit breakers, Miniature circuit breaker and its types. **(3 Lectures)**

Electrical Wiring: Conduit wiring (basic idea of house hold wiring). Basics of wiring: Star and Delta Connections. Preparation of extension board, Wiring Materials (Basic information about the wiring components). **(2 Lectures)**

Reference Books:
- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja, S. Chand.
- Power System, V. K. Meheta, S. Chand
- Electrical Machines, S. K. Bhattacharya, McGraw Hill Education
- Performance and design of AC machines - M G Say ELBS Edn.

OR, PHY—H-SEC-T-01: 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

PHY—H-SEC-T-02: 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. **(3 Lectures)**

Solar energy: Solar energy, It's importance, storage of solar energy (Thermal storage and Electrical storage, Mechanical storage), solar pond (Basic idea), Principle of operation of non convective solar pond, applications of solar pond, solar water heating, flat plate collector, solar cooker (basic idea, Design principle and Constructional details of box type solar cooker and its limitation), solar furnace, solar green houses (basic idea, types and advantage), Solar Cell principle (No mathematical treatment), application of solar photovoltaic system, advantage and disadvantage of Photovoltaic solar energy conversion. **(6 Lectures)**

Wind Energy harvesting: Fundamentals of Wind energy, Basic principle of wind energy conversion, power of wind, Forces on the blades and thrust on turbine, Basic components of a Wind energy Conversion system, Advantage and disadvantage of Wind energy Conversion system. **(4 Lectures)**

Ocean thermal energy conversion(OTEC)(basic idea), Open cycle OTEC system, Closed cycle OTEC system, Basic idea of Heat exchanger, Basic principle of tidal power, Basic idea about components of tidal power plant, Estimate of power in simple Single basin tidal system **(3 Lectures)**

Geothermal Energy: Geothermal energy (Basic idea), Geothermal sources, , Hydrothermal resources (basic idea of vapour dominated system and liquid dominated system), applications of geothermal energy, advantages and disadvantages of geothermal energy. **(3 Lectures)**

Hydro Energy: Hydropower resources, Types of hydroelectric project (Run-of-river schemes, Storage schemes, Pumped-Storage schemes, Low head power plant, Medium head power plant, High head power station), environmental impact of hydro power sources. **(4 Lectures)**

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect (No mathematical treatment), materials used for piezoelectricity , recent application of piezoelectric generators.
(5 Lectures)

Electromagnetic Energy Harvesting: Linear generators (principle of linear generator, applications).
(2 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).
• https://www.yumpu.com/en/document/read/11678381/module-5-nptel

- http ://en. wikipedia. org/wiki/Renewable_energy

OR, PHY—H-SEC-T-02: 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.

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

PHY-H-GE-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-Y, η and σ by Searle's method. **(8 Lectures)**

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

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

Reference Books:
- A Treatise on General Properties of Matter by Sengupta Chatterjee, New Central Book Agency.
- Mechanics through Problems, Dhiranjan Roy, Ananda Dasgupta, 2022, Techno World.

- 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.
- Undergraduate Physics Companion (Vol-1), S. Pal, 1st edition, Suhrid Prakashani, Kolkata

Additional Books for Reference
- University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

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

1. To study the random error in observations.
2. Verification of vectors addition theorem using Gravesand's apparatus
3. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
4. To determine the height of a building using a Sextant.
5. To study the Motion of Spring and calculate (a) Spring constant, (b) g
6. To determine the Moment of Inertia of a Flywheel/ a rigid body by any method.
7. To determine the Young's Modulus of the material in the form of a bar by any method.
8. To determine the Modulus of Rigidity of a Wire by any method.
9. To determine the Young's Modulus of a Wire by Optical Lever Method.
10. To determine the value of g by any method.
11. To determine the Elastic Constants of a Wire by Searle's method.

Reference Books:
- Practical Physics Vol 1, Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
- 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-H-GE-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, A. B. Gupta, Haripada Roy, Books & Allied Ltd
- 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

PHY-H-GE-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 and H.T. Worsnop, 1971, Asia Publishing House
- Advanced Practical Physics, Vol 1, B. Ghosh, K. G. Majumder, Sreedhar Publication
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd
- 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-H-GE-T-02: 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 ferromagnetic 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, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
• Foundations of Electricity and Magnetism, Basudeb Ghosh, Books & Allied Ltd.
• 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
• Undergraduate Physics Companion (Vol-2), S. Pal, 1st edition 2022, Suhrid Prakashani, Kolkata
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PHY-H-GE-P-02: 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
11. Verification of Ohm's law with a tangent galvanometer.
12. Determination of the end corrections of a metre bridge and to measure the value of an unknown resistance incorporating end corrections.

Reference Books
- Practical Physics Vol 1, Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
- 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-H-GE-T-02: 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] (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:
- A Text Book on Light, B. Ghosh, K.G. Mazumder, Sreedhar Publisher.
- Advanced Acoustics, D. P. Roychowdhury, Chayan Publisher
- 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
- Undergraduate Physics Companion (Vol-2), S. Pal, 1st edition, 2022, Suhrid Prakashani, Kolkata

PHY-H-GE-P-02: WAVES AND OPTICS
Practical - 20 marks (Lab. Note Book - 05, Viva-Voce-05,Experiment -10) 60 Lectures

1. To investigate the motion of coupled oscillators.
2. To draw the frequency – resonance length curve of a sonometer wire and to determine an unknown frequency of a tuning fork.
3. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify X^2 - T Law.
4. To study Lissajous Figures
5. Familiarization with Schuster's focussing; determination of angle of prism.
6. To determine the Coefficient of Viscosity of water by any method.
7. To determine the Refractive Index of the Material of a Prism using Sodium Light.
8. To determine Dispersive Power of the Material of a Prism using Mercury Light
9. To determine the value of Cauchy Constants.
10. To determine the Resolving Power of a Prism.
11. To determine wavelength of sodium light using Fresnel Biprism.
12. To determine wavelength of sodium light using Newton's Rings.
13. To determine the wavelength of monochromatic/Laser light using Diffraction of Single Slit.
14. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
15. To determine the Resolving Power of a Plane Diffraction Grating.
16. To measure the intensity using photo sensor and laser in diffraction patterns of single and double slits.
17. 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:
- B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited.

- Advanced Practical Physics, Vol 1, B. Ghosh, K.G.Majumdar, Shreedhar Publishers.
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
- 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.