Department of Physics

Bachelor of Science (Hons.) in Physics
OR
Bachelor of Science (Hons.) with Research in Physics

based on NEP-2020

(Effective from academic session 2022-2023)

1. Introduction to Undergraduate Degree course in Physics

The BSc (Hons.) with research degree in Physics is an eight-semester course spread over four academic years. The teaching – learning process is student-centric and it involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. There is the combination of courses that include DSC (discipline specific core course), DSE (discipline specific elective courses), GE (generic elective courses). Thereby, bringing out the multidisciplinary approach and adherence to innovative ways within the curriculum framework. Moreover, it allows a student maximum flexibility in pursuing his/her studies at the undergraduate level to the extent of having the liberty to eventually design the degree with multiple exit options depending upon the needs and aspirations of the student in terms of his/her goals of life, without compromising on the teaching learning, both in qualitative and quantitative terms. This will suit the present-day needs of students in terms of securing their paths towards higher studies or employment.

2. Program Outcomes:

Program	Program Outcomes
B Sc (Hons.) with Research	After studying Physics in B.Sc. Program students will be able to: **PO1**: **In-depth disciplinary knowledge** Acquire comprehensive knowledge and gain an understanding of the fundamental principles and theoretical principles **PO2**: **Problem-Solving and Critical Thinking** Sharpen analytical thinking, problem-solving prowess, and critical reasoning which are versatile skills applicable across a multitude of domains. **PO3**: **Hands-on/ Laboratory Skills** Comprehensive hands-on/ laboratory exercises will impart analytical, computational and instrumentation skills. **PO4**: **Research skills** The course provides an opportunity to students to hone their research and innovation skills through internship/apprenticeship/ project/community outreach/dissertation/Academic Project/Entrepreneurship. **PO5**: **Communication Skills** The various DSCs, DSEs, SECs, GEs and AECs are designed to enhance student's ability to write methodical, logical and precise reports. **PO6**: **Lifelong learning skills and Entrepreneurship** Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life.

3. Program Specific Outcomes:

Program	Program Specific Outcomes
B Sc (Hons.) with Research	After studying Physics in B.Sc., **PSO1**: Students get accomplished in various mathematical techniques and programming languages. **PSO2**: Students will develop hands-on skills in experimental design, analysis, and interpretation of results. **PSO3**: Students will be proficient in designing, analyzing, and troubleshooting both analog and digital electronic circuits, and semiconductor devices used in various electronic applications, preparing graduates for careers in semiconductor industry.

4. Programme Duration and Exit Options

The minimum credits to be earned by the student per semester are 22 credits. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits which have to be secured for the purpose of award of Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Physics are listed in Table 1.

Table 1: Award with credit requirement

S. No.	Name of Award	Stage of Exit	Mandatory
1	Undergraduate certificate in Physics	After successful completion of Semester II	44
2	Undergraduate diploma in Physics	After successful completion of Semester IV	88
3	Bachelor of Science Physics (Hons.)	After successful completion of Semester VI	132
4	Bachelor of Science Physics (Hons. with Research	After successful completion of Semester VIII	176
5	Bachelor of Science Physics (Hons.) with Research in Physics (Major) and Discipline - 2 (Minor)	After successful completion of Semester VIII with minimum 32 GE credits in discipline -2 (minor)	176

After sixth semester, student may continue with 4-year UG Degree with Hons. If a student obtains 7.5 and above CGPA, after 6 semesters, s/he will be eligible to continue for UG degree Hons with Research in Physics. However, student will also have an option to choose UG degree with Hons.

Major Discipline (Physics)

A student pursuing four-year undergraduate programme in Physics (Core course) shall be awarded B.Sc. Honours degree with Major in Physics on completion of VIII Semester, if he/she secures in Physics at least 50% of the total credits i.e., at least 88 credits in Physics out of the total of 176 credits. He/she shall study 20 DSCs and at least 2 DSEs of Physics in eight semesters.

Minor Discipline (Discipline - 2)

A student of B.Sc. (Hons.) Physics may be awarded Minor in a discipline, other than Physics, on completion of VIII Semester, if he/she earns minimum 32 credits from seven GE courses of that discipline.

5. Definitions and Abbreviations

(i) **Academic Credit**: An academic credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/ field work per week.

(ii) **Courses of Study:** Courses of the study indicate pursuance of study in a particular discipline. Every discipline shall offer four categories of courses of study, viz. Discipline Specific Core (DSC) courses, Discipline Specific Electives (DSEs), Skill Enhancement Courses (SECs) and Generic Electives (GEs). Besides these four courses, a student will select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the University.

1. **Discipline Specific Core (DSC):** Discipline Specific Core is a course of study, which should be pursued by a student as a mandatory requirement of his/ her programme of study. In Bachelor of Science (Hons.) Physics programme, DSCs are the core credit courses of Physics which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020. A student will study three DSC courses each in Semesters I to VI; and one DSC course each in semesters VII and VIII.
2. **Discipline Specific Elective (DSE):** The Discipline Specific Electives (DSEs) are a pool of credit courses of Physics from which a student will choose to study based on his/ her interest. A student of Bachelor of Science (Hons.) Physics, gets an option of choosing one DSE of Physics in each of the semesters III to VI, while the student has an option of choosing a maximum of three DSE courses of Physics in semesters VII and VIII.
3. **Generic Elective (GE):** Generic Electives is a pool of courses offered by various disciplines of study (excluding the GEs offered by the parent discipline) which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond his/ her discipline specific course(s) of study, such DSEs shall be treated as GEs for that student.
4. **Skill Enhancement Courses (SECs)** are skill-based courses in all disciplines and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction. A student will study one Skill Enhancement Course of 2 credits each (following 1T+ 1P/ 0T+2P credit system) in all the semesters from I to VI. It is to be noted that in the semesters III, IV, V and VI; students can choose either one SEC paper or can join any Internship/ Apprenticeship/ Project (following two credit system).
5. **Ability Enhancement Course (AEC)** are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are Language and Literature and Environmental Science and Sustainable Development which are mandatory for all disciplines. Every student has to study "Environmental Science and Sustainable Development" courses I and II of two credits each in the first year (I/ II semester) and the second year (III/ IV semester), respectively.
6. **Value Added courses (VAC)** are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural and constitutional values; promote

critical thinking, Indian knowledge systems, scientific temperament, communication skills, creative writing, presentation skills, sports and physical education and team work which will help in all round development of students.

6. Attainment of Course outcome and Evaluation

A continuous evaluation will be carried out along with teaching, practical, assignments, quiz etc.

a. Teaching Methods

Theory + practical
Theory+ Tutorial
Theory+ Projects
Theory only

b. The class assignments for different course segments are as follows

Theory	1 credit	1 hour/week
Practical	1 credit	2 hours/week
Tutorial	1 credit	1 hour/week
Projects	1 credit	1 hour/week

Evaluation Methods:

Class assignments, Quiz, Test, Class Interaction, Practical's, Projects, Attendance Midterm Examination, End term Examination

7. Programme and Frame Work

Semester	Discipline Specific Core Course	Discipline Specific Elective (DSE)/ Generic Elective (GE)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)/ Project/ Dissertation	Value Addition Course (VAC)	Total Credits earned
1.	DSC1: Mathematical Physics I DSC2: Fundamental Topics of Physics DSC3: Mechanics	DSE1/GE1	AEC1	SEC1	VAC1	22
2.	DSC4: Electricity and Magnetism DSC5: Waves and Oscillations DSC6: Electrical Circuit Analysis	DSE2/GE2	AEC2	SEC2	VAC2	22
3.	DSC7: Mathematical Physics II DSC8: Thermal Physics DSC9: Analog systems and Applications	DSE3/GE3	AEC3	SEC3	VAC3	22
4.	DSC10: Mathematical Physics III	DSE4/GE4	AEC4	SEC4	VAC4	22

	DSC11: Elements of Modern Physics DSC12: Digital Systems and Applications					
5.	DSC13: Quantum Physics I DSC14: Electromagnetic Theory DSC15: Nuclear Physics	DSE5/GE5 DSE6/GE6		Internship/Apprenticeship/ Project/Community Outreach(2 Credits)		22
6.	DSC16: Solid State Physics DSC17: Statistical Physics DSC18: Computational Physics	DSE7/GE7 DSE8/GE8		Internship/Apprenticeship/ Project/Community Outreach(2 Credits)		22
7.	DSC19: Classical Mechanics	DSE9/GE9 DSE10/GE10 DSE11/GE11		Dissertation / Academic Project (6 Credits)		22
8.	DSC20: Elements of Spectroscopy	DSE12/GE12 DSE13/GE13 DSE14/GE14		Dissertation / Academic Project (6 Credits)		22

The detailed framework of undergraduate degree programme in Physics is provided in following Table 2.

Table 2: Semester-wise Course Frame Work

S. No.	Course Code	Course Type	Name of the Course	L	T	P	Total Credits
Semester I							
1	PHC101	DSC 1	Mathematical Physics I	3	0	1	4
2	PHC102	DSC 2	Fundamental Topics of Physics	3	1	0	4
3	PHC103	DSC 3	Mechanics	3	0	1	4
4		GE1	choose from the pool of courses*	3	1	0	4
5		SEC 1	choose from the pool of courses**				2
6		AEC 1	choose from the pool of courses offered by the University				2
7		VAC 1	choose from the pool of courses offered by the University				2
Total Credits 22							
Semester II							
1	PHC151	DSC 4	Electricity and Magnetism	3	0	1	4
2	PHC152	DSC 5	Waves and Oscillations	3	0	1	4
3	PHC153	DSC 6	Electrical Circuit Analysis	3	1	0	4

4		GE 2	choose from the pool of courses*				4
5		SEC 2	choose from the pool of courses**				2
6		AEC 2	choose from the pool of courses offered by the University				2
7		VAC 2	choose from the pool of courses offered by the University				2
				Total Credits 22			
Exit option after one year with 44 credits to get Undergraduate Certificate in Physics							
Semester III							
1	PHC201	DSC 7	Mathematical Physics II	3	0	1	4
2	PHC202	DSC 8	Thermal Physics	3	0	1	4
3	PHC203	DSC 9	Analog systems and Applications	3	0	1	4
4		GE3/DSE1	choose from the pool of courses*	3	1	0	4
5		SEC 3	choose from the pool of courses**				2
6		AEC 3	choose from the pool of courses offered by the University				2
7		VAC 3	choose from the pool of courses offered by the University				2
				Total Credits 22			
Semester IV							
1	PHC251	DSC 10	Mathematical Physics III	3	0	1	4
2	PHC252	DSC 11	Elements of Modern Physics	3	0	1	4
3	PHC253	DSC 12	Digital System and Applications	3	0	1	4
4		GE4/DSE2	choose from the pool of courses*				4
5		SEC 4	choose from the pool of courses**				2
6		AEC 4	choose from the pool of courses offered by the University				2
7		VAC 4	choose from the pool of courses offered by the University				2
				Total Credits 22			

Exit option after Two years with 88 credits to get Undergraduate Diploma in Physics							
Semester V							
1	PHC301	DSC 13	Quantum Physics I	3	1	0	4
2	PHC302	DSC 14	Electromagnetic Theory	3	0	1	4
3	PHC303	DSC 15	Nuclear Physics	3	0	1	4
4 5		GE5/DSE3	Choose 1 GE and 1 DSE from the pool of courses*				4 4
6	PHI301/PHP301/PHO301	Internship/Project/community outreach					2
							Total Credits 22
Semester VI							
1	PHC351	DSC 16	Solid State Physics	3	0	1	4
2	PHC352	DSC 17	Statistical Physics	3	0	1	4
3	PHC353	DSC 18	Computational Physics	3	0	1	4
4 5		GE6/DSE4	Choose GE/DSE from the pool of courses*				4 4
6	PHI351/PHP351/PHO 351	Internship/Project/ community outreach					2
							Total Credits 22
Exit option after three years with 132 credits to award the degree of B.Sc (Honours) in Physics if he/she earned 80 credits (from 18 DSC's and 2 DSE's) in Physics							
Semester VII							
1	PHC401	DSC 19	Classical Mechanics	3	1	0	4
2 3 4		GE/DSE*	Choose three DSE courses OR Choose two DSE and one GE courses OR Choose one DSE and two GE courses				4 4 4
5	PHD401	Dissertation (Part-1)					6
6	PHS 401	Seminar					2
							Total Credits 22
Semester VIII							
1	PHC451	DSC 20	Elements of Spectroscopy	3	1	0	4
2 3		GE/DSE	Choose three DSE courses OR Choose two DSE and one GE courses OR				4 4

4			Choose one DSE and two GE courses		4
5	PHD451	Dissertation (Part-2)			6
6	PHS 451	Seminar/Project			2
				Total Credits 22	
Exit option after Four years with 176 credits to award the degree of B.Sc (Honours with Research) in Physics and Minor (Discipline 2)					

**** The students have to maintain 22 credits each in VII and VIII semesters, respectively.***

6.1 Discipline Specific Core Papers (DSC): (Credit: 04 each)

A student will study three Discipline Specific Core Courses each in Semesters I to VI and one core course each in semesters VII and VIII. The semester wise distribution of DSC courses over eight semesters is listed in Table 3.

Table 3: Details of Discipline Specific Core (DSC) Courses

Course	Semester	Name of the Course
DSC1	I	Mathematical Physics I
DSC2	I	Fundamental Topics of Physics
DSC3	I	Mechanics
DSC4	II	Electricity and Magnetism
DSC5	II	Waves and Oscillations
DSC6	II	Electrical Circuit Analysis
DSC7	III	Mathematical Physics II
DSC8	III	Thermal Physics
DSC9	III	Analog systems and Applications
DSC10	IV	Mathematical Physics III
DSC11	IV	Elements of Modern Physics
DSC12	IV	Digital Systems and Applications
DSC13	V	Quantum Physics I
DSC14	V	Electromagnetic Theory
DSC15	V	Nuclear Physics
DSC16	VI	Solid State Physics
DSC17	VI	Statistical Physics
DSC18	VI	Computational Physics
DSC19	VII	Classical Mechanics

DSC20	VIII	Elements of Spectroscopy

6.2 Details of Discipline Specific Elective Papers: (4 credits each)

The Discipline Specific Electives (DSEs) are a pool of credit courses offered by the Department of Physics
from which a student will choose to study based on his/ her interest. A student of Bachelor of Science (Hons.) Physics gets an option of choosing one DSE of Physics in each of the semesters III to VI, while the student has an option of choosing a maximum of three DSE courses of Physics in semesters VII and VIII. The distribution of DSE courses is listed in Table 4.

Table 4: Pool of Discipline Specific Elective Courses (DSE)

S. No.	Course Code	Name of the Course
1	PHE101	Advanced Mathematical Physics
2	PHE102	Classical Dynamics
3	PHE103	Nano Materials and Applications
4	PHE104	Solid State Physics II
5	PHE105	Experimental Techniques
6	PHE106	Biophysics
7	PHE107	Electronics and Devices
8	PHE108	Electronics Lab (LabI)
9	PHE109	Quantum Physics II
10	PHE110	Research Methodology
11	PHE111	Solid State Physics Lab (Lab II)
12	PHE112	Physics of Materials
13	PHE113	Introduction to Particle Physics
14	PHE114	Physics of Devices and Instrumentation
15	PHE115	Medical Physics
16	PHE116	Earth Science
17	PHE117	Atmospheric Physics
18	PHE118	Optical Fiber Communication and Integrated Nonlinear Optics
19	PHE119	Applied Optics
20	PHE120	Materials Science and Energy Devices
21	PHE121	Astronomy and Astrophysics

6.3 Details of Skill Enhancement Courses (2 credits)**

In order to enhance the skills required for advanced studies, research and employability of students various Skill Enhancement Courses (SEC) will be offered to students that are listed in Table 5.

Table 5: Pool of Skill Enhancement Courses (SE)**

S. No	Course Code	Name of the Course
1	PHS101	Basics of Instrumentation
2	PHS102	Computational Physics Skills
3	PHS103	Physics Workshop Skills
4	PHS104	Scientific Writing
5	PHS105	Electrical circuit network Skills
6	PHS106	Sensors and Detectors Technology
7	PHS107	Renewable Energy and Energy Harvesting
8	PHS108	Mechanical Drawing
9	PHS109	Introduction to Lasers and Fiber Optics
10	PHS110	Radiation Safety
11	PHS111	Weather Forecasting
12	PHS112	Introduction To SCILAB Programming

In addition to the above proposed courses, students may select courses from the **Swayam.org as MOOCs courses** up to the permissible limit.

6.4 Details of Generic Elective Courses (GE) (4 credits)*

Generic Elective courses offer interdisciplinary education to students. Various generic elective courses offered by the Department of Physics are listed below in Table 6.

Table 6: Pool of Generic Elective Courses (GE)*

S. No	Course Code	Name of the Course
1	PHG101	Mechanics I
2	PHG102	Introduction to Electromagnetic Theory
3	PHG103	Digital, Analog circuits and Instrumentation
4	PHG104	Elements of Modern Physics
5	PHG105	Experimental Techniques
6	PHG106	Bio Physics
7	PHG107	Electronics Lab-I
8	PHG108	Electronics Lab-II
9	PHG109	Mechanics II
10	PHG110	Quantum Mechanics
11	PHG111	Mathematical Physics I
12	PHG112	Thermal Physics
13	PHG113	Waves and Optics
14	PHG114	Mathematical Physics II

15	PHG115	Solid State Physics
16	PHG116	Nuclear and Particle Physics

In addition to the above proposed courses, students may select courses from the **Swayam.org as MOOCs courses** upto the permissible limit.

DISCIPLINE SPECIFIC COURSES

SEMESTER I

PHC101: MATHEMATICAL PHYSICS I

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

The emphasis of course is on applications in solving problems of interest to physicists. The course will also expose students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

Course Outcomes:

CO No.	Course Outcome Statement	Bloom's Taxonomy Level
CO1	Explain and compute divergence and curl of vector fields.	B1, B2 (Remember, Understand)
CO2	Perform line, surface, and volume integration and apply Green's, Stokes' and Gauss's theorems.	B3, B4 (Apply, Analyze)
CO3	Apply vector calculus techniques to solve physics-related problems.	B3, B4 (Apply, Analyze)
CO4	Use curvilinear coordinates to solve problems with spherical and cylindrical symmetry.	B3, B4 (Apply, Analyze)
CO5	Explain basic probability concepts and apply them to physical problems.	B2, B3 (Understand, Apply)
CO6	Describe and use properties of the Dirac Delta function in physics applications.	B2, B3 (Understand, Apply)

CO-PO Mapping Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓				
CO3	✓	✓	✓			
CO4	✓	✓	✓			
CO5	✓	✓		✓		
CO6	✓	✓				

Course Content:

UNIT 1

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

(6 Lectures)

UNIT 2

Vector Calculus:

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

(5 Lectures)

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

(9 Lectures)

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

UNIT 3

Orthogonal Curvilinear Coordinates:

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

UNIT 4

Introduction to probability:

Independent random variable: Probability distribution functions, binomial, Gaussian and Poisson, with examples Mean and variance. **(3 lectures)**

UNIT 5

Dirac Delta function and its properties:

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

Reference Books:

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

PRACTICAL Mathematical Physics (Credit:01, 30 hours)

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

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

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

Referred Books:

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

PHC102: FUNDAMENTAL TOPICS OF PHYSICS

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

1. This course reviews the concepts of mathematical Physics and mechanics learnt at school from a more advanced perspective and goes on to build new concepts. The students will review about the concepts of electricity in more generalized form.

Course Outcomes:

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	To solve first and second-order differential equations using appropriate methods.	B3, B4 (Apply, Analyze)
CO2	To understand the basic principles of Newtonian mechanics and laws of motion.	B2 (Understand)
CO3	To differentiate between conservative and non-conservative forces and apply work-energy principles.	B3, B4 (Apply, Analyze)
CO4	To interpret electric field, electric potential, and apply them to real-world physical systems.	B2, B4 (Understand, Analyze)
CO5	To apply Coulomb's Law and interpret field and potential distributions in space.	B3, B4 (Apply, Analyze)
CO6	To apply Gauss's Law for evaluating electric fields in systems with spherical, cylindrical, and planar symmetry.	B3, B4 (Apply, Analyze)
CO7	To evaluate and solve boundary value problems in electrostatics and dielectric materials.	B4, B5 (Analyze, Evaluate)

CO-PO Mapping Matrix of Fundamental Topics of Physics

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		
CO2	✓	✓				
CO3	✓	✓	✓	✓		✓
CO4	✓	✓		✓		
CO5	✓	✓		✓		
CO6	✓	✓		✓		✓
CO7	✓	✓	✓	✓		✓

Course Content:

UNIT 1

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

(13 Lectures)

UNIT 2

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.

(9 Lectures)

UNIT 3

Work and Energy: Work and Kinetic Energy Theorem. Conservative and nonconservative 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.

(6 Lectures)

UNIT 4

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.

(7 Lectures)

UNIT 5

Electric Field in Matter: Polarization in matter, Bound charges and their physical interpretation. Field inside a dielectric, Displacement vector D, Gauss' Law in the presence of dielectrics, Boundary conditions for D, Linear dielectrics, Electric Susceptibility and Dielectric Constant, idea of complex dielectric constant due to varying electric field. Boundary value problems with linear dielectrics

(8 Lectures)

Reference Books:

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.

- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley andSons.University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

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

Lecture Plan for Fundamental Topics of Physics

UNIT 1: Differential Equations (10 Lectures)

Lecture 1: Introduction to differential equations; order, degree and types.
Lecture 2: First-order linear differential equations and integrating factor method.
Lecture 3: Second-order homogeneous equations with constant coefficients.
Lecture 4: Solution using auxiliary equation and complementary function.
Lecture 5: Particular integral method and complete solution.
Lecture 6: Wronskian: Concept and physical significance.
Lecture 7: General solution and linear independence of solutions.
Lecture 8: Existence and uniqueness theorems for initial value problems.
Lecture 9: Boundary value problems in physical systems.
Lecture 10: Applications of DEs in physics – heat, wave, and electrical circuits (qualitative).

UNIT 2: Dynamics (10 Lectures)

Lecture 1: Inertial and non-inertial frames; Galilean transformations.
Lecture 2: Newton's laws of motion: recap and applications.
Lecture 3: Motion of system of particles; center of mass motion.
Lecture 4: Conservation of linear momentum; examples.
Lecture 5: Principle of conservation of angular momentum.
Lecture 6: Variable mass systems: derivation of rocket equation.
Lecture 7: Impulse and momentum theorem; applications in collisions.
Lecture 8: Dynamics of circular motion; non-inertial pseudo forces.
Lecture 9: Equation of motion for projectile and vertical circular motion.
Lecture 10: Problem-solving session on multi-particle systems.

UNIT 3: Work and Energy (8 Lectures)

Lecture 1: Concept of work and power; scalar product of vectors.
Lecture 2: Work-energy theorem: derivation and examples.
Lecture 3: Conservative and non-conservative forces; energy loss.
Lecture 4: Potential energy and its relation with force.
Lecture 5: Potential energy diagrams; stability and equilibrium points.
Lecture 6: Mechanical energy conservation: applications in closed systems.
Lecture 7: Energy diagrams in oscillatory systems.
Lecture 8: Practice problems on energy conservation and force-potential gradient.

UNIT 4: Electric Field and Potential (9 Lectures)

Lecture 1: Electric field, electric flux and field lines.
Lecture 2: Coulomb's law and principle of superposition.
Lecture 3: Gauss's law: derivation and conceptual interpretation.
Lecture 4: Application of Gauss's law: spherical, cylindrical, and planar symmetry.
Lecture 5: Electric potential and its relation with electric field.
Lecture 6: Equipotential surfaces and field-potential plots.
Lecture 7: Energy stored in electric field.
Lecture 8: Electric dipole: field and potential.
Lecture 9: Force and torque on a dipole in uniform electric field.

UNIT 5: Electric Field in Matter (8 Lectures)

Lecture 1: Polarization in matter; bound charges.
Lecture 2: Displacement vector $\vec{D}$\vec{D}D and field inside dielectric.
Lecture 3: Gauss's law in dielectrics; boundary conditions.
Lecture 4: Electric susceptibility and dielectric constant.
Lecture 5: Clausius-Mossotti relation: derivation and applications.
Lecture 6: Linear dielectrics: field and energy relations.
Lecture 7: Boundary value problems in dielectrics.
Lecture 8: Concept of complex dielectric constant and varying dielectric media.

PHC103: MECHANICS

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

1. To apply the principles of rotational dynamics.
2. To examine elastic and inelastic collisions.
3. To solve problems involving simple, damped, and driven harmonic oscillators.
4. To analyze model of gravitational systems and central force interactions.
5. To analyze dynamics in non-inertial frames.
6. To employ the postulates of special relativity.

After completion of this course, students will be able to:

S.No.	Course Outcome Statement	Bloom's Level(s)
CO1	Demonstrate the ability to calculate torque, angular momentum, and moment of inertia for various rigid bodies and solve problems involving combined translational and rotational motion.	B3(Apply)
CO2	Analyze and distinguish between elastic and inelastic collisions using both laboratory and centre-of-mass reference frames.	B4 (Analyze)
CO3	Solve differential equations of simple harmonic motion and evaluate the behaviour of damped and driven oscillators, including resonance and energy dissipation characteristics.	B5 (Evaluate)
CO4	Apply the laws of gravitation and conservation principles to model central force motion, solve orbital dynamics problems, and interpret real-world applications such as GPS and satellite motion.	B3(Apply)
CO5	Evaluate motion in non-inertial reference frames by incorporating fictitious forces and express the velocity and acceleration components in cylindrical and spherical coordinate systems.	B5 (Evaluate)
CO6	Use the postulates of special relativity to perform Lorentz transformations, calculate time dilation, length contraction, relativistic energy-momentum, and analyze massless particle dynamics.	B4 (Analyze)

CO-PO Mapping Matrix of Functional Topics of Physics

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

Course Content:

UNIT 1

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)

UNIT 2

Collision: Elastic and inelastic collisions between particles. Center of mass and laboratory frames.

(3 lectures)

UNIT 3

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)

UNIT 4

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. **(4 Lectures)**

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.

(6 Lectures)

UNIT 5

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)**

UNIT 6

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

(9 Lectures)

Reference Books:

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

Additional Books for Reference

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

Lecture Plan- Mechanics (45 Lectures)

UNIT 1: Rotational Dynamics (12 Lectures)

Lecture1: Angular momentum of a particle
Lecture2: Angular momentum of a system of particles
Lecture3: Torque and relation with angular momentum
Lecture4: Conservation of angular momentum with examples
Lecture5: Rotation about a fixed axis – Basic concepts
Lecture6: Definition and physical meaning of Moment of Inertia
Lecture7: Moment of Inertia: Calculation for rectangular bodies
Lecture8: Moment of Inertia: Calculation for cylindrical bodies
Lecture9: Moment of Inertia: Calculation for spherical bodies
Lecture10: Kinetic energy of rotation
Lecture11: Rolling motion – translation + rotation
Lecture12: Sample problems involving rotational motion

UNIT 2: Collisions (3 Lectures)

Lecture1: Elastic collisions in 1D and 2D
Lecture2: Inelastic collisions and coefficient of restitution
Lecture3: Centre of mass and laboratory frames

UNIT 3: Oscillations (7 Lectures)
Lecture1: Simple Harmonic Motion – Definition and examples
Lecture2: Differential equation of SHM and its solution
Lecture3: Kinetic, potential, and total energy in SHM
Lecture4: Time-averaged values of energy in SHM
Lecture5: Damped oscillations – types of damping
Lecture6: Forced oscillations – transient and steady states
Lecture7: Resonance, sharpness of resonance, power dissipation, Quality Factor

UNIT 4: Gravitation & Central Force Motion (10 Lectures)
Lecture1: Newton's Law of Gravitation and gravitational potential energy
Lecture2: Inertial and gravitational mass
Lecture3: Potential and field due to spherical shell and solid sphere
Lecture4: Motion under a central force – general features
Lecture5: Two-body problem and its reduction to one-body problem
Lecture6: Solution to one-body problem – orbit types
Lecture7: Energy equation and energy diagrams
Lecture8: Kepler's Laws and their derivations
Lecture9: Satellite motion – circular and elliptical orbits
Lecture10: Applications: GPS, geosynchronous orbits, weightlessness, astronaut physiology

UNIT 5: Non-Inertial Systems (4 Lectures)
Lecture1: Non-inertial frames and fictitious forces
Lecture2: Uniformly rotating frames, centrifugal and Coriolis forces
Lecture3: Applications of Coriolis force
Lecture4: Components of velocity and acceleration in cylindrical and spherical Coordinates

UNIT 6: Special Theory of Relativity (9 Lectures)
Lecture1: Michelson-Morley Experiment and its implications
Lecture2: Postulates of special relativity
Lecture3: Lorentz transformations
Lecture4: Simultaneity, order of events, time dilation, length contraction
Lecture5: Relativistic addition of velocities
Lecture6: Relativistic transformation of velocity, frequency, and wave number
Lecture7: Variation of mass with velocity, massless particles
Lecture8: Mass-energy equivalence, relativistic Doppler effect
Lecture9: Relativistic momentum, energy, and four-vector formulation

PRACTICAL Mechanics (Credit:01, 30 hours)

Every student must perform at least 05 experiments

1. Measurements of length (or diameter) using vernier caliper, screw

gauge and travelling microscope.

2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine **g** and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

Reference Books

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

SEMESTER III

PHC201: MATHEMATICAL PHYSICS II

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

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

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

Course Outcome:

CO No.	Course Outcome Statement	Bloom's Taxonomy Level
CO1	Perform Fourier analysis of periodic functions and apply it to physical problems (e.g., vibrating strings).	B3, B4 (Apply, Analyze)
CO2	Explain and use special functions (Hermite, Legendre, Laguerre, Bessel) and solve related differential equations in physical applications.	B2, B3, B4 (Understand, Apply, Analyze)
CO3	Use Beta, Gamma, and Error functions in integration and related applications.	B3 (Apply)
CO4	Solve partial differential equations with examples relevant to physics.	B3, B4 (Apply, Analyze)
CO5	Use Scilab software for basic scientific computation and assess its advantages and limitations.	B3, B5 (Apply, Evaluate)

CO-PO Mapping Matrix of Mathematical Physics-II (PHC-201)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓	✓			
CO3	✓	✓				
CO4	✓	✓	✓			
CO5	✓	✓		✓	✓	

Course Content

UNIT 1

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.

(28 lectures)

UNIT 2

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.

(**13 Lectures**)

UNIT 3

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error.

(**4 Lectures**)

PRACTICAL Mathematical Physics II (Credit:01, 30 hours)

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

Solution of ODE
 	
First order Differential equation Euler, modified Euler and Runge-Kutta secondorder methods
Second order differential equationFixed difference method
	First order differential equation
	• Radioactive decay
	• Current in RC, LC circuits with DC source
	• Newton's law of cooling
	• Classical equations of motionSecond order
	Differential Equation
	• Harmonic oscillator (no friction)
	• Damped Harmonic oscillator
	  • Over damped
	  • Critical damped
	  • Oscillatory
	• Forced Harmonic oscillator
	  • Transient and

	• Steady state solution Apply above to LCR circuits also
Using Scicos / xcos	• Generating square wave, sine wave, saw toothwave • Solution to harmonic oscillator • Study of beat phenomenon Phase space plots

Reference Books:

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

PHC202: THERMAL PHYSICS

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

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

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

Course Outcomes:

CO No.	Course Outcome Statement	Bloom's Taxonomy Level
CO1	Define and distinguish between extensive and intensive variables, thermodynamic equilibrium, and state functions.	B1, B2 (Remember, Understand)
CO2	Explain and apply the Zeroth and First Law of Thermodynamics to different thermodynamic systems and processes.	B2, B3(Understand, Apply)
CO3	Calculate work done, internal energy changes, and heat transfer in isothermal, adiabatic, and other reversible processes.	B3, B4 (Apply, Analyze)
CO4	State and interpret Kelvin-Planck and Clausius statements of the second law and their implications.	B2, B5 (Understand, Evaluate)

Course Content

UNIT 1

Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

(8 Lectures)

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

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

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

Maxwell's Thermodynamic Relations:

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

(7 Lectures)

UNIT 2

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.

(6 Lectures)

Reference Books:

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

PRACTICAL Thermal Physics (Credit:01, 30 hours)

Every student must perform at least 04 experiments

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne'sconstant 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 Leeand 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 Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books

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

Semester III
PHC203: ANALOG SYSTEMS AND APPLICATIONS

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

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

Course Outcomes:

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	To describe the working principle of semiconductor diodes and their applications in rectification and regulation	B2 Understanding
CO2	Explain the structure and operation of bipolar junction transistors and analyze their characteristics	B2, B4 Understanding, Analyze
CO3	Analyze transistor biasing techniques and compute gains using h-parameter models	B4, B3 Analyzing, Applying
CO4	Evaluate feedback mechanisms and classify different amplifier types.	B5, B4 Evaluate, Analyze
CO5	To design the different experiments and analyze their characteristics along with lab reports	B6, B4, B5 Create, Analyze, Evaluate
CO6	Apply the concept of feedback and oscillations to design sinusoidal oscillators.	B4, B6 Create, Analyze

CO-PO Mapping Matrix of Analog Systems and Applications

CO/PO	PO1	PO2	PO 3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓			
CO3	✓	✓	✓			
CO4	✓	✓			✓	✓
CO5	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓		✓

Course Content:

UNIT 1

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.

(8 Lectures)

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

(6 lectures)

UNIT 2

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)

UNIT 3

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)

Feedback in Amplifiers: Effects of Positive and Negative Feedback on InputImpedance, Output Impedance, Gain, Stability, Distortion and Noise.

(4 lectures)

UNIT 4

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phaseshift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

(5 lectures)

UNIT 5

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. **Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator **(6 lectures)**

Reference Books:

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

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PRACTICAL Analog System and Applications (Credit:01, 30 hours)

Every student must perform at least 05 experiments

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point &efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltagedivider bias.
7. To study the frequency response of voltage, gain of a RC-coupled transistor
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitts's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain
14. To design inverting amplifier using Op-amp (741, 351) and study its frequency response
15. To design non-inverting amplifier using Op-amp (741, 351) & study its frequency response
16. To study the zero-crossing detector and comparator
17. To add two dc voltages using Op-amp in inverting and non-inverting mode
18. To design a precision Differential amplifier of given I/O specification usingOp-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.

Reference Books:

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

Semester V

PHC301: QUANTUM MECHANICS I

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objective

1. Introduce the fundamental principles and mathematical framework of quantum mechanics.
2. Solve time-dependent and time-independent Schrödinger equations for various quantum systems.
3. Interpret wave functions and compute physical observables using operator techniques.
4. Analyze bound states in potential wells and harmonic oscillators using analytical methods.
5. Apply angular momentum quantization and spin-related concepts to atomic systems in external fields.

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	Formulate and interpret the time-dependent and time-independent Schrödinger equations.	B2, B3 (Understand, Apply)
CO2	Analyze wave functions using normalization, probability current, and expectation values.	B4 (Analyze)
CO3	Apply operator algebra and commutators to quantum observables like position and momentum.	B3, B4 (Apply, Analyze)
CO4	Solve quantum mechanical problems involving free particles, harmonic oscillators, and square wells.	B3, B5 (Apply, Evaluate)
CO5	Understand bound states and apply boundary conditions to determine energy eigenvalues.	B2, B3 (Understand, Apply)
CO6	Examine the structure of hydrogen-like atoms and angular momentum quantization.	B2, B4 (Understand, Analyze)
CO7	Describe spin angular momentum, magnetic interactions, and interpret Stern-Gerlach and Zeeman effects.	B2, B4 (Understand, Analyze)

CO–PO Mapping Matrix of Quantum Mechanics

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓		✓		
CO3	✓	✓	✓			
CO4	✓	✓	✓	✓		
CO5	✓		✓			
CO6	✓		✓	✓		✓
CO7	✓	✓		✓		✓

Course Content:

UNIT 1

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

(6 Lectures)

UNIT 2

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

(10 Lectures)

UNIT 3

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

(11 Lectures)

UNIT 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells.

(10 Lectures)

UNIT 5

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

(8 Lectures)

Reference Books :

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

Additional Books for Reference

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

UNIT 1: Time Dependent Schrödinger Equation (6 Lectures)

Lecture 1: Introduction to time-dependent Schrödinger equation.

Lecture 2: Properties and interpretation of wave functions.

Lecture 3: Probability density and current density in 3D.

Lecture 4: Acceptability and normalization of wave functions.

Lecture 5: Linearity, superposition, eigenfunctions and eigenvalues.

Lecture 6: Free particle wave function and expectation values.

UNIT 2: Time Independent Schrödinger Equation and Wave Packets (10 Lectures)

Lecture 1: Stationary states and energy eigenvalues.

Lecture 2: General solution using linear combination of eigenfunctions.

Lecture 3: Gaussian wave packet evolution in 1D.

Lecture 4: Momentum space and Fourier transforms.

Lecture 5: Position-momentum uncertainty principle.

Lecture 6: Operators in momentum and position representation.

Lecture 7: Energy eigenvalue problems.

Lecture 8: Examples and applications of stationary states.

Lecture 9: Bound vs. unbound state comparison.

Lecture 10: Numerical and conceptual problem-solving.

UNIT 3: Bound States and Harmonic Oscillator (11 Lectures)

Lecture 1: General discussion of bound states.

Lecture 2: Continuity and boundary conditions.

Lecture 3: Square well potential and discrete energy levels.

Lecture 4: Introduction to quantum harmonic oscillator.

Lecture 5: Frobenius method for solving harmonic oscillator.

Lecture 6: Hermite polynomials and recursion relation.

Lecture 7: Ground state and zero-point energy.

Lecture 8: Uncertainty principle in oscillator.

Lecture 9: Energy level spacing and degeneracy.

Lecture 10: Visualizing eigenfunctions.

Lecture 11: Problem solving and numerical estimation.

UNIT 4: Quantum Theory of Hydrogen-like Atoms (10 Lectures)

Lecture 1: Schrödinger equation in spherical coordinates.

Lecture 2: Separation of variables technique.

Lecture 3: Angular momentum operators and quantum numbers.

Lecture 4: Radial equation and Frobenius method.

Lecture 5: Energy quantization in hydrogen-like atoms.

Lecture 6: Quantum numbers l and m; s, p, d shells.

Lecture 7: Degeneracy and symmetry.

Lecture 8: Shapes of probability density functions.

Lecture 9: Ground and first excited states.

Lecture 10: Applications in atomic spectra.

UNIT 5: Atoms in Electric and Magnetic Fields (8 Lectures)

Lecture 1: Angular momentum of electrons.

Lecture 2: Space quantization concept.

Lecture 3: Electron spin and magnetic moment.

Lecture 4: Stern-Gerlach experiment and interpretation.

Lecture 5: Larmor precession and gyromagnetic ratio.

Lecture 6: Bohr magneton and magnetic energy.

Lecture 7: Zeeman effect and spectral line splitting.

Lecture 8: Applications and real-world observations.

PHC302: ELECTROMAGNETIC THEORY

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

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

Course Outcomes:

S. No.	Course Outcome Statement	Bloom’s Level(s)
CO1	To solve problems related to electrostatics, magnetostatics, and Maxwell’s equations.	B3, B4 (Apply, Analyze)
CO2	To interpret and apply Maxwell's equations in time-varying and source-free regions.	B2, B3, B4 (Understand, Apply, Analyze)
CO3	To understand the propagation of electromagnetic waves through different media.	B2, B3 (Understand, Apply)
CO4	To analyze radiation properties and interaction of EM waves with matter and dielectric media.	B4, B5 (Analyze, Evaluate)
CO5	To apply concepts of reflection, refraction, and Fresnel's laws in EM wave propagation.	B3, B4 (Apply, Analyze)
CO6	To understand and explain polarization states of EM waves and their detection using optical devices.	B2, B3 (Understand, Apply)

CO–PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓		✓		
CO2	✓	✓		✓		
CO3	✓	✓				✓
CO4	✓	✓		✓		✓
CO5	✓	✓		✓		
CO6	✓	✓				✓

Course Content:

UNIT 1

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. **(11 Lectures)**

UNIT 2

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.

(9 Lectures)

UNIT 3

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). **(9 Lectures)**

UNIT 4

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.

(11 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)

Lecture Plan for Electromagnetic Theory

UNIT 1: Maxwell Equations and EM Basics (11 Lectures)

Lecture 1: Review of Maxwell's equations in integral and differential form.
Lecture 2: Displacement current and Ampere-Maxwell law.
Lecture 3: Scalar and vector potentials; gauge freedom.
Lecture 4: Lorentz and Coulomb gauge conditions.
Lecture 5: Boundary conditions at interface between media.
Lecture 6: Plane electromagnetic waves in free space.
Lecture 7: Plane waves in dielectric media.
Lecture 8: Poynting vector and energy conservation.
Lecture 9: Poynting theorem and its applications.
Lecture 10: Electromagnetic momentum and angular momentum.
Lecture 11: Physical meaning of energy density and momentum density.

UNIT 2: EM Wave Propagation in Unbounded Media (9 Lectures)

Lecture 12: Plane wave propagation through vacuum and isotropic dielectric medium.
Lecture 13: Transverse nature of EM waves; wave equation derivation.
Lecture 14: Refractive index, dielectric constant, and wave impedance.
Lecture 15: EM wave propagation through conducting medium and skin depth.
Lecture 16: Relaxation time and good conductor approximation.
Lecture 17: Plasma frequency and propagation through dilute plasmas.
Lecture 18: Refractive index of ionized media.
Lecture 19: Applications of skin depth and plasma behavior.
Lecture 20: Propagation of EM waves through ionosphere.

UNIT 3: EM Wave in Bounded Media (9 Lectures)

Lecture 21: Boundary conditions at plane interface between dielectric media.
Lecture 22: Laws of reflection and refraction for plane waves.
Lecture 23: Fresnel's formulae for perpendicular and parallel components.
Lecture 24: Brewster's angle and total internal reflection.
Lecture 25: Evanescent waves and their characteristics.
Lecture 26: Reflection and transmission coefficients at interfaces.
Lecture 27: Metallic reflection and normal incidence.
Lecture 28: Conceptual understanding of impedance matching.
Lecture 29: Applications in optical coatings and waveguides.

UNIT 4: Polarization of Electromagnetic Waves (11 Lectures)

Lecture 30: Description of linear, circular, and elliptical polarization.
Lecture 31: Propagation of EM waves in anisotropic media.
Lecture 32: Dielectric tensor and birefringence.
Lecture 33: Fresnel's formula for uniaxial crystals.
Lecture 34: Ordinary and extraordinary rays.
Lecture 35: Double refraction and its explanation.
Lecture 36: Detection of plane and elliptically polarized light.
Lecture 37: Use of retardation plates – quarter-wave and half-wave plates.
Lecture 38: Babinet compensator and Stokes parameters.
Lecture 39: Analysis of polarized light using optical components.
Lecture 40: Applications in LCDs, polarimeters and photonics.

UNIT 5: Rotatory Polarization (5 Lectures)

Lecture 41: Optical rotation and Biot's laws.
Lecture 42: Fresnel's theory of optical rotation.
Lecture 43: Specific rotation and measurement methods.
Lecture 44: Experimental verification of Fresnel's theory.
Lecture 45: Laurent's half-shade polarimeter: theory and applications.

Reference Books:

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

Additional Books for Reference

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

SEMESTER VII

PHC401: CLASSICAL MECHANICS

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The course aims

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

Course Outcomes:

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	To formulate and solve dynamical problems using Lagrangian and Hamiltonian approaches.	B3, B4 (Apply, Analyze)
CO2	To apply variational principles and conservation laws to classical systems.	B3, B4 (Apply, Analyze)
CO3	To understand and interpret the dynamics of two-body central force problems and classify orbital motion.	B2, B4 (Understand, Analyze)
CO4	To analyze small oscillations using normal coordinates and understand resonance in forced systems.	B4, B5 (Analyze, Evaluate)
CO5	To describe and apply the principles of special relativity in classical framework.	B2, B3 (Understand, Apply)
CO6	To explain and analyze advanced Hamiltonian formulations and basic concepts of chaos.	B2, B4 (Understand, Analyze)

CO–PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓		✓		
CO2	✓	✓		✓		
CO3	✓	✓				✓
CO4	✓	✓		✓		✓
CO5	✓	✓				✓
CO6	✓	✓		✓		✓

Course Content:

UNIT 1

Lagrangian and Hamiltonian Formulations of Mechanics: Calculus of variations, Hamilton's principle of least action, Lagrange's equations of motion, conservation laws,systems with a single degree of freedom, rigid body dynamics, symmetrical top, Hamilton's equations of motion, phase plots, fixed points and their stabilities. **(13 lectures)**

UNIT 2

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

UNIT 3

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

UNIT 4

Special Theory of Relativity: Lorentz transformation, relativistic kinematics and dynamics, $E=mc^2$.

(7 lectures)

UNIT 5

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

(6 lectures)

Lecture Plan for Classical Mechanics

UNIT 1: Lagrangian and Hamiltonian Formulations of Mechanics (13 Lectures)

Lecture 1: Calculus of variations and principle of least action.
Lecture 2: Euler-Lagrange equations and generalized coordinates.
Lecture 3: Lagrange's equations of motion for conservative systems.
Lecture 4: Applications of Lagrangian formulation to simple systems.
Lecture 5: Systems with single degree of freedom and rigid body dynamics.

Lecture 6: Conservation laws and cyclic coordinates.
Lecture 7: Symmetrical top: dynamics and precession.
Lecture 8: Hamilton's principle and derivation of Hamilton's equations.
Lecture 9: Hamiltonian formulation and canonical equations.
Lecture 10: Phase space, phase plots, and energy surfaces.
Lecture 11: Fixed points and their stabilities.
Lecture 12: Comparison of Lagrangian vs. Hamiltonian approaches.
Lecture 13: Problem-solving session and practice problems.

UNIT 2: Two-Body Central Force Problem (8 Lectures)
Lecture 1: Reduction to one-body problem in central force field.
Lecture 2: Equation of motion and first integrals.
Lecture 3: Classification of orbits: bound and unbound.
Lecture 4: Circular and elliptical orbit conditions.
Lecture 5: The Kepler problem: planetary motion.
Lecture 6: Scattering in central force field.
Lecture 7: Applications in atomic and astrophysical systems.
Lecture 8: Numerical and graphical problem solving.

UNIT 3: Small Oscillations (6 Lectures)
Lecture 1: Linearization of equations of motion near equilibrium.
Lecture 2: Normal coordinates and their significance.
Lecture 3: Examples of coupled oscillations.
Lecture 4: Free and forced oscillations.
Lecture 5: Resonance phenomena.
Lecture 6: Practice problems and physical interpretations.

UNIT 4: Special Theory of Relativity (6 Lectures)
Lecture 1: Lorentz transformation and its derivation.
Lecture 2: Length contraction and time dilation.
Lecture 3: Velocity addition and simultaneity.
Lecture 4: Relativistic dynamics and momentum.
Lecture 5: Mass-energy equivalence.
Lecture 6: Conceptual problems and applications in modern physics.

UNIT 5: Hamiltonian Mechanics and Chaos (7 Lectures)
Lecture 1: Canonical transformations and generating functions.
Lecture 2: Poisson brackets and their properties.
Lecture 3: Hamilton-Jacobi theory and applications.
Lecture 4: Action-angle variables and integrable systems.
Lecture 5: Perturbation theory basics.
Lecture 6: Classical chaos and sensitivity to initial conditions.
Lecture 7: Simple examples and overview of nonlinear dynamics.

Reference Books:

- H. Goldstein, Classical Mechanics.
- L.D. Landau and E.M. Lifshitz, Mechanics.

- I.C. Percival and D. Richards, Introduction to Dynamics.
- J.V. Jose and E.J. Saletan, Classical Dynamics: A Contemporary Approach.
- E.T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies.
- N.C. Rana and P.S. Joag, Classical Mechanics.
- Classical Mechanics, H.M. Agrawal, New age international, 2019.

PHC303: NUCLEAR PHYSICS

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objective

1. To examine the fundamental properties and structure of atomic nuclei.
2. To analyze nuclear models that explain stability and binding energy.
3. To investigate the mechanisms and theories behind alpha, beta, and gamma decay.
4. To study nuclear reaction types, dynamics, and conservation principles.
5. To explore the role of nuclear physics in astrophysical nucleosynthesis.

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	Describe the fundamental properties of nuclei and their measurable quantities.	B1, B2 (Remember, Understand)
CO2	Apply nuclear models to evaluate binding energies and nuclear stability.	B3, B4 (Apply, Analyze)
CO3	Analyze alpha, beta, and gamma decay mechanisms and interpret decay data.	B4, B5 (Analyze, Evaluate)
CO4	Evaluate nuclear reactions, cross-sections, and scattering parameters.	B4, B5 (Analyze, Evaluate)
CO5	Explain astrophysical processes of nucleosynthesis and heavy element formation.	B2, B3 (Understand, Apply)
CO6	Solve numerical problems related to decay, reactions, and nuclear energy.	B3, B4 (Apply, Analyze)
CO7	Interpret recent trends and research in nuclear physics based on foundational concepts.	B5, B6 (Evaluate, Create)

CO-PO Mapping Matrix of Nuclear Physics

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓	✓			
CO3	✓	✓	✓			
CO4	✓	✓	✓	✓		
CO5	✓			✓	✓	
CO6	✓	✓	✓	✓		
CO7	✓	✓		✓	✓	✓

Course Content:

UNIT 1

General Properties of Nuclei: Constituents of nucleus agnd 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)

UNIT 2

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)

UNIT 3

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

(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)

UNIT 4

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

(6 Lectures)

Reference Books

- *Introductory Nuclear Physics* – Kenneth S. Krane, (Wiley India Pvt. Ltd., 2008)
- *Concepts of Nuclear Physics* – Bernard L. Cohen, Tata McGraw-Hill (1998)
- *Introduction to the Physics of Nuclei & Particles* – R.A. Dunlap, Thomson Asia (2004)
- *Nuclear Physics* – H.M. Agrawal, PHI (2006)

Additional Books for Reference

- *Introduction to High Energy Physics* – D.H. Perkins, Cambridge University Press
- *Quarks and Leptons* – F. Halzen & A.D. Martin, Wiley India
- *Basic Ideas and Concepts in Nuclear Physics* – K. Heyde, IOP Publishing (2004)

Lecture Plan- Nuclear Physics (45 Lectures)

UNIT 1: General Properties of Nuclei (10 Lectures)

Lecture 1: Constituents of the nucleus and their intrinsic properties

Lecture 2: Quantitative facts about nuclear mass, charge, and radii

Lecture 3: Nuclear charge density and matter density

Lecture 4: Nuclear binding energy and average binding energy

Lecture 5: Variation of average binding energy with mass number

Lecture 6: Features of binding energy vs mass number curve and N/A plot

Lecture 7: Nuclear angular momentum and parity

Lecture 8: Magnetic and electric moments of the nucleus

Lecture 9: Nuclear excited states and transitions

Lecture 10: Summary and discussion on nuclear stability indicators

UNIT 2: Nuclear Models (12 Lectures)

Lecture 1: Liquid drop model approach

Lecture 2: Semi-empirical mass formula and explanation of terms

Lecture 3: Condition for nuclear stability and implications

Lecture 4: Two-nucleon separation energies and nuclear mass trends

Lecture 5: Fermi gas model: degenerate fermion gas

Lecture 6: Nuclear symmetry energy in Fermi gas model

Lecture 7: Experimental evidence for shell structure and magic numbers

Lecture 8: Basic assumptions of the nuclear shell model

Lecture 9: Concept of mean field in nuclear models

Lecture 10: Residual interaction and its effects

Lecture 11: Overview of nuclear forces and exchange forces

Lecture 12: Recap and problem-solving on nuclear model applications

UNIT 3: Radioactivity and Nuclear Reactions (17 Lectures)

Lecture 1: Basics of α-decay processes

Lecture 2: Theory of α-emission and tunneling

Lecture 3: Gamow factor and Geiger-Nuttall law

Lecture 4: Alpha spectroscopy and decay series

Lecture 5: Kinematics and energetics of β-decay

Lecture 6: Positron emission and electron capture

Lecture 7: Neutrino hypothesis and conservation principles

Lecture 8: Gamma-ray emission processes and kinematics

Lecture 9: Internal conversion and competition with γ-decay

Lecture 10: Types of nuclear reactions and conservation laws

Lecture 11: Reaction kinematics and threshold energy

Lecture 12: Q-value of nuclear reactions and its calculations

Lecture 13: Reaction cross-section and reaction rate concepts

Lecture 14: Compound nucleus and direct reaction mechanisms

Lecture 15: Resonance reactions and cross-section peaks

Lecture 16: Coulomb scattering and Rutherford scattering formula

Lecture 17: Recap and numerical problems on decay and reactions

UNIT 4: Nuclear Astrophysics (6 Lectures)

Lecture 1: Early universe and Big Bang nucleosynthesis

Lecture 2: Particle nuclear interactions and primordial nuclei formation

Lecture 3: Stellar nucleosynthesis and fusion chain

Lecture 4: Concept and significance of Gamow window

Lecture 5: Formation of heavy elements: s-process

Lecture 6: r-process path and final element abundance distribution

PHE103: NANO MATERIALS AND APPLICATIONS

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)
Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:
This course will develop basic understanding of the nano systems and their applications. The objectives of the course are:

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

Course Outcomes:

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

1. In the Nano systems and its implications in modifying the properties of materials at the nanoscale.509
2. Concept of Quantum confinement, 3D, 2D, 1D and 0D nanostructure with examples.
3. Different synthesis techniques including top down and bottom-up approaches.
4. Characterization of nanostructured materials using X-ray diffraction, electron microscopy, Atomic Force Microscopy and Scanning Tunneling Microscopy.
5. Optical properties of nanostructured materials, modification of band gap, excitonic confinement.

Course Content:

UNIT 1
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. **(10 Lectures)**

UNIT 2
SYNTHESIS OF NANOSTRUCTURE MATERIALS: Top down and Bottom-up approach,

Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots. **(10 Lectures)**

UNIT 3

CHARACTERIZATION: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **(8 Lectures)**

UNIT 4

OPTICAL PROPERTIES: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures. **(11 Lectures)**

UNIT 5

ELECTRON TRANSPORT: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **(6 Lectures)**

Reference books:

- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- 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).

PRACTICAL Nano Materials and Applications (Credit:01, 30 hours)

List of Experiments:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and

study its XRD.

9. Fabricate a thin film of nanoparticles by spin coating (or chemical route)and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

Reference Books:

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

PHE107: Electronics and Devices

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The course aims to develop a strong foundation in semiconductors, analog & digital electronics, signal processing, and high-frequency systems, equipping students with essential theoretical and practical skills.

1. Understand the Fundamentals of Semiconductor Devices – Develop a deep understanding of diodes, transistors, field-effect devices, and optoelectronic components like LEDs and solar cells, along with their structural properties and applications.
2. Gain Proficiency in Analog Electronics – Learn the working and applications of operational amplifiers (Op-Amps), impedance matching, amplification techniques, and signal conditioning methods essential for circuit design.
3. Master Digital Electronics Concepts – Understand logic circuits, registers, counters, comparators, A/D and D/A conversion, and microprocessor basics for digital system applications.

Course Outcomes:

S No.	Course Outcome Statement	Bloom's Level(s)
CO1	Explore semiconductor devices, including diodes, transistors, field-effect devices, and optoelectronic components like LEDs and solar cells.	B2(Understand)
CO2	Gain proficiency in analog electronics, covering operational amplifiers (Op-Amps), signal conditioning, impedance matching, and feedback circuits.	B3(Apply)
CO3	Develop expertise in digital electronics, including logic circuits, registers, counters, microprocessors, and A/D & D/A conversion techniques.	B3(Apply)
CO4	Analyze signal processing and communication techniques such as filtering, noise reduction, shielding, Fourier transforms, and modulation and Explore high-frequency devices.	B4(Analyze)

CO-PO Mapping Matrix of PHC405: Electronics

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓		✓		
CO3	✓	✓		✓		✓
CO4	✓	✓		✓		✓
CO5	✓	✓		✓		
CO6	✓	✓				✓

Course Content:

UNIT 1

SEMICONDUCTOR DEVICES: Diodes, junctions, transistors, field-effect devices, homo- and hetero-junction devices, device structure, characteristics, frequency dependence, and applications. Opto-electronic devices including solar cells, photo-detectors, and LEDs. **(12 Lectures)**

UNIT 2

ANALOG ELECTRONICS: Operational amplifiers (Op-Amps) and their applications, impedance matching, amplification using Op-Amps and instrumentation amplifiers, feedback circuits, and signal conditioning and recovery. **(12 Lectures)**

UNIT 3

DIGITAL ELECTRONICS: Logic circuits, registers, counters, comparators, A/D and D/A converters, and microprocessor and microcontroller basics. **(10 Lectures)**

UNIT 4

SIGNAL PROCESSING, COMMUNICATION & HIGH-FREQUENCY DEVICES: Filtering and noise reduction, shielding and grounding, Fourier transforms, modulation techniques, and high-frequency devices including generators and detectors. **(16 Lectures)**

Reference Books:

- Millman’s Integrated Electronics – Jacob Millman & Christos C. Halkias (McGraw-Hill)
- Electronic Devices and Circuit Theory – Robert L. Boylestad & Louis Nashelsky (Pearson)
- Op-Amps and Linear Integrated Circuits – Ramakant A. Gayakwad (Pearson)
- Digital Design: Principles and Practices – John F. Wakerly (Pearson)
- Microelectronic Circuits – Adel S. Sedra & Kenneth C. Smith (Oxford University Press)
- Signals and Systems – Alan V. Oppenheim, Alan S. Willsky (Pearson)
- Electronic Communication Systems – George Kennedy & Bernard Davis (McGraw-Hill)
- Microprocessor Architecture, Programming, and Applications with the 8085 – Ramesh S. Gaonkar (Penram International)

Lecture Plan- Electronics (45 Lectures)

UNIT 1: Semiconductor Devices (10 Lectures)

Lecture 1: Overview of semiconductor materials and intrinsic/extrinsic semiconductors.
Lecture 2: P-N junction diode: formation, characteristics, and dynamic resistance.
Lecture 3: Junction breakdown, Zener diode, and voltage regulation.
Lecture 4: Bipolar junction transistor (BJT): n-p-n and p-n-p configuration.
Lecture 5: Transistor characteristics in CE, CB, and CC modes.
Lecture 6: Field-effect transistor (FET): JFET, MOSFET – construction and working.
Lecture 7: Frequency response of BJT and FET devices.
Lecture 8: Hetero-junction and optoelectronic devices: LEDs and photodetectors.
Lecture 9: Solar cells: construction, characteristics, and efficiency.
Lecture 10: Summary and real-world device applications.

UNIT 2: Analog Electronics (10 Lectures)

Lecture 1: Introduction to operational amplifiers – ideal vs. practical characteristics.
Lecture 2: Inverting and non-inverting amplifier configurations using op-amps.
Lecture 3: Differential amplifier and common-mode rejection.
Lecture 4: Instrumentation amplifier: concept and design basics.
Lecture 5: Op-amp-based adder, subtractor, integrator, and differentiator.
Lecture 6: Signal conditioning circuits – concept and applications.
Lecture 7: Feedback amplifiers – types and their role in stability.
Lecture 8: Power amplifiers – classification and working (Class A, B, AB, C).
Lecture 9: Oscillator circuits using op-amps: Wien bridge, phase shift.
Lecture 10: Recap and practice problems on amplifier circuits.

UNIT 3: Digital Electronics (8 Lectures)

Lecture 1: Introduction to logic gates and Boolean algebra.
Lecture 2: Combinational logic design – half adder, full adder, multiplexers.
Lecture 3: Sequential circuits – flip-flops and shift registers.
Lecture 4: Counters and timers: asynchronous and synchronous types.
Lecture 5: Digital comparators and encoders/decoders.
Lecture 6: A/D and D/A converters – working and types.
Lecture 7: Basics of microprocessor and microcontroller architecture.
Lecture 8: Instruction sets and simple programming overview.

UNIT 4: Signal Processing, Communication & High-Frequency Devices (12 Lectures)

Lecture 1: Overview of analog vs. digital signal processing.
Lecture 2: Noise in electronic circuits – filtering and shielding techniques.
Lecture 3: Grounding and isolation in high-frequency systems.

Lecture 4: Fourier transforms – concept and applications in electronics.
Lecture 5: Modulation techniques – AM, FM basics and block diagrams.
Lecture 6: Demodulation and signal recovery.
Lecture 7: Generation of high-frequency signals – transistor oscillators.
Lecture 8: Tuned amplifiers – resonance and selectivity.
Lecture 9: Detectors – AM detector, envelope detector, superheterodyne.
Lecture 10: Power supply circuits and SMPS – working principle.
Lecture 11: Active filters – RC low-pass, high-pass, and band-pass filters.
Lecture 12: Recap and applications of electronic communication systems.

PHE108: ELECTRONICS LABORATORY(LAB-I)

Total Credits: 04

Total Hours: Practical:120

L	T	P	Cr
0	0	4	4

Course Objective:

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

Course Outcome:

S.No.	Course Outcome Statement	Bloom's Level(s)
CO1	Develop competency in handling electronic components and instruments for conducting experiments in electronics	B3(Apply)
CO2	Acquire and analyze data from various experimental setups using appropriate electronic systems and measurement techniques	B4(Analyze)
CO3	Design and implement basic electronic circuits on a breadboard based on given experimental objectives.	B6,B3(Create, Apply)
CO4	Maintain a clear and organized laboratory record documenting experimental procedures, results, and analysis.	B3, B5(Apply, Evaluate)

CO-PO Mapping Matrix of Electronics Laboratory

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓				
CO2	✓	✓	✓	✓			
CO3	✓	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		✓	✓

Course Content:

1. To study the various digital analog circuits:
4-bit discrete binary adder network, 8-bit DAC using 0808 IC without OP-amp.

2. To draw transfer characteristics of

(a) An OP-amp (741IC) in inverting mode in close loop.

(b) To determine offset voltage

(c) To determine CMRR of the OP-amp

3. To determine the band gap of a semiconductor (Ge)

4. To study the amplitude modulation with the help of CRO

(a) with I/O frequency at constant I/O voltage

(b) To study variation of percentage of modulation with I/O voltage at constant I/O frequency.

(c) Plotting modulated and demodulated wave

(d) To determine carrier frequency

5. To study the frequency response of RC coupled amplifier

(a) with feedback

(b) without feedback

6. To perform various mathematical, logical and jump operations for 8 bit numbers using 8085 microprocessor.

7. To perform various mathematical, logical operations and jump operations for 16 bit numbers using 8085 microprocessors.

8. To study a RC circuit as a low pass and high pass filter and study the RC c circuit as a differentiator and integrator.

Lecture Plan: Electronics Laboratory (LAB-I)

Lecture1: Familiarity with lab equipment, safety norms, lab record format
Lecture2: Understand digital addition and logic gates
Lecture3: Study of digital-to-analog conversion
Lecture4: Analyze gain and behavior in closed loop
Lecture5: Measure input offset in practical circuits
Lecture6: Test amplifier rejection of common-mode signals
Lecture7: Determine energy gap via V-I curve
Lecture8: Assess understanding of op-amp and basic circuits
Lecture9: Study of waveform under fixed amplitude
Lecture10: Observe how modulation index varies
Lecture11: Visualization and waveform analysis
Lecture12: Carrier analysis using signal tracing
Lecture13: Group discussion and error analysis
Lecture14: Study amplifier response and gain
Lecture15: Analyze changes in bandwidth and stability
Lecture16: Discuss impact of feedback on gain and distortion
Lecture17: Structure, programming model, machine cycle
Lecture18: Write and run programs for 8-bit math/logic
Lecture19: Learn control flow and conditional logic
Lecture20: Perform extended 16-bit operations
Lecture21: Study RC circuit as differentiator and integrator
Lecture22: Debug and optimize code with test inputs
Lecture23: Complete all pending entries, viva prep
Lecture24: Full assessment of practical knowledge

PHE109: Quantum Mechanics II

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

1. To strengthen the theoretical foundation of quantum mechanics and extend its application to more complex and practical physical systems.
2. To introduce perturbation techniques in quantum mechanics.
3. To explore the theory and computational techniques of quantum scattering.
4. To explore quantum mechanics from a relativistic perspective.

Course Outcomes:

After completion of this course, students will be able to:

S.No.	Course Outcome Statement	Bloom's Level(s)
CO1	Apply advanced concepts of quantum mechanics to analyze physical systems beyond the basics learned in introductory courses.	B3, B4 (Apply, Analyze)
CO2	Utilize time-independent and time-dependent perturbation theory to solve complex quantum systems.	B3(Apply)
CO3	Analyze quantum scattering processes using theoretical and computational methods.	B4(Analyze)
CO4	Evaluate quantum mechanical systems within a relativistic framework, including the Dirac and Klein-Gordon equations.	B5(Evaluate)
CO5	Develop problem-solving skills and use appropriate mathematical tools for modeling advanced quantum phenomena.	B6, B3 (Create, Apply)

CO-PO Mapping Matrix of Functional Topics of Physics

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		✓
CO5	✓	✓	✓	✓		✓

Course Content:

UNIT 1

Time independent Perturbation Theory: Time independent perturbation theory for non- degenerate and degenerate systems upto second order perturbation. Application to a harmonicoscillator, first order Stark effect in hydrogen atom, Zeeman effect with electron spin.

Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules. **(13 lectures)**

UNIT 2

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

UNIT 3

Scattering Theory: General considerations; kinematics, wave mechanical picture, scattering amplitude, differential and total cross-section. Green's function for scattering. Partial wave analysis: asymptotic behavior of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, optical theorem, phase shifts and its relation to potential, application to low energy scattering, exactly soluble problems; square-well, hard sphere, coulomb potential, Born approximation; its validity, Born series.

(9 lectures)

UNIT 4

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

(13 lectures)

Reference Books:

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

Lecture Plan- Quantum Mechanics II (45 Lectures)

Unit 1: Time Independent Perturbation Theory (13 lectures)

Lecture1: Overview of perturbation theory; conditions and scope
Lecture2: Non-degenerate perturbation theory – first order
Lecture3: Non-degenerate perturbation theory – second order
Lecture4: Application: Harmonic oscillator with perturbation
Lecture5: Degenerate perturbation theory – formalism
Lecture6: Application: Zeeman effect (without spin)
Lecture7: Zeeman effect including spin and magnetic interaction
Lecture8: First-order Stark effect in Hydrogen
Lecture9: Variational Principle – derivation and justification
Lecture10: Application to Helium atom – ground state
Lecture11: Electron interaction energy in Helium
Lecture12: Extension of variational method to excited states
Lecture13: WKB approximation: turning points, quantization, potential well

Unit 2: Time Dependent Perturbation Theory (10 lectures)

Lecture1: Time-dependent perturbation theory – formalism
Lecture2: Constant perturbation and transition probability
Lecture3: Fermi's Golden Rule and derivation
Lecture4: Coulomb excitation: example and interpretation
Lecture5: Sudden approximation – derivation and application
Lecture6: Adiabatic approximation and breakdown conditions
Lecture7: Harmonic perturbation: resonance, Rabi oscillations
Lecture8: Radiative transitions – dipole approximation
Lecture9: Einstein's A and B coefficients
Lecture10: Spontaneous and stimulated emission – semiclassical view

Unit 3: Scattering Theory (9 lectures)

Lecture1: Introduction to scattering, kinematics and observables
Lecture2: Wave mechanical approach, scattering amplitude
Lecture3: Differential and total cross-sections
Lecture4: Green's function method in scattering
Lecture5: Partial wave expansion – theory and application
Lecture6: Phase shifts – asymptotic behaviour, relation to potential
Lecture7: Scattering amplitude using phase shifts
Lecture8: Optical theorem and low energy scattering
Lecture9: Born approximation, examples: square well, hard sphere, Coulomb

Unit 4: Relativistic Wave Equations (13 lectures)

Lecture1: Need for relativistic quantum mechanics
Lecture2: Klein-Gordon equation – derivation and issues
Lecture3: Charge density, current, and negative probabilities
Lecture4: Coupling with EM field – minimal coupling
Lecture5: Dirac equation – derivation and motivation
Lecture6: Free particle solution of Dirac equation
Lecture7: Dirac matrices and algebra – properties
Lecture8: Probability density and current – physical interpretation
Lecture9: Non-relativistic limit of Dirac equation
Lecture10: Hydrogen atom solution from Dirac equation
Lecture11: Spin and magnetic moment – interpretation from Dirac theory
Lecture12: Orbital angular momentum non-conservation, spin concept
Lecture13: Negative energy solutions and positron theory

PHS101: BASICS OF INSTRUMENTS

Total Credits: 02 (Credits: Theory: 01, Practical: 01)

Total Hours: Theory: 15, Practical: 30

Course Objectives:

To expose the students to various aspects of instruments and their usage through hands-on mode. To provide them a thorough understanding of basics of measurement, measurement devices such as electronic voltmeter, oscilloscope, signal and pulse generators, impedance bridges, digital instruments etc.

Course Outcomes:

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	To understand the necessary working knowledge on accuracy, precision, resolution, range and errors/uncertainty in measurements.	B2, B3 (Understand, Apply)
CO2	To understand the measurement and errors in measurements keeping in mind with every specification of a basic instruments in the laboratory. •	B2, B3 (Understand, Apply)
CO3	Detailed Understanding of CRO and its significance.	B2, B3, B4 (Understand, Apply, Analyze)
CO4	To learn about principles of voltage measurement.	B2, B4 (Understand, Analyze)
CO5	Hands on ability to use basic instruments in the laboratory such as multimeters, CRO, signal generators etc.	B3, B4, B5(Apply, Analyze, Evaluate)

CO-PO Mapping Matrix of Basics of Instruments

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓	✓		✓
CO2	✓		✓	✓		✓
CO3	✓		✓	✓	✓	✓
CO4	✓	✓		✓		
CO5			✓	✓	✓	✓

Course Content:

UNIT 1

Basics of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Working principle of time interval, frequency and period measurement, time-base stability, accuracy and resolution.

(4 Lectures)

UNIT 2

Multimeter: Measurement of dc voltage and dc current, ac voltage, ac current and Specifications of electronic voltmeter/multimeter and their significance. AC milli-voltmeter, working of a digital multimeter.

(4 Lectures)

UNIT 3

Cathode Ray Oscilloscope: Specifications of CRO with block diagram and their significance. Measurement of voltage (dc and ac), frequency and time period. Special features of dual trace. Digital storage Oscilloscope: principle of working.

. **(4 Lectures)**

UNIT 4

Signal and Pulse Generators: Block diagram and specifications of low frequency signal and pulse generators. Distortion factor meter, wave analysis.

(3 Lectures)

Reference Books:

Essential Readings: 1)

- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan and N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

- Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.
- Electronic Instrumentation, H.S. Kalsi, 3rd Ed. Tata McGraw Hill.
- Additional Readings:
- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.

Lecture Plan for Basics of Instruments

UNIT 1: Basics of Measurement (4 Lectures)

Lecture 1: Importance of measurement in electronics; In terms of Accuracy, Precision, Sensitivity, Resolution, and Range

Lecture 2: Different types of errors in measurements and minimizations of errors.

Lecture 3: Frequency, period, and time interval measurements

Lecture 4: Time-Base Stability and measurement resolution and accuracy improvement techniques

UNIT 2: Multimeter (4 Lectures)

Lecture1: Basic working of multimeter, proper connection technique and range setting.

Lecture2: Multimeter specifications and significance; Specifications: range, resolution, input impedance, burden voltage.

Lecture3: Measurements of DC and AC voltage and current with precaution during measurements.

Lecture4: Working of a Digital Multimeter (DMM) with block diagram; advantages and limitations of DMMs.

UNIT 3: Cathode Ray Oscilloscope (4 Lectures)

Lecture 1: Introduction to CRO with block diagram; Its components and working.

Lecture 2: Measurement of Voltage, Time Period, and Frequency**.**

Lecture 3: Comparing waveform by dual trace feature of CRO and practical applications of dual-trace function.

Lecture 4: Digital Storage Oscilloscope (DSO); key difference from Analog CRO, Advantages of waveform storage and analysis.

UNIT 4: Signal and Pulse Generators (3 Lectures)

Lecture1: Signal Generators: block diagram and specifications.

Lecture2: Pulse generators and characteristics.

Lecture3: Distortion factor meter and waveform analysis

Practical: Basics of Instruments (Credit:01, 30 hours)

Every student must perform at least 05 experiments

1. Observe and calculate accuracy, precision, sensitivity, and resolution using standard lab instruments.

2. Understand working of a Digital Multimeter (block-wise) and interpret specifications.
3. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
4. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
5. Measure DC voltage, DC current, AC voltage, and AC current using a multimeter.
6. To measure Q of a coil and its dependence on frequency, using Q-meter.
7. Understand front panel and block diagram of CRO.
8. Measurement of voltage, frequency, time period and phase using an oscilloscope.
9. Observe and compare two signals using dual trace by CRO.
10. Phase difference measurement using CRO
11. Measurement of time period, frequency, average period using universal counter/frequency counter.
12. Measurement of rise, fall and delay times using oscilloscope.
13. Study and verify the block diagram and specifications of a function generator.

Measurement of distortion of a RF signal

Department of Physics

Bachelor of Science (Minor) in Physics

based on NEP-2020

(Effective from academic session 2022-2023)

1. Introduction to Undergraduate (Minor) Degree course in Physics

The undergraduate minor degree in Physics is an eight-semester course spread over four academic years. The teaching – learning process is student-centric and it involves both theory and practical components. The student gets a strong foundation in the subject and gains in-depth knowledge of Physics courses.

2. Programme Outcomes:

Program	Program Outcomes
B Sc (minor degree) in Physics	After studying Physics in B.Sc. Program students will be able to: **PO1**: **In-depth disciplinary knowledge** Acquire comprehensive knowledge and gain an understanding of the fundamental principles and theoretical principles of Physics. **PO2**: **Problem-Solving and Critical Thinking** Sharpen analytical thinking, problem-solving prowess, and critical reasoning which are versatile skills applicable across a multitude of domains. **PO3**: **Hands-on/ Laboratory Skills** Comprehensive hands-on/ laboratory exercises will impart analytical, computational and instrumentation skills. **PO4**: **Research skills** The course provides an opportunity to students to hone their research and innovation skills through internship/apprenticeship/ project/community outreach/dissertation/Academic Project/Entrepreneurship. **PO5**: **Communication Skills** The various DSCs, DSEs, SECs, GEs and AECs are designed to enhance student's ability to write methodical, logical and precise reports. **PO6**: **Lifelong learning skills and Entrepreneurship** Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life.

3. Program Specific Outcomes:

Program	Program Specific Outcomes
B Sc (Minor) in Physics	After studying Physics in B.Sc., **PSO1**: Students get accomplished in various mathematical techniques and programming languages. **PSO2**: Students will develop hands-on skills in experimental design, analysis, and interpretation of results. **PSO3**: Students will be proficient in designing, analyzing, and troubleshooting both analog and digital electronic circuits, and semiconductor devices used in various electronic applications, preparing graduates for careers in semiconductor industry.

4. Programme Duration and Exit Options

The minimum credits to be earned by the student per semester are 22 credits. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits which have to be secured for the purpose of award of Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Physics are listed in Table 1.

Table 1: Award with credit requirement

S. No.	Name of Award	Stage of Exit	Mandatory
1	Undergraduate Minor degree in Physics	After successful completion of Semester VIII with minimum 32 GE credits in Physics	32 credits in eight semesters

An undergraduate student may be awarded minor degree in Physics, on completion of VIII Semesters, if she/he earns minimum 32 credits from eight GE courses in eight semesters from the Department of Physics.

5. Definitions and Abbreviations

(i) **Academic Credit**: An academic credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/ field work per week.

(ii) **Generic Elective (GE) in Physics:** Generic Electives is a pool of courses offered by the Department of Physics, which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond his/ her discipline specific course(s) of study, such DSEs shall be treated as GEs for that student.

6. BASIC PRINCIPLES:

Within the context of the minor program, it is compulsory to take the courses as prescribed/approved by the academic council and to succeed in all such courses for the award of minor degree. These courses are designed by the schools/departments in consultation with other schools/departments.

Conditions For Application and Admittance into the Minor Program:

1. Students who enrolled for a four-year undergraduate degree program are eligible for enrolling into the minor program.
2. A student is eligible to register only for one minor program during their period of study following university notification.
3. The students have to complete a minimum 32 credits to be eligible for the award of minor degree.
4. Students can apply to the minor programs at the beginning of the first/second academic year considering the number of credits they have completed earlier to commencing the minors.
5. Students who want to start the minor program can start in the period when they apply for the minor program provided that they have successfully achieved all the academic requirements prescribed and they shall not have any backlog papers from the previous semester courses.

STANDING AND PROGRAM COMPLETION CONDITIONS:

In order to qualify for the award of minor degree, the number of credits (32 as prescribed) must be earned by the student.

7. WITHDRAWAL FROM THE MINOR PROGRAM, DISMISSAL:

1. Students can leave the minor program by submitting a withdrawal request to the Dean (Academics)/Registrar and COE which shall be duly vetted by the head of the department offering the minor programme. The Dean (Academics)/Registrar and COE shall approve the request following the university norms and notify the same.
2. Students leaving or dismissed from minor programs must repeat the courses in which they have failed and obtain a passing grade.
3. Students who are considered to be on leave from the major program, are deemed to be on leave from the minor program also.
4. Students who do not take courses from the minor program for two consecutive semesters are automatically deregistered from the minor program.
5. The Dean (Academics)/Registrar and Controller of Examinations are responsible for proper implementation of minor programs.

8. PROGRAMME AND FRAME WORK

S. No.	Course Code	Course Type	Name of the Course	L	T	P	Total Credits
Semester I							
1	PHG101	GE1	Mechanics I	3	1	0	4
							Total Credits 4
Semester II							
2	PHG102	GE2	Introduction to Electromagnetic Theory	3	1	0	4
							Total Credits 4
Semester III							
3	PHG103	GE3	Digital Analog Circuits and Instrumentation	3	1	0	4
							Total Credits 4
Semester IV							
4	PHG104	GE4	Elements of Modern Physics	3	1	0	4
							Total Credits 4
Semester V							
5	PHG105	GE5	Experimental Techniques	3	1	0	4
							Total Credits 4
Semester VI							
6	PHG106	GE6	Bio Physics	3	1	0	4
							Total Credits 4
Semester VII							
7	PHG107	GE7	Electronics Lab I	0	0	4	4
							Total Credits 4
Semester VIII							
8	PHG108	GE8	Electronics Lab II	0	0	4	4
							Total Credits 4

S. No	Course Code	Name of the Course
1	PHG101	Mechanics I
2	PHG102	Introduction to Electromagnetic Theory
3	PHG103	Digital, Analog circuits and Instrumentation
4	PHG104	Elements of Modern Physics
5	PHG105	Experimental Techniques
6	PHG106	Bio Physics
7	PHG107	Electronics Lab-I
8	PHG108	Electronics Lab-II
	PHG109	Mechanics II
6	PHG110	Quantum Mechanics
5	PHG111	Mathematical Physics I
6	PHG112	Thermal Physics
7	PHG113	Waves and Optics
8	PHG114	Mathematical Physics II
9	PHG115	Solid State Physics
10	PHG116	Nuclear and Particle Physics

GENERIC ELECTIVES

PHG101: Mechanics I

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objective:

1. To introduce students to the mathematical formulation of vectors and coordinate systems.
2. To apply ordinary differential equations for modeling physical systems in mechanics.
3. To examine the nature of physical laws and conservation principles in classical mechanics.
4. To analyze kinematics and dynamics of particles and systems using Newtonian mechanics.
5. To explore oscillatory motions and superposition principles relevant to mechanical vibrations.

Course Outcomes:

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

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	Describe the properties of vectors and their application in different coordinate systems.	B1, B2 (Remember, Understand)
CO2	Solve first and second-order ordinary differential equations with physical relevance.	B3, B4 (Apply, Analyze)
CO3	Apply dimensional analysis and physical laws to model mechanical systems.	B2, B3 (Understand, Apply)
CO4	Analyze conservation laws and equations of motion for particles and rigid bodies.	B4, B5 (Analyze, Evaluate)
CO5	Examine harmonic and damped oscillations and their physical interpretations.	B3, B4 (Apply, Analyze)
CO6	Interpret beat phenomena and complex oscillations using superposition principles.	B4, B5 (Analyze, Evaluate)
CO7	Solve numerical problems involving mechanical motion, forces, and oscillations.	B3, B4 (Apply, Analyze)

CO-PO Mapping Matrix of Mechanics I

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√				
CO2	√	√	√			
CO3	√	√	√	√		
CO4	√	√	√	√		√
CO5	√	√		√		
CO6	√			√	√	
CO7	√	√	√			√

Course Content:

UNIT 1

Scalars, vectors, plane polar coordinates, vectors in a plane, scalars, and pseudo-scalars, kinematics in a plane, vectors in a 3-dimensional space, the finite rotation formula

(10 Lectures)

UNIT 2

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

(10 Lectures)

UNIT 3

The nature of physical laws, Fundamental constants, dimensional analysis, the fundamental forces of nature. Conservation laws and Newton's equations, conservation of angular momentum, two-body scattering, two body collision kinematic, conservative forces-the concept of a potential, simple harmonic motion, examples of simple harmonic motion.

(15 Lectures)

UNIT 4

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

(10 Lectures)

Reference Books

- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley.

- Physics–Resnick, Halliday & Walker 9/e, 2010, Wiley University Physics, Ronald
- Lane Reese, 2003, Thomson Brooks/Cole.Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.

Lecture Plan for Mechanics I

UNIT 1: Vectors and Coordinate Systems (10 Lectures)

Lecture 1: Scalars and vectors – definitions and differences.

Lecture 2: Representation of vectors in a plane.

Lecture 3: Plane polar coordinates and transformations.

Lecture 4: Kinematics in two dimensions using vectors.

Lecture 5: Scalar and pseudo-scalar quantities in physics.

Lecture 6: Introduction to three-dimensional vector space.

Lecture 7: Time derivatives and acceleration in 3D motion.

Lecture 8: Vector operations and their geometric meaning.

Lecture 9: Finite rotation and its vector representation.

Lecture 10: Summary and practice problems on vector motion.

UNIT 2: Ordinary Differential Equations (10 Lectures)

Lecture 1: Introduction to ordinary differential equations (ODEs).

Lecture 2: First-order homogeneous differential equations.

Lecture 3: Applications of first-order ODEs in physical systems.

Lecture 4: Second-order homogeneous differential equations.

Lecture 5: Equations with constant coefficients and their solutions.

Lecture 6: Characteristic equations and general solutions.

Lecture 7: Examples from mechanics – motion under force.

Lecture 8: Forced and free oscillations (brief overview).

Lecture 9: Solving ODEs using standard methods.

Lecture 10: Recap and tutorial problem discussion.

UNIT 3: Classical Laws and Oscillatory Motion (15 Lectures)

Lecture 1: The nature and scope of physical laws.

Lecture 2: Fundamental constants and their roles.

Lecture 3: Dimensional analysis – techniques and applications.

Lecture 4: Classification of fundamental forces of nature.

Lecture 5: Newton's laws of motion and force equations.

Lecture 6: Conservation of momentum – linear and angular.

Lecture 7: Angular momentum conservation with examples.

Lecture 8: Kinematics of two-body systems.

Lecture 9: Scattering and collision dynamics.

Lecture 10: Concept of conservative forces and potential energy.

Lecture 11: Derivation and properties of potential energy functions.

Lecture 12: Introduction to simple harmonic motion (SHM).

Lecture 13: Examples and derivation of SHM equations.

Lecture 14: Energy and phase analysis in SHM.

Lecture 15: Numerical problem solving on conservation laws and SHM.

UNIT 4: Superposition of Harmonic Oscillations (10 Lectures)

Lecture 1: Principle of superposition and linearity.

Lecture 2: Superposition of two harmonic oscillations with equal frequency.

Lecture 3: Resultant motion for same frequency oscillations.

Lecture 4: Graphical interpretation and physical meaning.

Lecture 5: Superposition of harmonic motions with different frequencies.

Lecture 6: Beat phenomenon and derivation of beat frequency.

Lecture 7: Applications in acoustics and wave mechanics.

Lecture 8: Energy distribution in beat and superposed systems.

Lecture 9: Visualization and simulation exercises.

Lecture 10: Summary, concept integration, and practice problems.

PHG102: Introduction to Electromagnetic Theory

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objective:

1. To introduce vector calculus tools and their application in electrostatics.
2. To understand electric fields, potentials, and energy concepts using integral and differential forms of Maxwell's equations.
3. To analyze the behavior of dielectric and magnetic materials in electric and magnetic fields.
4. To explain the concepts of electromagnetic induction and derive wave equations for EM waves.
5. To apply boundary conditions and interpret reflection and transmission of electromagnetic waves.
6. To study energy flow, momentum, and angular momentum in electromagnetic fields.

Course Outcomes:

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

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	To apply vector calculus in the context of electric and magnetic fields and explain the basics of electric and magnetic field.	B1, B2, B4 (Remember, Understand, Analyze)
CO2	To explain dielectric polarization and calculate fields in linear dielectrics and capacitors.	B2, B3 (Understand, Apply)
CO3	To interpret magnetic field laws and analyze magnetization and vector potentials.	B2, B4 (Understand, Analyze)
CO4	To derive Maxwell's equations and apply them to electromagnetic induction and energy transfer.	B3, B4 (Apply, Analyze)
CO5	To evaluate and analyze electromagnetic wave propagation, energy, pressure, reflection and transmission coefficients.	B4, B5 (Analyze, Evaluate)
CO6	To solve physical problems involving electromagnetic waves in different media.	B4, B5, B6 (Analyze, Evaluate, Create)

CO–PO Mapping Matrix of Introoduction to Electromagnetic Theory

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓		✓		
CO3	✓	✓	✓	✓		
CO4	✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	✓	✓
CO6	✓		✓	✓	✓	✓

Course Content:

UNIT 1

Electric Field, Electric Potential and Electric Potential Energy

Scalar and vector product, gradient divergence, Coulomb's law Divergence of electric field, Gauss' law. Curl of electric field Stokes' theorem Electrostatic potential. Laplace's equation for electrostatic potential Laplace's equation in other fields Uniqueness of solution of Laplace's equation, Poisson equation and uniqueness of its solution. Method of images for planar surfaces. Work and energy in electrostatics. **(15 lectures)**

UNIT 2

Dielectric Properties of Matter:

Conductors and capacitors, Reciprocity theorem, Polarization and bound charges, Linear dielectrics, Electric displacement Fields in dielectrics. **(7 Lectures)**

UNIT 3

Magnetic Field:

Magnetic field due to a magnet, Magnetic field due to a steady current, Divergence and curl of magnetic field, Ampere's law. The vector potential, Magnetization and bound currents. Magnetic fields in matter. **(8 Lectures)**

UNIT 3

Electromagnetic Induction and Electromagnetic waves:

Maxwell's equations Work done by electromagnetic field Poynting's theorem Momentum in electromagnetic field Angular momentum in electromagnetic field Electromagnetic waves: the wave equation. Wave equation, Plane electromagnetic waves Energy carried by electromagnetic waves Pressure due to electromagnetic waves Refection and transmission of electromagnetic waves Reflection and transmission of electromagnetic waves. **(15 Lectures)**

Reference Books:

- Advanced Practical Physics for students, B.L.Flintand H.T. Worsnop, 1971,Asia Publishing House
- A Text Book of Practical Physics, I.Prakash & Ramakrishna,11thEd.,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 under graduate classes, D.P.Khandelwal,1985, Vani Pub.

Lecture Plan for Introoduction to Electromagnetic Theory

UNIT 1: Electric Field, Electric Potential and Electric Potential Energy (15 Lectures)

Lecture 1: Scalar product, vector product – definitions and applications

Lecture 2: Gradient and divergence – physical interpretation and examples

Lecture 3: Coulomb's Law – point charges and force interaction

Lecture 4: Divergence of electric field – Gauss's divergence theorem

Lecture 5: Gauss's Law – applications to symmetric charge distributions

Lecture 6: Curl of electric field – conservative nature of electrostatics

Lecture 7: Stokes' Theorem – connection with electric fields

Lecture 8: Electrostatic Potential – definition and relation to field

Lecture 9: Laplace's equation – derivation and application in electrostatics

Lecture 10: Laplace's equation in other physical contexts

Lecture 11: Uniqueness theorem – proof and significance

Lecture 12: Poisson's equation – physical relevance and solutions

Lecture 13: Method of images for planar surfaces – boundary condition method

Lecture 14: Work done in electrostatics – calculation using potential

Lecture 15: Electrostatic potential energy – system of charges

UNIT 2: Dielectric Properties of Matter (7 Lectures)

Lecture 1: Conductors and capacitors; Reciprocity theorem

Lecture 2: Polarization and bound charges in dielectric materials

Lecture 3: Linear dielectrics – concepts and examples

Lecture 4: Electric displacement vector and its relation to polarization

Lecture 5: Field equations in the presence of dielectrics

Lecture 6: Applications in capacitive systems – dielectric effects

Lecture 7: Boundary conditions at dielectric interfaces

UNIT 3: Magnetic Field (8 Lectures)

Lecture 1: Magnetic field due to permanent magnets – basic concepts

Lecture 2: Magnetic field due to steady currents – Biot–Savart law

Lecture 3: Divergence and curl of magnetic field – Maxwell's equations context

Lecture 4: Ampere's law – applications in symmetric configurations

Lecture 5: Vector potential – definition and relevance in magnetostatics

Lecture 6: Magnetization – physical meaning and macroscopic description

Lecture 7: Bound currents – surface and volume current densities

Lecture 8: Magnetic fields in matter – response of materials and boundary conditions

UNIT 4: Electromagnetic Induction and Electromagnetic Waves (15 Lectures)

Lecture 1: Derivation of Maxwell's equations – Gauss's laws

Lecture 2: Derivation of Maxwell's equations – Faraday's and Ampère-Maxwell law

Lecture 3: Work done by electromagnetic field on charges

Lecture 4: Poynting's theorem – derivation and physical interpretation

Lecture 5: Linear momentum in electromagnetic field

Lecture 6: Angular momentum in electromagnetic field

Lecture 7: Derivation of wave equation from Maxwell's equations – Part I

Lecture 8: Derivation of wave equation – Part II

Lecture 9: Plane electromagnetic waves in vacuum – field components

Lecture 10: Energy carried by EM waves – intensity and flux

Lecture 11: Radiation pressure – concepts and calculations

Lecture 12: Reflection of EM waves at dielectric boundaries

Lecture 13: Transmission of EM waves through dielectric boundaries

Lecture 14: EM wave behavior at conductor interfaces – reflection and loss

Lecture 15: Applications of EM wave theory in real-world systems

PHG103: Digital, Analog circuits and Instrumentation

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The course will lead to understand about:

1. Difference between analog and digital circuits.
2. Binary numbers, logic gates and Boolean algebra
3. Concepts of semiconductor devices and amplifiers.
4. Basic understanding of operational amplifiers.
5. Sinusoidal Oscillators and their applications.

Course Outcomes:

S. No	Course Outcome Statement	Bloom's Level(s)
CO1	Understanding about analog & digital circuits and their applications.	B2 (Understand)
CO2	Analyze and construct different types of logic gates using basic electronic components and their applications.	B4, B6 (Analyze, create)
CO3	Design and evaluate digital circuits based on Boolean functions.	B5, B6 (Evaluate, create)
CO4	Explain and analyze the working principles and characteristics of semiconductor diodes such as LED, photodiode, solar cell and their applications.	B3, B4 (Apply, Analyze)
CO5	Understanding and analyze the operation of different BJT transistor configurations.	B2, B4 (Understand, Analyze)
CO6	Analyze and design an amplifier and calculate amplifier parameters: gain, input/output impedance, and operating regions.	B4, B6 (Analyze, create)
CO7	Understanding and characteristics of the ideal and practical Op-Amps.	B2, B4 (Understanding, Analyze)
CO8	Understanding about Barkhausen criterion for sustained oscillations and analyze & determine the frequency of RC-based sinusoidal oscillators.	B2, B4, B5 (Understanding, Apply, Evaluate)

CO-PO Mapping Matrix of Digital, Analog circuits and Instrumentation

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓			✓		✓
CO2	✓	✓		✓		✓
CO3		✓	✓	✓		
CO4	✓			✓		✓
CO5	✓		✓	✓		
CO6	✓		✓	✓		✓
CO7	✓		✓	✓	✓	✓
CO8	✓			✓	✓	

Course Content:

UNIT 1

Digital Circuits:

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Min terms and Max terms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

(18 Lectures)

UNIT 2

Semiconductor Devices and Amplifiers:

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

(18 Lectures)

UNIT 3

Operational Amplifiers (Black Box approach):

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

UNIT 4

Sinusoidal Oscillators:

Barkhausen's Criterion for self-sustained oscillations. Determination of frequency RC oscillator.

(4 Lectures)

Reference Books:

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

Lecture Plan for Digital, Analog circuits and Instrumentation

UNIT 1: Digital Circuits (18 Lectures)

Lecture 1: Introduction to Digital vs. Analog Circuits
Lecture 2: Difference between analog & digital systems and their advantages and applications.
Lecture 3: Binary Number System
Lecture 4: Decimal to binary and binary to decimal conversion
Lecture 5: Introduction to Logic Gates (AND, OR, NOT)
Lecture 6: Universal Gates: NAND & NOR
Lecture 7: Implementation of all basic gates using universal gates.
Lecture 8: Truth tables and real-life applications of the different gates.
Lecture 9: De Morgan's Theorems with verification using truth tables
Lecture 10: Simplifying logic circuits using Boolean algebra
Lecture 11: Design of simple circuits using reduced expressions
Lecture 12: Definition of SOP and POS
Lecture 13: Minterms and Maxterms in depth
Lecture 14: Conversion of expressions from SOP to POS and vice versa
Lecture 15: Karnaugh Map (K-Map) Simplification
Lecture 16: Implementation of logic circuits from simplified expressions
Lecture 17: Examples of real logic circuits
Lecture 18: Design and testing of logic gates

UNIT 2: Semiconductor Devices and Amplifiers (18 Lectures)

Lecture 1: Basic introduction about semiconductors.
Lecture 2: Intrinsic vs extrinsic semiconductors

Lecture 3: Charge carriers and conductivity; concept of doping: n-type and p-type materials
Lecture 4: Formation of pn-junction diode & it's working.
Lecture 5: V-I Characteristics of a Diode in forward and reverse bias mode.
Lecture 6: Diode applications: Rectifiers (Half-wave, Full-wave), voltage regulators
Lecture 7: Working principles, symbols of LED, photodiode & solar cells.
Lecture 8: I-V characteristics and applications.
Lecture 9: Introduction to Bipolar Junction Transistors (BJTs).
Lecture 28: Transistor current components and current relations.
Lecture 10 CB, CE & CC transistor configurations and their input and output characteristics.
Lecture 11: Current gains and their relations.
Lecture 12: Graphical approach of DC load line, different operating regions and Q- point.
Lecture 13: Voltage divider bias circuit with analysis; Stability factor and thermal stability.
Lecture 14: CE Amplifier: Circuit diagram & Operation and its applications.
Lecture 15: Input & output impedance, Current gain, voltage gain & power gain of an amplifier
Lecture 16: Classification and operations of Amplifiers
Lecture 17: Class A, B & C and their applications
Lecture 18: Problem solving and practice of circuit designing

UNIT 3: Operational Amplifiers (Black Box approach) (5 Lectures)

Lecture 1: Historical background of Op-Amp, types and working
Lecture 2: Characteristics of Op-Amp: input & output impedance, gain, bandwidth, slew rate, CMRR, PSRR.
Lecture 3: Inverting & non-inverting configurations
Lecture 4: Integrator and differentiator circuits – working and uses.
Lecture 5: Op-Amp applications and lab use: sensors, comparator, filters.

UNIT 4: Sinusoidal Oscillators (4 Lectures)

Lecture 1: Introduction to Oscillators and applications in electronics
Lecture 2: Barkhausen criterion and concept of self-sustained oscillations.
Lecture 3: RC Phase shift oscillator and its design. Limitations and practical uses.
Lecture 4: Problem-solving: frequency calculations from different component values

PHG104: ELEMENTS OF MODERN PHYSICS

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The objectives of the course are:

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

Course Outcomes:

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

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

Course Content:

UNIT 1

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

(5 Lectures)

UNIT 2

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Energy-time uncertainty principle. **(6 Lectures)**

Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension. **(8 Lectures)**

UNIT 3

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension - across a step potential and across a rectangular potential barrier. **(8 Lectures)**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Natureof nuclear force, NZ graph, semi- empirical mass formula and binding energy. **(8 Lectures)**

UNIT 4

Radioactivity: stability of nucleus; Law of radioactive decay; Meanlife and half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. Fission and fusion - mass deficit, relativity and generation of energy; Fission – nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interactingwith Uranium 235; Fusion and thermo nuclear reactions.

(10 Lectures)

Reference Books:

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

PHG105: Experimental Techniques

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

This course will develop basic understanding of the solid materials and theirapplications.
The objectives of the course are:

1. To understand about the accuracy, precision, error and uncertainty analysis.
2. To understand about the signals and noise in a system.
3. To understand about the transducers and their applications.
4. To learn about various digital systems.
5. A basic idea about the vacuum systems.

Course Outcome:

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

CO1	Measurements in terms of statistical analysis of data using various tests.	B2, B3, B5 (Understand, Apply, Evaluate)
CO2	Apply statistical tools such as mean, standard deviation, and chi-square to analyze experimental data and basic curve fitting methods.	B3, B4, B5 (Apply, Analyze Evaluate)
CO3	Analyze impulse response, transfer function, and frequency response of measurement systems and describe various types of noise and their sources in measurement systems.	B3, B4, B5 (Apply, Analyze Evaluate)
CO4	Working, principle, efficiency and applications of transducers.	B1, B2 (Remember, Understand)
CO5	Analyze transducer characteristics and their suitability in industrial applications.	B2, B3, B5 (Understand, Apply, Evaluate)
CO6	Understand about digital multimeter, impedance bridges and Q-meters.	B1, B2 (Remember, Understand)
CO7	Understanding of vacuum and vacuum systems	B1, B2 (Remember, Understand)

CO-PO Mapping Matrix of Experimental Techniques

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓		✓		
CO2		✓		✓		
CO3		✓		✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓		✓	✓		
CO6	✓		✓	✓		✓
CO7	✓		✓	✓		✓

Course Content:

UNIT 1

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

(6 Lectures)

UNIT 2

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

(9 Lectures)

UNIT 3

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers.

(12 Lectures)

UNIT 4

Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. **(5 Lectures)**

UNIT 5

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

UNIT 6

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

(9 Lectures)

Reference Books:

- Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
- Experimental Methods for Engineers, J.P. Holman, McGraw Hill
- Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
- Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
- Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
- Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
- Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer

Lecture Plan for Experimental Techniques

UNIT 1: Measurements (6 Lectures)

Lecture 1: Basics of measurements: Accuracy vs Precision, Significant Figures
Lecture 2: Basics of measurements: Types of Errors: Gross, Systematic, Random
Lecture 3: Basics of measurements: Uncertainty Analysis and Error Propagation
Lecture 4: Arithmetic Mean, Deviation from Mean, Average Deviation
Lecture 5: Standard Deviation, Chi-Square
Lecture 6: Gaussian distribution and curve fitting

UNIT 2: Signals and Systems (9 Lectures)

Lecture 1: Signal Representation: Periodic and Aperiodic
Lecture 2: Impulse Response and Transfer Function
Lecture 3: Frequency Response: First-Order Systems
Lecture 4: Frequency Response: Second-Order Systems
Lecture 5: Introduction to Fluctuations/Noise in Measurement
Lecture 6: Noise in Measurement Systems
Lecture 7: Signal-to-Noise (S/N) Ratio and Noise Figure
Lecture 8: Noise in Frequency Domain: Power Spectral Density (PSD)
Lecture 9: Different type of Noise: Thermal, Shot, 1/f Noise, Shielding & Grounding Techniques

UNIT 3: Transducers & industrial instrumentation (working principle, efficiency, applications) (12 Lectures)

Lecture 1: Characteristics of Measurement Systems: Static
Lecture 2: Dynamic Characteristics: Step, Ramp & Impulse Response
Lecture 3: Zero, First, and Second Order System Models
Lecture 4: Higher Order System Behavior
Lecture 5: Electrical Measurement Systems
Lecture 6: Thermal Measurement Systems
Lecture 7: Mechanical Measurement Systems
Lecture 8: Calibration Techniques and Standards
Lecture 9: Introduction to Transducers and Sensors
Lecture 10: Classification of Transducers: Active & Passive
Lecture 11: Transducer Characteristics in terms of Linearity, Hysteresis, Repeatability
Lecture 12: Applications of Transducers and Sensors in Industrial Measurement Systems

UNIT 4: Digital Multimeter (5 Lectures)

Lecture 1: Introduction: Analog & Digital Instruments
Lecture 2: Block Diagram and Internal Working of a Digital Multimeter (DMM)
Lecture 3: Measurement of Voltage: DC & AC
Lecture 4: Measurement of Current and Capacitance
Lecture 5: Digital Multimeter: Accuracy, Resolution, and Range Considerations

UNIT 5: Impedance Bridges and Q-meter (4 Lectures)

Lecture 1: Principle and Balancing Conditions of RLC Bridge
Lecture 2: Q-Meter: Construction and Working Principle
Lecture 3: Measurement of Quality Factor (Q-factor) & Resonance
Lecture 4: Digital LCR Bridge: Block Diagram, working and Applications

UNIT 6: Vacuum Systems (9 Lectures)

Lecture 1: Introduction: Gas Laws, Pressure Units
Lecture 2: Concept of Mean Free Path & Molecular Flow
Lecture 3: Applications of Vacuum in Science and Technology
Lecture 4: Construction and Sealing of Vacuum Chamber
Lecture 5: Mechanical Pumps: Rotary Vane, Diaphragm
Lecture 6: Working Principle and Limitations of Diffusion Pumps
Lecture 7: Turbo Molecular Pumps: Working Principle and Advantages
Lecture 8: Basics of Pumping Speed, Conductance, and Throughput
Lecture 9: Different type of Pressure Gauges: Pirani, Penning, Ionization Gauges

PHG106: BIOPHYSICS

Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objective:

1. Understand the basic atomic and molecular building blocks relevant to biological systems.
2. Explain physical interactions such as electric, thermal, and Casimir forces in living systems.
3. Analyze heat transfer mechanisms in biomaterials using physical laws and equations.
4. Describe thermodynamic principles in the context of biological systems and processes.
5. Understand protein folding/unfolding and entropy in multi-particle systems.
6. Explore chemical thermodynamics, enzymatic kinetics, and the energetics of ATP processes in biological systems.

Course Outcomes:

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

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	To describe the structure and fundamental building blocks of living systems.	B1, B2 (Remember, Understand)
CO2	To explain various physical forces and interactions in biomaterials and biological states.	B2, B3 (Understand, Apply)
CO3	To apply the heat equation and analyze heat transfer phenomena in biological materials.	B3, B4 (Apply, Analyze)
CO4	To comprehend and apply thermodynamic principles to biological systems and multi-particle scenarios.	B2, B3 (Understand, Apply)

S. No.	Course Outcome Statement	Bloom's Level(s)
CO5	To analyze entropy contributions and phenomena such as protein folding, free energy changes, ATP processes and chemical thermodynamics in open biological systems.	B4, B5 (Analyze, Evaluate))
CO6	To integrate the concepts of chemical potential, energy conservation, and reaction kinetics in complex biological models.	B5, B6 (Evaluate, Create)

CO–PO Mapping Matrix of Biophysics

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓	✓			
CO3	✓	✓	✓	✓		
CO4	✓	✓	✓	✓	✓	
CO5	✓		✓	✓	✓	
CO6	✓		✓	✓	✓	✓

Course Content:

UNIT 1

Buiding 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.

Heat Transfer in biomaterials: Heat Transfer Mechanism, The Heat equation, Joule heating of tissue. **(18 lectures)**

UNIT 2

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)

UNIT 3

Open systems and chemical thermodynamics: Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis & synthesis, Entropy of mixing, The grand canonical ensemble, Hemoglobin **(8 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

Lecture Plan for Biophysics

UNIT 1 – Building Blocks & Structure of Living State (18 Lectures)

Lecture 1: Atoms, ions, and molecules essential for life – Part I

Lecture 2: Atoms, ions, and molecules essential for life – Part II

Lecture 3: Atoms, ions, and molecules essential for life – Part III

Lecture 4: Introduction to the concept of "What is Life?" – Part I

Lecture 5: Introduction to the concept of "What is Life?" – Part II

Lecture 6: Forces in biological systems: ionic and covalent bonds

Lecture 7: Forces in biological systems: hydrogen bonds and van der Waals interactions

Lecture 8: Summary and examples of biological forces

Lecture 9: Electric interactions in biomolecules

Lecture 10: Thermal interactions in biomolecules

Lecture 11: Electric dipoles in biology – Part I

Lecture 12: Electric dipoles in biology – Part II

Lecture 13: Casimir interactions – basic concepts

Lecture 14: Biological relevance of Casimir interactions

Lecture 15: Domains of physics in biological processes – Part I

Lecture 16: Domains of physics in biological processes – Part II

Lecture 17: Heat transfer mechanisms and introduction to the heat equation

Lecture 18: Joule heating in biological tissues

UNIT 2 – Living State Thermodynamics (19 Lectures)

Lecture 1: Thermodynamic equilibrium and the first law – Part I

Lecture 2: Thermodynamic equilibrium and the first law – Part II

Lecture 3: Thermodynamic equilibrium and the first law – Part III

Lecture 4: Entropy and the second law – Part I

Lecture 5: Entropy and the second law – Part II

Lecture 6: Physics of many-particle systems – Part I

Lecture 7: Physics of many-particle systems – Part II

Lecture 8: Physics of many-particle systems – Part III

Lecture 9: Two-state systems – concepts and examples

Lecture 10: Continuous energy distributions in biological systems

Lecture 11: Composite systems – interactions and energy exchange – Part I

Lecture 12: Composite systems – interactions and energy exchange – Part II

Lecture 13: Casimir contribution to free energy – Part I

Lecture 14: Casimir contribution to free energy – Part II

Lecture 15: Principles of protein folding – thermodynamics and kinetics

Lecture 16: Protein folding and unfolding – energy landscape

Lecture 17: Protein folding and unfolding – disorder and entropy

Lecture 18: Real-life case studies – biomolecular systems

Lecture 19: Numerical examples and applications in thermodynamic modeling

UNIT 3 – Open Systems and Chemical Thermodynamics (8 Lectures)

Lecture 1: Enthalpy, Gibbs Free Energy, and chemical potential – Part I

Lecture 2: Enthalpy, Gibbs Free Energy, and chemical potential – Part II

Lecture 3: Activation energy and rate constants

Lecture 4: Enzymatic reactions and catalysis

Lecture 5: ATP hydrolysis and synthesis

Lecture 6: Entropy of mixing

Lecture 7: Grand canonical ensemble and its biological relevance

Lecture 8: Hemoglobin oxygen binding – thermodynamic case study

PHG107: Electronics Lab- I

Total Credits: 04 (Credits: Practical: 04)

Total Hours: Practical: 120

L	T	P	Cr
0	0	4	4

Course Objective:

1. To provide the practical knowledge of experimental electronics.
2. To relate the theory through experiments of electronics.
3. To analyze the data obtained through the experiments and keep the record of the experiments.
4. To expose the students to handle the experiments with confidence and ease.

Course Outcomes:

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

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	Learn about various controls, ports, and display units of a Digital multimeter.	B3, B4, B5 (Apply, Analyze, Evaluate)
CO2	Understanding of Analog Instrument Design.	B2, B3, B4, B6 (Understanding, Apply, Analyze, Create)
CO3	To understand the concept of band gap through experiment and analyze it.	B2, B3, B4, B5 (Understanding, Apply, Analyze, Evaluate)
CO4	To understand the Hall coefficient, Hall angle, carrier concentration of Ge through Hall effect experiment.	B2, B3, B4, B5 (Understanding, Apply, Analyze, Evaluate)
CO5	Understanding of Boolean Algebra Using Logic Gates and applications.	B2, B3, B4, B5 (Understanding, Apply, Analyze, Evaluate)
CO6	Understanding of different transistor configurations and their properties.	B2, B3, B4, B5 (Understanding, Apply, Analyze, Evaluate)
CO7	Analyze and design amplifier circuits using BJT	B3, B4, B6 (Apply, Analyze, Create)
CO8	Learn to acquire data in various experimental systems.	B3, B4, B5 (Apply, Analyze Evaluate)

CO-PO Mapping Matrix of Electronics Lab- I

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	✓		✓	✓			✓
CO2	✓		✓	✓		✓	✓
CO3	✓		✓	✓	✓	✓	
CO4	✓	✓	✓	✓			
CO5	✓	✓					
CO6	✓	✓					
CO7			✓	✓			✓
CO8				✓			✓

Practicals: Electronics Lab-I (Credit:04, 120 Hrs)

1. To measure current, voltage, and resistance; understand accuracy/resolution by using digital multimeters.
2. To convert a micro ammeter into an ohm meter of different range and used to measure unknown resistance.
3. Characteristics of pn-junction diodes.
4. To study the variation of resistivity of Ge crystal with temperature by four probe method and hence to
   determine the band gap for it.
5. To study the Hall effect and hence to determine the Hall coefficient and Carrier concentration.
6. To measure temperature and calibrate using a reference thermometer.
7. Design AND, OR, NOT, NAND, NOR gates using diodes/transistors.
8. Verification of Boolean Algebra Using Logic Gates
9. Input and Output Characteristics of a BJT with different configuration such as CB, CE and CC.
10. Design of RC Coupled Amplifier for single and multi-stage configuration and their characteristics.

Hands on experience:

Design a home- made electronic set-up by use of basic electronic components.

References Books:

- Electric Circuits, S. A. Nasar, Schaum's outline series, Tata McGraw Hill (2004)
- Essentials of Circuit Analysis, Robert L. Boylestad, Pearson Education (2004)

- Electrical Circuits, M. Nahvi and J. Edminister, Schaum's Outline Series, Tata McGrawHill (2005)
- Fundamentals of Electric Circuits, C. Alexander and M. Sadiku, McGraw Hill (2008)
- Network analysis, M. E. Van Valkenburg, Third edition, Prentice Hall
- A Textbook of Electrical Technology, B. L. Thareja, A.K. Thareja, Volume II, S. Chand

PHG108: Electronics Lab-II

Total Credits: 04 (Credits: Practical: 04)

Total Hours: Practical: 120

L	T	P	Cr
0	0	4	4

Course Objective:

1. To provide the practical knowledge of experimental electronics.
2. To relate the theory through experiments of electronics.
3. To analyze the data obtained through the experiments and keep the record of the experiments.
4. To expose the students to handle the experiments with confidence and ease.

Course Outcomes:

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

S. No.	Course Outcome Statement	Bloom's Level(s)
CO1	To learn the basics of physics through experimental methods.	B2, B3 (Understand, Apply)
CO2	Design the adder circuit and analyze it.	B2, B3, B4, B6 (Understand, Apply, Analyze, Create)
CO3	Design the Op-Amp circuit on the bread board and learn the characteristics of Op-Amp along with CMRR	B2, B3, B4, B6 (Understand, Apply, Analyze, Create)
CO4	Detailed Understanding of CRO and its significance. And handle the experiments	B2, B3, B4, B5 (Understanding, Apply, Analyze, Evaluate)
CO5	Perform logical operations by using microprocessor.	B3, B4(Apply, Analyze)
CO6	Learn to acquire data in various experimental systems.	B3, B5 (Apply, Evaluate)

CO-PO Mapping Matrix of Electronics Lab-II (Credit:04, 120 Hrs):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓					✓
CO2	✓		✓	✓		✓
CO3	✓		✓	✓	✓	✓
CO4	✓		✓	✓		
CO5	✓	✓	✓	✓		✓
CO6			✓	✓		✓

Practicals: Electronics Lab-I (Credit:04, 120 Hrs)

1. To study the various digital analog circuits:
   4-bit discrete binary adder network, 8-bit DAC using 0808 IC without OP-amp.
2. To draw transfer characteristics of
   a. An OP-amp (741IC) in inverting mode in close loop.
   b. To determine offset voltage
   c. To determine CMRR of the OP-amp
3. To study the amplitude modulation with the help of CRO
   a. with I/O frequency at constant I/O voltage
   b. To study variation of percentage of modulation with I/O voltage at constant I/O frequency.
   c. Plotting modulated and demodulated wave
   d. To determine carrier frequency
4. To study the frequency response of RC coupled amplifier:
   a. with feedback
   b. without feedback
5. To perform various mathematical, logical and jump operations for 8-bit numbers using 8085 microprocessors.
6. To perform various mathematical, logical operations and jump operations for 16-bit numbers using 8085 microprocessors

Hands on experience:

Design a home- made electronic set-up by use of basic electronic components.

Reference Books:

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