MANAV RACHNA UNIVERSITY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF PHYSICS

PROGRAM STRUCTURE

&

DETAILED SYLLABUS

M.Sc. Physics

BATCH: 2019-2021

MANAV RACHNA UNIVERSITY
DEPARTMENT OF PHYSICS
M.Sc (PHP01)
SCHEME-B
SEMESTER-1

SUBJECT CODES	SUBJECT NAME	OFFERING DEPARTMENT	COURSE NATURE (Hard/Soft/ NTCC)	COURSE TYPE (Core/ Elective etc)	L	T	P	O	CONTACT HOURS PER WEEK	NO. OF CREDITS
PHH501B	Mathematical Physics	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH502B	Classical Mechanics	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH503B	Quantum Mechanics-I	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH504B	Physics of Electronic Devices	Physics	HARD	CORE	4	0	0	**0**	4	4
PHS505B	Computational Method and Programming	Physics	SOFT	CORE	1	0	2	**0**	3	2
PHH506B	Laboratory Work	Physics	PRACTICAL	CORE	0	0	6	**0**	6	3
TOTAL (L-T-P-/CONTACT HOURS/CREDITS)					**17**	**0**	**8**	**0**	**25**	**21**

SEMESTER - 2										
SUBJECT CODES	**SUBJECT NAME**	**OFFERING DEPARTMENT**	***COURSE NATURE (Hard/Soft/ NTCC)**	**COURSE TYPE (Core/ Elective etc)**	**L**	**T**	**P**	**O**	**CONTACT HOURS PER WEEK**	**NO. OF CREDITS**
PHH507B	Quantum Mechanics-II	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH508B	Statistical Mechanics	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH509B	Solid State Physics	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH510B	Atomic and Molecular Physics	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH512B	Laboratory Work	Physics	PRACTICAL	CORE	0	0	6	**0**	6	3
RDO503	Scientific Research I	Physics	NTCC (Non teaching credit course)	CORE	0	0	8	**0**	2	4
TOTAL (L-T-P-/CONTACT HOURS/CREDITS)					**16**	**0**	**14**	**0**	**24**	**23**

SEMESTER - 3										
SUBJECT CODES	**SUBJECT NAME**	**OFFERING DEPARTMENT**	**COURSE NATURE (Hard/Soft/ NTCC)**	**COURSE TYPE (Core/ Elective etc)**	**L**	**T**	**P**	**O**	**CONTACT HOURS PER WEEK**	**NO. OF CREDITS**
PHH601B	Nuclear and Particle Physics	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH602B	Electrodynamics and Plasma Physics	Physics	HARD	CORE	4	0	0	**0**	4	4
PHH603B	Advanced solid state physics	Physics	HARD	CORE	4	0	0	**0**	4	4
DEPARTMENTAL ELECTIVE	**Any one:**Fundamental Atmospheric Physics (PHH604B)/Synthesis and Characterization Techniques (PHH605B)	Physics	HARD	Elective	4	0	0	**0**	4	4
PHH607B	Laboratory Work	Physics	PRACTICAL	CORE	0	0	6	**0**	6	3
RDO603	Scientific Research II	Physics	NTCC (Non teaching credit course)	CORE	0	0	8	**0**	2	4
TOTAL (L-T-P-/CONTACT HOURS/CREDITS)					**16**	**0**	**14**	**0**	**24**	**23**

SEMESTER - 4										
SUBJECT CODES	SUBJECT NAME	OFFERING DEPARTMENT	COURSE NATURE (Hard/Soft/ NTCC)	COURSE TYPE (Core/ Elective etc)	L	T	P	O	CONTACT HOURS PER WEEK	NO. OF CREDITS
DEPARTMENTAL ELECTIVE	**(Any one):** Nanotechnology (PHH608B)/Advanced Atmospheric Physics (PHH609B)/Advanced PlasmaPhysics (PHH610B)/Condensed Matter Physics (PHH611B)	**PH**	**HARD**	**ELECTIVE**	**4**	**0**	**0**	**0**	**4**	**4**
PHN 612B	**PROJECT WORK**	**PH**	**NTCC (Non teaching credit course)**	**CORE**	**0**	**0**	**0**	**0**	**4**	**10**
	TOTAL (L-T-P-O/CONTACT HOURS/CREDITS)				**4**	**0**	**0**	**0**	**4**	**14**

Semester	Classroom Contact hours	Non-teaching Outcome hrs	Credits
First Semester	**25**	**0**	**21**
Second Semester	**24**	**8**	**23**
Third Semester	**24**	**8**	**23**
Fourth Semester	**8**	**4**	**14**
Total	**77**	**20**	**81**

MANAV RACHNA vidyanatariksha

MANAV RACHNA UNIVERSITY

Declared as State Private University vide Haryana Act 26 of 2014

PROGRAMME BOOKLET

M.Sc. Physics (PHP01)
(Batch: 2019-2021)
(Syllabus: Scheme B)

Department of Physics
Faculty of Applied Sciences
Manav Rachna University

MANAV RACHNA UNIVERSITY

Vision

To educate students in frontier areas of knowledge enabling them to take up challenges as ethical and responsible global citizens

Mission

- To impart outcome based holistic education
- To disseminate education in frontier areas
- To produce globally competitive, ethical and socially responsible human resources
- To produce human resources sensitive to issues of Environment and Sustainable Development
- To develop Environment and Sustainable development as a thrust area of research and development.

Quality Policy

To continuously learn from the best practices, study role models and develop transparent procedures for empowerment of stakeholders.

Strategic Objectives

- To facilitate, enhance & promote innovation in curriculum design and delivery and have Outcome-oriented Learning Culture.
- To promote Research Environment and Management Practices.
- To enhance the quality of the student learning experience.
- To provide Resources and Infrastructure for Academic Excellence.

DEPARTMENT OF PHYSICS

Vision

- To educate the students in frontier areas of Physics enabling them to take challenges to solve the problem of the society.

Mission

- To inculcate outcome based holistic education in frontier areas of Physics.
- To develop competent physicists who address future issues of the society.
- To conduct interdisciplinary research in thrust areas
- To produce good quality human resources sensitive to environmental and sustainable development issues.
- To produce globally competitive, ethical and socially responsible young minds

M.Sc Physics

Programme Outcomes (POs)

- Read, understand and interpret physical information – verbal, mathematical and graphical. Perform experiments and interpret the results of observation including an assessment of experimental uncertainties.
- Demonstrate a rigorous understanding of the core theories & principles of physics, which includes mechanics, electromagnetism, thermodynamics, & statistical and quantum mechanics.
- Learn the concepts as quantum mechanics, relativity, introduced at degree level in order to understand nature at atomic levels.
- Provide knowledge about material properties and its application for developing technology to ease the problems related to the society.
- Understand the set of physical laws, describing the motion of bodies, under the influence of system of forces.
- Understand the relationship between particles & atom, as well as their creation & decay. Relate the structure of atoms & subatomic particles and evaluate their problems. Understand physical properties of molecule the chemical bonds between atom as well as molecular dynamics.
- Analyze the applications of mathematics to the problems in physics & develop suitable mathematical method for such application & for formulation of physical theories.
- Learn the structure of solid materials & their different physical properties along with metallurgy, cryogenics, electronics, & material science.
- Understand the fundamental theory of nature at small scale & levels of atom & sub-atomic particles.
- The graduate has skills in planning and carrying out advanced physics experiments and is able to solve scientific problems by applying a combination of theory, numerical simulation, and experiments.
- Demonstrate engagement with current research and developments in the subject

MANAV RACHNA UNIVERSITY DEPARTMENT OF PHYSICS M.Sc. Physics (PHP01) SCHEME-B SEMESTER-1									
SUBJECT CODES	**SUBJECT NAME**	**OFFERING DEPARTMENT**	**COURSE NATURE (Hard/Soft/ NTCC)**	**COURSE TYPE (Core/ Elective etc)**	**L**	**T**	**P**	**O**	**NO. OF CREDITS**
PHH501B	Mathematical Physics	Physics	HARD	CORE	4	0	0	**0**	4
PHH502B	Classical Mechanics	Physics	HARD	CORE	4	0	0	**0**	4
PHH503B	Quantum Mechanics-I	Physics	HARD	CORE	4	0	0	**0**	4
PHH504B	Physics of Electronic Devices	Physics	HARD	CORE	4	0	0	**0**	4
PHS505B	Computational Method and Programming	Physics	SOFT	CORE	1	0	2	**0**	2
PHH506B	Laboratory Work-I	Physics	PRACTICAL	CORE	0	0	6	**0**	3
	TOTAL (L-T-P-/CREDITS)				**17**	**0**	**8**	**0**	**21**

SEMESTER – 2									
SUBJECT CODES	**SUBJECT NAME**	**OFFERING DEPARTMENT**	***COURSE NATURE (Hard/Soft/ NTCC)**	**COURSE TYPE (Core/ Elective etc)**	**L**	**T**	**P**	**O**	**NO. OF CREDITS**
PHH507B	Quantum Mechanics-II	Physics	HARD	CORE	4	0	0	**0**	4
PHH508B	Statistical Mechanics	Physics	HARD	CORE	4	0	0	**0**	4
PHH509B	Solid State Physics	Physics	HARD	CORE	4	0	0	**0**	4
PHH510B	Atomic and Molecular Physics	Physics	HARD	CORE	4	0	0	**0**	4

PHH512B	Laboratory Work-II	Physics	PRACTICAL	CORE	0	0	6	**0**	3
RDO503	Scientific Research-I	Physics	NTCC (Non-teaching credit course)	CORE	0	0	8	**0**	4
	TOTAL (L-T-P-/CREDITS)				**16**	**0**	**14**	**0**	**23**

SEMESTER – 3									
SUBJECT CODES	**SUBJECT NAME**	**OFFERING DEPARTMENT**	**COURSE NATURE (Hard/Soft/ NTCC)**	**COURSE TYPE (Core/ Elective etc)**	**L**	**T**	**P**	**O**	**NO. OF CREDITS**
PHH601B	Nuclear and Particle Physics	Physics	HARD	CORE	4	0	0	**0**	4
PHH602B	Electrodynamics and Plasma Physics	Physics	HARD	CORE	4	0	0	**0**	4
PHH603B	Advanced solid-state physics	Physics	HARD	CORE	4	0	0	**0**	4
PHH604B	Fundamental Atmospheric Physics	Physics	HARD	Elective (any one)	4	0	0	**0**	4
PHH605B	Synthesis and Characterization Techniques	Physics	HARD		4	0	0	**0**	
PHH607B	Laboratory Work-III	Physics	PRACTICAL	CORE	0	0	6	**0**	3
RDO603	Scientific Research-II	Physics	NTCC (Non-teaching credit course)	CORE	0	0	8	**0**	4
	TOTAL (L-T-P-/CREDITS)				**16**	**0**	**14**	**0**	**23**

SEMESTER – 4									
SUBJECT CODES	**SUBJECT NAME**	**OFFERING DEPARTMENT**	**COURSE NATURE (Hard/Soft/ NTCC)**	**COURSE TYPE (Core/ Elective etc)**	**L**	**T**	**P**	**O**	**CREDITS**
PHH608B	Nanotechnology	Physics	HARD	ELECTIVE (any one)	4	0	0	0	4
PHH609B	Advanced Atmospheric Physics	Physics	HARD		4	0	0	0	
PHH610B	Advanced Plasma Physics	Physics	HARD		4	0	0	0	
PHH611B	Condensed Matter Physics	Physics	HARD		4	0	0	0	
PHN612B	Project work	Physics	NTCC (Non-teaching credit course)	CORE	0	0	20	0	10
	TOTAL (L-T-P-O/CREDITS)				**4**	**0**	**0**	**0**	**14**

Total Credits Scheme

S. No.	Semester	Contact Hours	Credits
1	**I**	**25**	**21**
2	**II**	**24**	**23**
3	**III**	**24**	**23**
4	**IV**	**8**	**14**
Total		**81**	**81**

M.Sc. Physics- PHP01
Semester-I

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
PHH501B	Mathematical Physics	PHYSICS	CORE	4	0	0	4
PHH502B	Classical Mechanics	PHYSICS	CORE	4	0	0	4
PHH503B	Quantum Mechanics-I	PHYSICS	CORE	4	0	0	4
PHH504B	Physics of Electronic Devices	PHYSICS	CORE	4	0	0	4
PHS505B	Computational Method and Programming	PHYSICS	CORE	1	0	2	2
PHH506B	Laboratory Work-I	PHYSICS	CORE	0	0	6	3
TOTAL (L-T-P) /CREDITS)				17	0	8	21

Detailed Syllabus

SEMESTER 1

Course Title/Code	Mathematical Physics / PHH501B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To study matrix algebra and special functions which are applied to physics problems	
Course Outcomes (COs)		**Mapping**
CO1	Find Eigen values and Eigen vectors using matrix algebra.	**Employability**
CO2	Solve differential equations of special functions.	**Skill Development**
CO3	Find Fourier transforms, Laplace Transforms and Inverse LT for various functions applied to physics theory.	**Entrepreneurship**
Prerequisites (if any)	**Nil**	

SECTION – A

Vector Spaces and Matrices; linear independence: Bases; Dimensionality; Inner product; Linear transformations; Matrices; Inverse; Orthogonal and unitary matrices; independent elements of a matrix; Eigen values and eigenvectors; Diagonalization; Complete orthonormal sets of functions.

SECTION - B

Differential Equations and Special Functions; Second order linear ODEs with variable coefficients;

SECTION - C

Solution by series expansion; Legendre, Bessel, Hermite and Lagaurre equations; Physical applications; Generating functions; recursion relations.

SECTION - D

Integral Transforms, Laplace transform; First and second shifting theorems; inverse LT by partial fractions; LT of derivative and integral of a function; Fourier series; FS or arbitrary period; Half-wave expansions; Partial sums; Fourier integral and transforms; FT of delta function.

Textbooks/ Reference Books

- Mathematical Methods of Physics, by G Arfken
- Mathematical Methods of Physics, by G Arfken
- Matrices and Tensors for Physicists, by A W Joshi
- Mathematics for Physicists, by Mary L Boas
- Mathematics for Physicists, by Pipes

CO-PO Mapping

Course Code	Course	Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
PHH501B	Mathematical Physics	CO1	3	3	-	-	-	-	3	-	-	-	3
		CO2	3	3	-	-	-	-	3	-	-	-	3
		CO3	3	3	-	-	-	-	3	-	-	-	3

Course Title/Code	Classical Mechanics / PHH502B	
Course Type	CORE	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To study mechanics in Lagrang's formulation and Hamilton –Jacobi Equation .	
Course Outcomes (COs)		Mapping
CO1	Solve problems in many particles system and apply conservation laws.	Employability
CO2	Solve problems using Lagrange's equations.	Skill Development and Employability
CO3	Apply Hamilton-Jacobi equations.	Entrepreneurship
CO4	Do Canonical transformations, solve Poisson's brackets and further explain and solve problems related to small oscillations. They would further formulate Hamiltonian of various physical systems and solve them. The students would be able to construct new problems	Skill Development
Prerequisites (if any)	Nil	

SECTION – A

Preliminaries; Newtonian mechanics of one and many particle systems; conservation laws, work-energy theorem; open systems Constraints; their classification; D'Alembert's principle' generalized coordinates.

SECTION- B

Lagrange's equations; gyroscopic forces; dissipative systems; Jacobi integral; gauge invariance; generalized coordinates and momenta; integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations. Rotating frames; inertial forces; terrestrial and astronomical applications of coriolis force.

SECTION- C

Central force; definition and characteristics; Two-body problem, closure and stability of circular orbits; general analysis of orbits; Kepler's laws and equation; artificial satellites; Rutherford scattering.

SECTION- D

Principle of least action; derivation of equations of motion; variation and end points Hamiltonian formulation, Hamilton's principle and characteristic functions; Hamilton-Jacobi equation Canonical transformation; generating functions; Properties; group property; examples; infinitesimal generators; Poisson bracket; Poisson theorems; angular momentum PBs; small oscillations; normal modes and coordinates.

Text and Reference Books

- Classical mechanics by NC Rana and P.C. Joag (Tata Mc Graw Hill).
- Classical Mechanics, by H Goldstein Mechanics, by Sommerfeld (Academic Press)
- Introduction to Dynamics, by Perceival and D Richards (Cambridge Univ. Press. 1982).

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH502B	Classical Mechanics	CO1	3	3	1	-	3	-	2	-	-	2	2
		CO2	2	3	1	-	2	-	3	-	-	2	2
		CO3	3	3	1	-	3	-	3	-	-	3	3
		CO4	3	3	-	-	3	-	3	-	-	3	3

Course Title/Code	Quantum Mechanics I / PHH503B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To study Quantum Mechanical formulation and solve simple problems	
Course Outcomes (COs)		**Mapping**
CO1	Understand, explain and demonstrate various laws and concepts of essentials of Quantum physics related to its basic structure.	**Skill Development and Employability**
CO2	Explain the concepts of wave-function, Schrodinger equation and problem solving of He and other heavy elements.	**Skill Development**
CO3	Design and explain various mechanisms/working conditions of Time independent perturbation theory and its application.	**Entrepreneurship**
CO4	Solve the problems of Zeeman and Stark effects.	**Skill Development**
Prerequisites (if any)	**Nil**	

SECTION - A

Basic review of quantum mechanics, Revision; Inadequacy of classical mechanics; Schrodinger equation; Continuity equation; Ehrenfest theorem; Admissible wave functions; Stationary states, One-dimensional problems, wells and barriers; Harmonic oscillator by Schrodinger equation and by operator method.

SECTION - B

Uncertainty relation of *x* and *p*, States with minimum uncertainty product; General formalism of wave mechanics; Commutation relations; Representation of states and dynamical variables; Completeness of eigen functions

SECTION - C

Dirac delta function; bra and ket notation; Matrix representation of an operator; Unitary transformation. Angular momentum in QM; Central force problem: Solution of Schrodinger equation for spherically symmetric potentials; Hydrogen atom.

SECTION - D

Time-independent perturbation theory, Non-degenerate and degenerate cases Applications such as Stark effect.

Text and Reference Books

- Quantum Mechanics by Schiff
- Quantum Mechanics by J.J Sakurai
- Quantum Mechanics by Mathews and Venjatesan

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH503B	Quantum Mechanics-I	CO1	2	2	3	-	3	2	2	-	3	2	3
		CO2	2	2	2	-	3	2	2	-	2	2	3
		CO3	2	3	2	-	2	2	2	-	3	2	3
		CO4	2	3	2	-	2	2	2	-	2	2	2

Course Title/Code	Physics of Electronic Devices / PHH504B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To study different type of electronic devices, circuits and apply them to practical problems	
Course Outcomes (COs)		**Mapping**
CO1	Apply basics of Semiconductors, pn-junction, Zener and avalanche breakdowns, configurations and characteristics, JFET to solve numerical	**Employment**
CO2	Understand and analysis of CE, CB, and CC amplifiers, input and output impedances of amplifiers, Analysis of amplifiers with diagram.	**Skill Development**
CO3	Understand and analysis of frequency response of different amplifiers	**Entrepreneurship**
CO4	To understand and analysis of different types of Power amplifiers	**Skill Development and Employability**
Prerequisites (if any)	**Nil**	

SECTION - A: Basics of semiconductor electronics

Semiconductors: intrinsic and extrinsic semiconductors, charge densities in p and n type semiconductors, conduction by charge drift and diffusion, the pn-junction, energy level diagrams of pn-junction under forward and reverse bias conditions, derivation of pn-diode equation, Zener and avalanche breakdowns, clipping and clamping circuits; The bipolar junction transistor: Basic working principle, configurations and characteristics, voltage breakdowns, JFET: Basic working principle, configurations and characteristics the Ebers-Moll's model.

SECTION - B: Amplifier models, feedback and biasing

Two port network analysis: active circuit models, gain in decibels, equivalent circuit for BJT, the transconductance model for BJT, analysis of CE, CB, and CC amplifiers; An amplifier with feedback, effect of negative feedback on gain and its stability, distortions, input and output impedances of amplifiers, Analysis of amplifiers with voltage series, voltage shunt, Location of quiescent (Q) point, biasing circuits for amplifiers: fixed bias, emitter feedback bias & voltage feedback bias, bias sources for integrated circuits, Circuits for stabilization of Q-Point.

SECTION - C: Frequency response of amplifiers

Introduction, the amplifier pass band, mid-range response of CE cascade, the high frequency equivalent circuit (Miller effect), the high frequencies response, the frequency response of RC coupled CE amplifiers, gain-frequency plots of amplifier response, bandwidth of cascaded amplifiers, bandwidth criterion for the transistor, the gain-bandwidth product.

SECTION - D: Power amplifiers and regulators

Power amplifiers: class A large signal amplifiers, second and higher order harmonic distortions, the transformer coupled power amplifier, impedance matching, efficiency, push-pull amplifiers, class-B amplifiers, complementary stages, cross over distortions, class-AB operation, heat sinks;

Reference Books:

- Electronic fundamentals and applications (5^{th} ed.) by J. D. Ryder
- Integrated Electronics by J. Millman and C. C. Halkias
- Network analysis by Van Valkenburg
- Electronic devices and circuits by Y. N. Bapat
- Pulse, digital and switching waveforms by J. Millman and H. Taub
- Millman’s Electronic Devices & Circuits by J. Millman, C. C. Halkias

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH504B	Physics of Electronic Devices	CO1	2	-	-	3	1	1	-	3	2	3	3
		CO2	2	-	-	3	1	1	-	3	2	3	3
		CO3	2	-	-	3	1	1	-	3	2	3	3
		CO4	2	-	-	3	1	1	-	3	2	3	3

Course Title/Code	Computational Method and Programming / PHS505B	
Course Type	**CORE (Soft)**	
L-T-P Structure	**1-0-2**	
Credits	**2**	
Course Objective	To familiarize the students with different programming language in serial and parallel mode with applications	
Course Outcomes (COs)		**Mapping**
CO1	Use and apply main features of the MATLAB program development environment to enable their usage in the higher learning.	**Employment**
CO2	Implement simple mathematical functions/equations in numerical computing environment such as MATLAB	**Skill Development**
CO3	Interpret and visualize simple mathematical functions and operations thereon using plots/display.	**Skill Development and Employability**
CO4	Analyze the program for correctness and determine/estimate/predict the output and verify it under simulation environment using MATLAB.	**Skill Development**
Prerequisites (if any)	**Nil**	

Section A

Commands: Enter commands in MATLAB to perform calculations and create variables, Entering Commands, Naming Variables, Saving and Loading Variables, Using Built-in Functions and Constants, MATLAB Desktop and Editor, Write and save your own MATLAB programs .MATLAB Desktop and Editor, The MATLAB Editor, Running Scripts, Vectors and Matrices, Create MATLAB variables that contain multiple elements.

Section B

Manually Entering Arrays, Creating Evenly-Spaced Vectors, Array Creation Functions, indexing into and Modifying Arrays, Use indexing to extract and modify rows, columns, and elements of MATLAB arrays, Indexing into Arrays, Extracting Multiple Elements, Changing Values in Arrays, Array Calculations, Perform calculations on entire arrays at once, Performing Array Operations on Vectors

Section C

Calling Functions, Call functions to obtain multiple outputs, Obtaining Multiple Outputs from Function Calls, Obtaining Help, Use the MATLAB documentation to discover information about MATLAB features, Obtaining Help, Plotting Data, visualize variables using MATLAB's plotting functions, Plotting Vectors, Annotating Plots

Section D

Importing Data, Bring data from external files into MATLAB, Import Tool, Importing Data as a Table, Logical Arrays, Use logical expressions to help you to extract elements of interest from MATLAB arrays, Logical Indexing, Write programs that execute code based upon some condition, Programming Constructs: Decision Branching, solve computable mathematical problems, MATLAB in Physics

Reference and Text Books:

- Sastry: Introductory Methods of Numerical Analysis
- Rajaraman: Numerical Analysis
- Rajaraman: Fortran Programming
- Vetterming: Teukolsky, Press and Flannery: Numerical Recipes

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHS505B	Computational Method and Programming	CO1	3	2	1	1	1	0	1	-	-	3	3
		CO2	3	2	1	1	1	0	1	-	-	3	3
		CO3	3	2	1	1	1	0	1	-	-	3	3
		CO4	3	2	1	1	1	0	1	-	-	3	3

Course Title/Code	Laboratory work-I / PHH506B	
Course Type	CORE	
L-T-P Structure	0-0-6	
Credits	3	
Course Objective	To practice application of electronic components in power supply and other devices and measure half life of radioactive element	
Course Outcomes (COs)		Mapping
CO1	Understanding of the V-I characteristics of P-N diode, low-pass, high pass and band-pass filters.	Employment
CO2	Study and Examine the different rectifier circuits, amplifier circuits.	Skill Development
CO3	Analyse and design various circuits for OR, AND, NOT, NAND and NOR logic gates.	Entrepreneurship
CO4	Analyse clipping, clamping, modulation and demodulation in circuits. Application of CRO, differentiation and integration of various circuits, Study and apply.	Skill Development and Employability
Prerequisites (if any)	Nil	

List of Practicals

1. To study the frequency response of low-pass, high-pass and band-pass filters.
2. To study the rectifier circuits and to measure the ripple factors of C, L and π-section filters. Also study the stabilization characteristics of a voltage regulator consisting of IC-741.
3. To study the characteristics of a class-B push-pull amplifier.
4. To generate and find the frequency of saw-tooth waves using UJT.
5. To draw frequency response characteristics of a RC-coupled single stage BJT amplifier in all the three configurations.
6. To design circuits for OR, AND, NOT, NAND and NOR logic gates and verify their Truth tables.
7. To measure (a) phase difference, (b) deflection sensitivity and (c) frequency of an unknown ac signal using CRO.
8. To study the astable multivibrator.
9. To study the clipping and clamping circuits.

10. To study the differentiating and integrating circuits.
11. To determine various parameters of a pn-junction diode.
12. To study the modulation and demodulation circuits.

CO-PO Mapping

Course Code	Course	Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
PHH506B	Laboratory Work-I	CO1	3	3	1	3	1	1	1	1	1	2	2
		CO2	3	3	1	1	1	1	1	1	1	2	2
		CO3	3	3	1	1	1	1	1	1	1	2	2
		CO4	3	3	1	1	1	1	1	1	1	2	2

Semester-II

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
PHH507B	Quantum Mechanics-II	PHYSICS	CORE	4	0	0	4
PHH508B	Statistical Mechanics	PHYSICS	CORE	4	0	0	4
PHH509B	Solid State Physics	PHYSICS	CORE	4	0	0	4
PHH510B	Atomic and Molecular Physics	PHYSICS	CORE	4	0	0	4
PHH512B	Laboratory Work-II	PHYSICS	CORE	0	0	6	3
RDO503	Scientific Research I	PHYSICS	CORE	0	0	8	4
TOTAL (L-T-P) /CREDITS)				16	0	14	23

Detailed Syllabus

Course Title/Code	Quantum Mechanics ll / PHH507B	
Course Type	CORE	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	To develop familiarity with the physical concepts and facility with the mathematical methods of quantum mechanics and to have skills at formulating and solving physics problems	
Course Outcomes (COs)		Mapping
CO1	Discuss and interpret experiments/Theories that reveal the Schrodinger wave equation and Perturbation theory was not enough to solve the energy of He like atoms. Therefore variotional method and other approximation (like; WKB) methods were used.	Employability
CO2	Interpret and Apply the Collision in 3-D scattering; Laboratory and CM reference frames; Scattering amplitude; differential scattering cross section and total scattering cross section; Apply the scattering theory on solving the energetic particle-solid interaction and calculation of recoil/scatterer atoms.	Skill Development and Employability
CO3	Design and construct spectral problems using angular momentum. To understand and apply the Complex potential and absorption in scattering. Identical particles; Symmetric and anti symmetric wave functions; Collision of identical particles; Spin angular momentum; Spin functions for a many-electron system.	Entrepreneurship
CO4	Develop and explain the Semi classical theory of radiation; Transition probability for absorption and induced emission; Electric dipole and forbidden transitions; Selection rules	Skill Development
Prerequisites (if any)	Nil	

SECTION –A

Variational method,WKB approximation; Time dependent perturbation theory; Harmonic perturbati on; Fermi's golden rule; Adiabatic and sudden approximations.

SECTION – B

Collision in 3-D and scattering; Laboratory and centre of mass reference frames; Scattering amplitude; differential scattering cross section and total scattering cross section; Scattering by spherically symmetric potentials; Partial waves and phase shifts;

SECTION- C

Scattering by a perfectly rigid sphere and by square well potential, Complex potential and absorption. Identical particles; Symmetric and antisymmetric wave functions; Collision of identical particles; Spin angular momentum; Spin functions for a many-electron system.

SECTION- D

Semiclassical theory of radiation, Transition probability for absorption and induced emission, Electric dipole and forbidden transitions; Selection rules.

Text and Reference Books

- L I Schiff, Quantum Mechanics (McGraw-Hill)
- S. Gasiorowicz, Quantum Physics (Wiley)
- B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)
- A P Messiah, Quantum Mechanics
- J J Sakurai. Modern Quantum Mechanics
- P. M. Mathews, K. Venkatesan- A Textbook of quantum mechanics (McGraw-Hill)

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH507B	Quantum Mechanics-II	CO1	2	2	3	-	3	2	2	-	3	2	3
		CO2	2	2	2	-	3	2	2	-	2	2	3
		CO3	2	3	2	-	2	2	2	-	3	2	3
		CO4	2	3	2	-	2	2	2	-	2	2	2

Course Title/Code	Statistical Mechanics/ PHH508B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To develop familiarity with the physical concepts and facility with the mathematical methods of Statistical mechanics and to cultivate skills at formulating and solving physics problems	
Course Outcomes (COs)		**Mapping**
CO1	To develop familiarity with the physical concepts and facility with the mathematical methods of Statistical mechanics.	**Employability**
CO2	To cultivate skills at formulating and solving physics problems.	**Skill Development and Employability**
CO3	To provide a firm foundation to students in a very fundamental subject of Statistical Mechanics.	**Entrepreneurship**
Prerequisites (if any)	**Nil**	

SECTION- A

Foundations of statistical mechanics; specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox. Microcanonical ensemble, phase space, trajectories and density of states, Liouville's theorem,

SECTION - B

Canonical and grand canonical ensembles; partition function, calculation of statistical quantities, Energy and density fluctuations. Density matrix, statistics of ensembles, statistics of indistinguishable particles, Maxwell- Boltzman statistics,

SECTION - C

Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation. Cluster expansion for a classical gas, Virial equation of state, ising model, mean-field theories of the ising model in three, two and one dimensions Exact solutions in one dimension.

SECTION - D

Landau theory of phase transition, critical indices, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem. The Fokker-Planck equation.

Text and Reference Books

- Statistical and Thermal Physics, by F Reif
- Statistical Mechanics, by K Huang(John Wiley & Sons)
- Statistical Mechanics, R K Pathria
- Statistical Mechanics, R. Kubo
- Statistical Physics, Landau and Lifshitz

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH508B	Statistical Mechanics	CO1	3	3	3	3	3	2	3	-	-	-	3
		CO2	3	3	3	3	3	3	3	-	-	-	3
		CO3	3	3	3	3	3	3	3	-	-	-	3

Course Title/Code	**Solid State Physics / PHH509B**	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To study and analyze different types of crystal structure and to study the optical, electrical, magnetic and dielectric properties of materials.	
Course Outcomes (COs)		**Mapping**
CO1	Explain and analyze the XRD pattern and determine the crystal structure of a material.	**Employment**
CO2	Explain and apply different models for thermal properties of solids.	**Skill Development and Employability**
CO3	Explain and analyze the electrical properties of metals and semiconductors.	**Entrepreneurship**
CO4	Explain the theory related to superconductors.	**Skill Development**
Prerequisites (if any)	**Nil**	

SECTION – A

Recapitulation of basic concepts: Bravais lattice and Primitive vectors; Primitive, conventional and Wigner-Seitz unit cells; Crystal structures and lattices with basis, Lattice planes and Miller indices; Determination of crystal structure by diffraction: Reciprocal lattice and Brillouin zones (examples of sc, bcc and fcc lattices), Bragg and Laue formulations of X-ray diffraction by a crystal and their equivalence, Laue equations, Non-crystalline solids: Diffraction pattern, Monatomic amorphous materials, Experimental methods of structure analysis: the Laue, rotating crystal and powder methods.

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SECTION – B

Classical theory of lattice vibration (harmonic approximation): Vibrations of crystals with monatomic basis- Dispersion relation, First Brillouin zone, Group velocity, Two atoms per primitive basis- acoustical and optical modes; Quantization of lattice vibration: Phonons, Phonon momentum, Thermal properties: Lattice (phonon) heat capacity, Normal modes, Density of states in one and three dimensions, Models of Debye and Einstein; Thermal expansion, Thermal conductivity.

SECTION – C

Free electron gas model in three dimensions: Density of states, Fermi energy, Effect of temperature, Heat capacity of the electron gas, Experimental heat capacity of metals, Motion in magnetic fields and Hall effect; Failure of the free electron gas model and Band theory of solids: Periodic potential and Bloch's theorem, Kronig-Penney model, classification into metals, semiconductors and insulators; Tight binding method and its application to sc and bcc structures.

SECTION – D

Experimental survey: Superconductivity and its occurrence, Destruction of superconductivity by magnetic fields, Meissner effect, Type I and type II superconductors, Entropy, Free energy, Heat capacity, Energy gap, Isotope effect; Theoretical survey: Thermodynamics of the superconducting transition, London equation, Coherence length, Microscopic theory: Qualitative features of the BCS theory, BCS ground state wave function, Flux quantization in a superconducting ring; Dc and Ac Josephson effects, High T_c superconductors (introduction only).

Text and Reference Books

- Introduction to Solid State Physics (7th edition) by Charles Kittel
- Solid State Physics by Neil W. Ashcroft and N. David Mermin
- Applied Solid State Physics by Rajnikant
- Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
- Principles of the Theory of Solids (2nd edition) by J. M. Ziman

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH509B	Solid State Physics	CO1	3	2	-	2	2	2	2	2	-	2	2
		CO2	3	3	-	3	3	3	3	2	2	2	2
		CO3	3	3	-	3	-	3	3	3	3	2	2
		CO4	3	3	-	3	2	2	2	-	-	2	-

Course Title/Code	Atomic and Molecular Physics / PHH510B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	Illustrate the fundamental aspects of atomic and molecular physics using quantum mechanics at different levels to understand the structure and dynamics of both atoms and molecules	
Course Outcomes (COs)		**Mapping**
CO1	Explain spectrum of hydrogen and hydrogen like atoms using quantum theory and identify the effect of weak and strong magnetic field on the spectrum.	**Employability**
CO2	Study the hyperfine structure of atoms using different coupling schemes.	**Skill Development**
CO3	Study molecular spectra using different models of molecules.	**Entrepreneurship**
CO4	Study different spectrometers to study optical properties of molecules.	**Skill Development and Employability**
Prerequisites (if any)	**Nil**	

SECTION - A

Quantum states of one electron atoms-Atomic orbitals-Hydrogen spectrum-Pauli‘s principle-Spectra of alkali elements-Spin orbit interaction and fine structure in alkali Spectra-Equivalent and non-equivalent electrons-Normal and anomalous Zeeman effect- Paschen Back effect

SECTION – B

Stark effect-Two electron systems-interaction energy in LS and JJ Coupling-Hyperfine structure (qualitative)-Line broadening mechanisms (general ideas) Types of molecules-Diatomic linear symmetric top, asymmetric top and spherical top molecules

SECTION – C

Rotational spectra of diatomic molecules as a rigid rotor-Energy level and spectra of non rigid rotor-intensity of rotational lines-Stark modulated microwave spectrometer (qualitative) Vibrational energy of diatomic molecule-Diatomic molecule as a simple harmonic oscillator- Energy levels and spectrum-Morse potential energy curve-Molecules as vibrating rotator- Vibration spectrum of diatomic molecule-PQR branches IR spectrometer (qualitative), Raman effect

SECTION - D

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Born Oppenheimer approximation, Vibrational coarse structure of electronic bands, Progression and sequences, Intensity of electronic bands-Frank Condon Principle, Dissociation and pre-dissociation, Dissociation energy; Rotational fine structure of electronic bands, NMR: Basic principles – Classical and quantum mechanical description, Spin-spin and spin-lattice relaxation times, ESR: Basic principles – ESR spectrometer

Text and Reference Books

- Introduction to Atomic spectra—H.E.White(T)
- Fundamentals of molecular spectroscopy—C.B.Banwell (T)
- Spectroscopy Vol I, ll & Ill—Walker & Straughen
- Introduction to Molecular spectroscopy—GMBarrow
- Spectra of diatomic molecules—Herzberg
- Molecular spectroscopy—Jeanne L McHale
- Molecular spectroscopy—JMBrown
- Spectra of atoms and molecules—P.F.Bemat
- Modern spectroscopy—J.M.Holias

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH510B	Atomic and Molecular Physics	CO1	3	2	2	1	1	1	1	1	2	3	3
		CO2	3	2	2	1	1	1	1	1	2	3	3
		CO3	3	2	2	1	1	1	1	1	2	3	3
		CO4	3	1	1	2	1	2	2	1	2	2	3

Course Title/Code	Laboratory work-II / PHH512B	
Course Type	CORE	
L-T-P Structure	0-0-6	
Credits	3	
Course Objective	To demonstrate applications of electronic components in power supply and other electronic devices	
Course Outcomes (COs)		Mapping
CO1	Apply FET and MOSFET in amplifiers, Application of 741, ESR spectrometer	Employment
Prerequisites (if any)	Nil	

PRACTICALS LIST:

1. Experiment on Uni-Junction Transistor and its application.
2. Digital I: Basic Logic Gates, TTL, NAND and NOR.
3. Digital ll: Combinational Logic.
4. Flip-Flops.
5. Operational Amplifier (741).
6. Differential Amplifier.
7. Measurement of resistivity of a semiconductor by four probe method at different temperatures and Determination of band gap.
8. Determination of Lande's factor of DPPH using Electron-Spin resonance (E.S.R.) Spectrometer.
9. Measurement of Hall coefficient of given semicoundutor: Identification of type of semiconductor and estimation of charge carrier concentration.
10. To study the fluorescence spectrum of DCM dye and to determine the quantum yield of fluorescence maxima and full width at half maxima for this dye using monochromator.
13. To study Faraday effect using He-Ne Laser.
14. Experiment on FET and MOSFET characterization and application as an amplifier.

CO-PO Mapping

Course Code	Course	Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
PHH512B	Laboratory Work-II	CO1	3	2	2	2	2	-	-	3	2	3	2

Course Title/Code	Scientific Research-I/ RDO503	
Course Type	CORE	
L-T-P Structure	0-0-8	
Credits	4	
Course Objective	To impart knowledge on various analytical techniques	
Course Outcomes (COs)		Mapping
CO1	The student shall be able to describe research and its impact.	Skill Development
CO2	The student shall be able to identify broad area of research, analyze, the processes and procedures to carry out research.	Skill Development
CO3	The student shall be able to use different tools for literature survey	Skill Development
CO4	The student is able choose specific area of research and supervisor/mentor is finalized	Skill Development
CO5	To understand and adopt the ethical practice that are to be followed in the research activities	Employability
CO6	To work in groups with guidance	Employability
Prerequisites (if any)	Nil	

SECTION A

Unit 1: What is Research and its impact?

1.1 Capturing the current research trends

1.2 Insight about scientific research performed by renowned experts in the related field (case studies)

1.3 Do’s and Don’ts pertaining to research

SECTION B

Unit 2: Identification of Broad Area of research

2.1 Identification of thrust area of research for deciding broad area

2.2 Framing the research questions and hypothesis

2.3 Identification of the research gap based on feasibility of problem

2.4 Exploration of in-house and commercially available facilities related to broad area

SECTION C

Unit 3: Understanding the tools for Literature Survey

3.1 Finding research papers related to a topic
3.2 Understanding the different aspects of Literature search
3.3 Usage of different sources like Google scholar, WoS, SCI/ SCIE, PubMed, Scopus, ABDC, EBSCO etc.
3.4 Search for online journals relevant to research area
3.5 Indexing of Journals
3.5 Usage of scholarly networking sites like Research Gate, Mendeley, and Academia.edu etc.
3.6 Demo sessions on the usage of above mentioned sources

SECTION D

Unit 4: Review of research papers pertaining to broad area and specific area of research
4.1 Selection of relevant papers
4.2 Finding specific research problem from broad area of research
4.3 Literature survey and justification of specific research problem
4.4 Experimentation and data cleaning and verification
4.5 Understanding and selection of the research domain
4.6 Seeking information through published work w.r.t the problem
4.7 Reading & categorizing the downloaded/referred papers and structuring of the idea
4.8 Model design about framing the research questions

Unit 5: Report Writing and Presentation skill Development
5.1 Report making on the surveyed literature to cater the basic idea of the research papers
5.2 Compiling and analyzing the published results to justify and understand the proposed ideas
5.3 Usage of MS-PowerPoint and other technical resources for the presentation
5.4 Development of presentation skills and group addressing
5.5 Scientific/technical writing and ethical practice, project report

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
RDO503	**Scientific Research-I**	**CO1**	**2**	**2**	**-**	**2**	**2**	**3**	**3**	**3**	**2**	**2**	**2**
		CO2	**2**	**2**	**-**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
		CO3	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**-**	**-**	**-**
		CO4	**-**	**-**	**-**	**-**	**-**	**3**	**2**	**2**	**-**	**-**	**-**
		CO5	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**-**	**-**	**-**
		CO6	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**-**	**-**	**-**

Semester-III

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
PHH601B	Nuclear and Particle Physics	PHYSICS	CORE	4	0	0	4
PHH602B	Electrodynamics and Plasma Physics	PHYSICS	CORE	4	0	0	4
PHH603B	Advanced solid-state physics	PHYSICS	CORE	4	0	0	4
PHH604B	Fundamental Atmospheric Physics	PHYSICS	ELECTIVE (any one)	4	0	0	4
PHH605B	Synthesis and Characterization Techniques			4	0	0	
PHH607B	Laboratory Work-III	PHYSICS	CORE	0	0	6	3
RDO603	Scientific Research II	PHYSICS	CORE	0	0	8	4
TOTAL (L-T-P) /CREDITS)				16	0	14	23

Course Title/Code	Nuclear and Particle Physics / PHH601B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	Understanding of the nucleus and nucleon characteristics and understanding of the different nuclear models.	
Course Outcomes (COs)		**Mapping**
CO1	Students would be able to understand, explain and demonstrate various laws and concepts of nuclear and particle physics related to its basic nucleus structure. The students would be able to analyze and evaluate the related problems.	**Employment**
CO2	Students would be able to understand, compare and analyze various nuclear models proposed till date.	**Skill Development**
CO3	Students would be able to describe, analyze and evaluate the basic interaction mechanisms for charged particles and electromagnetic radiation relevant for radiation detectors and explain their importance for detecting various types of ionizing radiation at different energies.	**Entrepreneurship**
CO4	Students would be able to compare and simulate the basic features involved in alpha and beta decays, nuclear forces and formulate various kinds of nuclear reactions besides the fundamentals of elementary particle physics.	**Skill Development and Employability**
Prerequisites (if any)	**Nil**	

SECTION - A

Nuclear Interactions and Nuclear Reactions

Nucleon - nucleon interaction - Exchange forces and tensor forces - Meson theory of nuclear forces - Nucleon - nucleon scattering - Effective range theory - Spin dependence of nuclear forces - Charge independence and charge symmetry of nuclear forces - lsospin formalism - Yukawa interaction. Direct and compound nuclear reaction mechanisms - Cross sections in terms of partial wave amplitudes - Compound nucleus - Scattering matrix - Reciprocity theorem - Breit - Wigner one - level formula - Resonance scattering.

SECTION - B

Nuclear Models

Liquid drop model - Bohr - Wheeler theory of fission - Experimental evidence for shell effects - Shell model - Spin - Orbit coupling - Magic numbers – Angular momenta and parities of nuclear ground states - Qualitative discussion and estimates of transition rates - Magnetic moments and Schmidt lines - Collective model of Bohr and Mottelson.

SECTION - C

Nuclear Decay

Beta decay - Fermi theory of beta decay - Shape of the beta spectrum - Total decay rate- Angular momentum and parity selection rules - Comparative half - lives - Allowed and forbidden transitions - Selection rules - Parity violation - Two-component theory of neutrino decay - Detection and properties of neutrino - Gamma decay - Multipole transitions in nuclei – Angular momentum and parity selection rules - Internal conversion - Nuclear isomerism.

SECTION - D

Elementary Particle Physics

Types of interaction between elementary particles - Hadrons and leptons — Symmetry and conservation laws - Elementary' ideas of CP and CPT invariance - Classification of hadrons - Lie algebra, SU(2) - SU(3) multiplets - Quark model - Gell - Mann - Okubo mass formula for octet and decuplet hadrons - Charm, bottom and top quarks.

Text and Reference Books

- Bohr and ER Mottelson, Nuclear Structure, Vol. 1 (1969) and Vol.2, Benjamin, Reading, A, 1975.
- Kenneth S.Kiane, introductory Nuclear Physics,Wiiey, New York,1988.
- Ghoshal, Atomic and Nuclear Physics Vol. 2.
- P. H. Perkins, introduction to High Energy Physics, Addison-Wesley, London, 198
- Shirokov Yudin, Nuclear Physics Vol. I & 2, Mir Publishers, Moscow, 1982.
- D. Griffiths, introduction to Elementary Particles, Harper and Row, New York, 1987.

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH601B	Nuclear and Particle Physics	CO1	2	3	-	1	-	3	2	-	3	-	2
		CO2	2	3	-	1	-	3	2	-	3	-	2
		CO3	2	3	-	1	-	-	2	-	3	-	2
		CO4	2	3	-	3	-	3	2	-	3	-	3

Course Title/Code	Electrodynamics and Plasma Physics/ PHH602B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To learn Tensor formalism for EM wave and properties of Plasma	
Course Outcomes (COs)		**Mapping**
CO1	Student will be able to demonstrate an understanding of the use of Laplace equation, boundary conditions and method of images.	**Employment**
CO2	Students would be able to know and use coordinates transformation, Electrostatics and magnetostatics fundamentals, time dependent field, Maxwell's equations, Know and use of scalar potential, vector potential, gauge transformation.	**Skill Development**
CO3	Student would be able to analyze the power radiated by a point charge, radiation due to an oscillating electric dipole.	**Entrepreneurship**
CO4	Understanding of relativistic electrodynamics and basic understanding of Plasma state essential for research purpose.	**Skill Development**
Prerequisites (if any)	**Nil**	

SECTION – A

Electrostatics: Coulomb's law, Electric field, Gauss's law, Electric Potential, Poisson's equation and Laplace's equation, Work and energy in electrostatics, Techniques for calculating potentials: Laplace's equation, boundary conditions, Method of Images.

Magnetostatics: Biot Savart Law, Magnetic Scalar potential, Magnetic vector potential, magnetostatic fields in Matter: Magnetization, field of a magnetized object, magnetic field inside matter, Time dependent fields, Differential and integral forms of Maxwell's equations.

SECTION B

Electromagnetic Potentials: Scalar and vector potentials, D' Alembert Equations, Non uniqueness of potentials and gauge transformations, Lorentz Gauge, Coulomb's Gauge; Momentum in electromagnetic field, Lorentz force in terms of Scalar and vector potentials, Spherical Waves

Electrodynamics of a moving charge: Solution of inhomogeneous wave equation by Fourier analysis, Retarded Potentials, Lienard- Wiechart potentials.

SECTION C

Radiation from a point charge: EM fields of a point charge in motion, power radiated by a point charge, Radiation from an electric charge at low velocity (Larmor's Formula) and high velocity, Radiation due to an oscillating electric dipole.

SECTION D

Relativistic Electrodynamics: Transformation of electric and magnetic fields under Lorentz transformations, field tensor, invariants of electromagnetic field, Covariant formulation of electrodynamics (Maxwell's equation in covariant four tensor form), Lorentz force on a charged particle.
Plasma Physics
Elementary Concepts: concept of Temperature, Debye Shielding, Condition for plasma formation, Plasma Oscillations, Plasma Parameters, Magneto plasma, Plasma Confinement, Hydro dynamical Description of Plasma: Fundamental equations, Phase Velocity, Group Velocity.

Text and Reference Books

- Panofsky & Phillips: Classical Electricity and Magnetism
- Bittencourt: Fundamentals of Plasma Physics(Springer)
- Chen: Plasma Physics
- Jackson: Classical Electrodynamics

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH602B	Electrodynamics and Plasma Physics	CO1	2	3	2	2	2	2	2	1	2	3	3
		CO2	2	3	2	2	2	2	2	1	2	3	3
		CO3	2	3	2	2	2	2	2	1	2	3	3
		CO4	3	2	2	2	2	2	2	1	2	3	2

Course Title/Code	Advanced Solid State Physics / PHH603B	
Course Type	**CORE**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To study the optical, electrical, magnetic and dielectric properties of materials.	
Course Outcomes (COs)		**Mapping**
CO1	Understand and analyze the behavior of electrons in metals and semiconductors and to realize their importance in gaining vital information about the electrical properties of materials.	**Skill Development and Employability**
CO2	Understand the physics governing the optical properties of materials and to evaluate and analyze the optical properties of materials.	**Skill Development**
CO3	Understand the physics governing the dielectric properties of materials in order to explain their technological applications and to evaluate and analyze the dielectric properties of materials.	**Entrepreneurship**
CO4	Understand the classical and quantum physics governing the magnetic properties of materials in order to evaluate and analyze the magnetic properties of materials and to explain their technological applications..	**Skill Development**
Prerequisites (if any)	**Nil**	

SECTION- A

Semiconductor crystals and Fermi surfaces & metals

Semiconductor crystals: Band gap, Direct and indirect absorption processes, Motion of electrons in an energy band, Holes, Effective mass, Physical interpretation of effective mass, Effective masses in semiconductors, Intrinsic carrier concentration; Intrinsic mobility; Fermi surfaces and metals: Fermi surface and its construction for square lattice (free electrons and nearly free electrons), Electron orbits, Hole orbits, Open orbits; Wigner-Seitz method for energy bands, Cohesive energy;

SECTION- B

Optical properties of solids

Dielectric function of the free electron gas, Plasma optics, Dispersion relation for em waves, Transverse optical modes in a plasma, Transparency of alkalis in the ultraviolet, Longitudinal plasma oscillations, Plasmons and their measurement; Electrostatic screening, Screened Coulomb potential, Mott metal-insulator transition, Screening and phonons in metals; Optical reflectance, Kramers-Kronig relations, Electronic inter-band transitions, Excitons: Frenkel and Mott-Wannierexcitons; Raman effect in crystals

SECTION- C

Dielectrics and Ferroelectrics

Polarization, Macroscopic electric field, Dielectric susceptibility, Local electric field at an atom, Dielectric constant and polarizability, Clausius-Mossotti relation, Electronic polarizability, Classical theory of electronic polarizability; Structural phase transitions; Ferroelectric crystals and their classification; Landau theory of the phase transition; Anti-ferroelectricity, Ferroelectric domains; Piezoelectricity.

SECTION- D

Magnetism

Diamagnetism and paramagnetism: Magnetic susceptibility, Langevin diamagnetism equation, Quantum theory of diamagnetism; Quantum theory of paramagnetism- Curie law, Hund's rules, Paramagnetic susceptibility of conduction electrons; Ferromagnetism and anti-ferromagnetism: Ferromagnetic order, Mean field theory- Curie-Weiss law; Electrostatic origin of magnetic interactions, Magnetic properties of a two-electron system, Spin waves- magnons, Bloch $T^{3/2}$ law; Neutron magnetic scattering (principle); Ferromagnetic domains: Magnetization curve, Bloch wall, Origin of domains; Antiferromagnetic order and magnons.

Reference Books:

- Introduction to Solid State Physics (7th edition) by Charles Kittel
- Solid State Physics by Neil W. Ashcroft and N. David Mermin
- Applied Solid State Physics by Rajnikant
- Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
  Principles of the Theory of Solids (2nd edition) by J. M. Ziman

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH603B	Advanced solid state physics	CO1	-	2	-	3	-	-	-	-	-	2	2
		CO2	-	2	-	3	-	-	-	-	-	2	2
		CO3	-	2	-	3	-	-	-	-	-	2	2
		CO4	-	2	-	3	-	-	-	-	-	2	2

Course Title/Code	Fundamental Atmospheric Physics / PHH604B	
Course Type	**Elective**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	Understanding of advanced atmospheric thermodynamic and dynamic concepts; they have the ability to apply these independently and lead others in an operational or research environment.	
Course Outcomes (COs)		**Mapping**
CO1	Explain the physical laws governing the structure and evolution of atmospheric phenomena spanning a broad range of spatial and temporal scales.	**Employment**
CO2	Apply mathematical tools to study atmospheric processes.	**Skill Development**
CO3	Explain the principles behind, and use of, meteorological instrumentation.	**Entrepreneurship**
CO4	Describe, analyze and create graphical depictions of meteorological information.	**Skill Development and Employability**
Prerequisites (if any)		

SECTION – A

Essentials of atmospheric physics

Structure of the atmosphere: troposphere, stratosphere, mesosphere, thermosphere; Composition of air; Greenhouse effect and enhanced greenhouse effect; Transport of matter, energy and momentum in nature; Stratification and stability of atmosphere; Laws of motion, hydrostatic equilibrium; Elements of weather and climate of India

SECTION – B

Solar-terrestrial radiations

Physics of radiation; Interaction of light with matter; Rayleigh- and Mie- scattering. Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.) Solar and terrestrial spectra; UV radiation; Ozone depletion problem; IR absorption energy balance of the Earth atmosphere system;

SECTION – C

Atmospheric pollution & degradation

Air pollution, sources and classification of air pollutants, Factors governing air, water and noise pollutions, effects of air pollution on human health, animals and plants, sir pollution control, source and sinks of air pollutants, atmospheric stability and temperature inversion, Puffs and plumes, gaseous and particulate matters, wet and dry deposition, Residence time and reaction rates of pollutants, sulphur compounds, nitrogen compounds, carbon compounds, organic compounds, aerosols, toxic gases and radioactive particles trace gases.

SECTION – D

Aerosols & their impact on climate

Aerosols, shape and size of aerosols, aerosols sources: natural and anthropogenic, residence time, chemical composition, global spatial-temporal variability of aerosols, aerosols removal processes, interaction between aerosols and minor gas components, photochemical processes, precipitation of aerosols, interaction between tropospheric aerosols and ozone, interaction between aerosols and clouds.

Reference and Text Books:

- Meteorology for Scientists & Engineers: Ronald B. Still, Brooks/ Cole Cengage Learning 1995.
- Environmental Physics : Edbert B and Reink V Groundelle, John Wiley
- The Physics of Atmosphere : J.T. Hougtion, Cambridge Univ. Press, 1977
- Atmospheric Science: John M. Wallace & Peter V. Hobbs, Academic Press (2006)
- Meteorology for Scientists and Engineers: Ronald B. Stull, Brocks/Cole Cengage Learning (1995)
- The Lightning Discharge: Martin A. Uman, Academic Press (1987)

Co-Po mapping

Course Code	Course	Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
PHH604B	Fundamental Atmospheric Physics	CO1	2	3	-	-	-	2	1	-	3	-	2
		CO2	1	2	-	-	-	3	2	-	2	-	2
		CO3	2	3	-	-	-	2	2	-	1	-	3
		CO4	3	2	-	-	-	1	3	-	2	-	3

Course Title/Code	Synthesis and Characterization Techniques / PHH605B	
Course Type	**Elective**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To study the physical and chemical synthesis methods of materials and to study different types of surface and bulk characterization technique.	
Course Outcomes (COs)		**Mapping**
CO1	Understand, basic concept of thin films, nano-structures, and quantum confinement effects. Students will be able to handle/operate thin film deposition techniques and will evaluate the consequences of deposition parameters on the film quality (roughness, porosity, cracks etc) and, hence, applications.	**Employment**
CO2	Students will be able to explain/demonstrate the concepts growth processes by chemical and physical methods. Moreover, differences in the properties/applications of chemical method grown and physical method grown nano-structures will be examined by the students. Students will imagine/design/invent new experiments for the growth of unraveled nanomaterials.	**Skill Development**
CO3	Students will be able to calculate and examine the particle size change effect on the XRD patterns and determination of particle size using XRD. Similarly, quantum size confinement effects can be evaluated by students using, Raman, UV-vis, FTIR and PL-spectroscopy. They may create/invent new material with unique properties/applications.	**Entrepreneurship**
CO4	Students will be able to justify, and plan the characterization techniques like TEM, SEM, AFM on different nano-structures. Students will be able to estimate the morphology and size/roughness using such techniques. Other element specific techniques like XAS, XPS, Mössbauer will provide valence state determination of elements. Students will also be able to calculate the magnetic moments and dielectric constant from various materials..	**Skill Development**
Prerequisites (if any)	**Nil**	

SECTION- A

Physical synthesis methods of materials:
Introduction to bulk,thick films, thin films and mono-layers. Polycrystalline, strained, oriented, epitaxy films. Resistive heating technique, Electron beam evaporation technique, Sputtering techniques (D.C., R. F. and R. F. Magnetron), LASER deposition technique, Molecular beam epitaxy technique.

SECTION – B

Chemical synthesis methods of materials:
Introduction to top-down and bottom-up approaches of the synthesis of micro, nano and quantum dot materials. Solid state reaction method, Sol-gel method, Hydro-thermal method, Combustion method, Chemical bath deposition technique, Chemical Vapour deposition technique, Spin-coating method.

SECTION – C

X-rays and other optical spectroscopy techniques for characterization of materials: Brag rule for diffraction, X-ray diffraction and calculations for determining the grain size and lattice strain. Effect of grain size on the X-ray diffraction patterns. UV-visible absorption spectroscopy and its application for energy band-gap calculation for different sized materials, Raman and FTIR spectroscopy and their application for determining the defects states in materials. Photo-luminescence spectroscopy. X-ray absorption and X-ray emission spectroscopy (Qualitatively).

SECTION - D

Surface and Bulk property characterization techniques:
Scanning electron microscopy and Field-emission Scanning electron microscopy (SEM and FE-SEM), Transmission electron microscopy (TEM), Atomic Force Microscopy (AFM), Mössbauer spectroscopy and its application to determine the valence state of Fe in different materials, Vibrating sample magnetometer (VSM), Superconducting quantum interference device (SQUID), Calculation of magnetic moments from different magnetic samples, Application of L-C-R meter for determination of dielectric constant and dielectric loss for various dielectric materials.

Text Books:

- S. L. Kakani, Kakani Amit "Material Science" NEW AGE, 2010, ISBN-10: 8122430856, ISBN-13: 978-8122430851
- S O Pillai, Solid State Physics, New Age International; Eighth edition, 2018, ISBN-10: 9789386070920, ISBN-13: 978-9386070920

Reference Books:

- Donald L. Pavia, Introduction to Spectroscopy, Cengage Learning India Private Limited; 5 edition (2015), ISBN-10: 8131529169, ISBN-13: 978-8131529164.

- Colin N. Banwell and Elaine M. McCash, Fundamentals of Molecular Spectroscopy, McGraw Hill Education; Fourth edition, 2017, ISBN-10: 9352601734, ISBN-13: 978-9352601738
- William F. Smith, Javad Hashemi, Ravi Prakash, "Material Science and Engineering (In Si Units)", McGraw Hill Education; 5 edition, ISBN-10: 9781259062759, ISBN-13: 978-1259062759, 2017.
- R. Balasubramaniam, "Callister's Materials Science and Engineering", Wiley, 2nd edition, ISBN-10: 8126541601, ISBN-13: 978-8126541607, 2014.
- S. S. R. Kumar Challa, "Magnetic Characterization Techniques for Nanomaterials", Springer-Verlag Berlin and Heidelberg GmbH & Co. KG, ISBN: 9783662527795, 3662527790

CO-PO Mapping

Course Code	Course	Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
PHH605B	Synthesis and Characterization Techniques	CO1	3	2	-	2	3	-	-	3	-	2	2
		CO2	2	2	-	2	3	-	-	2	-	3	3
		CO3	2	3	-	2	3	-	-	2	-	2	2
		CO4	3	2	-	2	2	-	-	3	-	2	3

Course Title/Code	Laboratory Work-III / PHH607B	
Course Type	**Core**	
L-T-P Structure	**0-0-6**	
Credits	**3**	
Course Objective	To practice application of electronic components in power supply and other electronic devices	
Course Outcomes (COs)		**Mapping**
CO1	Students will have the Ability to learn Pulse Amplitude Modulation/Demodulation, FSK Modulation Demodulation using Timer/PLL, Fibre Optics communication.	**Skill Development and Employability**
Prerequisites (if any)	**Nil**	

Laboratory/Practical Course list:

1. Pulse Amplitude Modulation/Demodulation
2. Pulse position/Pulse width Modulation/Demodulation
3. FSK Modulation Demodulation using Timer/PLL
4. Microwave characterization and Measurement
5. PLL circuits and applications
6. Fibre Optics communication
7. Design of Active filters
8. BCD to Seven segment display
9. A/D and D/A conversion
10. Addition, substraction, multiplication & division using 8085/8086
11. Wave form generation and storage oscilloscope
12. Frequency, Voltage, Temperature measurements
13. Motor Speed control, Temperature control using 8086.
14. Trouble shooting using signature analyzer.
15. Assembler language programming on PC.
16. Study of line spectra on photographed plates/films and calculation of plate factor.

Course Code	Course	Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
PHH607B	**Laboratory Work-III**	**CO1**	2	2	2	3	2	-	-	2	-	2	3

Course Title/Code	Scientific Research-II / RDO603	
Course Type	Core	
L-T-P Structure	0-0-8	
Credits	4	
Course Objective	To impart knowledge on various analytical techniques	
Course Outcomes (COs)		Mapping
CO1	The students will be able to critically evaluate the work done by various researchers relevant to the research topic	Skill Development
CO2	To integrate the relevant theory and practices followed in a logical way and draw appropriate Conclusions	Skill Development
CO3	To understand the research methodologies/approaches/techniques used in the literature	Skill Development
CO4	To structure and organize the collected information or findings through an appropriate abstract, headings, reference citations and smooth transitions between sections	Skill Development
Prerequisites (if any)	Scientific Research-I (RDO503)	

Section A

Literature Survey (LS)/Design of Experiment

Collection of research papers related to previously identified gap/problem (15 papers or more) Comprehend and arrange the literature based on the idea framed, presenting the collected data and inferring it with the further scope of expansion and Designing the experiment wherever applicable.

Section B

Structuring of Review Paper and setting up of experimental facility

Analysis of different approach/methodology adopted by various researchers, Listing out the components of the paper/ setting up experimental facility w.r.t the problem, Identification of suitable Journal or Conference , Formatting/Styling the paper according to the respective template

Planning of experiments

Formulate experimental procedures with Modification of the experimental set-up, if required Procurement of materials

Section C

Execution of experiments/simulations

Conduct experiments/ build prototype ,Tabulating and recording data, Analysis and interpretation of the data, Comparison of the results with other reported experiments, Interpretation of observations, Integration of relevant theory, findings in a structured way and draw appropriate conclusions

Section D

Departmental Presentation

Structuring and preparation of PPT, Mock presentation, Review on presentation skills and content delivered both, Incorporating the review comments in the slides

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
RDO603	Scientific Research-II	CO1	-	-	-	-	-	3	2	3	-	-	-
		CO2	-	-	-	-	-	2	3	3	-	-	-
		CO3	-	-	-	-	-	3	3	2	-	-	-
		CO4	-	-	-	-	-	3	3	3	-	-	-

Semester-IV

Course Code	Course Name	Offering Department	Course Type	Structure			Credits
			Deptt./Allied Core/Elective/ Audit	L	T	P	
PHH608B	Nanotechnology	PHYSICS	ELECTIVE (Any one)	4	0	0	4
PHH609B	Advanced Atmospheric Physics			4	0	0	
PHH610B	Advanced Plasma Physics			4	0	0	
PHH611B	Condensed Matter Physics			4	0	0	
PHN612B	PROJECT WORK	PHYSICS	CORE	0	0	20	10
TOTAL (L-T-P) /CREDITS)				8	0	0	14

DETAILED SYLLABUS

Course Title/Code	Nanotechnology / PHH608B	
Course Type	Elective	
L-T-P Structure	4-0-0	
Credits	4	
Course Objective	The course is to make students understand the role of physics/ chemistry of nano-structures	
Course Outcomes (COs)		Mapping
CO1	To understand the behaviour of nonmaterial based on its physics/chemistry	Employment
CO2	To acquire knowledge about size effects and reaction kinetics at nanoscale	Skill Development
Prerequisites (if any)	Nil	

Section A

Size Effects on Structure and Morphology of Nanoparticles

Fundamental Properties - Size Effects on Structure and Morphology of Free or Supported Nanoparticles - Size and Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress - Effect on the Lattice Parameter - Effect on the Phonon Density of States - Nanoparticle Morphology - Equilibrium Shape of a Macroscopic Crystal - Equilibrium Shape of Nanometric Crystals - Morphology of Supported Particles.

Section B

Phase Transition in Nanostructures

Crystalline Phase Transitions in Nanocrystals - Phase Transitions and Grain Size Dependence - Elementary Thermodynamics of the Grain Size-Dependence of Phase Transitions- Influence of the Surface or Interface on Nanocrystals - Modification of Transition Barriers- Geometric Evolution of the Lattice in Nanocrystals-Grain Size Dependence- Influence of the Nanocrystal Surface or Interface on the Lattice Parameter.

Section C

Features of Nanoscale Growth

Fundamentals of homogeneous nucleation, Subsequent growth of nuclei, Growth controlled by diffusion, Growth controlled by surface process, Synthesis of metallic nanoparticles, Influences of reduction reagents, Forced hydrolysis, Controlled release of ions, Vapor phase reactions, Solid state phase segregation, Fundamentals of heterogeneous nucleation, Island or Volmer-Weber growth, Layer or Frank-van der Merwe growth, Island-layer or Stranski-Krastonov growth.

Section D

Applications of Nanostructures

Application of nano-structures in waste-water treatment, Application of nano-structures in bacteria entrapment, Application of nano-structures in Electronics. Application of nano-structures in photonics.

TEXT BOOKS

1. Frank Owens Charles Poole, Introduction to Nanotechnology, Wiley, 2007, ISBN-10: 8126510994, ISBN-13: 978-8126510993
2. Rao C. N., A. Muller, A. K. Cheetham, “Nanomaterials Chemistry”, Wiley- VCH, 2007.
3. Brechignac C., P. Houdy, M. Lahmani, “Nanomaterials and Nanochemistry”, Springer publication, 2007.
4. Sverre Myhra, John C. Rivière, “Characterization of Nanostructures”, CRC Press; 1st edition, 2016, ISBN-10: 1138198633, ISBN-13: 978-1138198630.
5. Bharat Bhushan, “Scanning Probe Microscopy in Nanoscience and Nanotechnology (NanoScience and Technology)”, Springer; 2010 edition, ISBN-10: 3642035345, ISBN-13: 978-3642035340

Course Code	Course	Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11
PHH608B	Nanotechnology	CO1	3	2	-	-	-	2	1	2	3	-	2
		CO2	2	3	-	-	-	3	2	-	2	-	3

Course Title/Code	Advanced Atmospheric Physics / PHH609B	
Course Type	**Elective**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	To bring students to an understanding of the basic processes involved in weather and to understand the major components of the earth-biosphere-atmosphere system and their interactions.	
Course Outcomes (COs)		**Mapping**
CO1	Demonstrate expert knowledge of the weather and climate of the Tropics	**Employment**
CO2	Apply basic atmospheric thermodynamic principles such as potential temperature, equivalent potential temperature, vapor pressure, mixing ratio and the first and second laws of thermodynamics to understand weather and climate issues	**Skill Development**
CO3	Create sophisticated computer programs and/or utilize those available on the web	**Entrepreneurship**
CO4	Work independently with an observational dataset or numerical simulation	**Skill Development**
Prerequisites (if any)	**Nil**	

SECTION – A

Cloud formation & microphysics of cloud

Adiabatic and atmospheric lapse rate, nucleation of water vapour & cloud condensation nuclei; thunderstorms; Microstructure of warm clouds; Cloud liquid water content & entrainment; Growth of cloud droplets in warm clouds: by condensation; by collection, by collision-coalescence; Microphysics of cold clouds: nucleation, growth & concentration of ice particles, formation of precipitation in cold clouds; Artificial modification of clouds & precipitation; modification of warm & cold clouds, inadvertent modification.

SECTION – B

Atmospheric electricity & lightning

Mechanisms of cloud electrification; precipitation powdered; connective mechanisms; electrochemical charge separation; charge structure of the clouds; thundercloud electric fields, Lightning initiation in a thundercloud; Cloud to ground; intra-cloud lightning; Positive lightning;

Lightning sprites; Blue jets, elves, Lightning fields: electric & magnetic fields; radiations from lightning

SECTION - C

Solar phenomena

Composition and structure of the sun, solar interior, solar radiations, solar cosmic rays, galactic cosmic rays, sunspots numbers and solar rotation, solar cycle, magnetically controlled solar phenomena, magnetic fields in solar interior and flux emergence, solar flares, corona mass ejection, solar corona, solar wind, solar radio bursts, noise storms, solar flux indices, Kp, Ap, F10.7, solar zenith angle.

SECTION – D

Ionosphere & its Importance

Formation of ionosphere, classification, photochemical processes, ion production, ionospheric parameters: electron, ion and neutral temperatures, ion composition and density, ion transportation, diurnal, seasonal and sunspot cycle variations of the ionised regions, irregularities and abnormalities in the ionosphere, propagation of electromagnetic waves in ionised atmosphere (ray treatment), propagation in presence/ absence of magnetic field, fundamental equation, effect of collision, Appleton-Hartree formula

Reference and Text Books:

- Atmospheric Science: John M. Wallace & Peter V. Hobbs, Academic Press (2006)
- Meteorology for Scientists and Engineers: Ronald B. Stull, Brocks/Cole Cengage Learning (1995)
- The Lightning Discharge: Martin A. Uman, Academic Press (1987)
- Dynamic Meteorology : Holton, J.R., 3rd edition ,Academic PressN.Yf. (1992).
- The Physics of Monsoons : R.N. Keshvamurthy ans M. Shanker Rao, Allied Publishers

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH609B	Advanced Atmospheric Physics	CO1	3	2	-	-	-	2	1	2	3	-	2
		CO2	2	3	-	-	-	3	2	-	2	-	3
		CO3	3	2	-	-	-	-	3	-	3	-	3
		CO4	2	3	-	-	-	2	3	-	3	-	2

Course Title/Code	Advanced Plasma Physics / PHH610B	
Course Type	**Elective**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	This course will provide new aspects of plasma concerning nonlinear electrostatic and electromagnetic waves for their diverse applications in communications, radiation generation, and particle acceleration. After completing this course the student will be in the position to start research work in any of these fields. This will also help developing the understanding in astrophysics.	
Course Outcomes (COs)		**Mapping**
CO1	Understand that using fundamental plasma parameters, under what conditions an ionised gas consisting of charged particles (electrons and ions) can be treated as plasma.	**Employment**
CO2	Able to distinguish the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena.	**Skill Development**
CO3	Able to determine the velocities, both fast and slow (drift velocities), of charged particles moving in electric and magnetic fields that are either uniform or very slowly in space and time.	**Entrepreneurship**
CO4	Formulate the conditions for a plasma to be in a state of thermodynamic equilibrium, or non-equilibrium, and analyse the stability of this equilibrium and account for the most important plasma instabilities	**Skill Development**
Prerequisites (if any)		

Section-A

Basics of plasmas

Plasma as a state of matter, concept of temperature, Debye length, plasma frequency, collisions, criteria for plasmas, dc conductivity, ac conductivity, Plasma production and measurements: dc discharge, rf discharge, photo-ionization, tunnel ionization, avalanche breakdown, laser produced plasmas, Langmuir probe.

Section-B

Waves and instabilities

Electromagnetic waves, Langmuir wave, ion acoustic wave, surface plasma wave, ionosphere propagation, two stream instability, Weibel instability. Plasma in relation with electromagnetic waves, electromagnetic wave propagation, propagation in inhomogeneous plasma, electrostatic waves in plasma, energy flow

Section-C

Plasma confinement

Single particle motion in a magnetic field, motion in magnetic and electric fields, motion in inhomogeneous and curved magnetic fields, magnetic moment invariance, mirror confinement, tokamak confinement

Section-D

Kinetic Theory and Non-linear effects

The meaning of f(v), Equations of Kinetic Theory, Plasma Oscillations and Landau damping, Kinetic effects in a Magnetic field, Sheaths, Ion acoustic Shock Waves, The pondermotive force, Non-linear Landau damping.

Text and Reference Books

1. Introduction to plasma physics and controlled fusion, F.F. Chen, Plenum Press (1084).
2. Interaction of electromagnetic waves with electron beams and plasmas, C.S. Liu and V.K. Tripathi, World Scientific (1994).
3. Principles of Plasma Physics, N.A.Krall and A.W.Trivelpiece, McGraw Hill (1973).
4. Fundamentals of Plasma Physics by Paul M. Bellan. Cambridge University Press (2006).

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH610B	Advanced Plasma Physics	CO1	2	2	-	2	-	-	2	-	2	2	2
		CO2	2	2	-	2	-	-	2	-	2	2	2
		CO3	2	2	-	2	-	-	2	-	2	2	2
		CO4	2	2	-	2	-	-	2	-	2	2	2

Course Title/Code	Condensed Matter Physics / PHH611B	
Course Type	**Elective**	
L-T-P Structure	**4-0-0**	
Credits	**4**	
Course Objective	Students would be able to understand the properties of condensed materials and underlying principles of classical mechanics, quantum mechanics, statistical mechanics and computers in order to develop the understanding of condensed materials in terms of structure and dynamics of the system under consideration. Students would be able to handle and identify their own research problem independently and take part in interdisciplinary research work.	
Course Outcomes (COs)		**Mapping**
CO1	Describe how different kinds of matter are described mathematically. They will analyze how material properties can be predicted on the basis of their structure and molecular mechanics.	**Employment**
CO2	Able to understand computational quantum theories and their application to a number of model systems.	**Skill Development**
CO3	Able to understand advanced quantum computational theories and their application to a number of model systems.	**Entrepreneurship**
CO4	Able to understand superconductivity in depth, on the basis of knowledge of advance quantum mechanics and higher mathematical techniques.	**Skill Development**
Prerequisites (if any)		

Section-A

Foundation of molecular orbital theory: MO theory

Foundations of the MO theory, The Huckel method, Huckel theory and the LCAO approximation, Semi-empirical MO theory, Molecular mechanics calculations, energy minimization, vibrational frequencies, and normal mode analysis.

Section-B

Fundamentals of many-electron system: Hartree-Fock theory

The basic Hamiltonian in a solid: Electronic and ionic parts, Born-Oppenheimer Approximation; The Hartree equations, Connection with variational principle; Exchange: The Hartree-Fock approximation, Hartree-Fock theory of free electrons- One electron energy, Band width, DOS, Effective mass, Ground state energy, exchange energy, correlation energy; Slater and Gaussian type orbitals, Restricted and unrestricted Hartree-Fock approximation, Koopmans's theorem; Description of quantum states and the Dirac notation, Density operators, Hartree Fock theory in Density-matrix form.

Section-C

Density Functional Theory

Basics of DFT, local density methods, gradient corrected methods, hybrid methods; Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond; Practical DFT in a many body calculation and its reliability.

Section-D

Superconductivity

Basic phenomena, Electron-electron interaction via lattice: Cooper pairs; London equations, coherence, Ginzsburg-Landau theory, BCS theory, Josephson effect, SQUID, excitations and energy gap, magnetic properties of type-I and type-II superconductors-characteristic length, flux lattice, introduction to high-temperature superconductors.

Text and Reference Books

- ABC of DFT, by K Burke and Rudy Magyar
- M. Tinkham, Introduction to Superconductivity, CBS
- Errol lewars, Introduction to the theory and applications of molecular and quantum mechanics.
- Ira N. Levine, Quantum chemistry
- Henrik Bruus and Karsten Flensberg, Many body quantum theory in Condensed matter Physics
- Mc Quarrie & Simon, Physical chemistry (Molecular approach)
- C. Kittel: Quantum Theory of Solids

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHH611B	Condensed Matter Physics	CO1	-	3	-	2	-	2	-	-	-	-	-
		CO2	-	-	-	-	-	-	-	-	-	-	-
		CO3	-	3	-	3	-	-	-	-	-	-	-
		CO4	-	3	-	3	-	-	-	-	-	-	-

Course Title/Code	Project work / PHN612B	
Course Type	**Core**	
L-T-P Structure	**0-0-20**	
Credits	**10**	
Course Objective	Understand and adopt the ethical practice that is to be followed in the research activities. Work in groups with guidance.	
Course Outcomes (COs)		**Mapping**
CO1	**To learn about research paper writing skills.**	**Employment**
Prerequisites (if any)		

CO-PO Mapping

Course Code	Course	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PHN612B	**Project Work**	**CO1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

CO-PO Mapping Matrix

Semester I

Courses Code	Courses Name	Course Outcomes	CO Statement	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
PHH 501B	Mathematical Physics	**CO1**	Find eigen values and eigen vectors using matri- algebra	3	3	-	-	-	-	3	-	-	-	3
		CO2	Solve differential equations of special functions	3	3	-	-	-	-	3	-	-	-	3
		CO3	Find Fourier transforms, Laplace Transforms and Inverse LT for various functions applied to physics theory	3	3	-	-	-	-	3	-	-	-	3
PHH 502B	Classical Mechanics	**CO1**	Students would be able to understand, e- plain and demonstrate fundamental laws and concepts classical mechanics and further analyze and solve related problems	3	3	1	-	3	-	2	-	-	2	2
		CO2	Students would be able to demonstrate the concept of generalized coordinates, compare and apply various invariance and	2	3	1	-	2	-	3	-	-	2	2

			symmetry laws and solve various related problems. They would further formulate lagrangian of various physical systems and solve them. Students would be able to hypothesize new problems.											
		CO3	Students would be able to describe and demonstrate the concepts of central body problems and apply Kepler's laws on motion of planetary bodies. They would also be able to formulate and construct a solution pertaining to it. They would be able to hypothesize and formulate central body problems.	3	3	1	-	3	-	3	-	-	3	3
		CO4	Students would be able to do Canonical transformations , solve Poisson's brackets and further e-plain and solve problems related to small oscillations. They would	3	3	-	-	3	-	3	-	-	3	3

			further formulate Hamiltonian of various physical systems and solve them. The students would be able to construct new problems											
PHH 503B	Quantum Mechanics-I	**CO1**	Students would be able to understand, e-plain and demonstrate various laws and concepts of essentials of Quantum physics related to it's basic structure, stratification, movement and solve related problems	2	2	**3**	**-**	**3**	**2**	**2**	**-**	**3**	**2**	**3**
		CO2	Students will be able to e-plain the concepts of wave-function, Schrodinger equation and problem solving of He and other heavy elements.	2	2	**2**	**-**	**3**	**2**	**2**	-	**2**	**2**	**3**
		CO3	Students will be able to understand various Operators (Momentum, Hamiltonian, Hermitian) etc. Students also able to solve the Bra-Ket matri-	2	3	**2**	**-**	**2**	**2**	**2**	**-**	**3**	2	3

		CO4	Students will be able to design and e-plain various mechanisms/working conditions of Time independent perturbation theory and its application to e-plain and solve the problems of Zeeman and Stark effects.	2	3	**2**	**-**	**2**	**2**	**2**	**-**	**2**	2	2
PHH 504B	Physics of Electronic Devices	**CO1**	Students would be able to apply basics of Semiconductors,pn-junction,Zener and avalanche breakdowns,configurations and characteristics,JFET to solve numerical problems with demostration	2	-	-	3	1	1	-	3	**2**	**3**	**3**
		CO2	Students would be able to understand and analysis of CE, CB, and CC amplifiers,input and output impedances of amplifiers,Analysis of amplifiers with diagram	2	-	-	3	1	1	-	3	**2**	**3**	**3**
		CO3	The frequency response of RC coupled CE amplifiers and gain-frequency plots of amplifier	2	-	-	3	1	1	-	3	**2**	**3**	**3**

			response											
		CO4	Students would be able to understand and analysis of different types of Power amplifiers	2	-	-	3	1	1	-	3	**2**	**3**	**3**
PHS505B	Computational Method and Programming	**CO1**	Use and apply main features of the MATLAB program development environment to enable their usage in the higher learning.	3	2	1	1	1	0	1	0	0	3	3
		CO2	Implement simple mathematical functions/equations in numerical computing environment such as MATLAB	3	2	1	1	1	0	1	0	0	3	3
		CO3	Interpret and visualize simple mathematical functions and operations thereon using plots/display.	3	2	1	1	1	0	1	0	0	3	3
		CO4	Analyze the program for correctness and determine/estimate/predict the output and verify it under simulation environment using MATLAB.	3	2	1	1	1	0	1	0	0	3	3

PHH 506B	Laboratory Work-I	**CO1**	Understanding of the V-I characterstics of P-N diode, low-pass, high pass and band-pass filters.	3	3	1	3	1	1	1	1	1	2	2
		CO2	Study and E-amine the different rectifier circuits, amplifier circuits.	3	3	1	1	1	1	1	1	1	2	2
		CO3	Analyse and design various circuits for OR, AND, NOT, NAND and NOR logic gates.	3	3	1	1	1	1	1	1	1	2	2
		CO4	Analyse clipping, clamping, modulation and demodulation in circuits. Application of CRO, differentiation and integration of various circuits, Study and apply multivibrator	3	3	1	1	1	1	1	1	1	2	2

Semester II

Courses Code	**Courses**	**Course Outcomes**	CO Statement	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**
PHH507B	Quantum Mechanics-II	**CO1**	discuss and interpret e-periments/Theories that	2	2	**3**	**-**	**3**	**2**	**2**	**-**	**3**	**2**	**3**

			reveal the Schrodinger wave equation and Perturbation theory was not enough to solve the energy of He like atoms. Therefore, variotional method and other appro-imation (like; WKB) methods were used.											
		CO2	Interpret and Apply the Collision in 3-D scattering; Laboratory and CM reference frames; Scattering amplitude; differential scattering cross section and total scattering cross section; Apply the scattering theory on solving the energetic particle-solid interaction and calculation of recoil/scatter er atoms.	2	2	**2**	**-**	**3**	**2**	**2**	-	**2**	**2**	**3**
		CO3	Design and construct spectral problems using angular	2	3	**2**	**-**	**2**	**2**	**2**	**-**	**3**	2	3

			momentum. Tounderstand and apply the Comple-potential and absorption in scattering. Identical particles; Symmetric and antisymmetric wave functions; Collision of identical particles; Spin angular momentum; Spin functions for a many-electron system.											
		CO4	Develop and e-plain the Semiclassical theory of radiation; Transition probability for absorption and induced emission; Electric dipole and forbidden transitions; Selection rules	2	3	**2**	**-**	**2**	**2**	**2**	**-**	**2**	2	2
PHH508B	Statistical Mechanics	**CO1**	To develop familiarity with the physical concepts and facility with the mathematical methods of S	3	3	3	3	3	2	3	**-**	**-**	**-**	3

			tatistical mechanics											
		CO2	To cultivate skills at formulating and solving physics probl ems	3	3	3	3	3	3	3	**-**	**-**	**-**	3
		CO3	To provide a firm foundation to students in a very fundamental subject of Statistical Mechanics	3	3	3	3	3	3	3	**-**	**-**	**-**	3
PHH5 09B	Solid State Physic s	**CO1**	E-plain and analyze the -RD pattern and determine the crystal structure of a material.	3	2	**-**	2	2	2	2	2	**-**	2	2
		CO2	E-plain and apply different models for thermal properties of solids	3	3	**-**	3	3	3	3	2	2	2	2
		CO3	E-plain and analyze the electrical properties of metals and semiconduct ors.	3	3	**-**	3	**-**	3	3	3	3	2	2
		CO4	E-plain the theory related to superconduct ors.	3	3	**-**	3	**-**	**-**	**-**	2	**-**	3	**-**
PHH5 10B	Atomi c and Molec ular Physic	**CO1**	E-plain spectrum of hydrogen and hydrogen like atoms	3	2	2	1	1	1	1	1	2	3	**3**

	s		using quantum theory and identify the effect of weak and strong magnetic field on the spectrum.											
		CO2	Studying the hyperfine structure of atoms using different coupling schemes.	3	2	2	1	1	1	1	1	2	3	**3**
		CO3	Studying molecular spectra using different models of molecules.	3	2	2	1	1	1	1	1	2	3	**3**
		CO4	Studying different spectrometer s to study optical properties of molecules.	3	1	1	2	1	2	2	1	2	2	3
PHH5 12B	Labora tory Work-II	**CO1**	Apply FET and MOSFET in amplifiers, Application of 741, ESR spectrometer	3	2	2	2	2	-	-	3	2	3	2
RDO5 03	Scienti fic Resear ch-I	CO1	The student shall be able to describe research and its impact.	**2**	**2**	**-**	**2**	**2**	**3**	**3**	**3**	**2**	**2**	**2**
		CO2	The student shall be able to identify broad area of research, analyze, the processes	**2**	**2**	**-**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

			and procedures to carry out research.											
		CO3	The student shall be able to use different tools for literature survey	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**-**	**-**	**-**
		CO4	The student is able choose specific area of research and supervisor/mentor is finalized	**-**	**-**	**-**	**-**	**-**	**3**	**2**	**2**	**-**	**-**	**-**
		CO5	To understand and adopt the ethical practice that are to be followed in the research activities	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**-**	**-**	**-**
		CO6	To work in groups with guidance	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**-**	**-**	**-**

Semester III

Courses Code	Courses	Course Outcomes	CO Statement	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
PHH 601B	Nuclear and Particle Physics	**CO1**	Students would be able to understand, e-plain and demonstrate various laws and concepts of nuclear and particle physics related to its basic nucleus structure. The students would be able to analyze and evaluate the related problems.	2	3		1		3	2		3		2
		CO2	Students would be able to understand, compare and analyze various nuclear models proposed till date.	2	3		1		3	2		3		2
		CO3	Students would be able to describe, analyze and evaluate the basic interaction mechanisms for charged particles and electromagnetic radiation relevant for radiation detectors and e-plain their importance for detecting various types of ionizing radiation at different energies.	2	3		1			2		3		2
		CO4	Students would be able to compare and simulate the basic features involved in alpha	2	3		3		3	2		3		3

			and beta decays, nuclear forces and formulate various kinds of nuclear reactions besides the fundamentals of elementary particle physics.											
PHH 602B	Electrodynamics and Plasma Physics	**CO1**	Student will be able to demonstrate an understanding of the use of Laplace equation, boundary conditions and method of images	2	3	2	2	2	2	2	1	2	3	3
		CO2	Students would be able to know and use coordinates transformation, Electrostatics and magentostatics fundamentals, time dependent field, Ma-well’s equations, Know and use of scalar potential, vector potential, gauge transformation	2	3	2	2	2	2	2	1	2	3	3
		CO3	Student would be able to analyze the power radiated by a point charge, radiation due to an oscillating electric dipole	2	3	2	2	2	2	2	1	2	3	3
		CO4	Understanding of relativistic electrodynamics and basic understanding of Plasma state essential for research purpose	3	2	2	2	2	**2**	2	**1**	2	3	2
PHH 603B	Advanced solid state physics	**CO1**	To understand and analyze the behavior of electrons in metals and semiconductors and to realize their importance in	**-**	2	**-**	3	**-**	**-**	**-**	-	-	2	2

			gaining vital information about the electrical properties of materials.											
		CO2	To understand the physics governing the optical properties of materials and to evaluate and analyze the optical properties of materials.	-	2	-	3	-	-	-	-	-	2	2
		CO3	To understand the physics governing the dielectric properties of materials in order to e-plain their technological applications and to evaluate and analyze the dielectric properties of materials.	-	2	-	3	-	-	-	-	-	2	2
		CO4	To understand the classical and quantum physics governing the magnetic properties of materials in order to evaluate and analyze the magnetic properties of materials and to e-plain their technological applications.	-	2	-	3	-	-	-	-	-	2	2
PHH 604B	Fundamental Atmospheric Physics	**CO1**	E-plain the physical laws governing the structure and evolution of atmospheric phenomena spanning a broad range of spatial and temporal scales.	2	3	-	-	-	2	1	-	3	-	2
		CO2	Apply mathematical tools to study	1	2	-	-	-	3	2	-	2	-	2

			atmospheric processes.											
		CO3	E-plain the principles behind and use of, meteorological instrumentation.	2	3	-	-	-	2	2	-	1	-	3
		CO4	Describe analyze and create graphical depictions of meteorological information.	3	2	-	-	-	1	3	-	2	-	3
PHH 605B	Synthesis and Characterization Techniques	**CO1**	Students will be able to understand, basic concept of thin films, nano-structures, and quantum confinement effects. Students will be able to handle/operate thin film deposition techniques and will evaluate the consequences of deposition parameters on the film quality (roughness, porosity, cracks etc) and, hence, applications.	3	2	-	2	3	-	-	3	-	2	2
		CO2	Students will be able to e-plain/demonstrate the concepts growth processes by chemical and physical methods. Moreover, differences in the properties/applications of chemical method grown and physical method grown nano-structures will be e-amined by the	3	2	-	2	3	-	-	2	-	3	3

			students. Students will imagine/design/invent new e-periments for the growth of unraveled nanomaterials.											
		CO3	Students will be able to calculate and e-amine the particle size change effect on the -RD patterns and determination of particle size using -RD. Similarly, quantum size confinement effects can be evaluated by students using, Raman, UV-vis, FTIR and PL-spectroscopy. They may create/invent new material with unique properties/applications.	2	3	-	2	3	-	-	2	-	2	2
		CO4	Students will be able to justify, and plan the characterization techniques like TEM, SEM, AFM on different nano-structures. Students will be able to estimate the morphology and size/roughness using such techniques. Other element specific techniques like -AS, -PS, Mössbauer will provide valence state determination of elements. Students will also	3	2	-	2	2	-	-	3	-	2	3

			be able to calculate the magnetic moments and dielectric constant from various materials.											
PHH 607B	Laboratory Work-III	**CO1**	Pulse Amplitude Modulation/Demodulation, FSK Modulation Demodulation using Timer/PLL, Fibre Optics communication	2	2	2	3	2	-	-	2	-	2	3
RDO 603	Scientific Research II	**CO1**	The students will be able to critically evaluate the work done by various researchers relevant to the research topic	-	-	-	-	-	**3**	**2**	**3**	-	-	-
		CO2	To integrate the relevant theory and practices followed in a logical way and draw appropriate Conclusions	-	-	-	-	-	**2**	**3**	**3**	-	-	-
		CO3	To understand the research methodologies/approaches/techniques used in the literature	-	-	-	-	-	**3**	**3**	**2**	-	-	-
		CO4	To structure and organize the collected information or findings through an appropriate abstract, headings, reference citations and smooth transitions between sections	-	-	-	-	-	**3**	**3**	**3**	-	-	-

Semester IV

Courses Code	Courses	Course Outcomes	CO Statement	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
PHH608	Nanotechnology	**CO1**	To understand the behaviour of nanomaterials based on its physics/chemistry	**3**	**2**	**-**	**-**	**-**	**2**	**1**	**2**	**3**	**-**	**2**
		CO2	To acquire knowledge about size effects and reaction kinetics at nanoscale	**2**	**3**	**-**	**-**	**-**	**3**	**2**	**-**	**2**	**-**	**3**
PHH609B	Advanced Atmospheric Physics	**CO1**	Demonstrate e-pert knowledge of the weather and climate of the tropics.	3	2	-	-	-	2	1	2	3	-	2

		CO2	Apply basic atmospheric thermodynamics principles such as potential temperature, equivalent potential temperature, vapour pressure, mi-ing ratio and first and second laws of thermodynamics to understand weather & climate issues.	2	3	-	-	-	3	2	-	2	-	3
		CO3	Create sophisticated computer programs and/or utilize those available on the web.	3	2	-	-	-	-	3	-	3	-	3
		CO4	Work independently with an observational dataset or numerical simulation.	2	3	-	-	-	2	3	-	3	-	2
PHH610B	Advanced Plasma Physics	**CO1**	Understand that using fundament	**2**	**2**	**-**	**2**	**-**	**-**	**2**	**-**	**2**	**2**	**2**

			al plasma parameters, under what conditions an ionised gas consisting of charged particles (electrons and ions) can be treated as a plasma.											
		CO2	Able to distinguish the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena.	**2**	**2**	**-**	**2**	**-**	**-**	**2**	**-**	**2**	**2**	**2**
		CO3	Able to determine the velocities, both fast and slow (drift velocities), of charged particles moving in electric and magnetic fields that are either uniform or vary slowly in space and time.	**2**	**2**	**-**	**2**	**-**	**-**	**2**	**-**	**2**	**2**	**2**

		CO4	Formulate the conditions for a plasma to be in a state of thermodynamic equilibrium, or non-equilibrium, and analyse the stability of this equilibrium and account for the most important plasma instabilities	**2**	**2**	**-**	**2**	**-**	**-**	**2**	**-**	**2**	**2**	**2**
PHH611B	Condensed Matter Physics	**CO1**	Students would be able to describe how different kinds of matter are described mathematically. They will analyze how material properties can be predicted on the basis of their structure and molecular mechanics.	-	3	-	2	-	2	-	-	-	-	-

		CO2	Students would be able to understand computational quantum theories and their application to a number of model systems.	-	3	-	-	-	-	-	-	-	-	3
		CO3	Students would be able to understand advanced quantum computational theories and their application to a number of model systems.	-	3	-	3	-	-	-	-	-	-	3
		CO4	Students would be able to understand superconductivity in depth, on the basis of knowledge of advance quantum mechanics and higher mathematical techniques.	-	3	-	3	-	-	-	-	-	-	3
PHN 612B	Project Work	**CO1**	Understand and adopt the ethical	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

			practice that are to be followed in the research activities. Work in groups with guidance											