UNIVERSITY OF CALICUT

Abstract

General and Academic IV - Faculty of Science- Modified Scheme and Syllabus of Integrated M.Sc. Physics (CCSS)Programme, in accordance with the Regulations for CCSS in the University Teaching Departments, with multiple entry and exit options (2024), w.e.f 2024 admission - Implemented- Orders Issued.

G & A - IV - J

U.O.No. 3236/2025/Admn   Dated, Calicut University.P.O, 25.02.2025

Read:-1. U.O.No. 16256/2024/Admn dated 24.10.2024.
2. Remarks from Chairman, Board of Studies in Physics PG dated 15.02.2025.
3. Remarks of the Dean, Faculty of Science dated 19.02.2025.
4. Orders of the Vice Chancellor in the file of even no. dated 24.02.2025.

ORDER

1. The Scheme and Syllabus of Integrated M.Sc. Physics (CCSS) in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024) was implemented in the University of Calicut, vide paper read as (1).
2. The Board of studies in Physics PG, vide paper read as (2), incorporated certain corrections and approved the modified scheme and syllabus of Integrated M.Sc. Physics (CCSS) Programme offered by Department of Physics, University of Calicut, with effect from 2024 admission, in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024).
3. The Faculty of Science, vide paper read as (3), approved the recommendation of the Board of Studies in Physics (PG).
4. The Vice Chancellor has approved the above recommendation and accorded sanction to implement the modified scheme and syllabus of Integrated M.Sc. Physics (CCSS) Programme offered by Department of Physics, University of Calicut, with effect from 2024 admission, in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024), exercising the powers as per clause 10(13) of Calicut University Act 1975.
5. The modified Scheme and Syllabus of Integrated M.Sc. Physics (CCSS) in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024), is thus Implemented with effect from 2024 Admission.
6. U.O.No. 16256/2024/Admn dated 24.10.2024 stands modified to this extent.
7. Orders are issued accordingly. (Syllabus appended)

Ajayakumar T.K

Assistant Registrar

To

The Head, Department of Physics
Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DoA/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

University of Calicut

Department of Physics

Course Structure and Syllabus

(With effect from 2024-2025)

For

Integrated M.Sc. Physics

(10 semesters/full time)

Under choice-based credit semester system (CCSS)

Courses to be offered by the Department

Abbreviation

- Discipline- Specific Courses (DSC) Major/minor – **C**
- Discipline- Specific Electives (DSE) – **E**
- Discipline- Specific Online/MOOC (DSO) – **M**

- Skill Enhancement Course (SEC) – **S**
- Value- Added Course (VAC) – **V**

- Multi-Disciplinary Course (MDC) – **D**

- Internship – **I**
- Project – **P**

IPH1C101
Subject
Semester
Course Category
Level and Serial Number

Semester-wise Course Details

Course Code	Course Name	Course Type	Credits	T-P	CE T	CE P	EE T	EE P	Total T	Total P
Semester 1										
IPH1C101	Concepts in Physics	DSC Major	4	3-1	35	15	35	15	70	30
IPH1C101	Concepts in Physics	DSC Minor	4	3-1	35	15	35	15	70	30
IPH1C102	Properties of Matter and Thermodynamics	DSC Minor	4	3-1	35	15	35	15	70	30
IPH1D101	The Universe	MDC	3	3-0	50	0	50	0	100	0
Semester 2										
IPH2C101	Modern Physics	DSC Major	4	3-1	35	15	35	15	70	30
IPH2C101	Modern Physics	DSC Minor	4	3-1	35	15	35	15	70	30
IPH2C102	Basics of Electronics	DSC Minor	4	3-1	35	15	35	15	70	30
IPH2D101	Physics of Everyday Life	MDC	3	3-0	50	0	50	0	100	0
Semester 3										
IPH3C201	Mechanics & Relativity	DSC Major	4	3-1	35	15	35	15	70	30
IPH3C202	Optics	DSC Major	4	3-1	35	15	35	15	70	30
IPH3C202	Optics	DSC Minor	4	3-1	35	15	35	15	70	30
IPH3C203	Introductory Solid State Physics and Spectroscopy	DSC Minor	4	3-1	35	15	35	15	70	30
IPH3D201	History and Philosophy of Science	MDC	3	3-0	50	0	50	0	100	0
IPH3V201	Basic Computational Tools	VAC	3	3-0	50	0	50	0	100	0
Semester 4										
IPH4C201	Mathematical Physics - I	DSC Major	4	4-0	50	0	50	0	100	0

IPH4C202	Classical Mechanics and Chaos	DSC Major	4	4-0	50 0	50 0	100 0
IPH4C203	Thermal Physics	DSC Major	4	3-1	35 15	35 15	70 30
IPH4S201	General Physics Laboratory	SEC	3	0-3	0 50	0 50	0 100
IPH4V201	Introduction to Machine learning	VAC	3	3-0	50 0	50 0	100 0
IPH4V202	Statistical Methods using R Programming	VAC	3	3-0	50 0	50 0	100 0
Semester 5							
IPH5C301	Electrodynamics – I	DSC	4	3-1	35 15	35 15	70 30
IPH5C302	Quantum Mechanics –I	DSC	4	4-0	50 0	50 0	100 0
IPH5C303	Computational Physics – I	DSC	4	3-1	35 15	35 15	70 30
IPH5E301	Elementary Astrophysics	DSE 1	4	4-0	50 0	50 0	100 0
IPH5E302	Planetary Sciences						
IPH5E303	Astronomical Instrumentation						
IPH5E304	Atmospheric Physics	DSE 2	4	4-0	50 0	50 0	100 0
IPH5E305	Medical Physics						
IPH5E306	Biophysics						
IPH5S301	Data Analysis and Visualization using Python	SEC	3	3-0	0 50	0 50	0 100
Semester 6							
IPH6C301	Statistical Mechanics	DSC	4	4-0	50 0	50 0	100 0
IPH6C302	Fundamentals of Solid State Physics and Spectroscopy	DSC	4	3-1	35 15	35 15	70 30
IPH6C303	Elecronics – I	DSC	4	3-1	35 15	35 15	70 30
IPH6E301	Quantum Mechanics – II	DSE 3	4	4-0	50 0	50 0	100 0
IPH6E302	Experimental Techniques						

IPH6E303	Machine Learning and Artificial Intelligence						
IPH6E304	Electrodynamics – II	DSE 4	4	4-0	50 0	50 0	100 0
IPH6E305	Plasma Physics						
IPH6E306	Group Theory and Applications						
IPH6S301	Optical Instrumentation	SEC	3	3-0	50 0	50 0	100 0
IPH6I301	Summer Internship		2			100	100
Semester 7							
IPH7C501	Nuclear and Particle Physics	DSC	4	4-0	50 0	50 0	100 0
IPH7C502	Modern Physics and Electronics Lab	DSC	4	0-4	0 50	0 50	0 100
IPH7C503	Electronics – II	DSC	4	4-0	50 0	50 0	100 0
IPH7E501	Optoelectronics	DSE 5 (Open)	4	4-0	50 0	50 0	100 0
IPH7E502	Astrophysics						
IPH7E503	Ideation to Entrepreneurship through Electronics						
IPH7E504	Solid State Physics	DSE 6	4	4-0	50 0	50 0	100 0
IPH7E505	Condensed Matter Physics						
IPH7E506	Nanoscience and Technology						
IPH7M501		DSO	4				
Semester 8							
IPH8C601	Mathematical Physics –II	DSC	4	4-0	50 0	50 0	100 0

IPH8C602	Computational Physics – II	DSC	4	2-2	25 25	25 25	50 50
IPH8C603	Advanced Electrodynamics	DSC	4	4-0	50 0	50 0	100 0
IPH8P601	Research Project	Project	12		50	50	100
IPH8E601	Materials Science	DSE 7	4	4-0	50 0	50 0	100 0
IPH8E602	Radiation Physics						
IPH8E603	Microprocessors and Microcontrollers						
IPH8M601	Research Methodology	DSO	4				
Semester 9							
IPH9C601	Molecular Spectroscopy	DSC	4	4-0	50 0	50 0	100 0
IPH9C602	Relativistic Mechanics	DSC	4	4-0	50 0	50 0	100 0
IPH9C603	Advanced Physics Lab	DSC	4	0-4	0 50	0 50	0 100
IPH9E601	Quantum Materials and Devices	DSE 8	4	4-0	50 0	50 0	100 0
IPH9E602	Advanced Nuclear Physics						
IPH9E603	Advanced Astrophysics						
IPH9E604	Soft Matter Physics	DSE 9	4	4-0	50 0	50 0	100 0
IPH9E605	High Energy Physics						
IPH9E606	Nuclear Instrumentation						
IPH9E607	Advanced Computational Physics						
Semester 10							
IPH10P601	Research Project	Project	20		50	50	100
IPH10C601	Mathematical	DSC	4	4-0	50 0	50 0	100 0

	Physics –II						
IPH10C602	Computational Physics – II	DSC	4	2-2	25 25	25 25	50 50
IPH10C603	Advanced Electrodynamics	DSC	4	4-0	50 0	50 0	100 0
IPH10C604	Quantum Field Theory	DSC	4	4-0	50 0	50 0	100 0
IPH10C605	Thin Film and Vacuum Technology	DSC	4	4-0	50 0	50 0	100 0
IPH10M601		DSO	4				

IPH1C101 **Credits: 4**

CONCEPTS IN PHYSICS **T – P: 3 -1**

	Course Outcome	**Cognitive level**

CO1	Understand the concepts of Newton's Laws of Motion	Understand
CO2	Apply Newton's Laws of Motion to solve different mechanical systems	Apply
CO3	Apply work-energy theorem to solve different mechanical systems	Apply
CO4	Analyze conservative systems and solve them using the conservation of mechanical energy.	Apply
CO5	Demonstrate skills to set up and perform experiments to test Newton's Laws of Motion and related concepts	Apply

I. Newton's Laws of Motion

Review of units, physical quantities and vectors, Force and Interactions, Newton's First Law, Newton's Second Law, Mass and Weight, Newton's Third Law, Free-Body Diagrams **(12 hours)**

II. Application of Newton's Laws

Using Newton's First Law: Particles in Equilibrium, Using Newton's Second Law: Dynamics of Particles, Apparent Weight and Apparent Weightlessness, Friction Forces, Fluid Resistance and Terminal Speed, Dynamics of Circular Motion, The Fundamental Forces of Nature. **(14 hours)**

III. Work and Kinetic Energy

Work, Kinetic Energy and the Work – Energy Theorem, Work and Energy with Varying Forces, Power **(8 hours)**

IV. Potential Energy and Energy Conservation

Gravitational Potential Energy, Elastic Potential Energy, Conservative and Non-conservative Forces, Force and Potential Energy, Energy Diagrams. **(11 hours)**

V. Laboratory Experiments

1. Young's Modulus of the Material of a Given Bar: Uniform Bending
    - Use an optic lever and telescope. Take measurements for a minimum of two lengths. Obtain the elevation (e) from the shift (s) in the telescope reading and calculate Y from it.
    - For each length of the bar, plot the load-elevation graph (using GeoGebra) and obtain m/e, and then calculate Y from it.

- Estimate the random error in the measurements and the error of the result using propagation of the error formulae.

2. Young's Modulus of the Material of a Given Bar: Non-Uniform Bending
    - Use a pin and a microscope. Take measurements for a minimum of two lengths. Obtain the depression (e) from the shift in the microscope reading and calculate Y from it.
    - For each length of the bar, plot the load-depression graph (using GeoGebra) and obtain m/e, and then calculate Y from it.
    - Estimate the random error in the measurements and the error of the result using propagation of the error formulae.
3. Verification of Newton's First Law: Equilibrium of a Particle
    - Analyze the two dimensional equilibrium problems using spring / digital force gauges.
    - Hang a weight from a chain that is linked at the ring to two other chains, one fastened to the ceiling and the other to the wall. Example 5.3 of Book 1.
    - Measure the angle between the chain from the ceiling and the horizontal and the tension in each of the three chains using spring/digital force gauges and verify with the theoretical predictions.
    - https://www.youtube.com/watch?v=XI7E32BROp0
4. Coefficient of Static Friction.
    - Determine the coefficient of static friction between a wooden block and a wooden plane.
    - Measure the angle at which the wooden block just starts to slide down an inclined wooden plane and hence calculate the static friction coefficient.
    - https://www.youtube.com/watch?v=gt8mr6pFSFE
      OR
    - Place the wooden block on a wooden plane surface and add mass to the pan attached to the block using a string through a frictionless pulley.
    - Find the mass required to initiate the sliding of the block.
    - Different trials can be done by adding mass on the top of the block and hence determine the coefficient of static friction.
    - Example 5.13 of Book 1.
    - https://www.youtube.com/watch?v=MSV6VafiUF4&t=443s
5. Acceleration of a Freely Falling Body.
    - Use the smartphone acoustic stopwatch to determine the duration of a free fall.
    - Measure the time of flight of a steel ball for different heights and plot a graph of distance versus. time squared (s vs. t^2). Determine g from the graph.
    - Experiment 2 of Book 2.

- Phyphox app may be used. https://phyphox.org/experiment/free-fall-2/ OR
- Use ExpEyes kit, electromagnet, and contact sensor to determine the duration of a free fall. https://expeyes.in/experiments/mechanics/tof.html

6. Verification of the Relation of Angular Velocity and Centrifugal Acceleration
    - Use the smartphone gyroscope and the accelerometer.
    - Attach the smartphone to some rotating arrangements and record the data from the gyroscope and accelerometer.
    - Plot angular velocity versus acceleration and verify the relation.
    - Experiment 18 of Book 2.
    - Phyphox app may be used. https://phyphox.org/experiment/centrifugal-acceleration/
7. Analysis of Bouncing Balls to Determine Gravitational Acceleration and Coefficient of Restitution.
    - After doing the experiment, the student should be able to understand the concept of inelastic collision.
    - Measure the time interval between successive bounces using a digital acoustic stopwatch and hence calculate g and coefficient of restitution
    - Experiment 12 of Book 2 and section 3.3 of Book 1
    - Phyphox app may be used. https://phyphox.org/experiment/inelastic-collision/
8. The Nearly Parabolic Trajectories of a Bouncing Ball
    - Perform Experiment 7 using Tracker tool.
    - Track the ball and plot the time versus position graph.
    - Measure the time interval between successive bounces and hence calculate g and coefficient of restitution.
    - Experiment 12 of Book 2 and section 3.3 of Book 1
    - https://www.youtube.com/watch?v=ocLQFMMLIGw
9. Verification of Newton's Second Law: Atwood's Machine
    - Determine the relationship between the vertical acceleration and the mass difference, using a smartphone accelerometer.
    - The vertical acceleration is registered using the built-in accelerometer of the smartphone.
    - By redistributing the masses of the supports, a linear relationship between the mass difference and the vertical acceleration is obtained.
    - Experiment 8 of Book 2.
    - https://phyphox.org/experiment/acceleration-without-g/
10. Analysis of Air Resistance and Terminal Speed to Determine the Drag Coefficient.
    - Record the motion of a light weight paper cup and Analyze it with Tracker tool (https://physlets.org/tracker/).

- Plot acceleration, velocity, and position with time.
- Repeat the experiment with different mass (by simply stacking the paper cups)
- Determine the Drag Coefficient.
- Experiment 27 of Book 2.
- https://www.youtube.com/watch?v=iujzK3uH1Yc

11. Projectile Motion: Kinematics.
    - Analyze projectile motion as a combination of horizontal motion with constant velocity and vertical motion with constant acceleration.
    - Drop two balls from a height, one from rest, and other simultaneously projected horizontally. Analyze the motion of both in the Tracker tool.
    - Section 3.3 of Book 1
    - https://www.youtube.com/watch?v=zMF4CD7i3hg
    - https://www.youtube.com/watch?v=Mi01anodoDE
    - https://www.youtube.com/watch?v=5I0NLNthJGc
12. Projectile Motion: Energy Conservation
    - Analyze the motion of the tossing ball / projectile in the Tracker tool.
    - Plot time versus the x-and y-components of velocity and acceleration.
    - Also plot the kinetic energy, potential energy (build data using define tool) and total energy.
    - https://www.youtube.com/watch?v=x0AWRLvgB28
    - https://www.youtube.com/watch?v=i07HeUWo8xc

Books and References:

1. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer,(Book 2).
3. https://phyphox.org/
4. https://physlets.org/tracker/
5. B.Sc Practical Physics by C L Arora.
6. Practical Physics by S L Gupta & V Kumar.
7. Fundamentals of Physics by David Halliday, Robert Resnick and Jearl Walker.
8. Physics for Scientists and Engineers by Paul A. Tipler and Gene Mosca.
9. Fundamentals of Physics by J. Richard Christman and William J. Francis.
10. NPTEL video lectures: https://nptel.ac.in/courses/115106090

IPH1C102 **Credits: 4**

PROPERTIES OF MATTER AND THERMODYNAMICS **T – P: 3 -1**

	Course Outcome	Cognitive level
CO1	Solve rigid body equilibrium problems	Apply
CO2	Explain the principle of buoyancy and its application in determining the behavior of floating and submerged objects.	Apply
CO3	Analyze various thermodynamic processes, including the work done during volume changes and the paths between thermodynamic states.	Analyze
CO4	Analyze heat engines and refrigerators, applying the principles of the second law to evaluate their efficiency.	Analyze
CO5	Develop skills to set up and perform experiments to test Newton's Laws of Motion, work energy theorem and different phenomenon exhibited by light.	Apply

I. Equilibrium and Elasticity

Conditions of Equilibrium, Center of Gravity, Solving Rigid body Equilibrium Problems, Stress, Strain and Elastic moduli, Elasticity and Plasticity **(10 hours)**

II. Fluid Mechanics

Gases, liquids and Density, Pressure in a Fluid, Buoyancy, Fluid flow, Bernoulli's Equation, Viscosity and Turbulence **(10 hours)**

III. Temperature, Heat and First Law of Thermodynamics

Temperature and Thermal Equilibrium, Thermodynamic systems, Work done during volume changes, Paths between Thermodynamic states, Internal Energy and First law of Thermodynamics, Kinds of Thermodynamic processes, Internal Energy of an ideal gas, Heat capacities of an ideal gas, Adiabatic process for an ideal gas **(15 hours)**

IV. The Second law of thermodynamics

Directions of thermodynamic processes, Heat Engines, Refrigerators, Second law of thermodynamics, The Carnot Cycle **(10 hours)**

V. Laboratory Experiments

1. Young's Modulus of the Material of a Given Bar: Uniform Bending
    - Use optic lever and telescope. Take measurements for minimum two lengths. Obtain the elevation (e) from the shift (s) in the telescope reading and calculate Y from it.
    - For each length of the bar, plot the load-elevation graph (using GeoGebra) and obtain m/e, and then calculate Y from it.
    - Estimate the random error in the measurements and the error of the result using propagation of error formulae.

2. Young's Modulus of the Material of a Given Bar: Nonuniform Bending
    - Use pin and microscope. Take measurements for minimum two lengths. Obtain the depression (e) from the shift in the microscope reading and calculate Y from it.
    - For each length of the bar, plot the load-depression graph (using GeoGebra) and obtain m/e, and then calculate Y from it.
    - Estimate the random error in the measurements and the error of the result using propagation of error formulae.
3. Torsion Pendulum- Determination of the Moment of Inertia and Rigidity Modulus.
    - Using identical masses on the disc, determine the moment of inertia of the disc.
    - Verify the moment of inertia by direct method, $I = \frac{1}{2}MR^2$
    - Using I, calculate rigidity modulus of the material of the wire $n = \frac{8\pi I}{r^4}\frac{L}{T^2}$
4. Static torsion - Rigidity modulus
    - Using Searle's static torsion apparatus, determine the rigidity modulus of the material of the rod.
5. Viscosity of a liquid - Poiseuille's Method
    - Fill the liquid in a vertically fixed burette with its lower end attached to a capillary tube, placed in horizontal position using a rubber tube.
    - Note the time taken to reach each 10cc of water and the height of the corresponding marking.
    - Also measure the radius of the capillary tube using the traveling microscope and estimate the viscosity of the liquid.
6. Viscosity of a liquid - Falling Ball Viscometer
    - Drop a polished steel ball into a glass tube of a somewhat larger diameter containing the liquid.
    - Record the time required for the ball to fall at constant velocity through a specified distance between reference marks.
    - Use the Stoke's law for the sphere falling in a fluid under effect of gravity, to estimate the viscosity of the liquid.
7. Surface tension of liquid - Capillary rise method
    - Clamp a clean capillary tube by dipping its lower end into the liquid in the beaker.
    - Measure the rise of water in the tube using a traveling microscope.
    - Also measure the radius of the capillary tube using the traveling microscope and estimate the surface tension of the liquid.
    - Density of the liquid can be determined using Hare's apparatus of can be given
8. Density of the liquid using manometer
    - Fill a manometer tube partially with water. Pour the given oil (or any liquid which does not mix with water) into the left arm of the tube until the oil–water interface is at the midpoint. Both arms of the tube are open to the air.

- Measure the heights of the oil and water using a traveling microscope and hence estimate the density of the oil assuming that of water.
- Example 12.4 of book 1

9. Verification of Boyle's law and Charle's law
   - Boyle's law (PV= a constant) states that at a constant temperature, volume of a gas is inversely proportional to pressure.
   - Determine the volume - pressure relation at constant temperature using the water column.
   - Plot the pressure versus volume graph and verify Boyle's law.
   - Verify the law at minimum two different temperatures.
   - Charle's law (V/T = a constant) states that at constant pressure, volume is directly proportional to temperature.
   - In this experiment determine the temperature – volume relation at constant pressure using the water column.
   - Plot the temperature versus volume graph and verify the Charle's law.
   - Verify the law at minimum two different pressures.
10. Verification of Gay-Lussac's law

- Gay-Lussac's law (P/T = a constant) states that at constant volume, pressure is directly proportional to temperature.
- In this experiment determine the temperature – pressure relation at constant pressure using metallic bulb and water column or pressure gauge or using Jolly's bulb apparatus.
- Plot the temperature versus volume graph and verify the Charle's law.

11. Thermal conductivity by Searle's method
    - Determine the thermal conductivity of copper or any other metal using Searle's method / apparatus.
12. Temperature coefficient of resistance of a metal
    - Resistance of metals increases with increase in temperature.
    - Measure the resistance of the metal coil, using Carey Foster's bridge or Potentiometer or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature.
    - Plot graph and find the temperature coefficient of resistance.
13. Thermo emf of a Thermocouple
    - Study the variation of thermo emf of a thermocouple as a function of temperature of the hot junction while maintaining the cold junction at 0 degree Celsius.
14. Newton's law of cooling
    - According to Newton's law of cooling, the rate of heat loss of a hot body is proportional to the difference in temperature between the body and the surroundings.
    - The calorimeter is filled with hot water and the variation in temperature is noted as a function of time.

- Cooling rate graph is plotted and law is verified.
- Emissivity of the surface of the calorimeter can also be determined.
- ExpEYES with PT1000 sensor may be used to record the temperature.
- https://expeyes.in/experiments/thermal/cooling.html

15. Characteristics of NTC thermistor
    - Resistance of Negative Temperature Coefficient (NTC) thermistors decreases with increase in temperature.
    - Measure the resistance of the thermistor, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature.
    - Plot the graph and study the characteristics.
16. Melting point of wax
    - Fill a test tube with wax until half and use a thermometer inside the wax / test tube to measure wax temperature. Avoid the thermometer touching the test tube.
    - Immerse the test tube in a water bath with the help of a stand, in such a way that the wax is below the water level.
    - Use a suitable flame / heating rate and measure the wax temperature as a function of time at a suitable time interval.
    - Plot temperature versus time graph. ExpEYES and PT1000 sensor may be used to record the temperature.
    - https://expeyes.in/experiments/thermal/cooling.html
    - The temperature increases initially and remains constant until the wax melts completely. The flat temperature gives the melting point of wax (The melting point depends on the type of wax used)

Books and References:

1. University Physics with Modern Physics- Hugh D. Young, Roger A. Freedman,15th Edition (Book 1)
2. Intermediate Dynamics (Edn.2) by Patrick Hamill
3. An Introduction to Mechanics by Daniel Kleppner and Robert J. Kolenkow
4. Mechanics by Keith R. Symon
5. Concepts in Thermal Physics by Stephen J Blundell and Katherine M. Blundell
6. Thermal Physics by Charles Kittel and Herbert Kroemer
7. An Introduction to Thermal Physics by Daniel V. Schroeder
8. Heat and Thermodynamics by Mark Zemansky, Richard Dittman.

IPH1D101 **Credits: 3**

THE UNIVERSE **T – P: 3 - 0**

	Course Outcome	**Cognitive**

		level
CO1	Describe the importance of Astronomy	Understand
CO2	Describe the measurement of stellar distance	Apply
CO3	Explain the eclipses and occultation	Apply
CO4	Explain the large scale structure of the Universe	Understand

I. **Basic Astronomy**

Importance of Astronomical research, Scale of the Universe, the Celestial Sphere, equatorial, Horizontal, galactic coordinates, Rising and setting times, Constellations, Star catalogues and maps, Astronomical time systems **(12 hrs)**

II. **Stellar Distances and Magnitudes**

Distances of stars from the trigonometric parallaxes. Stellar motions. Magnitude scale and magnitude systems. Atmospheric extinction, Absolute magnitudes and distance modulus. colour index. Black-body approximation and temperatures of stars. (**12 hrs)**

III. **The Sun and Planets**

Origin of the solar system. Atmosphere and Internal structure of Sun, Sun spots and magnetic fields on the sun. Solar activity, Planetary Configurations, Eclipses and Occultations, The Structure and Surfaces of Planets, Minor Bodies of the Solar System-Dwarf planets, Asteroids, Meteorites. **(12 hrs)**

IV. **Large Scale structure of the Universe**

Different types of Celestial Bodies-Variable stars, Binary stars, White Dwarfs, Neutron stars, Black holes, Clusters of stars, Galaxies, groups and clusters of galaxies, Active galaxies, quasars, Blazars, Different theories of the origin of the Universe **(12 hrs)**

References

1. H. Karttunen, P. Kroger, H. Oja, M. Poutanen, K. J. Donner (Eds.): " Fundamental Astronomy"
2. Baidyanath Basu M : "An introduction to Astrophysics" (Prentice Hall of India)
3. B.W. Carroll & D.A. Ostille : "Modern Astrophysics", (Addison Wesley, 1996)
4. Frank H Shu: The Physical Universe: An Introduction to Astronomy

IPH2C101 **Credits: 4**

MODERN PHYSICS **T – P: 3 - 1**

	Course Outcome	**Cognitive level**
CO1	Describe the dual nature of particle and waves	Understand
CO2	Explore the basic ideas of Rutherford – Bohr model of the atom	Apply
CO3	Describe the fundamental principles of nuclear and particle physics.	Understand
CO4	Analyze nuclear structure and properties, including nuclear forces and decay processes, estimate the energy associated with nuclear mechanism.	Apply
CO5	Analyze experimental evidence supporting wave-particle duality	Apply

I. Particle like Properties of Electromagnetic Radiation and Rutherford-Bohr Model of the Atom

Review of electromagnetic waves; Photoelectric effect; Blackbody radiation; Compton Effect; Other photon processes; Concept of photon, Basic properties of atoms; Thomson model; Rutherford nuclear atom; Line spectra; Bohr model; Frank-Hertz experiment; Correspondence principle; Deficiencies of Bohr model. **(16 hours)**

II. Wavelike Properties of Particles

De Broglie hypothesis; Uncertainty relationships for classical waves; Heisenberg uncertainty relationships; Wave packets; Probability and randomness; Probability amplitude. **(9 hours)**

III. Nuclear Properties

Introduction, basic properties, charge, mass, binding energy, nuclear force, relative strength, Nuclear angular momentum, Nuclear moments, Parity. Magnetic dipole moments, binding energy. **(10 hours)**

IV. Nuclear Models

Liquid drop model, Shell Model, semi empirical mass formula, stability of nucleus, nuclear decay, Nuclear Fission and Fusion, energy released in fission and fusion, concept of fission and fusion reactors. **(10 hours)**

V. Laboratory practical

1. Determination of Plank's constant using LEDs
   - Observe the turn-on voltage, V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing).
   - Plot graph using Python, fit a straight line to get the $1/\lambda - V_0$ slope and estimate the value of h.
   - Calculate the % error.
   - Programmable voltage source of ExpEYES may be used to find the turn-on voltage.
2. Continuous and line spectra- Determination of the wavelengths and photon energy.
   - Familiarize the initial adjustments and measurements in the spectrometer.
   - Mount the grating at normal incidence on the spectrometer.
   - Determine the wavelengths of the sodium vapor lamp and calculate the associated photon energy.
   - Determine the approximate range of the wavelengths of the continuous spectrum of incandescent/white LED lamp or any one coloured LED and calculate the associated photon energy.
   - The readings of the first order spectrum will be enough. Number of lines/m of the grating can be given.
3. Mercury spectrum- Determination of wavelength and photon energy.
   - Determine wavelength of any four prominent lines and associated photon energy of the mercury spectrum using a spectrometer with grating at normal incidence.
   - The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.
4. Hydrogen spectrum - Determination of wavelengths and calculation of the Rydberg’s constant.
   - Determine the wavelengths and photon energy in eV of the prominent lines of the Balmer series of the Hydrogen spectrum using a spectrometer with grating at normal incidence.
   - Calculate the Rydberg’s constant and estimate the % error.
   - The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given
5. Wave Packets - Analysis of beats in sound.
   - The experiment is intended to understand the concept of wave packet, phase and group velocities.
   - Generate sounds waves of two near frequencies using smartphone/ExpEYES/Function generator and the
   - Superimposed wave can be recorded and Analyzed using smartphone/ExpEYES/CRO.

- Change the separation between the frequencies and compare the results with the theoretical values.
- https://expeyes.in/experiments/sound/beats.html
- Multi Tone generator and Audio scope tools of Phyphox may be used https://phyphox.org/experiment/tone-generator/

6. Analysis of Hydrogen spectra using the Tracker Video Analysis tool.
   - Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra.
   - Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant.
   - Estimate the % error.
   - Pre-recorded video of the Hydrogen spectra can be used.
   - https://physlets.org/tracker/.
   - https://www.youtube.com/watch?v=UCCPkJpUQEw
7. Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.
   - Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra.
   - Plot wavelength vs intensity, get λ and using Wein's law max calculate the surface temperature.
   - Pre- recorded video of the solar spectra can be used.
8. Verification of Wein's displacement law and Stefan's law using incandescent bulb.
   - Calibrate the video of the spectra of the incandescent bulb in the Tracker tool using two laser wavelengths/lines of mercury spectra.
   - Plot wavelength vs intensity and note λ_{max}.
   - Repeat the experiment by increasing the operating voltage of the incandescent bulb (hence increasing the temperature of the source).
   - From the plots, verify the Wein's displacement law and Stefan's law.
9. Black body radiation- total energy output.
   - Plot Planck's radiation formula.
   - Evaluate the area under the curve and x- axis(total radiance over all wavelengths) by numerical integration and hence verify Stephan's law

Books and References:

1. Modern Physics (Fourth Edition, an Indian Adaptation) by Kenneth S. Krane
2. Introduction to Nuclear and Particle Physics - V K Mittal, R C Verma and S C Gupta (Book 1)
3. https://phyphox.org/
4. https://physlets.org/tracker/

5. https://expeyes.in/
6. Modern Physics for Scientists and Engineers" by John Morrison.
7. Concepts of Modern Physics By Arthur Beiser.
8. Modern Physics by Raymond A. Serway.
9. Modern physics by Randy Harris.
10. Nuclear and Particle Physics: An Introduction by Brian R. Martin and Graham Shaw.
11. Nuclear and Particle Physics: An Introduction by S. N. Ghoshal and T. K. Basak.
12. Nuclear Physics: Theory and Experiment by Raj Kumar Gupta.

IPH2C102 **Credits: 4**

BASICS OF ELECTRONICS **T – P: 3 - 1**

	Course Outcome	**Cognitive level**
CO1	**Mastering Basic Electronics Concepts:** master the fundamental concepts of voltage and current sources, semiconductor properties and basic circuit theorems and their working principles.	Apply
CO2	**Proficiency in Transistor and Amplifier Technologies:** gain proficiency in the operation and application of transistor technologies, analyze various biasing techniques, AC models, and amplifier circuits, equipping them to design and optimize amplifier configurations for enhanced performance.	Apply
CO3	**Application of Digital Electronics Principles:** acquire skills in digital electronics, logic gates, Boolean algebra, and logic simplification techniques, apply these principles to design and test digital components facilitating the development of digital systems and circuits.	Analyze
CO4	**Integrate theoretical knowledge to practical electronics circuits:** design, troubleshoot, and optimize electronic circuits and systems in both lab-based and real-world scenarios.	Understand

I. Semiconductor Devices

Voltage and current sources, Thevenin's and Norton's Theorem, semiconductors, intrinsic and extrinsic semiconductors, diode forward and reverse characteristics, Half-wave and full wave rectifier, Zener diode and Zener regulator. **(10 Hours)**

II. Bipolar Junction Transistor Amplifier

Bipolar junction transistor, un-biased and biased transistor, transistor currents, CE connection, current gain, load line and operating point, transistor biasing: voltage-divider bias, ac modes: emitter biased amplifier, ac models, T and PI transistor models. Voltage amplifiers: voltages gain, loading effect, multistage amplifiers, common collector amplifier, power amplifiers. **(13 hours)**

III. Field Effect Transistors and Operational Amplifiers

Field Effect Transistors: FETs and MOSFETS, Differential amplifiers, Operational Amplifier: 741, Oscillators: Wien-bridge oscillators, Active filters, Regulated power supplies: series and shunt regulators. **(10 Hours)**

IV. Digital Electronics

Analog and digital quantities, Logic Gates, Boolean Algebra and Logic simplification: De-Morgan's theorem, Karnaugh map, NAND and NOR gates, binary adder, Decoders and Encoders, Multiplexers and Demultiplexers, Flip-flops, Counters, registers and memories, Microprocessors and microcontrollers. **(12 Hours)**

Laboratory Experiments

1. I-V characteristics of diodes: forward & reverse (ordinary diodes, Zener diodes, LEDs (tri-colour) using ExpEYES or Seelab-3 module.
2. Construction of half-wave and full-wave rectifiers using ExpEYES or Seelab-3 module.
3. Construction of a DC power supply system using diodes, RC filter networks and ICs.
4. Construction of a Thevenin's equivalent circuit of a 4-bit digital to analog network.
5. Transistor input & output characteristics using ExpEYES or Seelab-3 module.
6. Construction of a CE amplifier and study dc characteristics.
7. Construction of a FET - CS amplifier and study dc characteristics.
8. Study of Digital Gates: OR, AND, NOT, NOR, EX-OR using ExpEYES or Seelab-3 module.
9. Construction of a CE amplifier circuit using ExpEYES or Seelab-3 module.
10. Study the DA convertor using ExpEYES or Seelab-3 module.
11. Study binary adder circuit using ExpEYES or Seelab-3 module.
12. Study of flip flops (binary SR/JK/JKMS) using ExpEYES or Seelab-3 module.

Text Books

1. Electronic Principles, Albert Malvino, David J. Bates, (SIE) | 7th or Higher Edition, Mc GrawHill Education.
2. Principles of Electronics, V. K. Mehta, Rohit Mehta, S. Chand & Company.
3. Digital Fundamentals, Floyd, 10th or Higher Edition, Pearson.

4. Digital Principles and Applications, Leach, Malvino and Saha, 6th or Higher Edition, TMH.

Books of Reference

1. Fundamentals of Microprocessors and Microcomputers, B. Ram, 2nd or Higher Edition, Dhanapathi Rai & Sons.
2. Microprocessor Architecture: Programming and applications with the 8085, Ramesh S. Gaonkar, New Age Publishers.
3. The 8051 Microcontroller, Kenneth J. Ayala, Thomson, Delmar Learning, 2nd Edition.
4. Electronic devices and circuit theory by Robert L. Boylstead & L. Nashelsky, Pearson Education.
5. ExpEYES (Experiments for Young Engineers and Scientists) manual, by CSpark Research, New Delhi.
6. Integrated Electronics, J. Millman and C. Halkias, TMH India

IPH2D101 **Credits: 3**

PHYSICS OF EVERYDAY LIFE **T – P: 3 -0**

	Course Outcome	**Cognitive level**
CO1	Describe the components of an electricity bill	Understand
CO2	Explain the working of an automobile engine	Understand
CO3	Illustrate the working of digital memory devices	Apply
CO4	Explain the working of global positioning system	Understand

I. Basics of Electricity

Ohm's law, power consumption, Joule heating-saving electricity-ways to minimize power consumption. **(12 hours)**

II. Concept of Temperature & Electromagnetic Waves

Conversion of Work into Heat vice versa, Heat Engines, Carnot's Cycle, Carnot engine & efficiency, Refrigerator, magnetron, design of microwave ovens. **(12 hours)**

III. Physics of Digital Memory Devices

Photoelectric effect-recording of audio and video operating principles of magnetic hard disk drive, Charge coupled device (CCD), principle of CCD camera. **(10 hours)**

IV. Mobile Communication and Global Positioning System (GPS)

Wire and wire-less communication, Common cellular networks components, Protocols. Fundamentals of GSM & CDMA Network, GSM & CDMA Frequency Band. GPS: Operating principles of GPS Accuracy and errors in GPS navigation. **(11 hours)**

Text Books:

1. Concepts of Physics volume I and II by H C Verma, Bharati Bhavan Publishers and Distributors.
2. Fundamentals of Physics by D. Halliday, R. Resnick, J. Walker, John Wiley & Sons.
3. Mobile Cellular Telecommunications: Analog and Digital Systems by William C. Y. Lee; Tata McGraw Hill Publication.
4. Wireless Communications: Principles and Practice by Theodore S. Rappaport; Pearson / PHI Publication.

References:

1. University Physics by F. W. Sears, M. Zemansky, R. A. Freedman, and H. D. Young, Pearson Education.
2. Wireless Communications and Networks: 3G and Beyond by ItiSahaMisra; Tata McGraw Hill Publication.
3. Wireless and Digital Communications by Dr. KamiloFeher; PHI Publication.
4. WI-FI, BLUETOOTH, ZIGBEE and WIMAX, H. Labiod, H. Afifi, C. De Santis, Springer-2007.

IPH3C201 **Credits: 4**

MECHANICS & RELATIVITY **T – P: 3 - 1**

	Course Outcome	**Cognitive level**
CO1	Learn the Galilean invariance of Newton's laws of motion	Understand
CO2	Understand translational and rotational dynamics of a system of particles	Understand
CO3	Apply Kepler's laws to describe the motion of planets and satellite in circular orbit	Apply
CO4	Understand Einstein's postulates of special relativity	Understand
CO5	Apply Lorentz transformations to describe simultaneity, time dilation and length contraction	Apply
CO6	Use various instruments for measurements and perform experiments related to rotational dynamics, elastic properties, fluid dynamics, acceleration due to gravity, collisions, etc.	Apply
CO7	Use propagation of errors to estimate uncertainty in the outcome of an experiment and perform the statistical analysis of the random errors in the observations	Apply

I. Fundamentals of Dynamics

Inertial and Non-inertial frames, Newton's Laws of Motion and their invariance under Galilean transformations. Momentum of variable mass system: motion of rocket. Dynamics of a system of particles, principle of conservation of momentum. Impulse. Determination of centre of mass of discrete and continuous objects having cylindrical and spherical symmetry, Differential Analysis of a static vertically hanging massive rope.

Work and Energy: Work and Kinetic Energy Theorem. Conservative forces and examples (Gravitational and electrostatic), non-conservative forces and examples (velocity dependent forces e.g. frictional force, magnetic force). Potential Energy. Energy diagram. Stable, unstable and neutral equilibrium. Force as gradient of the potential energy. Work done by non-conservative forces.

Collisions: Elastic and inelastic collisions. Kinematics of 2 → 2 scattering in centre of mass and laboratory frames. **(13 Hours)**

II. Rotational Dynamics

Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Determination of moment of inertia of symmetric rigid bodies (rectangular, cylindrical and spherical) using parallel and perpendicular axes theorems. Kinetic energy of rotation. Motion involving both translation and rotation.

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications. **(12 Hours)**

III. Central Force Motion

Central forces, Law of conservation of angular momentum for central forces, Two-body problem and its reduction to equivalent one-body problem and its solution. Concept of effective potential energy and stability of orbits for central potentials of the form kr^n (for n = 2 and -1) using energy diagram, discussion on trajectories for n = −2. Solution of Kepler's problem, Kepler's laws for planetary motion, orbit for artificial satellites. **(10 Hours)**

IV. Relativity

Postulates of special theory of relativity, Lorentz transformations, simultaneity, length contraction, time dilation, proper length and proper time, Life time of a relativistic particle (for example muon decay time and decay length). Space-like, time-like and light-like separated events. Relativistic transformation of velocity and acceleration. Variation of mass with velocity, Mass-energy Equivalence. Transformation of Energy and Momentum. **(10 Hours)**

V. Laboratory Experiments

1. To study the random errors in observations. It is advisable to keep observables of the order of least count of the instruments.
2. To determine the moment of inertia of a symmetric as well as asymmetric flywheel.
3. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
4. To determine g and velocity for a freely falling body using Digital Timing Technique.
5. To determine the Young's Modulus of a Wire by Optical Lever Method.
6. To determine the vertical distance between two given points using sextant.
7. To determine the coefficients of sliding and rolling friction experienced by a trolley on an inclined plane.
8. To verify the law of conservation of linear momentum in collisions on air track.

Suggested additional Activities:

1. Virtual lab collision experiments on two dimensional elastic and inelastic collisions (for example available on

a) https://archive.cnx.org/specials/2c7acb3c-2fbd-11e5-b2d9-e7f92291703c/collision-lab/#simadvanced-sim
b) https://phet.colorado.edu/en/simulations/collision-lab
c) Amrita Virtual Mechanics Lab : https://vlab.amrita.edu/?sub=1&brch=74

References:

Essential Readings:

1. An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education.
3. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education.
4. Classical Mechanics by Peter Dourmashkin, 2013, John Wiley and Sons.
5. https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_(Dourmashkin)/
6. Introduction to Classical Mechanics With Problems and Solutions, David Morin, 2008, Cambridge University Press.
7. Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
8. Introduction to Special Relativity, Robert Resnick, 2007, Wiley.

Additional Readings:

1. Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
2. University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
3. Classical Mechanics, H. Goldstein, C. P. Poole, J. L. Safko, 3/e, 2002, Pearson Education.
4. Newtonian Mechanics, A.P. French, 2017, Viva Books.

References (for Laboratory Work):

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worshnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.

4. A Text Book of Practical Physics, Vol I, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
5. An introduction to Error Analysis: The study of uncertainties in Physical Measurements, J. R. Taylor, 1997, University Science Books

IPH3C202 **Credits: 4**

OPTICS **T - P: 3 - 1**

	Course Outcome	**Cognitive level**
CO1	Define the basic principles of optics.	Remember
CO2	Analyze optical phenomena using Fermat's Principle, such as reflection and refraction.	Analyze
CO3	Analyze optical phenomena of interference	Analyze
CO4	Apply diffraction principles to analyze patterns produced by various apertures and obstacles.	Apply
CO5	Explain the fundamentals of polarization and holography	Understand
CO6	Demonstrate skills to set up and perform experiments to test various optics principles and phenomena	Apply

I. Fermat's principle

Fermat's principle, Laws of reflection and refraction, Ray paths in inhomogeneous medium, mirage, looming, graded index atmosphere (qualitative idea only) Refraction and reflection by a single spherical surface, Thin Lens, The principal foci and focal length of a lens. **(11 hrs)**

II. Interference

Superposition of two sinusoidal waves, interference of light waves, Interference pattern, Intensity distribution, Young's double slit experiment, Fresnel's mirrors, Fresnel biprism, Interference with white light, Interference by a plane film, Cosine law, Colors on thin film, Newton's rings and practical applications, Michelson interferometer. **(13 hrs)**

III. Diffraction

Fraunhofer Diffraction, single slit diffraction pattern, two slit Fraunhofer diffraction pattern, N slit diffraction pattern, plane diffraction grating, Fresnel diffraction: Half period Zone, diffraction by circular aperture, zone plate. **(8 hrs)**

IV. Polarisation & Holography

Linearly polarised light, Plane of polarisation, Brewster's law, Double refraction, Malu's law, Production of polarised light, polariser, reflection, double refraction, interference of polarized light - Production and analysis of various polarized light. Principles of Holography, construction and reconstruction of Hologram, Contrast with photography, Applications of Holography. **(13 hrs)**

V. Laboratory Experiments

1. Spectrometer - i-d curve.
2. Spectrometer - i1 - i2 curve.
3. Verification of Malu’s law.
4. Determination of Brewster’s angle.
5. Spectrometer - Diffraction Grating - Dispersive power.
6. Spectrometer -Diffraction Grating - Resolving power.
7. Spectrometer -Quartz prism - Refractive indices of quartz for the ordinary and extra ordinary rays.
8. Newton’s rings -Wavelength of sodium light.
9. Air wedge - Angle of the wedge, radius of a thin wire.
10. LASER -Wavelength using transmission grating

Text Books:

1. Optics, Ajoy Ghatak, 7^{th} Edn, Pearson
2. A textbook of optics, N. Subramaniam, Brij Lal & M.N. Avadhanulu, 25^{th} Edn, 2020 (Reprint), S. Chand

Reference Books:

1. Optics, Eugine Hetch, 5th Edn (Global Edn) Pearson Education Limited 2017.
2. Optics by D S Mathur.
3. Wave Optics and its Applications, Rajpal S Sirohi, Orient Longman.
4. Optical Communications, M. Mukunda Rao, Universities Press.
5. Instructor’s solution Manual for Introduction to optics, Frank L Pedrotti, Leo M. Pedrotti and Leno S Pedrotti, 3rd Edn.

IPH3C203 **Credits: 4**

INTRODUCTORY SOLID STATE PHYSICS AND SPECTROSCOPY T – P: 3 – 1

	Course Outcome	**Cognitive level**
CO1	Application of Schrodinger equation for solving different physical systems.	Apply
CO2	Understanding of Crystalline and Amorphous Solids and distinguishing between them.	Understand
CO3	Explain band theory of solids and apply it in explaining the electronic structure of materials.	Analyze
CO4	Describe the process of absorption and emission of radiation and understand the Einstein coefficients governing these processes and their relation.	Understand
CO5	Apply the spectroscopic techniques to identify material properties.	Apply
CO6	Develop practical skills to perform spectra and material property related experiments and analyse characteristics of different spectras.	Apply

I. Quantum Mechanics

Quantum Mechanics, Wave Equation, Schrodinger's equation : Time Dependent form, Expectation Values, Operators, Schrodinger's Equation : Steady state form, Particle in a box problem.

II. Bonding in Solids and Energy Bands

Crystalline and amorphous solids, Ionic Crystal, Covalent Crystal, Van der Waal's bond, Metallic bond, Band Theory of Solids.

III. **Introduction to Spectroscopy**

Electromagnetic spectrum and Quantization of energy, Types of molecular energies and spectroscopic methods, Spectral line width and emission of radiation, Einstein coefficient (excluding derivation), Lasers

IV. **Spectroscopic Methods of sample analysis**

Microwave spectroscopy, Infrared Spectroscopy (vibration spectra only), Electronic spectroscopy, Raman spectroscopy: Introduction, Quantum theory of Raman scattering, Rotational Raman spectra of linear molecules

V. Laboratory Experiments

1. Band gap of a semiconductor
   - Measure the reverse bias current/resistance of a semiconductor diode as a function of temperature, using Carey Foster's bridge or Potentiometer or Ex-pEYES or any other suitable method.

- Plot the logarithm of resistance/current against the inverse of temperature.
- From the slope, the band gap from the semiconductor can be obtained.

2. Wavelength of laser using grating
   - The laser light diffracted from the transmission grating is allowed to fall on a screen and record the maxima points in a paper and calculate the wavelength of the laser.
   - Determine the number of lines/ meter of the grating using the green line of the mercury.
3. Single slit diffraction using laser - Determination of slit width.
   - The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper.
   - From the width of the central maxima or the position of minimum intensity points, calculate the slit width.
   - Verify the slit width using a traveling microscope.
   - Wavelength of laser can be found using diffraction grating of known N.
4. Determine the numerical aperture (NA) of an optical fiber using a laser
   - Couple the light from the laser source onto one of the fiber ends and the light coming from the other end is allowed to fall on a screen(sheet having circular markings) placed perpendicular to the axis of the fiber.
   - Measure the diameter of the laser beam on the screen and the distance between the screen and fiber output end and hence calculate the NA.
5. Determination of the dispersive power of a solid prism using a spectrometer
   - Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer.
   - Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.
6. Spectrometer-Determination of the Cauchy's constants of the given prism
   - Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors.
   - Determine A and B from the $\mu - 1/\lambda^2$ graph.
7. Determine the refractive index of (a) given liquid and (b) the material of a lens, by forming a liquid lens.
   - Through this experiment the students are expected to get the concepts of image formation, combination of lenses andradius of curvature of the surface of lens.
   - Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.
8. Determine the focal length of the combination of two lenses separated by a distance.

- Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross-slit screen holder, nodal slide (for placing the lenses) and plane mirror arrangement.
- Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation.
- $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$
- The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study.
- https://www.youtube.com/watch?v=IOlEEtyNPBg
- https://www.youtube.com/watch?v=tNo4Ipk74SU

9. Air wedge-determination of the radius of a thin wire/human hair/thin foil.
    - Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates.
    - Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.
10. Newton's rings-determination of the wavelength of sodium light
    - Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source.
    - Determine the radius of curvature by Boy's method and determine the wavelength of the source.
11. Construction of the center tapped full wave rectifiers and regulated power supply
    - Construct a center tapped full wave rectifier without filter and with a filter.
    - Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter.
    - Observe the variation of the ripple factor with load resistance, when filter is used.
    - Construct 5V/12V regulated power supply using 78XX IC.
12. Study the characteristics of Zener diode and construct a voltage regulator
    - Study the V-I characteristics of zener diode and hence determine the breakdown voltage.
    - https://expeyes.in/experiments/electronics/zenerIV.html
    - Construct a voltage regulator using a zener diode and determine the percentage of voltage regulation.
13. Flywheel- Determination of the Moment of Inertia
    - This experiment aims to help students grasp the concept of energy conservation and the dynamics of rotation.
    - Do at least 9 trials for different masses and number of turns wound on the axil.

14. Compound Pendulum- Acceleration Due to Gravity and Moment of Inertia and Verification of Parallel Axis Theorem
    - Plot a graph of distance of knife edge from one end Vs period of oscillations. Using the measurement from the graph, calculate g.
    - Calculate the radius of gyration and hence the moment of inertia about CM. Compare the result obtained by the direct calculation $I_{CM} = \frac{ML^2}{12}$
15. Sonometer - Determine the Frequency of AC
    - Estimate the linear mass density of the wire.
    - Draw L^2-m graph and from the slope calculate the frequency.

Books and References:

1. Concepts of Modern Physics, Arthur Beiser 6th Edition (Book 1)
2. Molecular structure and spectroscopy, (Second edition) G. Aruldhas (Book 2).
3. Kittel's Introduction to Solid State Physics, Wiley India Edition.
4. Solid State Physics Structure and properties of materials by M. A. Wahab (Third Edition).
5. Solid State Physics" by Neil W. Ashcroft and N. David Mermin.
6. Solid State Physics: Essential Concepts by David W. Snoke.
7. Principles of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash.
8. Spectra of Atoms and Molecules by Peter F. Bernath.
9. Molecular Spectroscopy by Jeanne L. McHale
10. https://phyphox.org/
11. https://physlets.org/tracker/
12. https://expeyes.in/

IPH3D201 **Credits: 3**

HISTORY AND PHILOSOPHY OF SCIENCE **T – P: 3 - 0**

	Course Outcome	**Cognitive level**
CO1	Describe the contribution of early India and China in science	Understand
CO2	Describe the contribution of Arabs	Understand
CO3	Describe the science growth in middle ages	Understand
CO4	Describe the philosophy of Science and scientific temper	Apply

I. Contribution of Early India and China

Science in Vedas, Mathematics, Astronomy and medicine, Golden age of Indian Science, Psychology, Chemistry and metallurgy. Early history of Science in China, Astronomy, Mathematics, Medicine and Chemistry.

II. Role of Arabs in the history of Science and Science in the middle Ages

Dark age in Europe and the rise of Islam, Alchemy, Physics Mathematics, Astronomy and medicine, The Transfer of Knowledge from East to West, Historical role of Arabs, Arab traders and Transfer of Technology. European Science in the Middle Ages: Science and monastic orders, The Sign of coming down.

III. Science in the middle ages

Europe (1450-1550), the fall of Aristotelian universe, Bruno, Copernicus, Galileo. Tycho Brahe, Kepler, Medicinal chemistry, advancement in India, The Kerala school, Neelakanda Somayaji, Sankara Warrier, Narayana, Madhava, Puthumana Somayajin. The spread of Indian science, Modern scientific outlook: Gilbert, Francis Bacon, Descartes. Newton and after, Mathematics, century after Newton, Mechanics, astronomy, structure of matter. Industrial revolution and its impact on science, Mechanistic universe and scientific determinism, Science and French revolution. Modern medicine to nanotechnology, germ theory and birth of microbiology, frontiers in biology, human genome project, breakdown of classical physics, quantum theory and atomic structure, development of nuclear physics, IT, BT and NT.

IV. Concepts in philosophy of science

Introduction, what is science, science and pseudoscience, scientific reasoning, deduction and induction, inference, scientific explanation, components of science, realism and anti -realism, unity of science and reductionism, scientific change and scientific revolution, inductivism, paradigms and research, research traditions model, Technologism, science and technology, philosophical problems in science, science and values, Scientism and scientific temper, science and religion, science and society.

Books and References:

1. An introduction to history and philosophy of science by R V G Menon (Longman Pearson)
2. What is this thing called science? 4th Edn., Alan chalmers, (University of Queensland Press).

IPH3V201 **Credits: 3**

BASIC COMPUTATIONAL TOOLS **T – P: 3 - 0**

	Course Outcome	**Cognitive level**
CO1	To introduce the basic concepts of operating systems, file management, and essential commands for both Windows and Linux environments.	Understand
CO2	To learn the basics of data visualization using GNU Plot for scientific and business data presentation.	Apply
CO3	To introduce additional tools and software for effective data handling and processing.	Apply
CO4	To master LaTeX for creating professional and technical documents such as reports, papers, and presentations.	Apply

I. Operating System Basics (Windows & Linux)

Overview of Windows and Linux environments, Differences between Windows and Linux, GUI vs. CLI (Command Line Interface);Windows Basics :File explorer navigation, Creating, copying, and moving files and folders, Task Manager and system performance monitoring, Common Windows shortcuts and tips; Linux Basics: Directory structure and navigation using terminal commands, Basic Linux commands (e.g., ls, cd, cp, mv, rm, cat, less, grep),File permissions and management (chmod, chown),Introduction to Bash scripting; Working with File Systems: File types and extensions, Disk management and partitioning, Networking basics (ping, traceroute) **(12 hours)**

II. Data Visualization and Plotting with GNU Plot

Introduction to GNU Plot:Installation and setup (Windows and Linux),Overview of GNU Plot features;Basic Plotting:Plotting 2D graphs: lines, points, histograms,Customizing plots (axes, labels, legends);Advanced Plotting:Plotting 3D graphs,Parametric and polar plots,Fitting data to functions;Output Formats and Exporting Plots:Exporting plots to PNG, PDF, SVG, and other formats,Creating publication-ready plots(**12 hours)**

III. Other Essential Tools for Data Processing

Text Editing and Scripting Tools:Introduction to Notepad++ (Windows) and Vim/Emacs (Linux),Basic text manipulation using regular expressions;Version Control with Git:Introduction to Git and version control concepts,Basic Git commands (init, clone, add, commit, push, pull),Collaborating using GitHub/GitLab;Data Manipulation with Python:Introduction to Python for data analysis (basic syntax, libraries like NumPy, Pandas),Reading, writing, and processing data files **(12 hours)**

IV. Document Preparation with LaTeX

Introduction to LaTeX,What is LaTeX,Installing and setting up LaTeX (TeX Live, MiKTeX, Overleaf);Basic LaTeX Structure:Document classes (article, report, book),Sections, paragraphs, and environments,Formatting text (bold, italics, lists);Mathematical Typesetting:Writing equations and mathematical symbols,Using equation environments (inline vs. display math),Referencing equations;Creating Tables and Figures:Inserting and customizing tables,Adding figures and captions,Positioning figures and tables within the document;Bibliography and Citations,Using LaTeX for presentations (Beamer)**(12 hours)**

References:

1. The Linux Command Line: A Complete Introduction by William E. Shotts Jr.
2. Gnuplot in Action: Understanding Data with Graphs by Philipp K. Janert
3. Pro Git by Scott Chacon and Ben Straub
4. Python for Data Analysis by Wes McKinney
5. LaTeX: A Document Preparation System by Leslie Lamport

IPH4C201 **Credits: 4**
MATHEMATICAL PHYSICS - I **T - P: 4 - 0**

	Course outcome:	**Cognitive level**
CO1	Describe coordinate systems appropriate for different physical problems. Applies it to solve Laplace's equation in different coordinate systems.	Analyze
CO2	Distinguish the class of objects called tensors, their classifications and use. Perform transformation operations and get the corresponding transformation matrices. Learn procedures for matrix diagonalization.	Evaluate
CO3	Identify differential equations of special nature and the ways to solve them.	Analyze
CO4	Illustrate special functions as solutions to problems in atomic, molecular nuclear, and solid state physics etc. and will put them in use.	Analyze
CO5	Distinguish Fourier series and integral transforms of different types and their properties.	Analyze

I. Vectors

Rotation of coordinates, Orthogonal curvilinear coordinates, Gradient, Divergence and Curl in orthogonal curvilinear coordinates, Rectangular, cylindrical, and spherical polar coordinates, Laplacian operator, Laplace's equation– application to electrostatic field and wave equations, Vector integration. **(11 hours)**

II. Matrices and Tensors

Basic properties of matrices (Review only), Orthogonal matrices, Hermitian and Unitary matrices, Similarity and unitary transformations, Diagonalization of matrices, Definition of Tensors, Contraction, Direct products,, 'quotient rule, Pseudo tensors, Dual tensors, Levi Cevita symbol, irreducible tensors. **(11 hours)**

III. Second Order Differential Equations

Partial differential equations of Physics, Separation of variables, Singular points, Ordinary series solution, Frobenius method, A second solution, Self-adjoint differential equation, eigen functions and values, Boundary conditions, Hermitian operators and their properties, Schmidt orthogonalization, Completeness of functions. **(14 hours)**

IV. Special functions

Gamma function, Beta function, Delta function, Dirac delta function, Bessel functions of the first and second kinds, Generating function, Recurrence relation, Orthogonality, Neumann function, Spherical Bessel function. **(12 hours)**

V. Generating functions and Polynomials

Legendre polynomials, Generating function, Recurrence relation, Rodrigues' formula, Orthogonality, Associated Legendre polynomials, Spherical harmonics, Hermite polynomials, Laguerre polynomials.

Text Book:

1. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, 6^{th} Edition, Academic Press, 2005)

Books for Reference:

1. Mathematical Methods for Physics, J. Mathews and R. Walker, 2^{nd} Edition, Benjamin
2. Applied Mathematics for Engineers and Physicists, L. I. Pipes and L. R. Harvill, 3^{rd} Edition, McGrawHill
3. Advanced Engineering Mathematics, Erwin Kreyzig, 8th edition, Wiley
4. Advanced Engineering Mathematics, M. Greenberg, 2^{nd} edition, Pearson India, 2002.
5. Matrices and tensors in Physics, A.W. Joshi, New Age International Publishers.
6. Tensors and Their Applications, Nazrul Islam, New Age International, 2006

IPH4C202 **Credits: 4**

CLASSICAL MECHANICS AND CHAOS **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Apply the Lagrangian and Hamiltonian formalisms to simple classical systems and compare with Newtonian systems.	Apply
CO2	Solve problems like motion under central force, rigid body dynamics and periodic motions using Lagrangian and Hamiltonian mechanisms using appropriate mathematical equations	Analyze
CO3	Analyze non-linear nature of many of the simple systems.	Analyze

I. Lagrangian and Hamiltonian Formulation

Preliminary ideas about Constraints and Generalized coordinates, D'Alemberts principle and Lagrange's equation, Velocity dependent potentials, Simple applications of Lagrangian formulation, Hamilton's Principle, Conservation theorems and symmetries, Lagrange's equation from Hamilton's principle, Two- body central force problems, Equivalent one - body and one dimensional problem, Kepler problem, Inverse square law of force, Laplace-Lenz vector, Scattering in a central force field, Transformation to lab coordinates. **(15 hours)**

Text: Book 1

II. Hamiltonian Formulations

Legendre Transformation and Hamilton's equations, Cyclic co-ordinates and conservation theorems, Principle of least action, Canonical transformations and examples, Infinitesimal canonical transformations, Poisson brackets and other canonical invariants, Equation of motion in Poisson bracket form, Angular momentum Poisson brackets, Hamilton-Jacobi equation, Hamilton's principal and characteristic function, H-J equation for the linear harmonic oscillator, Separation of variables, Action-angle variables, H-J formulation of the Kepler problem, H-J equation and the Schrodinger equation. **(15 hours)**

Text: Book 1

III. Kinematics of Rigid Bodies

Independent co-ordinates, orthogonal transformation, Transformation matrix, Euler angles, Euler theorem, Infinitesimal rotation, Rate of change of a vector, Centrifugal and Coriolis forces, Inertia tensor, Euler's equation of motion, Torque-free motion of a rigid body, Precession of Equinoxes and satellite orbits. **(14 hours)**

Text: Book 1

IV. Small Oscillations

Formulation of the problem, Eigenvalue equation, Eigenvectors and Eigenvalues, Orthogonality, Principal axis transformation, Frequencies of free vibrations, Normal coordinates, Free vibrations of a linear triatomic molecule, Forced vibration and Dissipative forces. **(8 hours)**

Text: Book 1

V. Nonlinear Equations and Chaos

Introduction, Singular points of trajectories, Nonlinear oscillations, Limit cycles, Chaos: Logistic map, Definitions, Fixed points, Period doubling, Universality. **(8 hours)**

Text: Book 2

Text Books:

1. Classical Mechanics, Herbert Goldstein, Charles P. Poole and John Safko, 3rd Edition, Pearson Education, 2011. (Book 1)
2. Classical Mechanics, V. B. Bhatia Narosa Publications, 1997. (Book 2)

Books for Reference:

1. Chaos and Integrability in Nonlinear Dynamics, Michael Tabor, Wiley, 1989.
2. Classical Mechanics, N. C. Rana and P. S. Joag, Tata McGraw Hill, 2011.
3. Introduction to Classical Mechanics, R. G. Takwale and P. S. PuranikTata McGraw Hill, 1978.
4. Introduction to Classical Mechanics, Atam P. Arya2nd Edition, Addison Wesley, 1998.
5. Nonlinear Dynamics, Muthusamy Lakshmanan, Shanmuganathan Rajaseekar, Springer Verlag, 2002.

IPH4C203 **Credits: 4**

THERMAL PHYSICS **T-P: 3-1**

	Course Outcome	**Cognitive level**
CO1	Apply concepts and laws of thermodynamics to describe physical processes and systems	Apply
CO2	Understand the basic idea of entropy	Understand
CO3	Understand the concept of thermodynamic potentials	Understand
CO4	Understand the theoretical concepts leading to certain non-equilibrium phenomena initiated due to the motion of molecules in a confined geometry	Understand
CO5	Understand and appreciate the role of statistical routes in modelling specific thermodynamic systems.	Understand

I. Laws of Thermodynamics

Macroscopic point of view – Microscopic point of view – Macroscopic versus Microscopic points of view – Scope of Thermodynamics – Thermal equilibrium and Zeroth Law – Concept of temperature – Ideal-Gas temperature – Thermodynamic equilibrium – Equation of state –Intensive and extensive coordinates –Internal energy function – Mathematical formulation of First Law – Concept of Heat – Differential form of the First Law – Heat capacity- Kelvin-Planck statement of the Second Law – Refrigerator; Clausius' statement of the Second Law – Equivalence of Kelvin-Planck and Clausius statements. (11 Hrs)

II. Entropy

Entropy – Entropy of the ideal gas – TS diagram – Entropy and reversibility – Entropy and irreversibility – Principle of increase of entropy – Applications of the Entropy Principle – Entropy and disorder – Exact differentials - – PV diagram for a pure substance – PT diagram for. (8 Hrs)

III. Thermodynamic Potentials and Phase Transitions

Characteristic functions – Enthalpy – Helmholtz and Gibbs functions – Condition for an exact differential – Maxwell's relations – TdS equations – First-order phase transitions and Clausius-Clapeyron equation – Clausius-Clapeyron equation and phase diagrams - Kinetic Theory of Gases – Mean Free Path – transport Phenomena – Viscosity- Conduction – Diffusion. (11 Hrs)

IV. Classical and Quantum Statistics Maxwell- Boltzmann distribution – Probabilistic deduction of the law – Properties of Maxwell- Boltzmann distribution – Mean RMS and Most probable speeds – Limits of Classical Statistics – Quantum

Statistics – Density of states- Bose-Einstein statistics – Thermal radiation – Fermi- Dirac statistics - comparison and applicability. (15 Hrs)

V. Laboratory Experiments

1. Newton's law of cooling.
2. Thermal conductivity of a bad conductor by Lee's Disc method.
3. Thermo emf of a Thermocouple.
4. Band gap of a semiconductor.
5. Characteristics of NTC thermistor.
6. Thermal conductivity by Forbes method.
7. Simulate the Thermodynamic process in PV diagram and estimate the work done by numerical integration.
8. Simulate the Carnot Cycle in PV diagram and estimate the efficiency by numerical integration

Books of Study:

1. Module 1 to 4: Heat and Thermodynamics, 8thEdn. – Mark W. Zemansky and Richard H. Dittman – McGraw-Hill.
2. Module 5: Modern Physics 3rd Edn - Kenneth Krane – Wiley India

Reference Books:

1. Thermal Physics, 2nd Edn - SC Garg, RM Bansal, CK Ghosh, McGraw-Hil

2. Fundamentals of Statistical and Thermal Physics, F. Reif, Waveland Press Inc.

3. Statistical Physics, Berkely Physics Course, Volume 5, Tata McGraw-Hil

IPH4S201 **Credits: 3**

GENERAL PHYSICS LABORATORY **T - P: 0 - 3**

	Course Outcome	Cognitive level
CO1	Demonstrate skills to set up and perform experiments to test basic electronics	Analyze
CO2	Demonstrate skills to set up and perform experiments to test geometrical optics	Analyze

I. Electronics Laboratory Experiments

1. Operational Amplifier - Inverting, Non-inverting, Voltage follower.
2. LCR circuits-Resonance using DSO/.
3. Voltage multiplier (doubler, Tripler) (Connections to be realized through soldering. The de- soldering has to be carried out at the end of the experiment).
4. Multivibrator using transistors.
5. Flip-Flop circuits -RS and JK using IC's.
6. Verification of De-Morgan's Theorem using basic gates.
7. Photo diode V-I characteristics. Determine quantum efficiency and responsivity of the PD.
8. Study the characteristics of LED (3 colours) and LDR.
9. Wave shaping R-C circuits -integrator and differentiator.
10. OPAMP- adder, subtractor.

II. Optics Laboratory Experiments

1. Polarimeter - Specific rotation of sugar solution.
2. Numerical aperture of an optical fibre by semiconductor laser.
3. Spectrometer - Diffraction Grating - Normal incidence.
4. Spectrometer - Diffraction Grating -Minimum deviation.
5. e/m measurement - Thomson's apparatus.
6. Measurement of Stefan's Constant.
7. Planck's constant using LEDs (Minimum 3 numbers).
8. Hydrogen Spectrum - Measurement of Balmer series lines.

9. Franck - Hertz Experiment.

Reference Books:

1. B.Sc Practical Physics- C L Arora.
2. Practical Physics- S L Gupta & V Kumar.
3. Advanced Practical Physics for students - B L Worksnop and H T Flint.
4. A practical approach to Nuclear Physics, 1 st Edition, K. Muraleedhara Varier- Narosa Publishing House.

IPH4V201 **Credits: 3**

INTRODUCTION TO MACHINE LEARNING **T - P: 3 - 0**

	Course Outcome	**Cognitive level**
CO1	To introduce students to machine learning techniques with a focus on scientific and engineering-related problems.	Analyze
CO2	Equip students with practical skills in using machine learning libraries in Python, such as scikit-learn and TensorFlow.	
CO3	To teach students how to apply machine learning algorithms to experimental data and simulations.	
CO4	To bridge the gap between traditional data analysis and advanced machine learning applications.	Analyze

I. Introduction to Machine Learning and Supervised Learning

Overview of Machine Learning: Introduction to machine learning concepts (supervised, unsupervised, reinforcement learning) and their relevance in scientific applications (data analysis, pattern recognition, anomaly detection), Machine Learning Workflow: Data pre-processing, feature engineering, training, testing, and model evaluation, Supervised Learning Techniques: Linear regression, polynomial regression, classification algorithms (decision trees, support vector machines, k-nearest neighbours), and model evaluation metrics (accuracy, precision, recall, confusion matrix, cross-validation), Introduction to scikit-learn: Overview of the library, loading and processing datasets, and building simple supervised learning models.

Practical Using Python:

Installing and importing scikit-learn, Applying linear regression and classification algorithms to datasets, Evaluating models using metrics and performing cross-validation. **(10 hours)**

II. Unsupervised Learning, Clustering, and Dimensionality Reduction

Introduction to Clustering: k-means, hierarchical clustering, and DBSCAN for discovering patterns in unlabelled data, Dimensionality Reduction Techniques: Principal Component Analysis (PCA) and t-SNE for reducing the dimensionality of large datasets (e.g., spectroscopic data, experimental measurements), Anomaly Detection: Using unsupervised learning techniques to detect outliers or rare events in datasets, Applications of Unsupervised Learning: Exploratory data analysis and finding hidden structures in data.

Practical Using Python:

Clustering datasets using k-means and hierarchical clustering, Reducing the dimensionality of high-dimensional data using PCA and visualizing results, Detecting anomalies in datasets using unsupervised learning techniques. **(10 hours)**

III. Neural Networks, Deep Learning, and Advanced Techniques

Introduction to Neural Networks: Overview of perceptrons, activation functions, multi-layer neural networks (MLP), and deep learning concepts, Deep Learning Frameworks (TensorFlow/Keras): Building and training neural networks using TensorFlow and Keras, Applications in Scientific Research: Use cases such as classifying images, recognizing patterns in time-series data, or modeling complex systems using neural networks, Physics-Informed Machine Learning Models: How to incorporate physical laws and constraints into machine learning models to improve predictions, Simulation-Based Learning: Applying reinforcement learning and genetic algorithms to simulate systems, solve optimization problems, and enhance simulations.

Practical Using Python:

Implementing basic neural networks using Keras or TensorFlow, Training deep learning models on large datasets (e.g., image data or time-series data), Visualizing the performance of neural networks and interpreting predictions.

(10 hours)

IV. Applications, Optimization, and Case Studies in Machine Learning

Real-World Applications: Key applications in fields such as quantum mechanics, astrophysics, and material science, Optimization Techniques: Techniques for hyperparameter tuning and improving model performance, Reinforcement Learning and Genetic Algorithms: Using these techniques for optimization problems and simulations, Case Studies in Machine Learning: Review of notable applications in various fields, exploring how machine learning techniques have solved complex scientific problems.

Practical Using Python:

Applying reinforcement learning to optimize simulations (e.g., path optimization in physical systems), Using genetic algorithms for parameter tuning in experiments or simulations, Case study implementation: Developing machine learning solutions for real-world problems. **(18 hours)**

Textbooks:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow by Aurélien Géron.
2. Machine Learning for Physics and Astronomy by Hélène Courtois, Gilles Sciolla, and Roderik Overzier.

IPH4V202 **Credits: 3**

STATISTICAL METHODS USING R-PROGRAMMING **T - P: 3- 0**

	Course Outcome	**Cognitive level**
CO1	To introduce students to fundamental statistical methods used in research and data analysis	Understand
CO2	To equip students with practical skills in applying statistical techniques using R programming for analyzing experimental data.	Apply
CO3	To enable students to interpret statistical results and apply these methods to real-world physics problems.	Apply

I. Introduction to Statistics, R Programming, and Descriptive Statistics

Introduction to Statistical Methods: Importance of statistics in research, basic concepts (population, sample, random variables), Introduction to R Programming: Installation, environment setup, basic R syntax, data structures (vectors, matrices, data frames, lists), Descriptive Statistics: Measures of central tendency, dispersion (variance, standard deviation, quartiles), basic plotting (histogram, boxplot, scatter plot).

Practical Using R:

Writing basic R programs for simple statistical analysis, Creating and manipulating data structures in R, Visualizing data using base R plotting functions. **(10 hours)**

II. Probability Distributions, Hypothesis Testing, and Confidence Intervals

Probability Theory: Basic probability concepts, conditional probability, Bayes' theorem, Probability Distributions: Binomial, Poisson, Normal distributions; practical applications, Hypothesis Testing: Null and alternative hypotheses, type I and II errors, significance level, p-values, Tests of Significance: z-test, t-test (one-sample and two-sample), F-test, Chi-square test, Confidence Intervals: Calculating for mean, proportion, variance; interpreting results.

Practical Using R:

Implementing descriptive statistics and probability distributions using R, Performing hypothesis tests (e.g., t.test(), chisq.test()), Calculating and interpreting confidence intervals, Simulating random variables and calculating probabilities. **(10 hours)**

III. Regression, Correlation, and Error Analysis

Correlation: Pearson and Spearman correlation coefficients; real-world applications, Regression Analysis: Simple and multiple linear regression, least squares estimation, goodness-of-fit, residuals analysis, Error Analysis: Types of errors in experimental data (random and systematic), propagation of errors, uncertainty estimation, Chi-Square Goodness of Fit: Testing the fit of a model to data.

Practical Using R:

Performing correlation analysis, Implementing simple and multiple linear regression models in R, Visualizing regression lines, diagnostic plots, and residuals, Conducting error analysis and chi-square tests for model fitting. **(10 hours)**

IV. Advanced Topics in Statistical Methods

Monte Carlo Methods: Simulation techniques for estimating uncertainties and analyzing experimental data, Advanced Data Visualization: Enhancing plots, interactive visualizations, and reporting, Applications in Research: Case studies of statistical methods applied to real-world data.

Practical Using R:

Simulating random processes using Monte Carlo methods, Applying statistical techniques to various real-world problems, Developing a comprehensive analysis workflow. **(18 hours)**

Text Books:

1. Fundamentals of Mathematical Statistics by S.C. Gupta and V.K. Kapoor (Sultan Chand & Sons).

Supplementary Books:

1. Statistics for Engineers and Scientists by William Navidi.
2. R for Data Science by Garrett Grolemund and Hadley Wickham
3. Introduction to Probability and Statistics for Engineers and Scientists by Sheldon M. Ross.

IPH5C301 **Credits: 4**

ELECTRODYNAMICS I **T - P: 3-1**

	Course Outcome	**Cognitive level**
CO1	Explain the basic characteristics of electric charge, electric potential, and electric field in vacuum as well as various media.	Understand
CO2	Describe the basics of magnetostatics such as electric current, vector potential and magnetic field and their behaviours in vacuum and in various media	Understand
CO3	Solve the boundary value problems	Apply, Analyze

I. Basic Electrostatics

Electric field - Continuous charge distribution-Divergence and curl of electrostatic fields, Gauss' Law - Applications of Gauss' Law, Fields due to: Spherically symmetric charge distribution, Uniformly charged spherical conductor, Line charge, Infinite plane sheet of charge, Electric field at a point between two oppositely charged parallel plates. **(10 hours)**

II. Electric potential and energy

Poisson's equation and Laplace's equation, The potential of a localized charge distribution, Work and Energy in electrostatics - The work done to move a charge - Energy of a point charge distribution and continuous charge distribution, Conductors - Basic properties-induced charges, Surface charge and force on a conductor- Capacitors - expression of parallel plate capacitor - Energy stored in parallel plate capacitor. **(10 hours)**

III. Electric fields in matter

Basics of dielectric polarisation and polarisation of charges, dielectric susceptibility and permittivity. The field of a polarized object, Bound charges and physical interpretation, The field inside a dielectric, The electric displacement, Gauss's law in presence of dielectric, Linear dielectrics, Susceptibility, permittivitty and dielectric constant, boundary value problems with linear dielectrics, Energy in dielectric system. **(10 hours)**

IV. Magnetostatics and Magnetic fields in Matter

The Lorentz force law - Magnetic fields, Magnetic forces, Currents-Linear -Surface and Volume current density - Biot -Savart law, The magnetic field of steady current - Divergence and curl of B, Applications of Ampere's law, Magnetic field of a toroidal coil, Comparison of magnetostatics and electrostatics - Magnetic vector potential.

Basics of magnetic susceptibility, dia, para and ferromagnetic materials, magnetic dipoles, The field of a magnetized objects, bound currents and physical interpretation, The magnetic field inside matter, The Ampere's law in magnetize materials, Boundary conditions, Linear and non-linear media. **(18 hours)**

V. Laboratory Experiments

1. Deflection magnetometer – Magnetic dipole moment – Tan A and Tan B positions.
2. Searle' vibration magnetometer – Find the ratio of magnetic dipole moments.
3. Circular coil – Variation of field with distance – m and Bs.
4. Potentiometer – Resistance and resistivity.
5. Potentiometer – Calibration of ammeter and low voltage voltmeter.
6. Mirror Galvanometer – Figure of merit.
7. Carey Foster's bridge – Resistance and Resistivity.
8. Conversion of Galvanometer to ammeter and calibration using potentiometer.
9. Conversion of Galvanometer to voltmeter and calibration using potentiometer.
10. Verification of maximum power transfer theorem

Text Books:

1. Introduction to Electrodynamics, David J Griffiths.
2. BSc Physics Practical Physics, C L Arora.
3. Practical Physics, S L Gupta and V Kumar

Reference Books:

1. Electricity and Magnetism, Berkeley Physics Course: Vol.2:, 2nd Edn. by Edward M. Purcell.
2. Electricity and magnetism by Arthur F Kip.
3. Physics Vol. II by Resnick and Halliday.
4. Electricity and Magnetism by Hugh D Young and Roger A Freedman.
5. Vector Analysis M R Spiegel, S Lipschutz, D Spellman - Schaum's outline - McGraw Hill.
6. Electromagnetics by Edminister - Schaums Outline - Tata McGraw Hill.

IPH5C302 **Credits: 4**

QUANTUM MECHANICS - I **T – P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Illustrate the importance of Hilbert space in quantum mechanics	Apply
CO2	Solve Schrödinger equation in different situations	Apply
CO3	Calculate the CG Coefficients	Analyze
CO4	Compute eigenvalues and eigenstates of three-dimensional central field problems	Apply
CO5	Illustrate the wave function of a multi-fermionic system using slater determinant	Apply

I. Origin of Quantum Mechanics and Mathematical Tools

Essential structure of Classical Mechanics and its Inadequacy. Linear Vector Spaces-Hilbert Space; Dimension and Basis of a Vector Space; Square-Integrable Functions; Wave Functions; Dirac's Bra and Ket notation; Schwarz Inequality. Operators- Adjoint of an Operator; Hermitian Operators; Unitary Operators; Commutator Algebra; Commutator of Operators and Uncertainty Relation; Functions of Operators; Eigenvalues and Eigenvectors of an Operator. Representation in Discrete Bases- Matrix Representation of Bras, Kets and Operators; Change of Bases and Unitary Transformations; Matrix Representation of the Eigenvalue Problem. Representation in Continuous Bases- Position and Momentum Representations and relation between them. **(12 hours)**

II. Postulates of Quantum Mechanics and Exactly Solvable Problems in one Dimension

The State of a System; Probability Density; Superposition Principle, Observables and Operators. Measurement in Quantum Mechanics- How Measurements Disturb Systems; Expectation Values; Complete Sets of Commuting Operators; Measurement and the Uncertainty Relations. Time Evolution of the System's State- Time Evolution Operator; Schrodinger Equation and Wave Packets; The Conservation of Probability; Time Evolution of Expectation Values.

Connecting Quantum to Classical Mechanics- Poisson Brackets and Commutators; The Ehrenfest Theorem.

Stationary States; Infinite square well; Delta function Potential; Finite square well; Finite Potential Barrier; Harmonic Oscillator. **(12 hours)**

III. Quantum Dynamics and Angular Momentum The equation of motion.

Schrodinger, Heisenberg and the Interaction pictures of time development. The linear harmonic oscillator in the Schrodinger and Heisenberg pictures. Orbital Angular Momentum- Angular Momentum Opeartors; Angular Momentum Algebra; Simultaneous Eigenfunctions of Lz and L2 ; Properties of the Spherical Harmonics; Matrix Representation of Angular Momentum Operators; Addition of angular momenta; Clebsh-Gordon coefficients. Spin Angular Momentum- Spin 1/2 and the Pauli Matrices. Coupling of Orbital and Spin Angular Momenta. **(16 hours)**

IV. Exactly Solvable Problems in three Dimensions

The Free Particle in Spherical Coordinates; The Spherical Square Well Potential; The Isotropic Harmonic Oscillator; The Hydrogen Atom; Effect of Magnetic Fields on Central Potentials. **(10 hours)**

V. Symmetry and Conservation Laws

Space-time symmetries- Space translation and conservation of linear momentum; Time translation and conservation of energy; Space rotation and conservation of angular momentum; Space inversion and time reversal.

Identical particles- Identical Particles in Classical and Quantum Mechanics; Exchange Degeneracy; Construction of symmetric and antisymmetric wave functions; Slater determinant; Pauli exclusion principle; Bosons and Fermions; Spin wave functions for two electrons; The ground state of He atom. **(10 hours)**

Text books

1. Nouredine Zettili, Quantum Mechanics: Concepts and Applications, Second Edition, John Wily & Sons Ltd, 2009.
2. V. K. Thankappan, Quantum Mechanics, Second Edition, New Age International Publishers, 1993.
3. David J. Griffiths, Introduction to Quantum Mechanics, Second Edition, Pearson education International, 2005.
4. R. Shankar, Principles of Quantum Mechanics, Second Edition, Kluwer Academic/ Plenum Publishers, 1994.

Reference books

1. R. Eisberg & R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles, John Wiley.
2. Thomas E Jordan, Quantum Mechanics in Simple Matrix Form, John Wiley & Sons Ltd, 1986.
3. Claude Cohen Tannoudji, Bernard Diu and Frank Laloe, Quantum Mechanics, Volumes I and II, 1996.

4. L. I. Schiff, Quantum Mechanics, McGraw Hill, 1968.
5. J. J. Sakurai, Modern Quantum Mechanics, Addison-Wesley, 2010.
6. J. D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics, McGraw Hill, 1998.
7. P. M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, TataMcGraw Hill, 1978

IPH5C303 **Credits: 4**

COMPUTATIONAL PHYSICS - I **T – P: 3 - 1**

	Course Outcome	**Cognitive level**
CO1	Understand and explain the fundamental concepts and methods of numerical analysis.	Understand
CO2	Apply numerical techniques to solve various mathematical problems in physics.	Apply
CO3	Analyze and interpret the results of computational experiments.	Apply
CO4	Develop algorithms and write computer programs to implement numerical methods.	Analyze
CO5	Evaluate the accuracy and efficiency of different numerical methods	Evaluate

I. General Numerical Techniques

Evaluation of numerical determinants, solution of linear systems, Inverse of a matrix: Gauss-Jordan Method, Eigenvalue Problems, Roots of transcendental equations: Bisection method, Method of false position and Newton-Raphson Method. **(12 hours)**

II. Interpolation and Curve Fitting

Difference calculus, Forward-backward differences, Newton’s forward and backward interpolation formulas, Lagrange’s interpolation formula, Least-square curve fitting: linear and non-linear. **(11 hours)**

III. Numerical Integration

Numerical integration: Trapezoidal rule, Simpson’s 1/3 and 3/8 rules, Random number generation, Monte Carlo Integration, evaluation of π. **(11 hours)**

IV. Numerical Solutions of Ordinary Differential Equations

Ordinary differential equations (ODEs): Euler’s method, Modified Euler's method, and Runge-Kutta Methods (2nd and 4th order) for solving ODEs, Higher order ODEs. **(11 hours)**

V. Laboratory Experiments: Students must complete at least 10 experiments from the list provided, with a minimum of 2 experiments from each of Modules 1-4. Students can use one of the following programming languages: Fortran, C, Python, Matlab, or Mathematica.

1. Find the roots of a quadratic equation which can give even complex roots.
2. List the prime numbers between two integers specified.
3. Write a program for finding the determinant and inverse of a 3 x 3 matrix.
4. Write a program for plotting square wave using Fourier series coefficients.
5. Find the roots of a transcendental equation using Bisection / Regula Falsi/Newton-Raphson method with an accuracy specified.
6. Interpolate from the list of data given using Newton's forward / backward interpolation / Lagrange interpolation formula and visualize the curve.
7. Fit the set of data to a straight line using least square curve fitting formula and visualize it.
8. Fit the set of data to a polynomial of degree 2 using least square curve fitting formula and visualize it.
9. Find the integral of the given function between the limits supplied using Trapezoidal formula / Simpson's 1/3 or 3/8 rule and find the error in evaluation.
10. Solve the first order differential equation using Euler's formula or modified Euler's formula.
11. Solve the first order differential equation using second /fourth order Runge-Kutta formula.
12. Write a program for finding the inverse of a 3 x 3 matrix using Gauss /Gauss-Jordan method.
13. Find the Eigen values & Eigen vectors of a 3 x 3 matrix.
14. Evaluation of Pi using Monte Carlo method
15. Random walk simulation in 2D

Text Books:

1. Numerical Mathematical Analysis, J. B. Scarborough, 6th Edition, Oxford and IBH)
2. Introductory Methods of Numerical AnalysisS. S. Shastry, Prentice Hall of India, 1983.

Reference Books:

1. Computer Programming in Fortran 90, V. Rajaraman, PHI: New Delhi, 1990.
2. Numerical Recipes in C: The Art of Scientific Computing, , W. H.; Teukolsky, S. A.; Vetterling, W. T.; Flannery, B. P., Cambridge University Press: New York, 1992.
3. Python Programming and Numerical Methods: A Guide for Engineers and Scientists, Kong, Q.; Siauw, T.; Bayen, A; Elsevier Academic Press: San Diego, 2020
4. Applied Numerical Analysis, Gerald, C. F.; Wheatley, P. O., Pearson Education: Upper Saddle River, NJ, 2004.

5. Understanding Molecular Simulation: From Algorithms to Applications, Frenkel, D.; Smit, B.; Academic Press: San Diego, 2001.
6. Guide to Monte Carlo Simulations in Statistical Physics, Landau, D. P.; Binder, K. A, Cambridge University Press: Cambridge, 2014.
7. Computational Physics, Giordano, N. J.; Nakanishi, H. Pearson: Boston, 2005.
8. An Introduction to Computer Simulation Methods: Applications to Physical Systems, Gould, H.; Tobochnik, J.; Christian, W., Pearson: San Francisco, 2007.

References (Laboratory Experiments):

1. Python for Education - B P Ajithkumar; e-book freely downloadable from www.expeyes.in/documents/mapy.
2. Introduction to Python for Engineers and Scientists - Sandeep Nagar - Apress publications.
3. Python Tutorial Release 3.0.1 - editors: Guido van Rossum, Fred L. Drake, Jr. (http://www.altaway.com/
4. Introductory methods of numerical analysis, 5th Edn. - S. S. Shastry - Prentice Hall of India.
5. Computational Physics - V. K. Mittal, R. C. Verma and S. C. Gupta - Ane Books.
6. Programming in Python 3: A Complete Introduction to the Python Language, 2 nd Edn. - Mark Summerfield - Developer's library.
7. www.python.org
8. Python Essential Reference - David M. Beazley - Pearson Education.
9. Core Python Programming - Wesley J Chun - Pearson Education.
10. How to Think Like a Computer Scientist: Learning with Python - Allen Downey, Jeffrey Elkner, Chris Meyers; http://www.greenteapress.com/thinkpython/thinkpython.pdf.
11. Numerical Methods in Engineering and Science - B. S. Grewal - Khanna Publishers, New Delhi.
12. Numerical methods for scientists and engineers - K. Sankara Rao, PHI.

IPH5E301 **Credits: 4**

ELEMENTARY ASTROPHYSICS **T - P: 4 - 0**

	Course Outcome:	**Cognitive level**
CO1	Perform the observation of celestial objects	Apply
CO2	Estimate the physical properties of stars using photometric techniques	Apply, Analyze
CO3	Describe the evolutionary states of stars based on the masses	Understand
CO4	Explain the formation and evolution of galaxies	Understand
CO5	Describe the planetary system and explain the basic formation scenario of exoplanets	Understand

I. Coordinates and Observation Techniques

The celestial sphere, The horizontal system, The equatorial system, The Galactic coordinates , The sidereal time, Stellar distances – parallax method, Optical telescopes – Properties and aberrations, Radio telescopes, other wavelength regions. **(12 hours)**

Text: Book1

II. Photometric Concepts and Magnitudes

Intensity, Flux density, Luminosity, Apparent Magnitudes, Absolute magnitudes, Magnitude systems, Spectral formation, Saha and Boltzmann equation, Spectral classification: The Harvard spectral classification, The Yerkes Spectral Classification, Peculiar Spectra, The Hertzsprung-Russel Diagram. **(12 hours)**

Text: Book1 & Book 2

III. Stellar Evolution

The contraction of stars towards the main-sequence, The main-sequence phase, The Giant phase, The final stages of evolution, White dwarfs, Neutron stars, Black holes (qualitative idea only). **(10 hours)**

Text: Book1

IV. Galaxies

The Milky way Galaxy, Stellar luminosity function, The rotation of the Milky way, Structural components of the Milky way, The formation and evolution of the Milky way, The classification of Galaxies, Luminosities and Masses, Galactic Structure, Dynamics of Galaxies, Systems of Galaxies , Active galaxies and quasars, The origin and Evolution of Galaxies. **(14 hours)**

Text: Book 1

V. The Solar System

Planetary configurations, Orbit of the earth and visibility of Sun, Orbit of the moon, Eclipses and Occultations, The structure and surface of planets, Atmospheres and Magnetospheres, Photometry, polarimetry and spectroscopy, Thermal radiations of the planets, Minor bodies of the solar system, origin of the solar system. **(12 hours)**

Text: Book 1

Books and References

1. Fundamental Astronomy, H. Karttunen, P. Kroger, H. Oja, M. Poutanen, K. J. Donner (Eds.) (Book 1).
2. An introduction to Astrophysics, Baidyanath Basu M, Prentice Hall of India (Book 2).
3. Modern Astrophysics, B.W. Carroll & D.A. Ostille, Addison Wesley, 1996).
4. The Physical Universe: An Introduction to Astronomy, Frank H Shu.

IPH5E302 **T-P: 4-0**

PLANETARY SCIENCES **Credits: 4**

	Course Outcome:	**Cognitive level**
CO1	Describe the concepts of planetery sciences	Understand
CO2	Explain the kinematics and dynamics of planetary bodies	Apply
CO3	Describe the structure of planets	Understand
CO4	Describe the formation and evolution of planets	Understand
CO5	Identify exoplanets and analyze of their atmosphere	Analyze

I. Key Concepts in Planetary Science

A brief history, Inventory of the solar system, Planets and planetary properties, formation of the solar system. **(8 hours)**

Sections 1.1 to 1.5 of Fundamental Planetary Science: Jack Lissauer & Imke de Pater (Latest Edition)

II. Dynamics

The two body problem – Kepler's Laws of Planetary Motion, Newton's Laws of Motion and Gravity, Reduction of the Two-Body Problem to the One-Body Problem, Generalization of Kepler's Laws, Orbital Elements, Bound and Unbound Orbits, Stability of the Solar System ,Orbits of the Eight Planets, Survival Lifetimes of Small Bodies, Dynamics of Spherical Bodies, Moment of Inertia, Gravitational Interactions, Orbits about an Oblate Planet, Gravity Field, Precession of Particle Orbits, Torques on an Oblate Planet. **(14 hours)**

Sections 2.1, 2.4, 2.5, 2.6 of Fundamental Planetary Science: Jack Lissauer & Imke de Pater (Latest Edition)

III. Planetary Atmospheres, Surfaces and interiors

Thermal Structure, Sources and Transport of Energy Observed Thermal Profiles, Atmospheric Composition, Clouds, Meteorology, Coriolis Effect, Winds Forced by Solar Heating, Mineralogy and Petrology, Minerals, Rocks, Material under High Temperature and Pressure, Cooling of a Magma, Planetary Interiors, Interior Structure of the Earth, Shape and Gravity Field, Internal Heat: Sources, Losses and Transport, Surface Morphology. **(14 hours)**

Sections 5.1 to 5.4 and 6.1 to 6.4 of Fundamental Planetary Science: Jack Lissauer & Imke de Pater (Latest Edition).

IV. Planet Formation

Solar System Constraints, Star Formation: A Brief Overview , Molecular Cloud Cores, Collapse of Molecular Cloud, Cores, Young Stars and Circumstellar Disks, Evolution of the Protoplanetary Disk, Infall Stage, Disk Dynamical Evolution, Chemistry in the Disk, Clearing Stage, Growth of Solid Bodies, Planetesimal Formation, From Planetesimals to Planetary Embryos, Formation of the Terrestrial Planets, Dynamics of the Final Stages of Planetary Accumulation, Accretional Heating and Planetary Differentiation, Accumulation (and Loss) of Atmospheric Volatiles, Formation of the Giant Planets. **(14 hours)**

Sections 15.1 to 15.6 of Fundamental Planetary Science: Jack Lissauer & Imke de Pater (Latest Edition)

V. Extrasolar planets

Detecting extra solar planets- different methods, observations, exoplanet statistics, Physics of exoplanets, Exoplanet formation models. **(10 hours)**

Sections 14.1 to 14.5 and 15.11 of Fundamental Planetary Science: Jack Lissauer & Imke de Pater (Latest Edition)

Reference books:

1. Fundamental Planetary Science: Jack Lissauer & Imke de Pater (Latest Edition) - Cambridge University Press
2. The Solar System: Therese Encrenaz and Jean-Pierre Bibring (Latest Edition) - Astronomy and Astrophysics Library, Springer
3. The Origin and Evolution of the Solar System: Michael M. Woolfson - IoP CRC Press
4. Moons and Planets, W.K. Houtmann, Wadsworth Publishing Company 4th Ed.
5. Exoplanets - Edited by Sara Seager - University of Arizona Press 2011

IPH5E303 **T-P: 4-0**

ASTRONOMICAL INSTRUMENTATION **Credits: 4**

	Course Outcome	Cognitive level
CO1	Describe the basic concepts of telescope design and application of optical instruments	Understand, Apply
CO2	Design detector systems for various wavelength ranges	Apply
CO3	Explain basic concepts of astronomical imaging and design relevant instruments	Apply
CO4	Describe the basic concepts of astronomical spectroscopy and design various spectroscopes for single object and multi-object observations	Understand, Apply
CO5	Describe and design various astronomical techniques for analyzing the light to understand the physical and chemical properties of celestial objects	Understand, Apply

I. Telescopes

Basic concepts and designs – Relecting and refracting telescopes, Optical telescopes, Ultra violet and X-ray telescopes, Infrared telescope, Radio telescopes, Telescope mounting, Aberrations. **(12 hours)**

Relevant sections from chapter 1 of Astrophysical Techniques by C R Kitchin and Section 3.2, 3.3, 3.4, 3.5 of Fundamental Astronomy by Karttunen et al

II. Detectors

Optical and Infrared detectors, Semiconductors, Detector index, Detector parameters, Charge coupled devices, Super conducting and tunnel junction detectors, Ultra violet detectors, Radio detectors, X- ray and gamma ray detectors. **(12 hours)**
Relevant sections from chapter 1 of Astrophysical Techniques by C R Kitchin.

III. Astronomical Imaging and Photometry

Basics of Photography and electronic imaging, Scanning, Interferometry, Michelson optical interferometer and radio interferometer, Occultations – Background and techniques, Radar – theoretical concepts and Equipment, Photometry – filter systems and stellar parameters, Photometers – Instruments and observing techniques. **(12 hours)**

Relevant sections from Chapter 2 and 3 of Astrophysical Techniques by C R Kitchin

IV. Astronomical Spectroscopy

Diffraction gratings, Prisms, Interferometers, Fibre optics, Spectroscopes – basic design concepts, Grating spectroscopy, Integral field spectroscopy, Multi-object spectroscopy, techiques and designs. **(12 hours)**

Relevant sections from Chapter 4 of Astrophysical Techniques by C R Kitchin

V. Other Astronomical techniques

Basic concepts of Astrometry, Polarimetry – polarimeters and spectropolarimetry, Solar telescopes and spectrohelioscopes, Coronograph, Magnetometry. **(12 hours)**

Relevant sections from Chapter 5 of Astrophysical Techniques by C R Kitchin

Reference books:

1. Astrophysical Techniques by C R Kitchin
2. H. Karttunen, P. Kroger, H. Oja, M. Poutanen, K. J. Donner (Eds.): " Fundamental Astronomy
3. Electronic Imaging in Astronomy: Detectors and Instrumentation - Ian S. McLean, Springer, 2008
4. Adaptive Optics for Astronomical Telescopes - John W. Hardy, Oxford Series in Optical & Imaging Sciences, 1998
5. Astrotomography: Indirect Imaging Methods in Observational Astronomy, Editors: H.M.J. Boffin, D. Steeghs, J. Cuypers, Springer Lecture series, 2001
6. Interferometry and Synthesis in Radio Astronomy - Thompson, Moran & Swenson, Wiley, 2001
7. Lucky Exposures:: Diffraction Limited Astronomical Imaging through the Atmosphere - Robert Tubbs, VDM Verlag Dr. Müller, 2010
8. Astronomical Image and Data Analysis - J.-L. Starck, F. Murtagh, Astronomy and Astrophysics Library, 20

IPH5E304 **Credits: 4**
ATMOSPHERIC PHYSICS **T - P: 4 - 0**

	Course Outcome:	Cognitive level
CO1	Explain the basic structure of the atmosphere and its constituents stratified to several layers.	Understand
CO2	Apply the concepts of pressure, temperature, humidity to atmosphere in climate change.	Apply
CO3	Apply thermodynamical concepts and latent energy to Analyze stability of air parcel	Apply
CO4	Understand basic atmospheric photochemistry and the role of trace gases.	Understand
CO5	Apply the concept of electric field to atmosphere in the form of lightning and learn about lightning protection measures.	Apply

I. Introduction to Atmospheric Physics

The atmosphere-Origin and Composition of the atmosphere, Different layers of the atmosphere, Vertical thermal structure of the atmosphere–distribution of pressure and temperature, Global distribution of precipitation Measurement techniques: air temperature, relative humidity, pressure, rainfall, Introduction to atmospheric boundary layer, Green-house effect, global warming. **(13 hours)**

II. Atmospheric Thermodynamics

Adiabatic processes –concept of an air parcel, lapse rate, thermodynamic parameters and diagrams, Atmospheric stability- unsaturated air, saturated air, conditional and convective instability. CAPE, CINE, CIFK and CISK. **(9 hours)**

III. Atmospheric Radiation and Photochemistry

Radiation: The spectrum of radiation – Black body radiation, Planck function, radiative properties of non-black bodies, Scattering and absorption by air molecules and particles, Atmospheric windows, solar constant, Surface radiation budget and net radiation, radiative forcing, Atmospheric photochemistry of NO, NO_2, O_3, CH_4, CO, Absorption of radiation by trace gases.**(15 hours)**

IV. Atmospheric Electricity

Cloud morphology, structure and dynamics of thunder clouds, Fair weather electric field in the atmosphere and potential gradient, Ionisation in the atmosphere, conduction currents, point discharge current, air Earth currents, Electric field in thunderstorm, theories of thundercloud electrification, Lightning discharge, global electric circuit, Cloud electrification mechanisms, Physics of lightning-lightning protection. **(11 hours)**

V. Optical features of the atmosphere

Refraction, scattering, Diffraction phenomena, aurorae, Indian monsoon. **(12 hours)**

Books and References:

1. Atmospheric Physics, J. V. Iribarne, H.R. Cho, Springer, 1980 (Book 1)
2. Atmospheric Science, John M. Wallace. Peter V. Hobbs, Elsevier, 2006 (Book 2)
3. Atmospheric Chemistry and Physics, John H. Seinfeld, Spyros N. Pandis, John Wiley & Sons, 2006.
4. Basics of Atmospheric Science 2nd Edition, A. Chandrasekar, PHI, 2010
5. Rainbows, Halos and Glories, Robert Greenler, Cambridge University Press, 1980.
6. Atmosphere, Weather and Climate 9th edition, Roger G. Barry, Richard J Chorley, Routledge, 2017.

IPH5E305 **Credits: 4**

MEDICAL PHYSICS **T – P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Describe the basic principles of biophysics.	Understand
CO2	Illustrate the working of ECG and EEG.	Apply
CO3	Analyze ultrasound and X-ray imaging.	Analyze
CO4	Analyze the application of NMR.	Analyze
CO5	Analyze applications of lasers in medicine.	Analyze

I. Physical Foundations of Biophysics

Free energy, Internal energy, Thermodynamics and Statistical mechanics, Reaction kinetics. Transport Processes: Diffusion, Osmosis, Surface tension, Viscosity, thermal conduction. Oxidation and reduction, redox potential, examples of redox potential in biological systems. Membrane Physics: Diffusion through cell membrane, factors affecting diffusion, Membrane potentials: Resting potentials, action potentials, Hodgkin-Huxley model for membrane transport. Donnan equilibrium, Goldman equation. **(11 hours)**

Text: Book 1

II. Fundamentals of Medical Instrumentation

Physiological systems of the body, sources of biomedical signals, basic medical instrumentation systems, performance, constraints and regulations, intelligent medical instrumentation systems. Origin of bioelectric signals, ECG, EEG, EMG. Recording electrodes and microelectrodes, Transducers and biosensors. **(10 hours)**

Text: Book 2

III. Ultrasound and X-ray Medical Imaging Systems

Ultrasonic Imaging-properties of ultrasound, modes of ultrasound transmission-pulsed, continuous, pulsed Doppler, ultrasound imaging, ultrasonic diagnosis, ultrasonic transducers, X-rays- Instrumentation for diagnostic X-rays, visualization of X-rays-flouroscopy, X-ray filters, X-ray films, Image intensifiers, Special technique-grid, contrast media, Angiography, X-ray computed tomography - Computed tomography, basic principle, contrast scale, system components-scanning system, processing unit, viewing part, storage unit, Helical CT scanner. **(9 hours)**

Text: Book 2 & 3

IV. Nuclear Medical Imaging Systems

Nuclear Medical imaging systems-radio isotopes in medical imaging systems, physics of radioactivity, uptake monitoring equipment, radioisotope rectilinear scanner, gamma camera, Emission computed tomography, Positron emission tomography (PET Scanner) Principles of NMR, Image reconstruction techniques, Basic NMR components, Biological effects of NMR imaging, advantages of NMR imaging. **(9 hours)**

Text: Book 2

V. Lasers in Medicine

Special properties of laser beam (coherence, collimation, monochromaticity), laser active medium, focal length of the laser lens, Laser-tissue interactions, Basic principles of Nd-YAG, CO2, and Argon Lasers, An overview of their clinical applications with special reference to Gynecology, pulmonary, neurosurgery, dermatology, ophthalmology. Photodynamic therapy, Laser safety measures. **(9 hours)**

Text: Book 4

Text Book:

1. Biophysics: An Introduction, Rodney Cotterlie, Wiley (Book 1).
2. Handbook of Biomedical Instrumentation, R S Khandpur, Tata Mcgraw Hill (Book 2).
3. Leslie Cromwell, Biomedical Instrumentation and measurements, Prentice hall of India, New Delhi (Book 3).
4. Lasers in Medicine - An Introductory Guide, Gregory Absten, Springer Science Publications (Book 4).

Reference Books:

1. Medical Physics by J R Cameron and J G Skofonick, Wiley Eastern.
2. The physics of medical imaging by S Webb, Hilger Publications.
3. Techniques for radiation dosimetry by K Mahesh and D R Vij, Wiley Eastern Limited.
4. Clinical nuclear medicine by Maisey, Britton, Chapman and Hall.
5. Ultra sound in Medicine, by F Duck, IOP Publications.
6. Medical Instrumentation Application and Design, by John G. Webster, John Wiley and sons.

7. Introduction to Biomedical equipment technology, John M. Brown, John Wiley and sons.
8. Medical Imaging Physics, W. R. Hendee & E. R. Ritenour, (3rd edn.), Mosbey Inc.

IPH5E306 **Credits: 4**

BIOPHYSICS **T – P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Describe the basic principles of biophysics.	Understand
CO2	Illustrate the difference between is nano world so different from macro world and predict what's going on there by incorporating physical ideas like Random walk, Diffusion, probabilistic facts, etc.	Analyze
CO3	Analyze the bacteria motion and compare with motion of fish	Evaluate
CO4	Analyze the thermodynamic basis of various biochemical reactions in cells and tissues.	Analyze
CO5	Analyze the role of action potential in nerve impulses, and the physics of signal communication via neural systems.	Analyze

I. Physical Foundations of Biophysics

Introduction, Heat, Cell physiology - Internal gross anatomy, External gross anatomy, The molecular parts list– Small, Medium-size molecules, Big molecules, Macromolecular assemblies, Bridging the gap: Molecular devices - The plasma membrane, Molecular motors, Enzymes and regulatory proteins, The overall flow of information in cells. (12 hours)

II. The Molecular Dance

Probabilistic facts of life- Discrete distribution, Continuous distribution, Expectation and variance, addition and multiplication rules, Decoding the ideal gas law- Temperature reflects the average kinetic energy of thermal motion, The complete distribution of molecular velocities is experimentally measurable, Boltzmann distribution, Activation barriers and control reaction rates, Relaxation to equilibrium, Statistics of genetics & heredity: historical example, Brownian motion- Just a little more history, Random walks lead to diffusive behavior, Diffusion law is model independent, Friction is quantitatively leads to diffusion- Einstein's relation, Other random walks- The Confirmation of polymers, Diffusion rules the sub cellular world, Diffusion follows a differential equation- Fick's law, Diffusion equation, Precise statistical prediction of random processes, Functions, Derivatives, and snakes under the rug, Biological Applications of Diffusion-

The permeability of artificial membranes is diffusive, Diffusion sets a fundamental limits on bacterial metabolism. (18 hours)

III. Life in the slow lane: The low Reynolds number world- Why do not bacteria swim like fish?

Friction in Fluids- Sufficiently small particles can remain in suspension indefinitely, The rate of sedimentation depends on solvent viscosity, Its hard to mix a viscous liquid, Low Reynolds number- Viscous force in Newtonian fluid, Relative importance of friction and inertia, time-reversal properties of dynamical law and dissipative character, Biological Applications- Swimming and Pumping, To Stir or Not to Stir?, Foraging, Attack, and Escape, Vascular networks, Viscous drag at DNA replication fork. (10 hours)

IV. Entropy, Temperature, and Free energy

How to measure disorder; Entropy- The Statistical Postulate, Entropy is a constant times the maximal value of disorder, Temperature- Heat flows to maximise disorder, Temperature is a statistical property of a system in equilibrium, The Second Law- Entropy increases spontaneously when a constraint is removed, Three remarks, Open Systems- Free energy of a subsystem reflects the competition between entropy and energy, Entropic forces as derivate of free energy, Microscopic systems- The Boltzmann distribution follows from the statistical postulate, The minimum free energy, principle also applies to microscopic systems. (11 hours)

V. Nerve Impulses

The problem of nerve impulses- Phenomenology of action potential, Cell membrane as an electrical network, Simplified mechanism of action potential- The puzzle, mechanical analogy, Nerve, Muscle, synapse

Books for Study:

1. Biological Physics: Energy, Information, Life (Student Edn.) by Philip Nelson. (Book 1)

2. Biophysics- An Introduction (2nd Edn.), Roland Glaser

3. Biophysics: An Introduction, 2nd Edn by Rodney Cotterill

4. Biophysics: An Introduction, 2nd Edn by Rodney Cotterill

5. Physical Biology of the Cell, R. Phillips, J. Kondev and J. Theriot

IPH5S301 **Credits: 3**

DATA ANALYSIS AND VISUALIZATION USING PYTHON **T – P: 3 - 0**

	Course Outcome	**Cognitive level**
CO1	To introduce students to data analysis techniques using Python.	Understand
CO2	To equip students with practical skills in data visualization to interpret and present scientific data effectively.	Apply
CO3	To develop proficiency in using Python libraries such as NumPy, Pandas, Matplotlib, and SciPy for handling, analyzing, and visualizing large datasets.	Understand, Apply
CO4	To teach students how to use Python for numerical simulations.	Apply

I. Introduction to Data Analysis, Python Libraries, and Data Manipulation

Overview of Data Analysis: Importance in scientific research, examples of data analysis in experiments (e.g., time-series analysis, measurements),Python Basics for Data Analysis: Introduction to essential Python libraries – NumPy, Pandas, and Matplotlib. Data Structures and Manipulation: Arrays, DataFrames, handling multidimensional datasets, techniques for data cleaning, filtering, and transformation using Pandas, Handling Large Datasets: Practical strategies for managing large datasets and working with time-series data, including interpolation and resampling

Practical Using Python:

Importing, cleaning, and organizing data using Pandas, Performing basic statistical analysis (mean, median, standard deviation) on datasets, Manipulating data structures and performing mathematical operations on experimental data. **(10 hours)**

II. Data Visualization and Advanced Techniques

Introduction to Data Visualization: Importance of visual representation in research and data communication, Matplotlib Basics: Plotting line graphs, scatter plots, bar charts, histograms, box plots, and customizing visualizations ,Advanced Visualization Techniques: Creating 3D plots, contour plots, error bars, heatmaps, and vector field visualizations, Seaborn: Enhancing visualizations with Seaborn for more aesthetic representation, Practical Data Visualization: Best practices for choosing the right plot type, adding legends, labels, annotations, and fine-tuning plot aesthetics.

Practical Using Python:

Creating basic plots to visualize data (line graphs, scatter plots, bar charts), Enhancing plots with legends, labels, annotations, and error bars using Matplotlib, Visualizing complex datasets with 3D plots, heatmaps, and Seaborn enhancements. **(13 hours)**

III. Curve Fitting, Data Modelling, and Error Analysis

Curve Fitting: Linear and nonlinear regression, polynomial fitting, least squares fitting, and evaluating model fit, Using SciPy for Modelling: Employing SciPy for curve fitting, numerical integration, and solving ordinary differential equations, Error Analysis: Understanding types of errors, propagation of errors, uncertainty estimation, and their impact on data interpretation, Modelling Experimental Data: Fitting data to physical models, evaluating fit quality, and interpreting fitted parameters.

Practical Using Python:

Implementing linear and nonlinear curve fitting using Python, Performing error analysis and calculating uncertainties, Applying models to real-world datasets and visualizing fits with error bands. **(7 hours)**

IV. Numerical Methods, Simulations, and Applications

Introduction to Numerical Methods: Techniques for solving differential equations, numerical integration (Simpson's rule, trapezoidal rule), and Monte Carlo simulations, Simulating Systems: Numerical simulations for various systems (e.g., motion, wave propagation), solving equations of motion, and modeling dynamics, Visualizing Simulation Results: Presenting results from numerical simulations and interpreting their physical significance, Applications in Data Analysis: Case studies of using Python for data analysis and modeling in diverse scientific fields.

Practical Using Python:

Simulating physical systems (e.g., projectile motion, oscillators) and visualizing the results, Solving ordinary differential equations using SciPy's odeint and solve_ivp, Implementing Monte Carlo simulations for estimating quantities and solving problems. **(12 hours)**

Text books

1. Python for Data Analysis by Wes McKinney.
2. A Student's Guide to Python for Physical Modeling by Jesse M. Kinder and Philip Nelson

Reference books

1. Python Data Science Handbook by Jake VanderPlas.
2. Numerical Methods in Physics with Python by Alex Gezerlis

IPH6C301 **Credits: 4**

STATISTICAL MECHANICS **T-P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Discuss the connection between statistics and thermodynamics	Analyze
CO2	Demonstrate an understanding of the terminology, concepts and principles of describing equilibrium properties of physical systems in a statistical mechanical framework	Apply
CO3	Derive partition function and compute thermodynamics relations for various real-world physical systems	Create
CO4	Comprehend the statistical behaviour of ideal Bose and Fermi systems	Analyze
CO5	Qualitatively explain aspects of the statistical physics of systems with an interaction between its constituent components	Understand

I. Foundations of statistical mechanics:

Specification of states of a system, Contact between statistics and Thermodynamics, Classical Ideal gas, Entropy of mixing and Gibbs paradox, Sackur-Tetrode Equation. **(10 hours)**

II. Ensemble Theory:

Microcanonical ensemble, phase space, trajectories and density of states, Liouville's theorem, canonical and grand canonical ensembles, partition function, Equipartition Theorem, calculation of statistical quantities. **(13 hours)**

III. Quantum Statistical Mechanics

Density matrix, statistics of Microcanonical, Canonical and Grand canonical Ensemble, Example: Electron in a magnetic field, Free Particle in a box, Statistics of indistinguishable particles. **(14 hours)**

IV. Ideal Systems:

Density matrix of a system of non-interacting particles. Ideal gas in quantum mechanical ensembles, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics, Thermodynamics of ideal Bose and Fermi gases, Bose-Einstein condensation. **(14 hours)**

V. Phase Transitions and Fluctuations:

Cooperative phenomena, Dynamical model of Phase transitions, Bragg-William approximation, Ising Model, Equilibrium thermodynamic Fluctuations, Brownian motion and Langevin theory. **(9 hours)**

Text Book:

1. Statistical Mechanics, R. K. Pathria & Paul D Beale, 4th Ed, Elsevier, 2021

Reference Books:

1. Statistical Mechanics, K Huang, John Wiley (NY), 2nd Edition, 1987.
2. Statistical and Thermal Physics, F. Reif, Tata McGraw Hill (ND), 2008.
3. Statistical Physics Part 1, Landau and Lifshitz, 3rd edition, Elsevier, 2011.

IPH6C302 **Credits: 4**

FUNDAMENTALS OF SOLID STATE PHYSICS AND SPECTROSCOPY **T - P: 3 - 1**

	Course Outcome:	**Cognitive level**
CO1	Describe the different crystal structures	Understand
CO2	Illustrate the role of reciprocal vector in analysing the XRD pattern	Apply
CO3	Analyze the basic mechanism of interaction of electromagnetic radiations with electronic excitation of molecules	Analyze
CO4	Analyze the basic mechanism of interaction of electromagnetic radiations with rotational excitation of molecules	Analyze
CO5	Estimate the energy exchanged between the electromagnetic radiation with atoms and molecules	Apply

I. Introduction to Solid state Physics

Classification of solids, Crystals-periodic arrays of atoms and molecules, Lattice translation vectors, Basis and the crystal structure, Primitive cell, Fundamental types of lattices, Two dimensional lattice types, Three dimensional lattice types, Index system for crystal planes-Miller Indices, Importance of Miller Indices, Crystal structures-NaCl, CsCl, Hexagonal close packed structure (hcp), Diamond structure, Cubic ZnS structure, Non ideal crystal structures, Random stacking and polytypism, Solving of problems. (12 Hours)

II. Reciprocal Lattice and X-ray diffraction

Diffraction of waves by crystals, Scattered wave amplitude, Reciprocal lattice vectors, Diffraction conditions, Laue equations, Brillouin Zones, Reciprocal lattice to sc lattice, X-ray Diffractometers, Fundamentals of powder X-ray diffraction. (10 Hours)

III. Basic Elements of Spectroscopy

Quantum states of electrons in atoms - Pauli's exclusion principle, calculation of spin-orbit interaction energy in one electron systems, fine structure of spectral lines in hydrogen and alkali atoms. Equivalent and non-equivalent electrons, two electron systems, interaction energy in LS and j j couplings, spectra of helium and alkaline earth elements. Normal and anomalous Zeeman effects, Stark effect, Paschen-Back effect (all in one electron system only).

Hyperfine structure of spectral lines - Calculation in one electron systems: Line broadening mechanisms - line shape functions for Doppler and natural broadening. (13 Hours).

IV. Microwave Spectroscopy

The rotation of molecules; Rotational spectra; diatomic molecules- The rigid diatomic molecule, intensity of spectral lines, The effect of isotopic substitution, Polyatomic molecules-linear, symmetric top, Technique and instrumentation of microwave spectroscopy. (10 Hours)

V. Laboratory Experiments

1. Y and σ-Interference Method (a) elliptical (b) hyperbolic fringes. To determine Y and σ of the material of the given specimen by observing the elliptical and hyperbolic fringes formed in an interference setup
2. Y & σ by Koenig's method.
3. Dielectric constant by Lecher wire - To determine the wavelength of the waves from the given RF oscillator and the dielectric constant of the given oil by measurement of a suitable capacitance by Lecher wire setup.
4. Constants of a thermocouple and temperature of inversion.
5. Susceptibility measurement by Quincke's and Guoy's methods - Paramagnetic susceptibility of salt and specimen.
6. Conductivity, Reflectivity, sheet resistance and refractive index of thin films.
7. Determination of Band gap energy of Ge and Si using diodes.
8. Thermionic work function - To determine the thermionic work function of the material of the cathode of the given vacuum diode/triode from the characteristic at different filament currents.
9. Ionic conductivity of KCl / NaCl crystals.
10. To study the Thermoluminescence of F-centres of Alkali Halides.
11. Variation of dielectric constant with temperature of a ferroelectric material (Barium Titanate).
12. Dielectric constant of a non-polar liquid.

Textbooks (Solid State Physics):

1. Introduction to Solid state Physics (7th Edition or above) Charles Kittel.
2. Solid State Physics, 3rd Edn. S O Pillai, New age international Pvt Ltd.
3. A text book of optics, Dr N Subrahmanyam Brijlal and Dr M N Avadhanulu, 23 Edn, S Chand Publishers.

References (Solid State Physics):

1. Solid state physics, M A Wahab, 3rd Edn, Narosa Publishers.
2. Solid state physics, Neil W Ashcroft, N David Mermin, Cengage learning publishers

Textbooks (Spectroscopy):

1. Introduction to Atomic Spectra, H. E. White, McGraw Hill.
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, Tata Mc-Grow Hill, 1996.

References (Spectroscopy):

1. Molecular structure and Spectroscopy, G Aruldas, Prentice Hall of India, 2002.
2. Spectroscopy- Vol. I and II, Straughan and Walker (Eds), Chapman and Hall.
3. Introduction to molecular spectroscopy, G. M. Barrow, McGraw Hill.

IPH6C303 **Credits: 4**

ELECTRONICS – I **T – P: 3 - 1**

	Course Outcome	**Cognitive level**
CO1	**Mastering Basic Electronics Concepts:** master the fundamental concepts of voltage and current sources, semiconductor properties and basic circuit theorems and their working principles.	Apply
CO2	**Proficiency in Transistor and Amplifier Technologies:** gain proficiency in the operation and application of transistor technologies, analyze various biasing techniques, AC models, and amplifier circuits, equipping them to design and optimize amplifier configurations for enhanced performance.	Apply
CO3	**Application of Digital Electronics Principles:** acquire skills in digital electronics, logic gates, Boolean algebra, and logic simplification techniques, apply these principles to design and test digital components facilitating the development of digital systems and circuits.	Analyze
CO4	**Integrate theoretical knowledge to practical electronics circuits:** design, troubleshoot, and optimize electronic circuits and systems in both lab-based and real-world scenarios.	Understand

I. Semiconductor Devices

Voltage and current sources, Thevenin's and Norton's Theorem, semiconductors, intrinsic and extrinsic semiconductors, diode forward and reverse characteristics, Half-wave and full wave rectifier, Zener diode and Zener regulator. **(10 Hours)**

II. Bipolar Junction Transistor Amplifier

Bipolar junction transistor, un-biased and biased transistor, transistor currents, CE connection, current gain, load line and operating point, transistor biasing: voltage-divider bias, ac modes:

emitter biased amplifier, ac models, T and PI transistor models. Voltage amplifiers: voltages gain, loading effect, multistage amplifiers, common collector amplifier, power amplifiers. **(13 hours)**

III. Field Effect Transistors and Operational Amplifiers

Field Effect Transistors: FETs and MOSFETS, Differential amplifiers, Operational Amplifier: 741, Oscillators: Wien-bridge oscillators, Active filters, Regulated power supplies: series and shunt regulators. **(10 Hours)**

IV. Digital Electronics

Analog and digital quantities, Logic Gates, Boolean Algebra and Logic simplification: De-Morgan's theorem, Karnaugh map, NAND and NOR gates, binary adder, Decoders and Encoders, Multiplexers and Demultiplexers, Flip-flops, Counters, registers and memories, Microprocessors and microcontrollers. **(12 Hours)**

Laboratory Experiments

13. I-V characteristics of diodes: forward & reverse (ordinary diodes, Zener diodes, LEDs (tri-colour) using ExpEYES or Seelab-3 module.
14. Construction of half-wave and full-wave rectifiers using ExpEYES or Seelab-3 module.
15. Construction of a DC power supply system using diodes, RC filter networks and ICs.
16. Construction of a Thevenin's equivalent circuit of a 4-bit digital to analog network.
17. Transistor input & output characteristics using ExpEYES or Seelab-3 module.
18. Construction of a CE amplifier and study dc characteristics.
19. Construction of a FET - CS amplifier and study dc characteristics.
20. Study of Digital Gates: OR, AND, NOT, NOR, EX-OR using ExpEYES or Seelab-3 module.
21. Construction of a CE amplifier circuit using ExpEYES or Seelab-3 module.
22. Study the DA convertor using ExpEYES or Seelab-3 module.
23. Study binary adder circuit using ExpEYES or Seelab-3 module.
24. Study of flip flops (binary SR/JK/JKMS) using ExpEYES or Seelab-3 module.

Text Books

5. Electronic Principles, Albert Malvino, David J. Bates, (SIE) | 7th or Higher Edition, Mc GrawHill Education.
6. Principles of Electronics, V. K. Mehta, Rohit Mehta, S. Chand & Company.
7. Digital Fundamentals, Floyd, 10th or Higher Edition, Pearson.
8. Digital Principles and Applications, Leach, Malvino and Saha, 6th or Higher Edition, TMH.

Books of Reference

7. Fundamentals of Microprocessors and Microcomputers, B. Ram, 2nd or Higher Edition, Dhanapathi Rai & Sons.
8. Microprocessor Architecture: Programming and applications with the 8085, Ramesh S. Gaonkar, New Age Publishers.
9. The 8051 Microcontroller, Kenneth J. Ayala, Thomson, Delmar Learning, 2nd Edition.
10. Electronic devices and circuit theory by Robert L. Boylstead & L. Nashelsky, Pearson Education.
11. ExpEYES (Experiments for Young Engineers and Scientists) manual, by CSpark Research, New Delhi.
12. Integrated Electronics, J. Millman and C. Halkias, TMH India

IPH6E301 **Credits: 4**

QUANTUM MECHANICS - II **T – P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Calculate the differential cross section of a scattering process	Analyze
CO2	Investigate quantum mechanical systems using time independent approximation methods	Apply
CO3	Investigate quantum mechanical systems using variational method	Apply
CO4	Analyze the energy and wave function of a system under the effect of harmonic perturbation	Analyze
CO5	Solve free Dirac and Klein – Gordon equation and interpret their solutions	Analyze

I. Scattering

cross section and scattering amplitude; Low energy scattering by a central potential; The method of partial waves; Phase shifts; Optical theorem, Convergence of partial wave series; Scattering by a rigid sphere; Scattering by a square well potential; High energy scattering; Scattering integral equation and Born approximation. **(10 hours)**

II. Time Independent Perturbation Theory

The WKB approximation, Connection formulae, Barrier tunneling, Application to decay- bound states, Penetration of a potential barrier,

Time- independent perturbation theory, Non-degenerate and degenerate cases, Anharmonic oscillator, Stark and Zeeman effects in hydrogen. **(13 hours)**

III. Variational Method

The variational equation, ground state and excited states, the variation method for bound states, Application to ground state of the hydrogen and helium atoms. **(7 hours)**

IV. Time Dependent Perturbation Theory

Transition probability, Harmonic perturbation, Interaction of an atom with the electromagnetic field, Induced emission and absorption, The dipole approximation, The Born approximation and scattering amplitude. **(12 hours)**

V. Relativistic Quantum Mechanics

The Dirac equation, Dirac matrices, Solution of the free-particle Dirac equation, Equation of continuity, Spin of the electron, Non-realistic limit, Spin-orbit coupling, Covariance of the Dirac equation, Bilinear covariants, Hole theory, The Weyl equation equation for the neutrino, Non-conservation of parity, The Klein Gordon equation, Charge and current densities, The Klein-Gordon equation, Charge and current densities, The Klein -Gordon equation equation with potentials, Wave equation for the photon, Charge conjugation for the Dirac, Weyl and Klein Gordon equation. **(18 hours)**

Text books

3. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Second Edition, John Wily & Sons Ltd, 2009.
4. Quantum Mechanics, V. K. Thankappan, Second Edition, New Age International Publishers, 1993.
5. Introduction to Quantum Mechanics, David J. Griffiths, Second Edition, Pearson education International, 2005.
6. Principles of Quantum Mechanics, R. Shankar, Second Edition, Kluwer Academic/ Plenum Publishers, 1994

Reference books

3. Quantum Mechanics in Simple Matrix Form, Thomas E Jordan, John Wiley & Sons Ltd, 1986.
4. Quantum Mechanics, Volumes I and II, Claude Cohen Tannoudji, Bernard Diu and Frank Laloe, 1996.
5. Quantum Mechanics, L. I. Schiff, McGraw Hill, 1968.
6. Modern Quantum Mechanics, J. J. Sakurai, Addison-Wesley, 2010.
7. Relativistic Quantum Mechanics, J. D. Bjorken and S. D. Drell, McGraw Hill, 1998
8. A Textbook of Quantum Mechanics, P. M. Mathews and K. Venkatesan, Tata McGraw Hill, 1978.

IPH6E302 **Credits: 4**

EXPERIMENTAL TECHNIQUES **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Explain vacuum, Gauges to measure vacuum, types of pumps and their utility, cryogenics etc.	Understand
CO2	Demonstrate different thin film fabrication techniques, thickness measurement and application of thin films.	Apply
CO3	Analyze different types of particle accelerators and their working and specific applications.	Analyze
CO4	Analyze using different nuclear techniques.	Analyze
CO5	Apply X-ray techniques to characterize materials.	Apply

I. Vacuum Techniques

Units and basic definitions, Roughing pumps - Oil sealed rotary vacuum pump and Sorption pump, High vacuum pumps – Turbo molecular pump, Diffusion pump, Oil vapour booster pump, Ion pumps - Sputter ion pump and Getter ion pump, Cryo pump, Vacuum guages - Pirani gauge, Thermocouple gauge, penning guage (Cold cathode Ionization guage) and Hot filament ionization gauge, Vacuum accessories – Diaphragm, Gate valve, Butterfly valve, Baffle and isolation valves, magnetic valves, adjustable valves, air inlet valves, Traps - Liquid nitrogen trap, Sorption traps, and gaskets and O rings. **(15 hours)**

Text: Book 1

II. Thin film techniques

Introduction, Fabrication of thin films, Thermal evaporation in vacuum – Resistive heating, Electron beam evaporation and laser evaporation techniques, Sputter deposition, Glow discharge, Thickness measurement by quartz crystal monitor, optical interference method, electrical conductivity measurement, Thermo electric power, Interference filters - Multi layer optical filters, Technological Applications of thin films. **(12 hours)**

Text: Book 1

III. Accelerator techniques

High voltage DC accelerators, Cascade generator, Van de Graaff accelerator, Tandem Van de Graaff accelerator, Linear accelerator, Cyclotron, Synchrotron (Electron and proton), Ion sources – Ionization processes, simple ion source, ion plasma source and RF ion source, Ion implantation – techniques and profiles, Ion beam sputtering– principles and applications. **(12 hours)**

Text: Book 1

IV. Materials Analysis by nuclear techniques

Introduction, Basic principles and requirements, General experimental setup, mathematical basis and nuclear reaction kinematics, Rutherford backscattering – introduction, Theoretical background – classical and quantum mechanical, experimental set up, energy loss and straggling and applications. Neutron activation analysis – principles and experimental arrangement, applications, Proton induced X-ray Emission – principle and experimental set up, applications to water samples, human hair samples and forensic samples, limitations of PIXE. **(12 hours)**

V. X- Ray Diffraction Technique

Introduction, Lattice planes and Bragg's Law, Diffractometer - Instrumentation, Single crystal and Powder diffraction, Scherrer equation, Structure factor, Applications of XRD - Crystallinity, Unit Cell Parameters, Phase transition studies, thin film studies, Awareness on Powder Diffraction File (PDF) of the International Centre for Diffraction Data. **(9 hours)**

Text: Book 2

Text Books

1. Advanced Experimental Techniques in Modern Physics, K. Muraleedhara Varier, Antony Joseph and P. P. Pradyumnan, Pragati Prakashan, Meerut, 2006 (Book 1).
2. Elements of Modern X-ray Physics, Jens Als Nielsen and Des McMorrow, John Wiley and Sons 2000 (Book 2)

Reference Books:

1. Scientific foundations of vacuum techniques – S. Dushman and J.M. Laffer, John Wiley New York (1962).
2. Thin film phenomena – K.L. Chopra, Mc Graw Hill (1983).
3. R. Sreenivasan – Approach to absolute zero - Resonance magazine Vol 1 no 12 , vol 2 nos 2, 6 and 10.
4. R. Berry, P.M. Hall and M.T. Harris – Thin film technology – Van Nostrand (1968).
5. Dennis and Heppel – Vacuum system design.
6. Nuclear Micro analysis – V. Valkovic.
7. B.D. Cullity, Elements of X-ray diffraction, Addison Wesley Inc (1978).
8. Useful Link for XRD- http://pd.chem.ucl.ac.uk/pdnn/powintro/whatdiff.htm

IPH6E303 **Credits: 4**

MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE **T - P: 4-0**

	Course Outcome	Cognitive level
CO1	Master the fundamental concepts and algorithms of machine learning, including supervised and unsupervised learning, enabling the analysis and modeling of complex data.	Understand
CO2	Develop skills in applying AI techniques such as neural networks, deep learning, and reinforcement learning to solve problems in physics, enhancing their capability to handle large datasets and perform predictive modeling	Apply
CO3	Integrate theoretical knowledge with practical skills to design, implement, and optimize machine learning models and AI systems for real-world physics applications.	Create
CO4	Acquire proficiency in evaluating model performance, hyperparameter tuning, and deploying machine learning models, ensuring the effectiveness and efficiency of AI systems in various physics applications.	Evaluate

I. Introduction to Machine Learning

Overview of machine learning and its applications in physics. Supervised learning: regression, classification, decision trees, and support vector machines. Unsupervised learning: clustering, dimensionality reduction (PCA, LDA). **(12 hours)**

II. Neural Networks and Deep Learning

Basics of neural networks: perceptrons, activation functions, backpropagation, Deep learning architectures: convolutional neural networks (CNNs), recurrent neural networks (RNNs), Training deep networks: optimization techniques, regularization, dropout. **(12 hours)**

III. Reinforcement Learning

Fundamentals of reinforcement learning: Markov decision processes, policy and value functions, Basic algorithms: Q-learning, SARSA, Deep Q-Networks (DQN), Applications of reinforcement learning in physics simulations. **(12 hours)**

IV. Advanced AI Techniques

Natural Language Processing (NLP): text processing, sentiment analysis, language models, Generative models: Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs). AI in scientific computing: automated data analysis, AI-driven experiments. **(12 hours)**

V. Practical Implementations and Projects

Implementing machine learning models using Python libraries (NumPy, SciPy, Scikit-Learn, TensorFlow, PyTorch).

Case studies and projects: applying machine learning and AI techniques to real-world physics problems.

Evaluating model performance, hyperparameter tuning, and deployment. (12 hours)

Text Books:

1. Pattern Recognition and Machine Learning, Bishop, Springer
2. Deep Learning, Goodfellow, Bengio, and Courville, MIT Press
3. Machine Learning: A Probabilistic Perspective, Murphy, MIT Press.
4. Artificial Intelligence: A Modern Approach, Russell and Norvig, Pearson.

Reference Books:

1. The Elements of Statistical Learning, Hastie, Tibshirani, and Friedman, Springer.
2. Deep Learning with Python, Chollet, Manning Publications.
3. Reinforcement Learning: An Introduction, Sutton and Barto, MIT Press.
4. Speech and Language Processing, Jurafsky and Martin, Pearson.

IPH6E304 **Credits: 4**

ELECTRODYNAMICS - II **T - P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Design electrical circuits	Apply
CO2	Solving boundary value problems using special techniques	Apply
CO3	Analyze transmission of electromagnetic waves in vacuum and also through different media	Analyze
CO4	Analyze the radiation from a moving charge	Analyze

I. Electromagnetic Induction

Ohm's law, electromotive force, motional emf, Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils - Growth and decay of current in LR and CR circuits - measurement of high resistance by leakage - growth of charge and discharge of a capacitor through LCR circuit - theory of BG - measurement of charge sensitiveness, calibrating the BG, HMS. **(10 hours)**

II. Transient Currents and Network theorems

Production of AC, RMS and peak values, AC through L, C, R, LC, CR, LR and LCR - resonance and half power frequency, Q factor - Power in AC-power factor AC bridges - Anderson and Rayleigh bridge. Kirchhoff's laws, Voltage sign and current direction, Solution of simultaneous equations using determinants, Source conversion, Superposition theorem, Ideal equivalent circuits, Thevenin's theorem,- Norton's theorem, Maximum power transfer theorem. **(12 hours)**

III. Electrodynamics

Faraday's law, induced electric field, inductance, energy in magnetic fields - Maxwell's equations, Maxwell's modification of Ampere's law, Potential functions, Gauge transformations and gauge fixing, Maxwell's equations and magnetic charges, Maxwell's equations inside matter, Boundary conditions, uniqueness theorem, Method of images with simple examples, Multipole expansion, Ponderable media, Dielectrics. **(14 hours)**

IV. Electromagnetic waves

Waves in one dimension, The wave equation, sinusoidal waves, boundary conditions: Electromagnetic waves in vacuum, Wave equation for E and B, monochromatic plane waves in vacuum, energy and momentum of E.M. waves, Poynting vector - Electromagnetic waves in matter, Propagation through linear media, Plane waves in non-conducting medium, Polarization, Reflection and Refraction, Dispersion in dielectrics, conductors and plasma, Superposition of waves, Group velocity, Kramers-Kronig relations. **(14 hours)**

V. Electromagnetic Radiation

Radiation from moving point charge, electric and magnetic dipole radiation, radiation from an arbitrary source, radiation reaction and its physical basis. Antenna – fundamentals, directional properties of dipole antennas, travelling wave antennas. **(10 hours)**

Text Books:

1. Classical Electrodynamics, J. D. Jackson, 3rd Ed., Wiley, 1999.
2. Introductory Electrodynamics, David Griffiths, 4th Ed.,Prentice Hall of India, 2012.
3. Electricity and Magnetism by R. Murugeshan.
4. Text book of Electrical technology Volume 1-Basics of Electrical Engineering by B. L Theraja and A. K Theraja.
5. Field and Wave Electromagnetics, David K. Cheng, 2nd Ed., Addisson Wesley.

IPH6E305 **Credits: 4**

PLASMA PHYSICS **T - P: 4 - 0**

	Course Outcome:	Cognitive level
CO1	Explore the motion of plasma particles in electric and magnetic fields. Enable to identify adiabatic invariants.	Analyze
CO2	Apply the principles of electrodynamics to understand the production and propagation of waves in plasma	Apply.
CO3	Analyze the factors affecting instability of plasma.	Analyze
CO4	Analyze Landau damping and its effects in plasma.	Analyze
CO5	Explain free electron laser action in plasma. Analyzes the hurdles in plasma confinement.	Analyze.

I. Introduction to Plasma Physics

Existence of plasma, Definition of Plasma, Debye shielding 1D and 3D, Criteria for plasma, Applications of Plasma Physics (in brief), Single Particle motions -Uniform E & B fields, Non-uniform B field, Non uniform E field, Time varying E field, Adiabatic invariants and applications. **(14 hours)**

II. **Plasma as Fluids and waves in plasma**

Introduction –The set of fluid equations, Maxwell's equations, Fluid drifts perpendicular to B, Fluid drifts parallel to B, The plasma approximations , Waves in Plasma - Waves, Group velocity, Phase velocity, Plasma oscillations, Electron Plasma Waves. **(10 hours)**

III. Waves in Plasma

Sound waves, Ion waves, Validity of Plasma approximations, Comparison of ion and electron waves, Electrostatic electron oscillations with B, Electrostatic ion waves with B, The lower hybrid frequency, Electromagnetic waves with B0, Cutoffs and Resonances, Electromagnetic waves parallel to B0, Experimental consequences, Hydromagnetic waves, Magnetosonic waves, The CMA diagrams. **(10 hours)**

IV. Equilibrium and stability

Hydro magnetic equilibrium, The concept of diffusion of magnetic field into plasma, Classification of instability, Two stream instability, the gravitational instability, Resistive drift waves, the Weibel instability. **(12 hours)**

V. Kinetic Theory

The meaning of f(v), Equations of kinetic theory, Derivation of the fluid equations, Plasma oscillations and Landau damping, the meaning of Landau damping, Physical derivation of Landau damping, Ion Landau damping, Kinetic effects in a magnetic field, Plasma confinements (qualitative idea only). **(12 hours)**

Text Books:

1. Introduction to Plasma Physics and Controlled Fusion, F. F. Chen, Volume I and II, Springer, 2006.

Books for Reference:

1. Classical Electrodynamics, J. D. Jackson, Wiley Eastern, 1978.
2. Introduction to Plasma Theory, D. R. Nicholson
3. Principles of Plasma Physics N. A. Krall and A. W. Trivelpiece, McGraw-Hill (Recent edition).

IPH6E306 **Credits: 4**

GROUP THEORY AND APPLICATIONS **T – P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Describe the groups and subgroups	Understand
CO2	Analyze the applications of Symmetry groups	Analyze
CO3	Analyze the applications of finite groups	Understand
CO4	Evaluate the applications of group theory in quantum mechanical problems	Evaluate

I. Introduction

Definition of a Group, Subgroups, Conjugacy Classes, Homomorphism of Groups, The Symmetric Group, Direct and Semi-direct Products. **(8 hours)**

II. Molecular Symmetry

Elements of Molecular Symmetry, The Symmetry Group of a Molecule, Symmetry Point Groups. **(8 hours)**

III. Representations of Finite Groups

Vector Spaces, Group Action on Vector Spaces, Reducible and Irreducible Representations, Irreducible Representations of Point Groups, The Regular Representation, Tensor Product of Representations, Decomposition of Reducible Representations, Irreducible Representations of Direct Products, Induced Representations. **(16 hours)**

IV. Elementary Applications - I

General considerations, Level Splitting under Perturbation, Selection Rules, Molecular Vibrations. **(8 hours)**

V. Elementary Applications - II

Young tableau and its uses for Clebsch-Gordon decomposition. Classification of elementary particles in terms of representations of SU(3), SU(4) and SU(6), Dynamical symmetries, symmetry group of hydrogen atom. **(20 hours)**

Book of Study:

1. Group Theory for Physicists with Applications, Pichai Ramadevi and Varun Dubey, Cambridge University Press, 2019.
2. Classical Groups, Wybourne.
3. Lie Groups & their Lie Algebra Gilmore.
4. Continuous Groups of Transformations Eisenhart

Reference Books:

1. Chemical group theory, Techniques and applications, D. Monchev and D. H. Rauvray, Gordon and Breach Publishers.
2. Chemical group theory: introduction and fundamentals, D. Monchev and D. H. Rauvray, Gordon and Breach Publishers.

IPH6S301 **Credits: 3**

OPTICAL INSTRUMENTATION **T – P: 3 - 0**

	Course Outcome	**Cognitive level**
CO1	To provide students with a fundamental understanding of optical components and systems.	Understand
CO2	To equip students with practical skills in setting up, aligning, and calibrating optical instruments..	Apply
CO3	To introduce laser applications in measurement, communication, and industrial processes.	Apply
CO4	To prepare students for careers in optics by providing hands-on experience with laser and fiber optic technologies.	Apply

I. Fundamentals of Optical Instrumentation

Optical Components and Systems: Lenses, mirrors, prisms, gratings, and optical filters, Lasers in Optical Systems: Principles of laser operation, types of lasers (He-Ne, semiconductor, fiber lasers), Introduction to Optical Measurement Systems: Overview of instruments such as spectrometers, interferometers, and polarimeters, Laser Safety: Understanding laser safety protocols, including handling high-power lasers, goggles, and beam enclosures.

Practical:

- Setting up basic optical experiments using lenses, mirrors, and prisms.
- Measuring beam properties (divergence, intensity) from He-Ne or diode lasers. **(12 hours)**

II. Laser Alignment, Calibration, and Fiber Optics

Laser Alignment Techniques: Best practices for laser beam alignment, adjusting for parallelism and focus, Calibration of Optical Systems: Methods for calibrating spectrometers, interferometers, and optical sensors, Introduction to Fiber Optics:

Types of optical fibers, light propagation through fibers, and fiber optic sensors, Fiber Coupling Techniques: Efficient coupling of laser light into optical fibers for minimal signal loss.

Practical:

- Aligning a laser beam through multiple optical components.
- Calibrating an optical setup for experiments like Young's double-slit experiment.
- Experimenting with light transmission in single-mode and multimode optical fibers. **(12 hours)**

III. Measurement Techniques and Laser Applications

Interferometry: Michelson and Fabry-Pérot interferometers for precise distance and refractive index measurements, Laser Doppler Velocimetry (LDV): Applications in fluid mechanics and material strain measurements, Laser-Based Distance Measurement: Using time-of-flight (TOF) lasers for non-contact measurements, Optical Communication Systems: Principles of data transmission using fiber optics, including signal loss and dispersion.

Practical:

- Setting up a Michelson interferometer for measuring the wavelength of light.
- Using laser distance sensors for accurate rangefinding.
- Measuring the numerical aperture of an optical fiber using a laser diode**.**

(12 hours)

IV. Advanced Applications and Industrial Uses of Lasers

Laser Cutting and Welding: Principles of laser-material interaction, industrial lasers used for machining and fabrication, Lasers in Biomedical Applications: Use of lasers in medical imaging, surgery, and diagnostics, Holography and 3D Imaging: Basics of holography and laser-based 3D imaging technologies, Simulation-Based Learning: Applying reinforcement learning and genetic algorithms to optimize simulations.

Practical:

- Demonstrating laser cutting on various materials using low-power laser systems.
- Setting up a basic holography experiment using a laser and photographic plates.
- Using laser-based techniques to simulate physical systems. **(12 hours)**

References:

1. Optics by Ajoy Ghatak, 7th Edition, Pearson.
2. Laser Fundamentals by William T. Silfvast, Cambridge University Press.
3. Optical Electronics by A. Yariv, 5th Edition, Oxford University Press.
4. Fundamentals of Photonics by Bahaa E. A. Saleh and Malvin Teich, Wiley.

IPH6I301 **Credits: 2**

SUMMER INTERNSHIP

The internship can be experimental or theoretical. The projects may be carried out either utilizing the facilities in the Department or elsewhere. They should obtain an attendance certificate from the outside institution where the work is carried out and also a certificate in the Internship Report that the work had been carried out by the concerned student at that institution/industry. The students shall prepare a detailed report on their work. This shall be attested by the teacher-in-charge concerned at the center (and the relevant authority at the external institution, if the work had been carried out at some other centre/industry). The students shall submit the internship report before the commencement of the next semester. Summer Internship. A presentation of the project and a comprehensive viva voce on the project will be held and evaluated by a committee consist of supervisor, HoD and an internal examiner. The Project does not carry CE component.

IPH7C501 **Credits: 4**

NUCLEAR AND PARTICLE PHYSICS **T-P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Analyze fundamental properties of nuclear force and nature of binding of the nucleons	Understand
CO2	Interpret various properties of nuclei in terms of proposed models and estimate the energy released in various nuclear phenomena	Apply
CO3	Understand the working of various radiation detectors and estimate the radioactivity of materials	Apply
CO4	Analyze the classification of elementary particle in terms of their fundamental characteristics and interactions.	Analyze

I. Nuclear Forces

The deuteron and two-nucleon scattering experimental data, Simple theory of the deuteron structure, Low energy n-p scattering, characteristics of nuclear forces, Spin dependence, Tensor force, Scattering cross sections, Partial waves, Phase shift, Singlet and triplet potentials, Effective range theory, p-p scattering. **(10 hours)**

Text: Book 1

II. Nuclear Models, Fission and Fusion

Shell model potential, Valence Nucleons, Spin-orbit potential, Magnetic dipole moments, Electric quadrupole moments, limitations, Collective structure, Nuclear vibrations, Nuclear rotations, Liquid drop Model, Semi-empirical Mass formula, stability of the nucleus, Energetics of Fission process, Controlled Fission reactions, reactor stability, Fusion process, Characteristics of fusion, solar fusion, Controlled fusion reactors. **(12 hours)**

Text: Book 1

III. Nuclear Decay

Basics of alpha decay and theory of alpha emission, Beta decay, Energetics of beta decay, Fermi theory of beta decay, Comparative half-life, Allowed and forbidden transitions, Selection rules, Parity violation in beta decay. Neutrino-characteristics. Energetics of Gamma Decay, Multipole moments, Decay rate, Angular momentum and parity selection rules, Internal conversion, Lifetimes. **(12 hours)**

Text: Book 1

IV. Nuclear Radiation Detectors and Nuclear Electronics: Gas detectors – Characteristics, Ionization chamber, 4p counters, Proportional counter and G M counter, Scintillation detector, Photo Multiplier Tube (PMT), Semiconductor detectors – Ge(Li), Si(Li) and surface barrier detectors, Detector efficiency, intrinsic and geometry depend and efficiency Preamplifiers, Amplifiers, Single channel Analyzers, Multi- channel Analyzers, counting statistics, energy measurements, timing measurements, 4p measurements. **(12 hours)**

Text: Book 2

V. Particle Physics: Four basic forces - Gravitational, Electromagnetic, Weak and Strong - Relative strengths, Classification of particles, Yukawa's theory, Conservation of energy and masses, Electric charges, Conservation of angular momentum, Baryon and lepton numbers, Conservation of strangeness, Conservation of isospin and its components, Conservation of parity, Charge conjugation, CP violation, time reversal and CPT theorem. Extremely short lived particles, Resonances - detecting methods and experiments, Internal symmetry, The Sakata model, SU (3), The eight fold way, Gellmann and Okubo mass formula, Quarks and quark model, Confined quarks, Experimental evidence, Coloured quarks. **(14 hours)**

Text Book: Book 3

Text Books:

1. Introductory Nuclear Physics, K. S. Krane, Wiley.
2. Nuclear Radiation Detectors, S. S. Kapoor and V. S. Ramamurthy, Wiley.
3. The particle hunters, Y. Neeman and Y. Kirsh, Cambridge University Press

Books for Reference:

1. Nuclear Physics – Experimental and theoretical, H. S. Hans, New Age International, 2001).
2. Radiation Detection and Measurement, G. F. Knoll, Fourth Edition, Wiley, 2011.
3. The ideas of particle physics – an introduction for scientists, G. D. Couoghlan, J. E. Dodd and B. M. Gripalos, Cambridge Press

4. Introduction to elementary particles, David Griffiths, Wiley, 1989.
5. An Introduction to Nuclear Physics, S. B. Patel, New Age International Publishers
6. Introductory Nuclear Physics, Samuel S. M. Wong, Prentice Hall, India.
7. Concepts of Nuclear Physics, B. L. Cohen, Tata McGraw Hill.
8. Nuclei and Particles, E. Segre, Benjamin, 1967.
9. Nuclear Radiation Detection: Measurement and Analysis, K Muraleedhara Varier, Narosa.

IPH7C502 **Credits: 4**

MODERN PHYSICS AND ELECTRONICS LAB **T - P: 0 – 4**

	Course Outcome	Cognitive level
CO1	Demonstrate skills to set up and perform experiments to test fundamental quantum mechanics	Evaluate
CO2	Demonstrate skills to set up and perform experiments to test electronics	Evaluate

I. Modern Physics laboratory Experiments

1. Ultrasonic interferometer – velocity of sound in liquids - To determine the velocity of ultra sonic waves in the given liquid and hence the compressibility.
2. Determination of band gap energy in Si and Ge by Four probe method.
3. Absorption spectrum of KMnO4 - To determine the wavelengths of the absorption bands for KMnO4 solution.
4. Hall effect in semiconductors - To determine the carrier concentration in the given specimen of semiconducting material by means of the Hall effect.
5. Photoelectric effect - Determination of Planck’s constant (White light and filters or LEDs of different colours may be used).
6. Thomson’s e/m measurement - To determine the charge to mass ratio of the electron by Thomson’s method using a CRT.
7. Frank-Hertz experiment - To measure the critical ionization potentials of Mercury by drawing current vs. applied voltage in a discharge tube.
8. ESR spectrometer – Determination of g factor.
9. Thermionic work function - To determine the thermionic work function of the material of the cathode of the given vacuum diode/triode from the characteristics at different filament currents.
10. Optical fibre characteristics - To determine the numerical aperture, attenuation and band width of the given optical fibre specimen.
11. Study of LED characteristics - Determination of wavelength of emission, I-V characteristics and variation with temperature, variation of output power vs. applied voltage.

12. Fabry Perot etalon - Determination of wavelength and thickness of air film.
13. Thermo emf of bulk samples – Al, Cu, Brass etc.
14. Determine the thermal conductivity of the given bulk specimen using the given setup.
15. Zener voltage characteristics at low and ambient temperatures - To study the variation of the Zener voltage of the given Zener diode with temperature.
16. Study of LED characteristics - Determination of wavelength of emission, I-V characteristics and variation with temperature, variation of output power vs. applied voltage.
17. Plot the characteristic curve of a gaseous detector -GM counter.
18. Verify inverse square law for radiation detector.
19. Find the counting statistics for GM counter.
20. Find dead time and resolving time of a GM counter.
21. Determine the resolution of a scintillation detector

II. Electronics Laboratory Experiments

1. Voltage Regulator

   a) Half-wave and full-wave rectifier experiments with ExpEYES-17 kit.

   b) Diode I-V characteristics (ExpEYES-17) and voltage regulation using transistors with feedback (regulation characteristics with load for different input voltages and variation of ripple factor with load)

   c) Diode I-V characteristics (ExpEYES-17) and voltage regulation using Op Amp with feedback (regulation characteristics with load for different input voltages and variation of ripple factor with load

2. BJT Amplifier

   a) CE input and output characteristics with ExpEYES-17 kit and transistor characteristics.

   b) Single stage RC coupled amplifier with and without Negative feedback (input, output resistance, frequency response)

   c) Two stage RC coupled amplifier (input and output resistance and frequency response including Bode plots)

   d) Complementary symmetry Class B push-pull power amplifier (transformerless) (I/O impedances, efficiency and frequency response)

   e) Darlington pair amplifier (gain, frequency response, input &output resistances)

   f) Differential amplifier using transistors (I/O impedances, frequency response, CMRR)

   g) Bootstrap Amplifier (frequency response, input & output resistance)

   h) Two-stage IF amplifier (Gain and frequency response, bandwidth)

   i) Amplitude modulation and detection using transistors (modulation index & recovery of modulating signal)

3. FET and MOSFET

    a) RC coupled FET amplifier - common source (frequency response, input & output impedances).

    b) MOSFET amplifier (frequency response, input & output impedances).

    c) UJT characteristics and relaxation oscillator (construct relaxation oscillator & sharp pulse generator)

    d) Characteristics of a Silicon controlled rectifier (Half-wave and full wave) Negative resistance oscillator. (for different frequencies)

4. Operational Amplifiers

    a) Use of IC 741 - Determination of input offset voltage, current, CMRR, slew rate, and use as Inverting and non-inverting amplifier and difference amplifier, summing amplifier and comparator.

    b) Sawtooth generator using transistors and Miller sweep circuit using OPAMPS (for different frequencies)

    c) Schmidt trigger using transistors and OPAMPS - Trace hysteresis curve, determine LTP and UTP.

    d) Analog integration and differentiation using OPAMPS (study the integrator characteristics & differentiator).

    e) Analog computation using OPAMPS (LM324) Differential equations / Simultaneous equations.

    f) Second order Low pass, High Pass and Band Pass filters using OPAMP (study the frequency response).

    g) Square, Triangular and Saw tooth generator, Voltage controlled oscillator using Op Amp (Refer R. A. Gayakwad, Ch.8).

    h) IC 555 Timer circuit- Astable and monostable multi vibrators,

    i) IC 555 Timer circuit -VCO missing pulse detector and sawtooth generator.

    j) Op-Amp experiments with ExpEYES-17: Inverting & non-inverting amplifiers, RC differentiation and integration amplifiers.

    k) IC555 oscillator experiments with ExpEYES-17:

5. Oscillators

    a) Wien bridge oscillator using OP AMP (For different frequencies, distortion due to feedback resistor, compare with design values)

    b) Phase shift and Quadrature oscillator with OP AMP (Refer R. A. Gayakwad)

    c) Crystal Oscillator (for different frequencies & evaluation of frequency stability)

6. Digital Circuits, Microprocessors and Microcontrollers

a) Logic gates experiments with ExpEYES-17 kit: AND, OR, EX-OR, NOT gates, Clock divider etc.

b) Operation and working of Arithmetic and Logic circuits IC 7483, IC 74181

c) Shift registers IC 74166 and IC 74198 with ExpEYES-17 or other kits.

d) Counters IC 7490 A, IC 7493 A, IC 74193 with ExpEYES-17 or other kits

e) Organize M X N random access memory with basic memory unit (Verify the READ and WRITE operations)

f) Microprocessors experiments (simple experiments) addition, subtraction, multiplication and division using 8085

g) Square wave generation using Microprocessor 8085 and programmable peripheral interface 8255.

h) Programming Atmel microcontroller (square wave generation, sine wave generation with inbuilt D/A converter)

i) Programming experiments with Atmega32 microcontroller training kit, KuttyPy: 8bit-LED operations, A/D and D/A convertor, square wave generation etc.

Mini-Project

(Students have to do a mini electronic project leading to understanding and applications of the theory. A few examples are given below. They can choose other projects in consultation with the teacher-in-charge.

1. Construction of a complete power supply circuit.
2. Experimental projects / coding with ExpEYES-17 kit.
3. Microcontroller projects with KuttyPy kit.

IPH7C503 **Credits: 4**

ELECTRONICS - II **T– P: 4– 0**

	Course Outcome	**Cognitive level**
CO1	Master the operation and application of transistor technologies, operational amplifiers, and digital logic circuits, enabling the design and analysis of amplifiers, signal processors, and control systems.	Analysis
CO2	Acquire skills in programming and deploying microprocessors and microcontrollers, particularly focusing on assembly language and embedded C programming for the AVR architecture, to implement real-world applications and devices.	Apply
CO3	Integrate theoretical knowledge from physics and electronics to design, troubleshoot, and optimize electronic circuits and systems, enhancing their functionality and efficiency in lab-based and real-world scenarios	Analyze
CO4	Analyze arithmetic circuits, flip-flops, registers, counters, D/A-A/D converters, arithmetic and logic units, and memory organization, and their implementation in digital systems.	Analyze
CO5	Analyze various amplifier configurations, analog integrators, differentiators, electronic analog computation, active filters, oscillators, comparators, zero crossing detectors, and Schmitt triggers to enhance performance and application	Analyze

I. Transistor Amplifiers

BJT: Biasing and AC models, voltage amplifiers, power amplifiers, emitter follower, **FET**: H-parameters, FET small signal model, biasing the FET, analysis of common source and common drain amplifiers at low and high frequencies, FET as VVR and its applications, **MOSFET**: Circuit symbol and equations, small signal model, CMOS and Digital MOSFET gates. **(12 hours)**

II. Operational Amplifier:

Covers dual input differential amplifier DC and AC analysis, Op-Amp block diagram representation, analysis of a typical Op-Amp equivalent circuit, and open loop configurations. Discusses Op-Amp parameters and applications with negative feedback. **(12 hours)**

III. OPAMP Applications:
Focuses on various amplifier configurations, analog integrators and differentiators, electronic analog computation, active filters, oscillators, comparators, zero crossing detectors, and Schmitt triggers. **(12 hours)**

IV. Digital Electronics (12 hours): Includes arithmetic circuits, flip-flops, various types of registers, counters, and D/A-A/D converters, arithmetic and logic unit, memory organization. **(12 hours)**

V. Microprocessors and Microcontroller: Examines the architecture of the 8085 microprocessor, microcontroller basics, registers and memory, assembly language programming and introduces AVR microcontroller, registers, memory, programming and applications. **(12 hours)**

Text Books:

1. Malvino, Electronic Principles, 6th Edition, TMH India
2. Integrated Electronics, Millman and Halkias, TMH India
3. Op-Amps and Linear Integrated Circuits, R. A. Gayakwad, 3rd Edition, PHI
4. Fundamentals of Microprocessors and Microcomputers, 2nd Edition, B. Ram, Dhanapathi Rai & Sons.
5. The AVR Microcontroller and Embedded Systems: Using Assembly and C, Mazidi & Mazidi, Prentice Hall)

Reference Books:

1. Electronic Devices and Circuit Theory, Robert L. Boylstead & L. Nashelsky, Pearson Education).
2. Electronic Devices, Floyd, 5th Edition, Pearson Education.
3. Microelectronic Circuits: Analysis & Design, M. H. Rashid, PWS Publishing Company
4. Linear Integrated Circuits, D. R. Choudhuri, S. Jain, New Age International Publishers
5. Embedded C Programming and the Atmel AVR, Barnett, O’cull, Cox, Cengage Learning

IPH7E501 **Credits: 4**

OPTOELECTRONICS **T-P: 4-0**

	Course Outcome	Cognitive level
CO1	A fundamental understanding of semiconductor physics - enabling learners to analyze the behaviour of semiconducting materials and explore their applications in various optoelectronic devices.	Understanding
CO2	Develop an understanding of how light interacts with electrons in semiconductors. Students will gain knowledge of fundamental processes that are crucial for the development and operation of various optoelectronic devices.	Understanding
CO3	Learners will learn about light detection and emission and how these principles are utilized in various technologies, from imaging sensors and solar cells to optical communication and semiconductor lasers.	Understanding
CO4	Differentiate between the function and science of different optoelectronic devices.	Analyze
CO5	Learners will develop the critical thinking and analytical skills to design, optimize, and implement LEDs for various applications.	Analyze

I. Semiconductor physics for optoelectronics

Classification; Intrinsic and extrinsic semiconductors; Energy band diagrams; The density of States; electrical conductivity and conduction mechanism in semiconductors; Fermi level in intrinsic and extrinsic semiconductors and its dependence on temperature and carrier concentration. Carrier generation – recombination, mobility, drift-diffusion current; Semiconductors compensation doping; nondegenerate and degenerate semiconductors; Direct Band and Indirect band semiconductors: E-K Diagrams; compound semiconductors, III-V and II-VI compounds, ZnO, ITO, GaN. **(13 hours)**

II. Basics of optoelectronics

Emission and absorption processes; Photon statistics; The behaviour of electrons; Electrons in a periodic lattice; The absorption and emission of light by semiconductors; Fluorescence; Scattering; Photoluminescence and Electroluminescence. **(11 hours)**

III. Photodetectors

Photodetectors; Imaging sensors; CCD and CMOS sensors, sensing and imaging in different regions of e. m. spectrum; Photodiodes; avalanche and heterojunction photodiodes, phototransistors, photoconductive gain; photovoltaic effects; Solar Cells. **(12 hours)**

IV. Optical systems for communication

Optical systems for communication; Photonic lattice and other low-dimensional materials for optoelectronic applications; Semiconductor lasers; Population Inversion at a Junction; emission Spectra for p-n Junction Lasers; The Basic Semiconductor Laser; heterojunction Lasers. **(10 hours)**

V. Light-emitting Diodes

Visible light-emitting diodes; Physics of LEDs; Optical properties of LEDs; Radiative and non-radiative recombination; Electrical properties; Current-voltage characteristics; Efficiencies; Material systems for visible LEDs; GaP and GaAsP, AlGaAs/GaAs, AlGaInP/GaAs, InGaN; High-efficiency LEDs and novel technologies; White LED; White light; Phosphor-converted white LEDs; Multi-chip white; Applications of LEDs; Packaging of LEDs. **(14 hours)**

Text Books:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson, 2nd Ed., 2013.
2. Solid State Electronic Devices, Ben G. Streetman and S K Banerjee Pearson, 7th Ed., 2016

References:

1. Handbook of Optoelectronics Volume I, John P Dakin & Robert G W Brown, 2006 by Taylor & Francis Group.
2. S. M. Sze and K. N. Kwok, “Physics of Semiconductor Devices,” 3rd edition, John Wiley & Sons, 2006

IPH7E502 **Credits: 4**

ASTROPHYSICS **T - P: 4 - 0**

	Course Outcome:	**Cognitive level**
CO1	Perform the observation of celestial objects	Apply
CO2	Estimate the physical properties of stars using photometric techniques	Apply, Analyze
CO3	Describe the evolutionary states of stars based on the masses	Understand
CO4	Explain the formation and evolution of galaxies	Understand
CO5	Describe the planetary system and explain the basic formation scenario of exoplanets	Understand

I. Coordinates and Observation Techniques

The celestial sphere, The horizontal system, The equatorial system, The Galactic coordinates , The sidereal time, Stellar distances – parallax method, Optical telescopes – Properties and aberrations, Radio telescopes, other wavelength regions. **(12 hours)**

Text: Book1

II. Photometric Concepts and Magnitudes

Intensity, Flux density, Luminosity, Apparent Magnitudes, Absolute magnitudes, Magnitude systems, Spectral formation, Saha and Boltzmann equation, Spectral classification: The Harvard spectral classification, The Yerkes Spectral Classification, Peculiar Spectra, The Hertzsprung-Russel Diagram. **(12 hours)**

Text: Book1 & Book 2

III. Stellar Evolution

The contraction of stars towards the main-sequence, The main-sequence phase, The Giant phase, The final stages of evolution, White dwarfs, Neutron stars, Black holes (qualitative idea only). **(10 hours)**

Text: Book1

IV. Galaxies

The Milky way Galaxy, Stellar luminosity function, The rotation of the Milky way, Structural components of the Milky way, The formation and evolution of the Milky way, The classification of Galaxies, Luminosities and Masses, Galactic Structure, Dynamics of Galaxies, Systems of Galaxies , Active galaxies and quasars, The origin and Evolution of Galaxies. **(14 hours)**

Text: Book 1

V. The Solar System

Planetary configurations, Orbit of the earth and visibility of Sun, Orbit of the moon, Eclipses and Occultations, The structure and surface of planets, Atmospheres and Magnetospheres, Photometry, polarimetry and spectroscopy, Thermal radiations of the planets, Minor bodies of the solar system, origin of the solar system. **(12 hours)**

Text: Book 1

Books and References

1. Fundamental Astronomy, H. Karttunen, P. Kroger, H. Oja, M. Poutanen, K. J. Donner (Eds.) (Book 1).
2. An introduction to Astrophysics, Baidyanath Basu M, Prentice Hall of India (Book 2).
3. Modern Astrophysics, B.W. Carroll & D.A. Ostille, Addison Wesley, 1996).
4. The Physical Universe: An Introduction to Astronomy, Frank H Shu.

IPH7E503 **Credits: 4**

IDEATION TO ENTREPRENEURSHIP THROUGH ELECTRONICS **T - P: 4 - 0**

	Course Outcome:	**Cognitive level**
CO1	Explain the problem solving steps in the innovation and Entrepreneurship	Apply
CO2	Describe the working of microcontrollers	Understand
CO3	Design the circuits for various applications	Apply
CO4	Design the products based on the circuits	Analyze

I. Ideation and Concept Development

Introduction to Innovation and Entrepreneurship, Role of innovation in entrepreneurship; importance of creativity in problem-solving, Idea Generation Techniques: Brainstorming, Mind Mapping, SCAMPER, SWOT Analysis, Problem Identification and Solution Mapping: Identifying real-world problems, defining value propositions, and mapping out potential solutions, Design Thinking: Empathy mapping, user centered design, ideation, prototyping, and testing, Case Studies: Examples of successful product ideas and how they were conceptualized. **(10 hours)**

II. Embedded device fundamentals

Introduction to microcontrollers (Atmega32): Overview of microcontroller architecture using KuttyPy Plus, training platform, Programming Basics: Introduction to programming microcontrollers with C. Interpreting datasheets, shortlisting bill of materials for making circuit boards, interfacing embedded devices with computers. Creating a microcontroller based circuit on a breadboard. Creating science application oriented projects such as smart temperature control, basic input/output scheduled operation, and timers. Lab Sessions: Hands-on experience with writing and uploading code using the IDE. **(12 hours)**

III. Circuit design fundamentals

Basic electronics training using SEELab, Signal processing circuits such as filters, and amplifiers, creating schematic diagrams, layouts, and PCBs with KICAD (with practical demo), introduction to device packages (through hole, SMD, various connectors), SMD soldering, creating scalable projects circuit testing, simulating circuits with circuit simulator built into SEELab software., Simulating circuits with LTSPICE. **(12 hours)**

IV. Interfacing Peripheral Devices with Microcontroller

Interfacing Techniques: Working with sensors, actuators, and communication protocols (I2C, SPI, UART home automation systems, and simple robotic applications using KuttyPy Plus, Lab Sessions: Real-world projects where students design, program, and test systems that incorporate sensor data and device control, Interfacing scientific instruments with laptops using Python. Will cover communication protocols such as GPIB, USBTMC, and RS232, plotting datasets, and feature extraction (curve fitting) using scipy. **(14 hours)**

V. Fabrication of a Product

Prototyping and Design – Basics of 3D printing, laser cutting, mechanical design: designing enclosures), practical Applications: connecting microcontrollers to various sensors and devices, focusing on real-time data acquisition and control, advanced projects: developing IoT devices,
and mechanical components for devices using 3D printing and laser cutting, integrated product fabrication: combining electronics, PCB, and mechanical components into a fully functional product, fabrication of projects: including designing, building, and testing a complete product from concept to final prototype. **(12 hours)**

TEXT BOOKS

1. The AVR Microcontroller and Embedded systems using Assemble and C by M.A. Mazidi, S Naimi and S. Naimi.
2. Design Thinking: New Product Development Essentials from the PDMA by Abbie Griffin, Charles H. Noble, and Serdar S. Durmusoglu.
3. Embedded C Programming and the Atmel AVR, by Richard H. Barnett, Larry O'Cull, and Sarah Cox.
4. The Art of Electronics, by Paul Horowitz and Winfield Hill.

REFERENCES:

1. Kuttypy Documentation : https://kuttypy.readthedocs.io/en/latest/
2. Atmega32 Reference https://www.microchip.com/en-us/product/atmega32
3. Atmega32: https://ww1.microchip.com/downloads/en/DeviceDoc/doc2503.pdf
4. KiCAD Handbook: https://docs.kicad.org/

IPH7E504 **Credits: 4**

SOLID STATE PHYSICS **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Describe the relevance of vibratory excitations in crystals. Arrive at a proper explanation for specific heat based on various models	Analyze
CO2	Explain the free electron model and interpret the properties of metals. ain a deeper understanding of the energy bands based on the properties of carriers.	Understand
CO3	Apply the Quantum mechanical and statistical mechanical knowledge into the understanding solid state properties	Apply
CO4	Interpret properly the thermal, electrical and magnetic properties of aterials. Enable the student to understand the current research going on in the related areas	Analyze
CO5	llustrate using phase diagrams, phase transitions in materials leading to superconductivity and different types of superconductors	Analyze

I. Crystal structure and Lattice Vibrations

Reciprocal lattice, Brillouin zones, Vibrations of monatomic and diatomic lattices, Quantization of lattice vibrations, Inelastic scattering of neutrons, Einstein and Debye models of specific heat. **(10 hours)**

II. Electron States and semiconductors

Free electron gas in three dimensions, heat capacity of electron gas, electrical conductivity and Ohm’s law, Experimental electrical resistivity of metals, Motion in magnetic fields, Hall effect, Thermal conductivity of metals (Wiedemann-Franz law), Nearly free electron model-origin of energy bands, Magnitude of energy gap, Bloch functions, Kronig Penny model, Semiconductor crystals: band gap, direct/indirect bad gap SCs, Equation of motion, Holes, Effective masses in semiconductors. **(14 hours)**

III. Dielectric and Ferroelectric properties

Theory of Dielectrics: Polarisation, Dielectric constant, Local Electric field, Dielectric polarisability, Clausius- Mossotti relation, Polarisation from dipole orientation, Dielectric losses, Ferroelectric crystals, Order-disorder type ferroelectrics, Properties of BaTiO3, Polarisation catastrophe, Displacive type ferroelectrics, Landau theory of ferroelectric phase transitions, Ferroelectric domain, Antiferroelectricity, Piezoelectricity, Applications of Piezoelectric. **(12 hours)**

IV. Magnetic properties

Langevin's diamagnetism equation, Quantum theory of diamagnetism of mononuclear systems, Quantum theory of paramagnetism, Hund's rule, Paramagnetic susceptibility of conduction electrons, Ferro, Anti and Ferri magnetism: Curie point and the exchange integral, Magnons, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetic order. Weiss theory of ferromagnetism, Ferromagnetic domains, Bloch walls, Origin of domains, Novel magnetic materials: GMR-CMR materials (qualitative). **(12 hours)**

V. Superconductivity

Meissner effect, Type I and Type II superconductors, Heat capacity, Microwave absorption, Energy gap, Isotope effect, Free energy of superconductor in magnetic field and the stabilization energy, London equation and penetration of magnetic field, Cooper pairs and the B C S ground state (qualitative), Flux quantization, Single particle tunneling, DC and AC Josephson effects, High Tc superconductors (Qualitative) - description of thecuprates). Technological applications of superconductivity. **(12 hours)**

Textbooks:

1. Introduction to Solid State PhysicsC.Kittel, 7th Ed., Wiley Eastern.
2. Elements of Solid State Physics, Srivastava J. P., .2nd Edition, Prentice Hall of India

References:

1. Solid State Physics, A. J. Dekker, Macmillan, 1958.
2. Solid State Physics, N.W.Ashcroft and Mermin, Brooks Cole, 1976.
3. Principles of the Theory of Solids, Ziman J. H., Cambridge, 1964.
4. Nanoclusters and Nanocrystals, Hari Singh Nalwa, Ed., American Scientific Publishers, 2003.

IPH7E505 **Credits: 4**

CONDENSED MATTER PHYSICS **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Explain the free electron model and interpret the properties of metals. Gain a deeper understanding of the energy bands based on energy and wave vector.	Understand
CO2	Interpret Fermisurface and its construction	Analyze
CO3	Effectively apply the Quantum mechanical and statistical mechanical knowledge into the understanding transport properties	Apply
CO4	Evaluate the magnetic and ferroelectric properties of materials, theoretical explanation of different classification	Evaluate
CO5	Study of different defects in crystals and understanding of different types low dimensional materials and structures	Analyze

I. Energy Bands

Wave Equation for an Electron in a Periodic Potential, Bloch Functions, Brillouin Zones, $\epsilon{-}k$ Diagram under Free Electron Approximation, Nearly Free Electron Approximation - Diffraction of Electrons by Lattice Planes and Opening of Gap in $\epsilon{-}k$ Diagram, Effective Mass of Electrons in Crystals, Holes, Tight Binding Approximation. **(10 Hrs)**

II. Fermi Surface

Construction of Fermi Surface, Experimental Methods of Study of Fermi Surface, Cyclotron Resonance, de Hass van Alphen Effect. Electron Interaction: Perturbation Formulation, Dielectric Function of an Interacting Electron Gas (Lindhard’s Expression), Static Screening, Screened Impurity, Kohn Effect, Friedel Oscillations and Sum Rule, Dielectric Constant of Semiconductor, Plasma Oscillations. **(10 Hrs)**

III. Transport Properties

The Boltzmann Equation, Electrical Conductivity, General Transport Coefficients, Thermal Conductivity, Thermoelectric Effect, Hall Effect, Elementary Ideas on Quantum Hall Effect, Magnetoresistance, Elementary Ideas of Giant Magneto-Resistance and Colossal Magneto-Resistance. **(10 Hrs)**

IV. Magnetism and Ferroelectricity

Theories of Ferromagnetism, Weiss and Heisenberg Model - Conditions for Ferro- and Antiferro-Magnetic Order, Spin Waves and Magnons, Bloch's T 3/2 Law, Antiferromagnetic Order, Neel Temperature. Diluted Magnetic Semiconductors: Elementary Concepts. Ferroelectricity: Ferroelectric Crystals, Classification of Ferroelectric Crystals, Polarization Catastrophe, Soft Optical Phonons, Landau Theory of Phase Transition - Second and First Order Transition. Multiferroics: Elementary Concept. **(15 Hrs)**

V. Crystal defects and Nanostructures

Lattice Defects, Frenkel and Schottky Defects, Line Defects, Edge and Screw Dislocations - Burger's Vector, Plannar (Stacking) Faults - Twin Planes and Grain Boundaries, Color Centers - Mechanism of Coloration of a Solid, F - center, Other Color Centers. Excitons: Loosely Bound, Tightly Bound, Excitonic Waves, Electron - Hole Droplets. Solids: Amorphous Materials, Quasi - Crystals, Nanostructured Materials - Classification based on Spatial Extension (0-D, 1-D and 2-D), 0-D Nanostructures - Quantum Dots, Widening of Band Gap in Quantum Dots, 1-D Nanostructures - Quantum Wires, Tubes, Belts, 2-D Nanostructures - Quantum Wells – Superlattices. **(15 Hrs)**

Text Books:

1. Introduction to Solid State Physics, C. Kittel.
2. Quantum Theory of Solids, C. Kittel
3. Text Book of Nanoscience and Nanotechnology, B. S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday

Reference Books:

1. Introduction to Modern Solid State Physics, Yuri M. Galperin
2. Introduction to Solids, Azaroff
3. Elementary Solid State Physics, Omar
4. Solid State Physics, Aschroft & Mermin.
5. Science of Engineering Materials and Carbon Nanotubes, C. M. Srivastava & C. Srinivasan.
6. Solid State Physics, A. J. Dekkar.

7. Solid State Physics, R. L. Singhal.
8. Low Dimensional Semiconductor Structures, K. Bamam and D. Vvedensky.
9. Semiconductor Quantum Dots, L. Banyal and S. W. Koch.
10. An Introduction to the Physics of Low Dimensional Semiconductors, J. H. Davies.
11. Principles of Nanoscience and Nanotechnology, Ed. H. S. Nalwa
12. Solid State Physics, S. O. Pillai
13. The Physics of Quasicrystals, Eds. Steinhardt and Ostulond

IPH7E506 **Credits: 4**

NANOSCIENCE AND TECHNOLOGY **T - P: 4 - 0**

	Course Outcome	Cognitive level
CO1	Describe 0-d,1-d,2-d,3-d nanosystems and to identify the specific properties of nanosized alloys, metals, semiconductors etc.	Analyze
CO2	Correlate the optical, electronic, photonic, dielectric, magnetic etc. behaviour of nanomaterials with their quantum properties.	Apply
CO3	Explain different synthesis methods based on physical and chemical principles.	Apply
CO4	Characterize nanomaterials using XRD, SEM,AFM, etc.	Analyze

I. Introduction to Various Nanomaterials

Natural and classical nanosystems. Low dimensional materials. Zero -, one -, two - and three dimensional nanostructuresquantum dots, quantum wells, quantum rods, quantum wires. Nanosized metals and alloys, semiconductors, ceramics. Fullerens, Nanotubes. Comparison with bulk materials. Application in electronics, communication, medicine etc. **(12 Hrs)**

II. Quantum states of nanoparticles

Quantum confinement in semiconductorsparticle in a box like model for quantum dots, effective mass approximation, weak confinement, strong confinement, Size and shape dependency in optical, emission, electronic, transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical; catalytic and photocatalytic properties. **(12 Hrs)**

III. Synthesis of nanomaterials Physical techniques (bottom up approach)

Physical vapour deposition, electron beam evaporation, sputter deposition, laser ablation, ion beam mixing, plasma deposition. Physical methods-mechanical milling, laser ablation, sputtering, microwave plasma etc. Chemical methods-chemical reduction and oxidation, solgel processes, photolysis, radiolysis, metal-organic chemical vapor deposition. molecular self-assemblies, surface engineering. **(12 Hrs)**

IV. Designing of advanced nanomaterials

Integrated nanocomposites, functional nanomaterials and nanostructured thin films. Development of nanoscale catalysts, sensitizers, sensors, composites, polymers, ceramics, biomaterials, pharmaceuticals, nanopaints, nanofluids, optical, fluorescent, electronic, magnetic and photonic devices, future perspectives of nanotechnolgy. **(12 Hrs)**

V. Characterization techniques

X-ray diffraction technique, Scanning Electron Microscopy - environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques -AFM, Nanoindentation, Small-angle X-ray and neutron scattering, DLS, Ellipsometer, Confocal microscopy. **(12 Hrs)**

Text Books:

1. Physics of Low Dimensional Structures, J. H. Davis, (Cambridge Press), 1998.
2. Semiconductor Quantum Dots, L. Banjaj and S. W. Koch.
3. Low Dimensional Semiconductors, M. J. Kelly, Clarendon,1955
4. NanoTechnology:Principles and Practices, Sulabha Kulkarni, CPC-New Delhi 2007
5. Nano:The essentials:Understanding nanoscience and Nanotechnology, Pradeep T TMCGH, New Delhi 2007
6. Characterization of Materials, J. B. Wachtman and Z. H. Kalman, ButterworthHeinmann, USA, 1993.
7. Experimental Physics, Modern Methods, R. A. Dunlop.
8. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle ,(CBS Pub.), 1986.

IPH8C601 **Credits: 4**

MATHEMATICAL PHYSICS - II **T - P: 4 - 0**

	Course outcome: **After completion of the full course the student should be able to**	**Cognitive level**
CO1	In general, physical phenomena are expressed in equations involving complex quantities. Sometimes we get complex solutions to equations. Solving such problems requires special procedures. On completing this module he/she will gain the skill for solving and interpreting such problems.	Analyze
CO2	Address the class of objects called groups and the symmetry operations expressed as group elements. Understand group properties.	Evaluate
CO3	Group representations provide the understanding of applications of group theory in quantum mechanics. Different discrete and continuous groups and gauge principles are introduced here.	Apply
CO4	Understand calculus of variation in a level suitable for application in various physical problems in physics.	Understand
CO5	Understand various integral transforms and Green's functions and their applications in physical problems obeying causality conditions,	Understand

I. Integral Transforms

Fourier Series, General properties, Advantages, Uses of Fourier series, Properties of Fourier series, Fourier integral, Fourier transform, Properties, Inverse transform, Transform of the derivative, Convolution theorem, Laplace transform, Inverse Transform and Convolution theorem. **(11 hours)**

Text: Book 1

II. Functions of Complex Variables

Introduction, Analyticity, Cauchy-Reimann conditions, Cauchy's integral theorem and integral formula, Laurent expansion, Singularities, Calculus of residues and applications. **(13 hours)**

Text: Book 1

III. Group Theory

Groups, Multiplication Table, Conjugate elements and classes, Subgroups, Direct product groups, Isomorphism and homomorphism, Permutation groups, Distinct groups of given order. **(10 hours)**

Text: Book 2

IV. Calculus of Variations

One dependent and one independent variable, Application of Euler equation, Generalization to several independent variables, Several dependent and independent variables, Lagrange Multipliers, Variation subject to constraints, Rayleigh-Ritz variational technique. **(11 hours)**

Text: Book 1

V. Integral equations and Green's function

Integral equations – introduction, Integral transforms and generating functions, Neumann series, separable kernel, Green's function – Non homogeneous equations, Green's function, Symmetry of Green's function, form of Green's function, Example – Quantum mechanical scattering. **(15 hours)**

Text: Book 1

Text Book:

1. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, 6^{th} Edition, Academic Press, 2005. (Book 1)
2. Elements of Group Theory For Physicists, A. W. Joshi, New Age International Publishers New Delhi, 2002. (Book 2)

Books for Reference:

1. Mathematical Methods for Physics, J. Mathews and R. Walker, 2^{nd} Edition, Benjamin
2. Applied Mathematics for Engineers and Physicists, L. I. Pipes and L. R. Harvill, 3^{rd} Edition, McGrawHill

3. Advanced Engineering Mathematics, Erwin Kreyzig, 8th edition, Wiley
4. Advanced Engineering Mathematics, M. Greenberg, 2nd edition, Pearson India, 2002.
5. Matrices and tensors in Physics, A.W. Joshi, New Age International Publishers
6. Tensors and Their Applications, Nazrul Islam, New Age International, 2006
7. Group Theory and Quantum Mechanics, M. Tinkham, Tata-McGraw-Hill

IPH8C602 **Credits: 4**

COMPUTATIONAL PHYSICS – II **T-P: 2-2**

	Course Outcome	**Cognitive level**
CO1	Understand and apply advanced numerical methods to solve complex physical problems	Apply
CO2	Develop and implement simulation techniques for physical systems.	Create
CO3	Analyze and interpret large data sets obtained from experiments and simulations.	Analyze
CO4	Design and optimize algorithms for numerical solutions in physics.	Create
CO5	Critically evaluate the accuracy, stability, and efficiency of various computational methods.	Evaluate

I. Numerical Solutions of Partial Differential Equations

Partial Differential Equations (PDEs): Classification and examples, Finite Difference Method for PDEs, Finite Element Method, Stability and convergence of numerical methods, Simulation of temperature distribution in a rod. **(12 hours)**

II. Statistical Methods and Monte Carlo Simulations

Basics of statistical mechanics, Monte Carlo methods: Importance sampling, Metropolis algorithm, Ising Model: Concepts, simulations, and phase transitions, Applications in statistical physics, Random walks and diffusion, Simulation of phase transitions in a magnetic system using Ising Model. **(12 hours)**

III. Computational Fluid Dynamics (CFD)

Introduction to fluid dynamics, Navier-Stokes equations, Discretization methods: Finite difference, finite volume, and finite element methods, Grid generation and boundary conditions, airflow simulation over a wing using Navier-Stokes equations. **(12 hours)**

IV. Computational Quantum Mechanics

Introduction to quantum mechanics, Schrödinger equation: Time-independent and time-dependent forms, Numerical solutions of Schrödinger equation, Variational and perturbation methods, Solving the Schrödinger equation for the hydrogen atom. **(12 hours)**

V. High-Performance Computing (HPC) and Parallel Processing

Basics of parallel computing, Parallel algorithms and architectures, Message Passing Interface (MPI) and OpenMP, Performance optimization techniques, Parallelization of molecular dynamics simulation. **(12 hours)**

Text Books:

1. Statistical Mechanics: Theory and Molecular Simulation, Tuckerman, M. E., Oxford University Press, 2010.
2. Computational Physics: Problem Solving with Python, Landau, D. P.; Páez, M. J.; Bordeianu, C. C., Wiley-VCH, 2018.
3. Understanding Molecular Simulation: From Algorithms to Applications, Frenkel, D.; Smit, B., Academic Press, 2001.
4. Numerical Simulation in Fluid Dynamics: A Practical IntroductionGriebel, M.; Dornseifer, T.; Neunhoeffer, T., SIAM, 1998.

Reference Books:

1. Giordano, N. J.; Nakanishi, H. Computational Physics; Pearson, 2005.
2. Press, W. H.; Teukolsky, S. A.; Vetterling, W. T.; Flannery, B. P. Numerical Recipes: The Art of Scientific Computing; Cambridge University Press, 2007.
3. Gould, H.; Tobochnik, J.; Christian, W. An Introduction to Computer Simulation Methods: Applications to Physical Systems; Pearson, 2007.
4. Thijssen, J. M. Computational Physics; Cambridge University Press, 2007.
5. Mortensen, M. Python for Computational Science and Engineering (A beginner's guide); CreateSpace Independent Publishing Platform, 2015.
6. Versteeg, H. K.; Malalasekera, W. An Introduction to Computational Fluid Dynamics: The Finite Volume Method; Pearson Education, 2007.
7. DeVries, P. L. A First Course in Computational Physics; Wiley, 1994.
8. Harvey Gould, Jan Tobochnik, Wolfgang Christian. Introduction to Computer Simulation Methods; Addison-Wesley, 1996.

IPH8C603 **Credits: 4**

ADVANCED ELECTRODYNAMICS **T-P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Analyze the wave propagation through waveguides using Maxwell's equations	Analyze
CO2	Analyze the nature of electric and magnetic fields in relativistic conditions	Analyze
CO3	Analyze the formation and characteristics of Plasma	Analyze
CO4	Evaluate the basics of quantization of field	Evaluate
CO5	Create the entanglement in the quantum systems	Create

I. Wave guides and Cavity Resonators

Penetration of fields into the conductors, Wave guides, Cylindrical, Rectangular, Energy flow and attenuation, Resonance cavities, Power losses, Fields and radiation of localized oscillating source, Electric dipole fields and radiation. **(12 hours)**

II. Relativistic Electrodynamics

Special theory of relativity, Lorentz transformations, Addition of velocities, 4-vectors, Covariance of electrodynamics, Transformations of electromagnetic fields, Lienard-Wiechert potentials, Larmor's formula and its relativistic generalization. **(12 hours)**

III. Plasma Physics

Plasma -Definition, concepts of plasma parameter, Debye shielding, Motion of charged particles in an electromagnetic field -Uniform electric and magnetic fields, Distribution function, Boltzmann and Vlasov equations, Derivation of moment equation, Fluid theory, Plasma oscillations, Hydromagnetic waves, Magnetosonic waves and Alfven waves. **(12 hrs)**

IV. Quantization of fields

The principles of canonical quantization of fields, Lagrangian density and Hamiltonian density, Second quantization of the Schrodinger wave field for bosons and fermions, Classical field theory of electrodynamics and gauge symmetry. **(12 hrs)**

V. Quantum Interpretation

Spin - spin correlation measurements and Bell's inequality, Composite systems and entanglement, Einstein Podolsky Rosen (EPR) paradox, Density matrices, Pure and mixed states, time evolution of density matrices, Bloch sphere, partial trace and entanglement entropy. **(12 hrs)**

Text Books:

1. Classical Electrodynamics, J. D. Jackson, 3rd Ed., Wiley,1999.
2. Introductory Electrodynamics, David Griffiths, 4th Ed.,Prentice Hall of India, 2012.
3. Electricity and Magnetism by R. Murugeshan.
4. Text book of Electrical technology Volume 1-Basics of Electrical Engineering by B.L Ther-aja and A.K Theraja.
5. Greiner and Reinhardt, Field Quantization, Spinger Verlag, 1996

Books for Reference:

1. Field and Wave Electromagnetics, David K. Cheng, 2nd Ed., Addisson Wesley.
2. Quantum Field theoryLewis H. Ryder, Cambridge University Press, 1995.
3. Field Theory – A modern primer, Pierre Ramond, Bengamin, 1996

IPH8P601 **Credits: 12**

RESEARCH PROJECT

The project can be experimental or theoretical. The projects may be carried out either utilizing the facilities in the Department or elsewhere. In case they carry out the projects outside the Department, this shall in no way affect their minimum attendance for the theory papers. Also, they should obtain an attendance certificate from the outside institution where the work is carried out and also a certificate in the Project Report that the work had been carried out by the concerned student at that institution. The students shall prepare a detailed report on their work. This shall be attested by the teacher-in-charge concerned at the center (and the relevant authority at the external institution, if the work had been carried out at some other centre). The students shall submit the project report before the commencement of the theory examinations. The same will be evaluated by a committee consisting of one external expert and the internal supervisor. A presentation of the project and a comprehensive viva voce on the project will be held and evaluated by a committee consist of supervisor, HoD and an internal examiner. The Project shall also carry an internal evaluation to the extent of 50%.

IPH8E601 **Credits: 4**

MATERIALS SCIENCE **T-P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Define different types of imperfections in crystals.	Understand
CO2	Analyze different phase diagrams and elucidate the expected properties.	Apply
CO3	Identify different types of silicates and understand the importance and application of ceramic materials.	Analyze
CO4	Explain unsaturated hydrocarbons, different types of polymerization and its application.	Analyze
CO5	Analyze types of liquid crystals, quasi crystals, fullerenes, nano structures and their applications.	Analyze

I. Imperfections in crystalline materials

Materials and its classifications, Thermodynamics of Schottky and Frenkel Defects, Equilibrium number of Point Defects as a function of temperature, Interstitial Diffusion, Self-diffusion, Determination of Diffusion constant, Edge and Screw Dislocations, Energy of Dislocation, Dislocation motion, Dislocation Multiplication: Frank-Read mechanism, Work Hardening of Metals. **(10 Hours)**

II. Alloys and Phase diagrams

Binary phase diagrams from Free energy considerations, case of complete miscibility, ibbs phase rule, The lever rule, Rules of solid solubility, Hume-Rothery Electron compounds, case of limited solid solubility, the Eutectic temperature. Design of alloys, Applications of alloys. **(12 Hours)**

III. Ceramic Materials

Silicate structure, Polymorphism, Solid solution, Non-ductile fracture, Plastic deformation of layered structures, Viscous deformation of glass, Electrical properties of ceramics, Application of ceramic materials. **(10 hours)**

IV. Polymers

Unsaturated hydrocarbons, Polymer size, Addition polymerization, Copolymerization, Condensation polymerization, Thermoplastic and thermosetting resins, Elastomers, Cross-linking, Branching, Application of polymers. **(12 Hours)**

V. Liquid crystals, Quasi crystals and Nanomaterials

Structure and symmetries of liquids, Liquid crystals and amorphous solids, Application of liquid crystals, Aperiodic crystals and quasicrystals, Formation and characterization of Fullerenes and tubules, Carbon nanotube based electronic devices, Synthesis and properties of nanostructured materials, Experimental techniques for characterizing nanostructured materials, Quantum size effect and its applications. **(16 Hours)**

Text Books:

1. Solid State Physics, A. J. Dekker (MacMillan, 1958)
2. Introduction to Solid State Physics, C. Kittel(Wiley Eastern, 1977).
3. Materials science and engineering-V Raghavan, (pHI, 2015)

Books for Reference:

1. Elements of Materials Science, L.H. Van Vlack (Addison Wesley)
2. Physics of Thin Films, K.L.Chopra.
3. Thin Films, O.S.Heavens
4. Multiple Beam Interferometry, Tolansky.
5. Transmission Electron Microscopy, Thomas.
6. The Physics of Quasicrystals, Ed. Steinhardt and Ostulond.
7. Handbook of Nanostructured Materials and Nanotechnology, Ed. Harisingh Nalwa

IPH8E602 **Credits: 4**

RADIATION PHYSICS **T-P: 4-0**

	Course Outcome: **After completion of the full course the student should be able to**	**Cognitive level**
CO1	Verify through experiments that radiations are primarily divided into ionising and nonionising. Also understand different sources under each category. Production methods of each will also be identified.	Analyze
CO2	Analyze the interaction mechanism of each category, giving emphasize to scattering and absorption.	Analyze
CO3	Evaluate the beneficial or harmful effects of radiations.	Evaluate
CO4	Analyze both stochastic and deterministic effects useful in planning for diagnosis and treatment.	Analyze
CO5	Implement proper shielding in laboratories where sources are stored and in transportation.	Analyze

I. Radiation source

Types of radiations, ionizing, non ionizing, electromagnetic, particles, neutral – gamma- neutrino-neutron, charged alpha, beta, gamma, and heavy ion sources, radioactive sources - naturally occurring, production of artificial isotopes, accelerators -cyclotrons, nuclear reactors. **(9 hours)** Ref 1, 2

II. Interaction of radiations with matter

Electrons - classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, specific energy loss, bremsstrahlung, range energy relation, energy and range straggling Heavy charged particles - stopping power, energy loss, range and range - energy relations, Bragg curve, specific ionization, Gamma rays - Interaction mechanism -

Photoelectric absorption, Compton scattering, Pair production, gamma ray attenuation, attenuation coefficients, Elastic and inelastic scattering, Cross sections, linear and mass absorption coefficients, stopping power, LET, Neutrons - General properties, fast neutron interactions, slowing down and moderation. **(15 hours)**

Ref 1,2

III. Radiation quantities, Units and Dosimeters

Particle flux and fluence, calculation of energy flux and fluence, Curie, Becquerel, exposure and its measurements, absorbed dose and its relation to exposure, KERMA, Biological effectiveness, weighting factors, (WR and WT), Equivalent dose, Effective dose, Dosimeters, Primary and secondary dosimeters, Pocket dosimeter, Films and solid dosimeter (TLD and RPL), Clincal and calorimetric devices , Radiation survey meter for area monitoring. **(12 hours)**

Ref 2,3

IV. Biological effects

Basic concepts of cell biology, Effects of ionizing radiations at molecular, sub molecular and cellular levels, secondary effects, free radicals, deterministic effects, stochastic effects, Effects on tissues and organs, genetic effects, Mutation and chromosomal aberrations, applications in cancer therapy, food preservation, radiation and sterilization. **(10 hours)**

Ref 3,4

V. Radiation protection, shielding and transport

Effective radiation protection, need to safeguard against continuing radiation exposure, justifcation and responsibility, ALARA, concept of radiologic practice. time distance and shielding, safety specifications. method of radiation control, Shielding factor for radiations, Choice of material, Primary and secondary radiations, Source geometry, Beta shielding, Gamma shielding, neutron shielding, Shielding requirements for medical, industrial and research facilities, handling of the source, sealing, transport and storage of sealed and unsealed sources. records, spills, waste disposal. **(14 hours)**

Books for Reference:

1. G. F. Knoll: Radiation detection and measurement (John Wiley & sons, Newyork, 2000)
2. K. Thayalan: Basic radiological physics (Jaypee Brothers Medical Publishers, New Delhi, 2003).
3. W. J. Meredith and J. B. Masse: Fundamental Physics of radiology (Varghese publishing house)

IPH8E603 **Credits: 4**

MICROPROCESSORS AND MICROCONTROLLERS **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Understand the basic concepts and architecture of microprocessors and microcontrollers	Understand
CO2	Analyze and design microprocessor-based systems and interfaces.	Analyze
CO3	Gain proficiency in programming microprocessors using assembly and higher-level languages.	Apply
CO4	Design, program, and troubleshoot microcontroller-based applications	Create
CO5	Critically evaluate and optimize the performance and efficiency of embedded systems.	Evaluate

I. Microprocessor 8085: Architecture and Organization

Basic concepts of microprocessors, Architecture of 8085 microprocessor, Instruction set and programming model of 8085, Addressing modes and timing diagrams, Interfacing memory and I/O devices. **(12 hours)**

II. Assembly Language Programming of 8085 and Applications

Basics of assembly language programming, Instruction set and programming of 8085. Writing and debugging assembly programs, Interrupts and interrupt handling in 8085, Programmable peripheral interface (PPI) IC 8255, Example programs with assembly language. **(12 hours)**

III. Microcontroller: Architecture and Organization

Introduction to AVR microcontrollers, Architecture of ATmega32 microcontroller, Instruction set and programming model of ATmega32, Memory organization and I/O ports Peripherals: Timers, counters, ADC, DAC, UART. **(12 hours)**

IV. Programming

Embedded C programming for ATmega32, Writing and debugging programs in Embedded C Interfacing with external devices: LEDs, switches, sensors, Real-time operating systems (RTOS) for microcontrollers, Developing and testing embedded applications. **(12 hours)**

V. Practical Applications with Examples

Practical applications and projects using ATmega32, Designing and implementing simple embedded systems, Case studies: Home automation, Data acquisition systems, Interfacing with communication modules: I2C, SPI, UART, Troubleshooting and optimizing embedded applications. **(12 hours)**

Text Books:

1. Microprocessor Architecture, Programming, and Applications with the 8085Gaonkar, R. S., New Age Publishers.
2. Ram, B. Dhanpat Rai Publications.
3. Mazidi, M. A.; Naimi, S.; Naimi, S. AVR Microcontroller and Embedded Systems: Using Assembly and C; Pearson Education.

Reference Books:

1. Microcomputers and Microprocessors: The 8080, 8085, and Z-80 Programming, Interfacing and Troubleshooting, Uffenbeck, J., Prentice Hall.
2. The Intel Microprocessors: Architecture, Programming, and Interfacing, Brey, B. B., Pearson Education.
3. Design with PIC Microcontrollers, Peatman, J. B., Pearson Education.
4. IC Microcontroller and Embedded Systems: Using Assembly and C for PIC18, Muhammad Ali Mazidi, Rolin McKinlay, Danny Causey. P, Pearson Education.
5. Programming and Customizing the 8051 Microcontroller, Predko, M., McGraw-Hill Education.
6. Programming and Interfacing the 8051 Microcontroller, Yeralan, S.; Ahluwalia, A., Addison-Wesley.

IPH9C601 **Credits: 4**

MOLECULAR SPECTROSCOPY **T-P: 4-0**

	Course Outcome	Cognitive level
CO1	Interpret the microwave spectra of the molecule and deduce various parameters	Apply
CO2	Interpret the IR spectra of molecule and deduce information about the molecule	Apply
CO3	Deduce molecular structure from combined analysis of raman and IR spectra	Apply
CO4	Interpret the UV-visible spectra and deduce properties of the molecules in ground and excited states	Apply
CO5	Identify the chemical environment of the molecule and apply the concept for imaging internal anatomy of samples	Analyze

I. Microwave Spectroscopy

Introduction, The Spectrum of a nonrigid rotator, Example of HF, Spectrum of a symmetric top molecule, Examples, Instrumentation for Microwave Spectroscopy – Information derived from rotational spectra. **(9 hours)**

Text: Relevant sections of Banwell and McCash and Barrow

II. Infrared Spectroscopy

Vibrational energy of an anharmonic oscillator - diatomic molecule (Morse Curve), IR spectra - Spectral Transitions and Selection Rules, The Vibration - Rotation Spectra of diatomic molecule, Born- Oppenheimer Approximation, Effect of Breakdown of Born-Oppenheimer Approximation, Normal modes of vibration of H_2O and CO_2, Spectra of symmetric top molecules, Examples, Instrumentation for Infrared Spectroscopy, Fourier transform IR spectroscopy. **(12 hours)**

Text: Relevant sections of Aruldas, Banwell

III. Raman Spectroscopy

Introduction, Rotational Raman Spectrum of diatomic and polyatomic molecules- linear and Symmetric top molecules, Vibrational Raman Spectrum of a Symmetric top molecule, Combined use of Raman and Infrared Spectroscopy in structure determination, Examples, Instrumentation for Raman Spectroscopy, Laser Raman Spectroscopy, Non-linear Raman effects, Hyper Raman Effect, Stimulated Raman effect and inverse Raman effect. **(12 hours)**

Text :(a) Relevant sections of Aruldas, Banwell & McCash and Straughan & Walker

IV. Electronic Spectroscopy of molecules

Vibrational coarse structure of electronic spectra, Vibrational analysis of band systems, Deslander's table, Progressions and sequences, Information derived from vibrational analysis, Franck-Condon Principle, Rotational fine structure and the R, P and Q branches, Fortrat Diagram, Dissociation Energy, Example of diatomic molecule. **(12 hours)**

Text: Relevant sections of Aruldas, Banwell & McCash

V. Spin Resonance Spectroscopy

Interaction between nuclear spin and magnetic #eld, Level population, Larmor Precession, Resonance condition, Bloch equations, Relaxation times, Spin-Spin and spin-lattice relaxation, The Chemical shift, Instrumentation for NMR spectroscopy, CWNMR and FTNMR, Imaging, Electron Spin Spectroscopy of the unpaired electron, Total Hamiltonian, Fine structure, Electron-Nucleus coupling and hyper#ne structure, ESR spectrometer, Mossbauer Spectroscopy : Resonance Fluorescence of gamma - rays, Recoilless emission of gamma - rays and Mossbauer Effect, Chemical shift, Effect of electric and magnetic fields, Example of Fe-57, Experimental techniques. **(15 hours)**

Text : For ESR & NMR : Relevant sections of Aruldas, Banwell & McCash and Straughan & Walker; For Mossbauer Effect : Aruldas and G.K. Wertheim

Text Books: Molecular structure and Spectroscopy, G Aruldas (Prentice Hall of India, 2002).

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, (Tata McGrow Hill, 1994).
2. Mossbauer Effect : Principles and applications, Gunther K. Wertheim (Academic Press).
3. Spectroscopy- Vol. I and II , Straughan and Walker (Eds) (Chapman and Hall).
4. Introduction to molecular Spectroscopy, G. M. Barrow, (McGraw Hill)

Books for Reference: 1. Raman spectroscopy, Long D. A., (Mc Graw Hill, 1977)

IPH9C602 **Credits: 4**

RELATIVISTIC MECHANICS **T-P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Apply the concepts of special theory of relativity length contraction and time dilation	Apply
CO3	Analyze the concept of geometry	Analyze
CO4	Evaluate the symmetry in Newtonian Mechanics	Evaluate
CO5	Analyze the redshift using general theory of relativity.	Analyze

I. Introduction to Special Relativity

The failure of classical concept of space, time, and velocity, Classical relativity, Michelson-Morley experiment, Einstein's Postulates, Consequences of Einstein's postulates, Relativity of time, Relativity of length, Relativistic velocity addition, Relativistic Doppler effect, Lorentz transformations - Length contraction, Time dilation, Velocity transformation, Simultaneity and clock synchronization - The twin paradox - Spacetime diagrams, Relativistic dynamics - Relativistic kinetic energy, Relativistic total energy and rest energy, Conservation laws in relativistic decays and collisions, Experimental tests of special relativity **(20 hours)**

Sections 2.1 to 2.9 of Modern Physics (4 th Edn.) by Kenneth Krane.

II. Geometry as physics

Gravity in geometry, Experiments in geometry, Different Geometries, Coordinates and line element, The non-Euclidian geometry as a sphere, The geometry of some more general surfaces, Coordinates and invariance. **(8 hours)**

Chapter 2, Gravity: An Introduction to Einstein's General Relativity.

III. Space-time and symmetry in Newtonian Mechanics

Early concept of energy, The principle of relativity and Galilean transformation, The principles of relativity, Symmetry and relativity, Form invariance of Physical laws, The energy and energy function, Laws of motion and the properties of space and time, the second law of motion, The third law of motion **(12 hours)**

IV. The general theory of relativity

Space and time in general relativity, Tests in general relativity, Deflection of star light, Delay of RADAR echoes, Precession of the perihelion of mercury, Gravitational radiation, Cosmology and general relativity, Tests of general theory of relativity **(8 hours)**

Sections 15.4 and 15.5 of Modern Physics (4 th Edn.) by Kenneth Krane.

V. General Considerations:

Space, time and gravitation, Tensors, Metric for weak gravitational field, The Energy-momentum tensor, Einstein's equations, Some applications of general relativity : Gravitational redshift, The Schwarzschild metric- motion of massless particle, The bending of light, Gravitational waves **(12 hours)**

Text: Arnab Rai Choudhuri, Relevant portions from Chapters 12 and 13

Textbooks:

1. Modern Physics, 4 th Edn. - Kenneth S. Krane - Wiley 51 Page 52 of 130
2. Arnab Rai Choudhuri: "Astrophysics for Physicists", Cambridge University Press
3. Gravity: An Introduction to Einstein's General Relativity, James B. Hartle, Pearson (2014).
4. Conceptual evolution of Newtonian and relativistic mechanics by Amitabha Ghosh, Springer (Undergraduate lecture notes in physics).

Reference books:

1. Gravity - an introduction to Einstein's general relativity, 1st Edn, James B. Hartle - Pearson Education
2. Introduction to dynamics by Amitabha Ghosh, Springer (2018).

IPH9C603 **Credits: 4**

ADVANCED PHYSICS LAB **T-P: 0 - 4**

	Course Outcome	**Cognitive level**
CO1	Demonstrate skills to set up and perform experiments to test the concepts in quantum mechanics/nuclear physics	Evaluate

1. Absorption spectrum of KMnO4 - To determine the wavelengths of the absorption bands for KMnO4 solution.
2. Photoelectric effect - Determination of Planck's constant (White light and filters or LEDs of different colours may be used)
3. Millikan's oil drop method - To measure the charge on the electron by means of the Millikan's oil drop apparatus.
4. Thomson's e/m measurement - To determine the charge to mass ratio of the electron by Thomson's method using a CRT.
5. Thermionic work function - To determine the thermionic work function of the material of the cathode of the given vacuum diode/triode from the characteristics at different filament currents.
6. Frank-Hertz experiment - To measure the critical ionization potentials of Mercury by drawing current vs. applied voltage in a discharge tube.
7. Compton scattering - To verify the theoretical expression for the energy of the Compton scattered gamma rays at a given angle using a Scintillation gamma spectrometer / determine the rest mass energy of the electron.
8. ESR spectrometer – Determination of g factor.
9. Photoelectric effect in lead - To get the spectrum of X rays emitted from lead target by photo electric effect using Cs-137 gammas.
10. Obtain the uv-visible absorption spectra of the given liquid/solid.
11. G.M. Counter plateau and statistics of counting- To obtain the plateau, operating voltage and to verify the distribution law satisfied by the radioactive decay.
12. Absorption coefficient for gamma rays-To determine the absorption coefficient of the given material for Cs-137 gamma rays using a G.M. Counter.
13. Absorption coefficient for beta rays-To determine the absorption coefficient of the given material for beta rays from beta sources using a G.M. Counter.
14. Feather analysis- End point energy- To determine the end point energy of the beta particles from a given source using Feather analysis.

15. Scintillation counter- To calibrate the given gamma ray (scintillation) spectrometer using standard gamma sources and to determine the energy of an unknown gamma ray source.
16. Compton scattering- To verify the theoretical expression for the energy of the Comp ton scattered gamma rays at a given angle using a Scintillation gamma spectrometer / determine the rest mass energy of the electron.
17. To verify the inverse square law in the emission of gamma rays from a radioactive source.
18. Half life of Indium- thermal neutron absorption- To determine the half life of In-116 by irradiation of In foil with neutron and beta counting using a GM counter.
19. Alpha spectrometer- To calibrate the given alpha spectrometer and determine the resolu tion.
20. Photoelectric effect in lead- To get the spectrum of X-rays emitted from lead target by photo electric effect using Cs-137 gammas
21. Band gap energy of the given thin film sample by four Probe method.
22. Find the thermal conductivity of the given crystal sample.
23. Obtain the uv-visible absorption spectra of the given liquid/solid.
24. Determine the dielectric constant of the given material using LCR high tester.
25. Obtain the powder diffraction data of the given sample and study its crystalline behaviour. Compare the values with ICDD.
26. Obtain the surface features of a thin film sample using AFM.
27. Find the etched pattern of the given crystal using an optical microscope
28. Distance determination to Cepheid variables based on their light curves
29. Classification of stars based on their spectra and the use of spectral classification in deriving distances to stars, etc)
30.

Reference Books:

1. B.Sc Practical Physics- C L Arora
2. Practical Physics- S L Gupta & V Kumar
3. Advanced Practical Physics for students- B L Worksnop and H T Flint
4. A practical approach to Nuclear Physics, 1 st Edition, K. Muraleedhara Varier- Narosa Publishing House.

IPH9E601 **Credits: 4**

QUANTUM MATERIALS AND DEVICES **T-P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Illustrate the band theory of solids	Apply
CO2	Analyze Van der Waals materials and their optoelectronic applications	Analyze
CO3	Analyze topological quantum materials	Analyze
CO4	Evaluate the quantum coupling in deciding the material properties	Evaluate

I. Introduction

Quantum materials and devices for quantum technologies, Crystal structure and symmetry: periodic lattice, reciprocal space, symmetry, and defects, Band theory of solids: review of basic concepts in quantum mechanics, Bloch wave, band structure, density of states, and quasiparticles. **(12 Hours)**

II. Low-dimensional quantum materials

Quantum confinement, Van der Waals materials and their optoelectronic properties, Color centers in solids, Quantum dots and single-photon sources. **(12 Hours)**

III. Topological quantum materials

Topology and Berry phase in solids, Topological insulators and their device applications Dirac, Weyl semimetals and their device applications, On-demand topological band engineering. **(12 Hours)**

IV. Quantum wells Coupling and Excitons

Coupling between Quantum wells, Super lattices, Wave functions and Density of States for super lattices, Unit cell for quantum well, for quantum wire and for quantum dot. Excitons in bulk, in Quantum structures and in hetero structures. **(12 Hours)**

V. Correlated quantum materials arising from many-body interactions

Band theory limitation and electron correlation, Metal-insulator transitions, Mott insulator, Mottronics, Magnetism, spintronics, Light-driven electronic phase transitions, Superconductivity, Josephson junction and superconducting qubits. **(12 Hours)**

Text Books:

1. Quantum Heterostructures: Microelectronics, V. V. Mitin, V. A. Kochelap, and M. A. Stroscio.
2. Quantum Wells, Wires, and Dots: Theoretical and Computational Physics, P. Harrison, John Wiley, 2000.
3. Quantum Wells: Physics and Electronics of two-dimensional systems, A. Shik, World Scientific, 1999.
4. Solid State Physics: An introduction, by Hofmann [online @ UW library]
5. Electronic Properties of Materials, by Rolf Hummel [online @ UW library]
6. Semiconductor Photonics of Nanomaterials and Quantum Structures, by Arash Rahimi-Iman [online @ UW library]

IPH9E602 **Credits: 4**

ADVANCED NUCLEAR PHYSICS **T-P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Explain the basics of nucleus, nuclear properties and decay in terms of various nuclear models.	Analyze
CO2	Apply these models to explain the filling up of neutron and protons inside shells and predict the properties of the nuclei.	Apply
CO3	Understand the mechanism of nuclear reactions and evaluate the kinematics and cross section	Evaluate
CO4	Analyze the dynamics in nuclear reactors and mechanisms of controlling fission reaction.	Analyze

I. Nuclear Shell Model:

Common potential for shell model, Wave function and nuclear potential, l, spin orbit term, realistic one body potentials, Nuclear volume parameter, single particle spectra of closed shell + 1 nuclei, two particle outside the shell, independent particle model, Hartree-Fock method. Coupling of spin and orbital angular momentum, magnetic dipole moment and electric quadrupole moment, Schmidt diagram; Single particle orbitals in deformed nuclei, perturbation treatment, asymptotic wave functions, single particle orbitals in an axially symmetric modified oscillator potential. **(16 hours)**

Text Books:

1. H. S. hans, Nuclear Physics Experimental and theoretical, New age international Publications, (2010)

2. S. G. Nilsson and I. Ragnarsson: "Shapes and Shells in Nuclear Structure", (Cambridge University Press; Revised ed. Edition, 2005)

II. Nuclear Collective Models:

Nuclear rotational motion- rotational energy spectrum and wave functions for even-even and odd A nuclei - Nuclear moments- collective vibrational excitations, Rotational Bands – The particle rotor model, strong coupling- deformation alignment, Decoupled bands - rotational alignment; two particle excitations and backbending; Fast nuclear rotation- the cranking model; Rotating harmonic oscillator. **(12 hours)**

Text Books:

1. H. S. Hans, Nuclear Physics Experimental and theoretical, New age international Publications, (2010)

2. R. R. Roy and B.P. Nigam: "Nuclear Physics- Theory and Experiment", (Wiley Eastern)

3. S.G. Nilsson and I. Ragnarsson: "Shapes and Shells in Nuclear Structure", (Cambridge University Press; Revised ed. Edition, 2005)

4. M K Pal: "Theory of Nuclear Structure", (East West Press Pvt. Ltd).

III. Nuclear Reactions:

Reactions and Cross-sections, Resonances, Breit-Wigner formula for $l = 0$, Compound Nucleus formation, continuum theory, statistical theory, evaporation probability, fission cross sections, Mass distribution of fission fragments, Heavy ion reactions. **(10 hours)**

Text Books:

1. R.R. Roy and B.P. Nigam:"Nuclear Physics- Theory and Experiment", (Wiley Eastern)

2. Kenneth S. Krane: "Introductory Nuclear Physics", (Wiley)

IV. Direct Reactions:

Plane wave theory of direct reaction, DWBA, inelastic scattering as direct process, nuclear spectroscopy from direct reactions, Pre-equilibrium model, exciton model, quantum mechanical models of pre-equilibrium emission. **(8 Hours)**

Text Book**:** H. S. Hans, Nuclear Physics Experimental and theoretical, New age international Publications, (2010)

V. Reactor Physics:

Interaction of neutrons with matter, Nuclear Fission, Neutron Chain Reacting Systems, Neutron balance conditions for criticality, Conversion and Breeding, Types of nuclear reactors, Reactor Power, Fuel Burnup, Neutron transport in reactors, Neutron current density, Equation of Continuity, Fricks law, Diffusion Equation, Neutron moderation, Leathergy, Multiscattered neutrons, Fermi Age theory, Age equation, Solutions to the age equation, Elastic moderation time, Slowing down kernels, Neutron absorption with moderation and fission, Weak absorption, Resonance escape, Thermal neutron spectra, Reactor Power, Criticality for reactor geometries. **(14 hours)**

Text Books for study

1. H. Enge: Introduction to Nuclear Physics” (Addison Wesley)

2. John. R. Lamarsh, Introduction to Nuclear Reactor Theory, Addison Wesley, USA

References:

1. H. S. Hans: Nuclear Physics – Experimental & theoretical (New Age International 2001)

2. Kenneth S Krance, Introductory nuclear physics, (Wiley india, 2012)

3. S. B. Patel, An introduction to nulcear Physics, (New Age International)

4. George I. Bell and Samuel Glasstone, Nuclear Reactor Theoy, Van Nostrand Reinhold

Company

IPH9E603 **Credits: 4**

ADVANCED ASTROPHYSICS **T-P: 4-0**

	Course Outcome: **After completion of the full course the student should be able to**	**Cognitive level**
CO1	Describe the interior of the stars and evolutionary state	Understand
CO2	Connect the observation of radiation in a particular wavelength from a celestial source to its possible nature and state.	Apply
CO3	Derive the physical properties of stars from their nature such as binarity and variability	Analyze
CO4	Describe the astrophysical phenomena such as black holes and gravitational waves using the concepts of general relativity	Apply
CO5	Explain the basic concepts of cosmological models	Understand

I. Stellar Structure

Hydrostatic equilibrium , Pressure equation of state, Energy generation in stars: Gravitation and the Kelvin – Helmholtz time scale, nuclear time scale, Quantum mechanical tunneling, nuclear reaction rates, Stellar nucleosynthesis, Energy transport and thermodynamics: Conduction, Convection, Radiation **(14 hours)**

Text: Chapter 10 of B.W. Carroll & D.A. Ostille : "Modern Astrophysics", (Addison Wesley, 1996).

II. Radiative Process:

Theory of Black Body Radiation-Photoelectric Effect-Pressure of Radiation -Absorption and Emission spectra - Doppler Effect - Zeeman Effect- Bremsstrahlung – Synchrotron Radiation - Scattering of Radiation – Compton Effect - and Inverse Compton effect, Basics of radiative transfer, Transfer equations **(12 hours)**

Text: Chapter 2 of Baidyanath Basu, Relevant portions from Chapter 9 of B.W. Carroll & D.A. Ostille : "Modern Astrophysics", (Addison Wesley, 1996)

III. The Nature of Stars:

Binary systems: The classification of binary stars, Mass determination using Visual binaries, Eclipsing, Spectroscopic binaries. Variable stars: Observations of pulsating stars, The physics of stellar pulsations, Non-radial stellar pulsations **(12 hours)**

Text: Relevant sections from Chapter 7 and Chapter 14 of B.W. Carroll & D.A. Ostille : "Modern Astrophysics", (Addison Wesley, 1996)

IV. General Relativity:

General Considerations – Space, time and gravitation, Tensors, Metric for weak gravitational field, The Energy-momentum tensor, Einstein's equations, Some applications of general relativity : Gravitational redshift, The Schwarzschild metric- motion of massless particle, The bending of light, Gravitational waves **(12 hours)**

Text: Arnab Rai Choudhuri, Relevant portions from Chapters 12 and 13

V. Cosmology:

Isotropy and homogeneity, The Red Shift, Scale factor and Distance , Cosmic microwave background, Equivalence principle, describing curvature, Robertson-Walker metric, proper distance, The Friedmann model, The history of the Universe (qualitative idea) **(10 hours)**

Text: Barbara Ryden Chapters 2 and 3

Relevant sections of Chapter 19 of Fundamental Astronomy by Karttunen et al

Books for Reference:

1. Steven Weinberg: "Gravitation & Cosmology", (John Wiley (1972).
2. T. Padmanabhan: "Theoretical Astrophysics", Vol 1 and 2 (Cambridge Uni versity Press, 2000).
3. Ajit K Kembhavi and Jayat V Narlikar: "Quasars and Active Galactic Nuclei", (Cambridge University Press, 1999).
4. F. Shu: "The Physical Universe, An Introduction to Astronomy", (Oxford University Press, 1982).
5. Fred Hoyle, Geoffrey, Jayant V Narlikar :"A Different Approach to Cos mology", (Cambridge University Press, 2000).
6. Baidyanath Basu:"An Introduction to Astrophysics", (Prentice Hall India , 1997).
7. R. C. Bless: "Discovering the Cosmos", (University Science Books,1996).
8. V. B. Bhatia: "Text Book of Astronomy and Astrophysics with Elements of Cosmology", (Narosa publications, 2001).

9. B. W. Carroll & D.A. Ostille : “Modern Astrophysics”, (Addison Wesley, 1996).
10. J. Binney & M. Merrifield:”Galactic Astronomy”,(Princeton University Press).
11. J. Binney & S. Tremaine:”Galactic Dynamics”, (Princeton University Press).
12. J. V. Narlikar,:”An Introduction to Cosmology”, (Third Edition, Cambridge University Press, 2002)
13. Barbara Ryden: “An Introduction to Cosmology”, (Second Edition, Cambridge University Press, 2017)
14. Arnab Rai Choudhuri: “Astrophysics for Physicists”, Cambridge University Press.
15. H. Karttunen, P. Kroger, H. Oja, M. Poutanen, K. J. Donner (Eds.): “Fundamental Astronomy”

IPH9E604 **Credits: 4**

SOFT MATTER PHYSICS **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Illustrate the thermodynamic properties of soft materials	Apply
CO2	Explain the basic ideas of colloidal systems	Understand
CO3	Explore the liquid crystal phases and its relevance in biology	Apply
CO4	Correlate the Pair Correlation Function and Radius of Gyration	Analyze
CO5	Illustrate the thermodynamics of self-assembly	Apply

I. Introduction to soft matter

Overview of soft matter, entropy in disordered systems; forces, energies, and time scales in soft matter, intermolecular forces, macromolecules, Rheological and Microrheological studies. **(12 hours)**

II. Colloidal systems

Surface phenomenon and stability of colloidal systems; The Poisson–Boltzmann equation, DLVO theory: van der Waals versus Electrostatic Interactions, Solutions of Colloidal Particles. **(12 hours)**

III. Liquid Crystals

Introduction to liquid crystals, Classification of liquid crystals, Electric and magnetic field effects, Kerr effect, Biological importance of liquid crystals, Elastic continuum theory. **(12 hours)**

IV. Polymers

Single-chain conformations, The ideal (or Gaussian) chain, Pair correlation function and radius of gyration, The Flory chain, Chains in interaction, The mean field approach, Scaling laws for athermal solutions. **(12 hours)**

V. Self-assembly and interface science

Thermodynamics of self-assembly, formation of aggregates, critical micellar concentration, soluble monolayer and Gibbs adsorption, insoluble monolayers, characterization of Langmuir monolayers; interactions in lamellar flexible systems, elasticity of neutral membranes. (12 hours)

Text Books:

1. Soft condensed matter by R. A. L. Jones, Oxford University Press.
2. Experimental and computational techniques in soft condensed matter physics edited by Jeffrey Olafsen, Cambridge University Press 2010.
3. Liquid Crystals: Nature delicate phase of matter by P. J. Collings, Princeton University Press.
4. Liquid crystals by S. Chandrashekar.
5. Polymer Physics by Tanaka Fumihiko, Cambridge University Press

Reference Books:

1. Intermolecular and surface forces by Jacob N. Israelachvili. Published by Academic Press.
2. The physics of liquid crystals by P. G. de Gennes and J. Prost. Published by Oxford Science Publications.
3. Soft matter physics- An introduction by Maurice Kleman and Oleg D. Lavrentovich. Published by Springer.

IPH9E605 **Credits: 4**

HIGH ENERGY PHYSICS **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Characterize the role played by symmetries in Quantum Field theories	Analyze
CO2	Correlate the idea of Spontaneous Symmetry Breaking and Higgs mechanism	Analyze
CO3	Explore the liquid crystal phases and its relevance in biology	Apply
CO4	Correlate the Pair Correlation Function and Radius of Gyration	Apply
CO5	Illustrate the thermodynamics of self-assembly	Apply

I. Gauge Theories

Introduction to Gauge symmetries – global and local gauge transformations, Abelian group U(1) (QED), Yang-Mills (Non-Abelian) groups – SU(2) (isospin), SU(3) C (QCD). **(10 Hours)**

II. Spontaneous Symmetry Breaking (SSB)

Ground state with spontaneous symmetry breaking, some examples; global symmetry breaking and Goldstone bosons, proof of Goldstone theorem, local symmetry breaking and Higgs mechanism for giving masses to vector bosons, examples-U(1), SU(2). **(12 Hours)**

III. Standard Model (SM)

Standard model of electroweak unification, gauge bosons, charged weak current and $W^{\pm}$, Z^0 neutral current, Higgs particle, experimental status. **(10 Hours)**

IV. Beyond Standard Model

(a) Introduction to Grand Unified Theories (GUTs) – SU(5) and SO(10), and proton decay predictions;

(b) Minimal Supersymmetric Standard Model (MSSM) and its extension, its predictions;

(c) Introduction to String Theories and Planck scale physics. **(15 Hours)**

V. Neutrino Physics

Solar and atmospheric neutrino puzzles, theory of neutrino oscillations in vacuum and medium (MSW mechanism), neutrino masses and leptonic mixings, survey of various neutrino oscillation experiments, seesaw mechanism for small neutrino masses. **(13 Hours)**

Books recommended:

1. Gauge Theory of elementary particle physics - Ta–Pei Cheng & Ling-Fong Li, (Oxford University Press, 1983).
2. Quarks and leptons: An introductory Course in Modern Particle Physics, by Francis Halzen & Alan D. Martin (John Wiley & Sons, 1984).
3. Introduction to Elementary Particles - David Griffiths (John Wiley & Sons, 1987).
4. A First Course in String theory, by Barton Zwiebach, (Cambridge Univ. Press, 2004).
5. Grand Unified theories - Graham G. Ross, (Oxford Univ. 1984).
6. Massive Neutrinos in Physics and Astrophysics – by R.N. Mohapatra & P.B. Pal (World Scientific Lecture Notes In Physics)

IPH9E606 **Credits: 4**

NUCLEAR INSTRUMENTATION **T-P: 4-0**

	Course Outcome	**Cognitive level**
CO1	Able to use various detectors for radiation detection	Apply
CO2	Able to use different type of detectors for laboratory and dosimetric applications.	Apply
CO3	Able to design and setup radiation measurement systems	Apply
CO4	To evaluate the uncertainties in the measured nuclear data.	Apply

I. Nuclear Radiation Sources

standard sources, accelerators, reactors, detectors and signals, gas detector, scintillation detectors, semiconductor detectors, solid state track detectors, neutron detectors, detector efficiency,- intrinsic and geometry dependent efficiency, position sensitive detectors, pulse shape discrimination. **(12 hours)**

II. Electronics for Pulse Processing

Oscilloscope, precision pulse generator, detector bias supply, preamplifier and amplifier, pulse height discriminator, single channel Analyzer, counter, timer, biased amplifier, coincidence and anticoincidence units,Multi-channel Analyzes, timing filter amplifier, gate and delay generator, constant fraction discriminator, Time to amplitude converter **(12 hours)**

III. Nuclear Instrumentation Standards

Nuclear instrumentation modules, standards, Computer automated measurements and control, VME modules, Digitizer. **(10 hours)**

IV. Data acquisition and analysis

data acquisition, cables, connectors, terminators,, shaping circuits, delay line, charged particle spectroscopy, neutron spectroscopy, neutron time of flight, Data analysis, differential and integral spectrum, particle identification and energy measurements, error analysis. **(12 hours)**

V. Familiarization of nuclear electronics modules and practical analysis (14 hours)

Text Book for study:

1. K Muraleedhara Varier, A practical approach to nuclear physics, Nerosa Publications, (2019)
2. Nicholas T Soulfanidis - Measurement and Detection of Radiation, second edition
3. G. F. Knoll, Radiation detection and measurements, 3rd edn, John Wiley, New York

References:

1. W. E. Burcham & M. Jobes – Nuclear and Particle Physics – Longman (1995)
2. Mcknlay, A. F., Bristol, Adam Hilger , Thermoluminescence Dosimetry-MedicalPhysics Handbook 5,,CRC Press, USA
3. W. J. Meredith and J.B.Massey “Fundamental Physics of Radiology” John Wright and sons, UK, 1989.
4. J. R. Greening “Fundamentals of Radiation Dosimetry”, Medical Physics Hand BookSeries Adam Hilger Ltd., USA

IPH9E607 **Credits: 4**

ADVANCED COMPUTATIONAL PHYSICS **T – P: 4 - 0**

	Course Outcome	Cognitive level
CO1	Understand and apply advanced numerical methods to solve complex physical problems	Apply
CO2	Develop and implement simulation techniques for physical systems.	Create
CO3	Analyze and interpret large data sets obtained from experiments and simulations.	Analyze
CO4	Design and optimize algorithms for numerical solutions in physics.	Create
CO5	Critically evaluate the accuracy, stability, and efficiency of various computational methods.	Evaluate

I. Numerical Solutions of Partial Differential Equations

Partial Differential Equations (PDEs): Classification and examples, Finite Difference Method for PDEs, Finite Element Method, Stability and convergence of numerical methods, Simulation of temperature distribution in a rod. **(12 hours)**

II. Statistical Methods and Monte Carlo Simulations

Basics of statistical mechanics, Monte Carlo methods: Importance sampling, Metropolis algorithm, Ising Model: Concepts, simulations, and phase transitions, Applications in statistical physics, Random walks and diffusion, Simulation of phase transitions in a magnetic system using Ising Model. **(12 hours)**

III. Computational Fluid Dynamics (CFD)

Introduction to fluid dynamics, Navier-Stokes equations, Discretization methods: Finite difference, finite volume, and finite element methods, Grid generation and boundary conditions, airflow simulation over a wing using Navier-Stokes equations. **(12 hours)**

IV. Computational Quantum Mechanics

Introduction to quantum mechanics, Schrödinger equation: Time-independent and time-dependent forms, Numerical solutions of Schrödinger equation, Variational and perturbation methods, Solving the Schrödinger equation for the hydrogen atom. **(12 hours)**

V. High-Performance Computing (HPC) and Parallel Processing

Basics of parallel computing, Parallel algorithms and architectures, Message Passing Interface (MPI) and OpenMP, Performance optimization techniques, Parallelization of molecular dynamics simulation. **(12 hours)**

Text Books:

1. Statistical Mechanics: Theory and Molecular Simulation Tuckerman, M. E., Oxford University Press, 2010.
2. Computational Physics: Problem Solving with Python, Landau, D. P.; Páez, M. J.; Bordeianu, C. C., Wiley-VCH, 2018.
3. Understanding Molecular Simulation: From Algorithms to Applications, Frenkel, D.; Smit, B., Academic Press, 2001.
4. Numerical Simulation in Fluid Dynamics: A Practical Introduction, Griebel, M.; Dornseifer, T.; Neunhoeffer, T., SIAM, 1998.

Reference Books:

1. Computational Physics, Giordano, N. J.; Nakanishi, H., Pearson, 2005.
2. Numerical Recipes: The Art of Scientific Computing, Press, W. H.; Teukolsky, S. A.; Vetterling, W. T.; Flannery, B. P., Cambridge University Press, 2007.
3. An Introduction to Computer Simulation Methods: Applications to Physical Systems, Gould, H.; Tobochnik, J.; Christian, W., Pearson, 2007.
4. Computational Physics, Thijssen, J. M., Cambridge University Press, 2007.
5. Python for Computational Science and Engineering (A beginner's guide), Mortensen, M., Create Space Independent Publishing Platform, 2015.
6. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K.; Malalasekera, W., Pearson Education, 2007.
7. A First Course in Computational Physics, DeVries, P. L., Wiley, 1994.
8. Wolfgang Christian. Introduction to Computer Simulation Methods, Harvey Gould, Jan Tobochnik, Addison-Wesley, 1996.

IPH10P601 **Credits: 20**

RESEARCH PROJECT

The project can be experimental or theoretical. The projects may be carried out either utilizing the facilities in the Department or elsewhere. In case they carry out the projects outside the Department, this shall in no way affect their minimum attendance for the theory papers. Also, they should obtain an attendance certificate from the outside institution where the work is carried out and also a certificate in the Project Report that the work had been carried out by the concerned student at that institution. The students shall prepare a detailed report on their work. This shall be attested by the teacher-in-charge concerned at the center (and the relevant authority at the external institution, if the work had been carried out at some other centre). The students shall submit the project report before the commencement of the theory examinations. . The same will be evaluated by a committee consisting of one external expert and the internal supervisor. A presentation of the project and a comprehensive viva voce on the project will be held and evaluated by a committee consist of supervisor, HoD and an internal examiner. The Project shall also carry an internal evaluation to the extent of 50%.

IPH10C601 **Credits: 4**

MATHEMATICAL PHYSICS - II **T - P: 4 - 0**

	Course outcome: **After completion of the full course the student should be able to**	**Cognitive level**
CO1	In general, physical phenomena are expressed in equations involving complex quantities. Sometimes we get complex solutions to equations. Solving such problems requires special procedures. On completing this module he/she will gain the skill for solving and interpreting such problems.	Analyze
CO2	Address the class of objects called groups and the symmetry operations expressed as group elements. Understand group properties.	Evaluate
CO3	Group representations provide the understanding of applications of group theory in quantum mechanics. Different discrete and continuous groups and gauge principles are introduced here.	Apply
CO4	Understand calculus of variation in a level suitable for application in various physical problems in physics.	Understand
CO5	Understand various integral transforms and Green's functions and their applications in physical problems obeying causality conditions,	Understand

I. Integral Transforms

Fourier Series, General properties, Advantages, Uses of Fourier series, Properties of Fourier series, Fourier integral, Fourier transform, Properties, Inverse transform, Transform of the derivative, Convolution theorem, Laplace transform, Inverse Transform and Convolution theorem. **(11 hours)**

Text: Book 1

II. Functions of Complex Variables

Introduction, Analyticity, Cauchy-Reimann conditions, Cauchy's integral theorem and integral formula, Laurent expansion, Singularities, Calculus of residues and applications. **(13 hours)**

Text: Book 1

III. Group Theory

Groups, Multiplication Table, Conjugate elements and classes, Subgroups, Direct product groups, Isomorphism and homomorphism, Permutation groups, Distinct groups of given order. **(10 hours)**

Text: Book 2

IV. Calculus of Variations

One dependent and one independent variable, Application of Euler equation, Generalization to several independent variables, Several dependent and independent variables, Lagrange Multipliers, Variation subject to constraints, Rayleigh-Ritz variational technique. **(11 hours)**

Text: Book 1

V. Integral equations and Green's function

Integral equations – introduction, Integral transforms and generating functions, Neumann series, separable kernel, Green's function – Non homogeneous equations, Green's function, Symmetry of Green's function, form of Green's function, Example – Quantum mechanical scattering. **(15 hours)**

Text: Book 1

Text Book:

3. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, 6th Edition, Academic Press, 2005. (Book 1)
4. Elements of Group Theory For Physicists, A. W. Joshi, New Age International Publishers New Delhi, 2002. (Book 2)

Books for Reference:

5. Mathematical Methods for Physics, J. Mathews and R. Walker, 2nd Edition, Benjamin
6. Applied Mathematics for Engineers and Physicists, L. I. Pipes and L. R. Harvill, 3rd Edition, McGrawHill
7. Advanced Engineering Mathematics, Erwin Kreyzig, 8th edition, Wiley
8. Advanced Engineering Mathematics, M. Greenberg, 2nd edition, Pearson India, 2002.

5. Matrices and tensors in Physics, A.W. Joshi, New Age International Publishers

6. Tensors and Their Applications, Nazrul Islam, New Age International, 2006

8. Group Theory and Quantum Mechanics, M. Tinkham, Tata-McGraw-Hill

IPH10C602 **Credits: 4**

COMPUTATIONAL PHYSICS – II **T-P: 2-2**

	Course Outcome	Cognitive level
CO1	Understand and apply advanced numerical methods to solve complex physical problems	Apply
CO2	Develop and implement simulation techniques for physical systems.	Create
CO3	Analyze and interpret large data sets obtained from experiments and simulations.	Analyze
CO4	Design and optimize algorithms for numerical solutions in physics.	Create
CO5	Critically evaluate the accuracy, stability, and efficiency of various computational methods.	Evaluate

I. Numerical Solutions of Partial Differential Equations

Partial Differential Equations (PDEs): Classification and examples, Finite Difference Method for PDEs, Finite Element Method, Stability and convergence of numerical methods, Simulation of temperature distribution in a rod. **(12 hours)**

II. Statistical Methods and Monte Carlo Simulations

Basics of statistical mechanics, Monte Carlo methods: Importance sampling, Metropolis algorithm, Ising Model: Concepts, simulations, and phase transitions, Applications in statistical physics, Random walks and diffusion, Simulation of phase transitions in a magnetic system using Ising Model. **(12 hours)**

III. Computational Fluid Dynamics (CFD)

Introduction to fluid dynamics, Navier-Stokes equations, Discretization methods: Finite difference, finite volume, and finite element methods, Grid generation and boundary conditions, airflow simulation over a wing using Navier-Stokes equations. **(12 hours)**

IV. Computational Quantum Mechanics

Introduction to quantum mechanics, Schrödinger equation: Time-independent and time-dependent forms, Numerical solutions of Schrödinger equation, Variational and perturbation methods, Solving the Schrödinger equation for the hydrogen atom. **(12 hours)**

V. High-Performance Computing (HPC) and Parallel Processing

Basics of parallel computing, Parallel algorithms and architectures, Message Passing Interface (MPI) and OpenMP, Performance optimization techniques, Parallelization of molecular dynamics simulation. **(12 hours)**

Text Books:

5. Statistical Mechanics: Theory and Molecular Simulation, Tuckerman, M. E., Oxford University Press, 2010.
6. Computational Physics: Problem Solving with Python, Landau, D. P.; Páez, M. J.; Bordeianu, C. C., Wiley-VCH, 2018.
7. Understanding Molecular Simulation: From Algorithms to Applications, Frenkel, D.; Smit, B., Academic Press, 2001.
8. Numerical Simulation in Fluid Dynamics: A Practical IntroductionGriebel, M.; Dornseifer, T.; Neunhoeffer, T., SIAM, 1998.

Reference Books:

9. Giordano, N. J.; Nakanishi, H. Computational Physics; Pearson, 2005.
10. Press, W. H.; Teukolsky, S. A.; Vetterling, W. T.; Flannery, B. P. Numerical Recipes: The Art of Scientific Computing; Cambridge University Press, 2007.
11. Gould, H.; Tobochnik, J.; Christian, W. An Introduction to Computer Simulation Methods: Applications to Physical Systems; Pearson, 2007.
12. Thijssen, J. M. Computational Physics; Cambridge University Press, 2007.
13. Mortensen, M. Python for Computational Science and Engineering (A beginner's guide); CreateSpace Independent Publishing Platform, 2015.
14. Versteeg, H. K.; Malalasekera, W. An Introduction to Computational Fluid Dynamics: The Finite Volume Method; Pearson Education, 2007.
15. DeVries, P. L. A First Course in Computational Physics; Wiley, 1994.
16. Harvey Gould, Jan Tobochnik, Wolfgang Christian. Introduction to Computer Simulation Methods; Addison-Wesley, 1996.

IPH10C603 **Credits: 4**

ADVANCED ELECTRODYNAMICS **T-P: 4-0**

	Course Outcome	Cognitive level
CO1	Analyze the wave propagation through waveguides using Maxwell's equations	Analyze
CO2	Analyze the nature of electric and magnetic fields in relativistic conditions	Analyze
CO3	Analyze the formation and characteristics of Plasma	Analyze
CO4	Evaluate the basics of quantization of field	Evaluate
CO5	Create the entanglement in the quantum systems	Create

I. Wave guides and Cavity Resonators

Penetration of fields into the conductors, Wave guides, Cylindrical, Rectangular, Energy flow and attenuation, Resonance cavities, Power losses, Fields and radiation of localized oscillating source, Electric dipole fields and radiation. **(12 hours)**

II. Relativistic Electrodynamics

Special theory of relativity, Lorentz transformations, Addition of velocities, 4-vectors, Covariance of electrodynamics, Transformations of electromagnetic fields, Lienard-Wiechert potentials, Larmor's formula and its relativistic generalization. **(12 hours)**

III. Plasma Physics

Plasma -Definition, concepts of plasma parameter, Debye shielding, Motion of charged particles in an electromagnetic field -Uniform electric and magnetic fields, Distribution function, Boltzmann and Vlasov equations, Derivation of moment equation, Fluid theory, Plasma oscillations, Hydromagnetic waves, Magnetosonic waves and Alfven waves. **(12 hrs)**

IV. Quantization of fields

The principles of canonical quantization of fields, Lagrangian density and Hamiltonian density, Second quantization of the Schrodinger wave field for bosons and fermions, Classical field theory of electrodynamics and gauge symmetry. **(12 hrs)**

V. Quantum Interpretation

Spin - spin correlation measurements and Bell's inequality, Composite systems and entanglement, Einstein Podolsky Rosen (EPR) paradox, Density matrices, Pure and mixed states, time evolution of density matrices, Bloch sphere, partial trace and entanglement entropy. **(12 hrs)**

Text Books:

6. Classical Electrodynamics, J. D. Jackson, 3rd Ed., Wiley,1999.
7. Introductory Electrodynamics, David Griffiths, 4th Ed.,Prentice Hall of India, 2012.
8. Electricity and Magnetism by R. Murugeshan.
9. Text book of Electrical technology Volume 1-Basics of Electrical Engineering by B.L Ther-aja and A.K Theraja.
10. Greiner and Reinhardt, Field Quantization, Spinger Verlag, 1996

Books for Reference:

4. Field and Wave Electromagnetics, David K. Cheng, 2nd Ed., Addisson Wesley.
5. Quantum Field theoryLewis H. Ryder, Cambridge University Press, 1995.
6. Field Theory – A modern primer, Pierre Ramond, Bengamin, 1996

IPH10C604 **Credits: 4**

QUANTUM FIELD THEORY **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Illustrate the canonical quantization of electromagnetic and Schrodinger field. Electron-photon interaction at a more fundamental level.	Understand
CO2	Substantiate the necessity of quantization for studying the behavior of identical many particle system, like atoms, molecules, nuclei.	Apply
CO3	Describe the canonical quantization of photon field	Apply
CO4	Calculate the Feynman propagator for any field	Analyze
CO5	Evaluate the interactions using current-current interactions	Evaluate

I. Classical Field Theory

Harmonic oscillator, The linear chain- classical treatment, the linear chain – quantum treatment, classical field theory, Hamiltonian formalism, Functional derivatives, Canonical quantization of nonrelativistic fields, Lagrangian and Hamiltonian for the Schroedinger field, Quantization of fermions and bosons, Normalization of Fock states. **(14 hours)**

II. Canonical quantization of Klein Gordon field

The neutral Klein – Gordon field Commutation relation for creation and annihilation operators, Charged Klein – Gordon field, Invariant commutation relations, Scalar Feyman propagator. **(10 hours)**

III. Canonical quantization of photon field

Maxwells equations, Larangian density for the Maxwell field, Electromagnetic field in the Lorentz gauge, Canonical quantization of the Lorentz gauge – Gupta-Bleuler method, Canonical quantization in the Coulomb gauge. **(12 hours)**

IV. Canonical quantization of spin ½ fields

Lagrangian and Hamiltonian densities for the Dirac field, Canonical quantization of the Dirac field, Plane wave expansion of the field operator, Feyman propagator for the Dirac field. **(12 hours)**

V. Interacting quantum fields and Quantum Electrodynamics

The interaction picture, Time evolution operator, Scattering matrix, Wick's theorem, Feynman rules for QED, Moller scattering and Compton scattering. **(12 hours)**

Text Book:

1. Field Quantization, Greiner and Reinhardt, Spinger-Verlag -1996.

References:

1. Quantum Field theory, Lewis H. Ryder, Cambridge University Press -1995.
2. Field Theory – A modern primer, Pierre Ramond, Benjamin – 1996.
3. Quantum Field Theory, Itzyskon and Zuber, McGraw Hill – 1989.
4. Quantum Field theory, Karson Huang, Wiley.

IPH10C605 **Credits: 4**

THIN FILM AND VACUUM TECHNOLOGY **T - P: 4 - 0**

	Course Outcome	**Cognitive level**
CO1	Explain vacuum, Gauges to measure vacuum, types of pumps and their utility, cryogenics etc.	Understand
CO2	Demonstrate different thin film fabrication techniques and their thickness measurement	Analyze
CO3	Analyze the applications of Thin films	Analyze
CO4	Analyze the crystal structure using X-ray Diffraction technique	Apply
CO5	Articulate various morphological analysis techniques related to nanomaterials	Analyze

I. Vacuum Techniques

Units and basic definitions, Roughing pumps - Oil sealed rotary vacuum pump and Sorption pump, High vacuum pumps – Turbo molecular pump, Diffusion pump, Oil vapour booster pump, Ion pumps - Sputter ion pump, Cryo pump, Vacuum gauges - Pirani gauge, Thermocouple gauge, penning guage Vacuum accessories – Diaphragm, Gate valve, Butterfly valve, Baffle and isolation valves, magnetic valves, adjustable valves, air inlet valves, Traps - Liquid nitrogen trap, Sorption traps, and gaskets and O rings. **(16 hours)**

II. Thin film fabrication

Introduction, Fabrication of thin films, Physical vapour deposition, chemical vapour deposition, Thermal evaporation in vacuum – Resistive heating, Electron beam evaporation, Pulsed laser deposition, Sputter deposition, Magnetron sputtering, Spray pyrolysis, Spin coating methods. **(13 hours)**

III. Film thickness measurement and Characterization

Thickness measurement by quartz crystal monitor, optical interference method, electrical conductivity measurement, Thermo electric power, Interference filters - Multi layer optical filters, Technological Applications of thin films. **(10 hours)**

IV. Structural Analysis using XRD

Introduction, Lattice planes and Bragg's Law, Diffractometer - Instrumentation, Single crystal and Powder diffraction, Scherrer equation, Structure factor, Applications of XRD - Crystallinity, Unit Cell Parameters, Phase transition studies, thin film studies, Powder Diffraction File (PDF) of the International Centre for Diffraction Data. **(9 hours)**

V. Morphological Analysis of nanomaterials

Introduction, Interaction of electron beam with matter, Scanning Electron Microscope (SEM), Instrumentation, Imaging using Secondary electrons, Backscattered electron imaging, Applications of SEM, Energy Dispersive X-ray spectroscopy, Transmission electron Microscopy, Scanning Probe Microscopes (SPM), Scanning Tunneling Microscope (STM), Atomic Force Microscope (AFM). **(12 hours)**

Textbooks:

1. Nanostructures and Nanomaterials- Synthesis, Properties, Guozhong Cao, Imperial College Press, 2004.
2. Advanced Experimental Techniques in Modern Physics, K. Muraleedhara Varier, Antony Joseph and P.P.Pradyumnan, Pragati Prakashan, Meerut, 2006.
3. Elements of Modern X-ray Physics, Jens Als Nielsen and Des McMorrow, John Wiley and Sons 2000.
4. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, Springer, 3rd Edition Springer 2015

Books for Reference:

1. Scientific foundations of vacuum techniques, S. Dushman and J.M. Laffer, John Wiley New York, 1962.
2. Thin film phenomena – K.L. Chopra, Mc Graw Hill, 1983.
3. Thin film technology, R. Berry, P.M. Hall and M.T. Harris, Van Nostrand, 1968.
4. Foundations of Vacuum Science and Technology, Lafferty J.M, Wiley, 1998.
5. Encyclopedia of nanotechnology, Bharat Bhushan, Springer, 2012.
6. Elements of X-ray diffraction, B.D. Cullity, Addison Wesley Inc., 1978.
7. Useful Link for XRD http://pd.chem.ucl.ac.uk/pdnn/powintro/whatdiff.htm

Pattern of Question Paper for Major, Minor, Elective, MDC, SEC, VAC courses (offered by the Department of Physics) in Integrated M.Sc. Physics w.e.f. 2024

Code: **Reg. No:**

Name:

FIRST to TENTH SEMESTER INTEGRATED M.SC. DEGREE EXAMINATION – w.e.f 2024,

Course Category

Code: (e.g. IPH1C101) - Subject (e.g. CONCEPTS IN PHYSICS)

Time: 3 hours **Total Marks = 50**

Section A

(8 Short questions each answerable within 7 minutes) (Answer **ANY EIGHT** questions, each carry 2 Marks)

Question Numbers 1 to 10 Total Marks 8 x 2 = 16

Section B

(3 essay questions each answerable within 20 minutes) (Answer **ANY THREE** questions, each carry 6 Marks)

Question Numbers 11 to 15 Total Marks 3 x 6= 18

Section C

(4 problems answerable each within 16 minutes)

(Answer **ANY FOUR** questions, each carry 4 Marks)

Question numbers 16 to 22 Total marks 4 x 4 = 16 marks