School of Physics

Course Structure and Syllabi for M.Sc. and I.M.Sc. Programs

Contents:

UNIVERSITY OF HYDERABAD
School of Physics
I.M.Sc. (Physics)
Course Structure and Course details
(Years 1–3; Semesters 1–6)
2020

I.M.Sc. Course Structure

(IPH – Integrated Physics, T – Theory, L – Lab, C – Choice-based course)

Semester I		**Total No. of Credits: 4.5**		
Title of the course		Contact hours and Credits		
		Classroom Lectures	Laboratory classes	Total Credits
Compulsory courses	**IPH 101** - Mechanics (A & B)*	3	0	3
	IPH 102 - Mechanics Lab	0	3	1.5

Semester 2		**Total No. of Credits: 4.5**		
	Title of the course	Contact hours and Credits		
		Classroom Lectures	Laboratory classes	Total Credits
Compulsory Courses	**IPH 151** - Vibrations and Waves (A & B)*	3	0	3
	IPH 152 – Vibrations and Waves Lab	0	3	1.5

Note: (…)*: A – For students who have studied Mathematics in +2 / Intermediate
B – For students who have NOT studied Mathematics in +2 / Intermediate

Semester 3		**Total No. of Credits: 8.5**		
Title of the course		Contact hours and Credits		
		Classroom Lectures	Laboratory classes	Total Credits
Compulsory Courses	**IPH 201** - Electricity and Magnetism	4	0	4
	IPH 202 – Electricity and Magnetism Lab	0	3	1.5
Choice-based course (Choose 1 out of all the options)	**IPH 203** – Biophysics	4	0	4

Semester 4		**Total No. of Credits: 13.5**		
Title of the course		Contact hours and Credits		
		Classroom Lectures	Laboratory classes	Total Credits
Compulsory Courses	**IPH 251** - Modern physics (including Special theory of relativity)	4	0	4
	IPH 252 - Mathematical methods for Physics	4	0	4
	IPH 253 - Heat and Thermodynamics lab	0	3	1.5
Choice-based course (Choose 1 out of all the options)	**IPH 254** – Optics of gadgets	4	0	4

Semester 5		**Total No. of Credits : 24**		
Title of the course		Contact hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
Compulsory Courses	**IPH 501** - Analytical Dynamics	4	0	4
	IPH 502 – Electronics	4	0	4
	IPH 503 – Optics	4	0	4
	IPH 504 - Quantum Physics	4	0	4
	IPH 505 – AC Circuits lab	2	4	4
	IPH 506 – Optics lab	2	4	4

Semester 6		**Total No. of Credits : 24**		
Title of the course		Contact hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
Compulsory Courses	**IPH 601** - Statistical thermodynamics	4	0	4
	IPH 602 - Structure and Properties of Matter	4	0	4
	IPH 603 - Atomic and Molecular Physics	4	0	4
	IPH 604 - Introduction to Nuclear, Particle and Astro Physics	4	0	4
	IPH 605 - Computer programming lab	2	4	4
	IPH 606 - Modern Physics lab	2	4	4

M.Sc. (I-IV Semesters)+ I.M.Sc. (VII-X Semesters)
Course Structure
2020

Semester I	Total No. of Credits : 21+4

Course No.	Name of the course	Contact hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credits
PH401	Mathematical Methods I	4	0	4
PH402	Classical Mechanics	3	0	3
PH403	Electromagnetic Theory I	3	0	3
PH404	Electronic Devices & Circuits	4	0	4
PH405	Quantum Mechanics I	4	0	4
PH406	Electronic Circuits Lab.	1	4	3

1. A part of Digital electronics syllabus is added to PH404-Electronics Devices & Circuits and it is now made 3(th)+1(Tut) credits. This is done to cover the topics **required for UGC-CSIR examination**

Semester II		**Total No. of Credits : 21+4**		
Course No.	Name of the course	Contact hours and Credits		
		Classroom Lectures	Experiments in Laboratorie	Total Credits

			s	
PH451	Mathematical Methods II	4	0	4
PH452	Electromagnetic Theory II	4	0	4
PH453	Quantum Mechanics II	4	0	4
PH454	Statistical Mechanics	4	0	4
PH455	Numerical Methods Theory and Lab	4	0	2
PH456	Modern Physics Lab	1	4	3

Digital Electronics Theory and Lab is moved to 4th Semester and Statistical Mechanics is brought to 2nd semester.

Semester III				**Total No. of Credits : 24**
Course No.	Name of the course	Contact hours and Credits		
		Classroom Lectures	Experiments in Laboratories	Total Credit
PH501	Solid State Physics	4	0	4
PH502	Particle Physics	4	0	4
PH503	Laser Physics	4	0	4
PH504	Atomic and Molecular Spectroscopy	3	0	3
PH505	Nuclear Physics	2	0	2
PH506	Solid State Physics Lab	1	4	3
PH507	Laser Physics Lab	1	4	3

Statistical Mechanics is moved to 2nd semester,

Atomic & Molecular Spectroscopy is brought to 3rd Semester, Project is removed and Nuclear Physics Course is added.

Structure of M.Sc. program
School of Physics
University of Hyderabad
Semester- IV

	Course content	Number of credits	Remarks
1	Specialization: A. Condensed matter physics B. Quantum optics C. Particle physics	2*4=8	Any two theory courses out of those listed in electives will be offered in each specialization.
2	Elective lab	1*4=4	Choose one of three lab courses
3	Choose 3A or 3B		
3A	Project	1*8=8	
3B	2 courses	2*4=8	Choose one lab course and one theory course.
	Total number of credits	20	

<u>Electives</u>:

Laboratory courses:

S.No	Course	Course Code
1	Digital electronics	PH551

2	Microwave and Nuclear physics	PH552
3	Advanced Computational methods	PH553

Theory courses:

S.No	Course	Course Code
1	Magnetism and Superconductivity	PH554
2	Many body theory	PH555
3	Probes of condensed matter	PH556
4	Soft Condensed Matter	PH557
5	Quantum theory of solids	PH558
6	Advanced statistical mechanics	PH559
7	Quantum optics	PH560
8	Nonlinear optics	PH561
9	Nonlinear spectroscopy	PH562
10	Photonics and Photonic devices	PH563
11	Quantum field theory	PH564
12	General theory of relativity	PH565
13	Lie groups and linear algebra	PH566
14	Advanced particle physics	PH567
15	Quantum Computations	PH568

(* Theory courses selected to be offered may vary depending on the faculty availability and choice of students. Two courses in each specialization with most number of takers will go into specialization courses in sl.no. 1. The other courses that are offered will move into electives under sl.no. 3B)

Foundation Courses:

FN119 - Electronics for everyone (For non-physics students)	4	0	4
FN225 - How things work, The Physics of everyday life (Foundation Course)	4	0	4
FN211 - Physics and our World (Foundation Course)	4	0	4

Vision:

- To Create and sustain an academic environment, that is vibrant and active and where students are in an enabling environment of excellence in pedagogic practices that help in achieving at their highest potential.
- To create and sustain research that is competitive globally, in basic, applied and interdisciplinary fields of physics and develop pathways and connectivity with industry through translational research and development

Mission:

- To create an avenue where students obtain a thorough exposure to the most recent developments in areas of basic and applied physics, and in related interdisciplinary subjects
- To provide a high class research atmosphere, that encompasses enabling national and international collaborations for creation and sustenance of cutting edge research
- To create and sustain a pedagogic environment of dedicated teachers and researchers, for training students in critical analysis of concepts , to apply domain knowledge to applied physics and other scientific areas of knowledge and to connect creatively to other systems of knowledge
- To provide to students the skills essential to adapting to changing needs of society in academics and industry.

Program Learning Outcome in I.M.Sc. (Physics)

The following are the Learning Outcomes expected of a student graduating with an IM.Sc. in Physics:

- Acquire
    1. a broad based and holistic perspective of physics and its areas of knowledge in relation to the other disciplines of science and mathematics enabled through courses offered in such areas.

    2. an understanding of physics at the appropriate level imparted through courses in the core curriculum consisting of the subjects: Classical Mechanics, Quantum Mechanics, Electromagnetic Theory, Statistical Mechanics and Electronics-this understanding being achievable through a student's thorough grasp of the basic concepts, and enabled by critical analyses and problems solving.

    3. competence in applying mathematical methods relevant to physics, for enabling a quantitative understanding and problem solving skills.

    4. the knowledge of applying core course learning to specialised areas as in, condensed matter physics, optics, high energy physics, or any other specialized emerging branches of physics that may be offered in the School from time to time.

- Demonstrate the ability to cognitively connect the knowledge acquired in fields of specialisation to experiments in these areas.

- Learn to analyse and interpret data so as to correlate the relevant physical theory and the corresponding experimental verification/validation.

- Develop the ability to comprehend developments in newer avenues of inquiry in physics, through problem solving skill training. and through exploratory activity through project work and research seminars.

- Develop a motivation for research and innovation, through honing problem solving skills, project activity, seminars, and interaction with internal and external experts in the subject at the School.

- Develop proficiency in computational skills and practices, acquiring competence in the use of relevant software.

- Develop technical communication skill in reporting the results of investigations in a precise manner.

- Develop skills that help in maintaining professionalism, and an outlook that is expected of a scholar in science, namely analytical thinking, scientific temper and objectivity in analysis.

- Develop Communication skill in reading, writing, comprehension, explain complex matter in a simple way and the ability to listen to others and alternate points of view.

Program Learning Outcome in M.Sc. (Physics)

The following are the Learning Outcomes expected of a student graduating with an M.Sc. in Physics:

- Acquire

i. an understanding of physics at the appropriate level imparted through courses in the core curriculum consisting of the subjects: Classical Mechanics, Quantum Mechanics, Electromagnetic Theory, Statistical Mechanics and Electronics-this understanding being achievable through a student's thorough grasp of the basic concepts, and enabled by critical analyses and problems solving.

ii. competence in applying mathematical methods relevant to physics, for enabling quantitative understanding and problem solving skills.

iii. the knowledge of applying core course learning to specialised areas as in, condensed matter physics, optics, high energy physics, and other specialized emerging branches of physics that may be offered in the School from time to time.

- Demonstrate the ability to cognitively connect the knowledge acquired in fields of specialisation to experiments in these areas.

- Learn to analysis and interpret data so as to correlate the relevant physical theory and the corresponding experimental verification/validation.

- Develop the ability to comprehend developments in newer avenues of inquiry in physics, through problem solving skill training. and through exploratory activity through project work and research seminars.

- Develop a motivation for research and innovation, through honing problem solving skills, project activity, seminars, and interaction with internal and external experts in the subject at the School.

- Develop proficiency in computational skills and practices, acquiring competence in the use of relevant software.
- Develop technical communication skill in reporting the results of investigations in a precise manner.

School of Physics
Name of the Academic Program … I.M.Sc.

Course Code: IPH101
Title of the Course: Mechanics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 3

Prerequisite Course / Knowledge (If any): Knowledge of general physics, algebra and calculus

Course Learning Outcomes (CLOs) (5 to 8)
After completion of this course successfully, the students will be able to:

CLO-1: Apply the concept of an inertial frame to solve physical problems. Apply Newton's laws of motion to physical systems using calculus.

CLO-2: Set up equations and solve simple harmonic oscillator with and without damping.

CLO-3: Apply conservation laws of energy, momentum and angular momentum to solve physical problems.

CLO-4: Apply polar coordinates to analyse problems such as planetary motion.

CLO-5: Apply the concepts of angular velocity vector, angular momentum and moment of inertia tensors to solve the rigid body dynamics

CLO-6: Analyse and Apply concepts of non-inertial frames.

Syllabus:

Unit-1: Review of Vector Algebra, Vector calculus; Coordinate systems.

Unit 2: Newton's laws and Inertial frames; Transformation of a vector under rotation of coordinate axes, Orthogonal transformations, Transformation matrix.

Unit 3: Motion under constant, time-dependent, position-dependent, and velocity-dependent forces; Projectile motion.

Unit 4: Application of Newton's laws: Pulleys, Inclined planes, Friction, Circular motion, Motion in gravitational field, Satellites and Planets

Unit 5: Symmetries and Conservation laws, Work and examples of computation of work, Work - Energy theorem, Conservative and Non-conservative forces, Definition of potential energy, Conservation of energy; Simple harmonic motion; Simple and double pendulum, Compound pendulum; Law of gravitation, Gravitational potential energy, Calculation of gravitational potential energy of systems with different geometries.

Unit 6: Centre of mass, Motion of centre of mass, Conservation of linear momentum, Collisions in one dimension

Unit 7: Momentum, Kinetic energy, Angular Momentum, Special case of a two-particle system, Torque and EOM. Conservation of Angular Momentum, Kepler's Laws of Planetary Motion, Satellites

Unit 8: Kinetic energy and Angular momentum of a system of particles, Degrees of freedom of a rigid body, Kinetic energy and angular momentum of a rigid body, Moment of inertia tensor, Combined rotational and translational motion, Euler's equations; Examples.

Unit 9: Motion in non-inertial frames, Centrifugal force and Coriolis force, Applications, Sideways deviation of a freely falling body, Cyclonic wind.

Books Recommended:

1. Mechanics (Berkeley Physics Course V1), Charles Kittel, Walter Knight, Malvin Ruderman (main Text)
2. University Physics, Sears and Zemansky, Addison Wesley series
3. Analytical Mechanics, Grant R. Fowles.
4. An introduction to Mechanics, D. Kleppner and R. J. Kolenkow (Mc Graw Hill)

5. Introductory Classical Mechanics, David Morin
6. Classical Mechanics, Arya

Course Code: **IPH 102**
Title of the Course: Mechanics Lab
Number of classes: 40, Lectures 0, Tutorial: 0, Practical: 40, Credits: 1.5

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge (If any): Basic knowledge of periodic motion, conservation principles, moment of inertia

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1: Measure time, speed, acceleration and time period

CLO-2: Measure acceleration due to gravity, Young's modulus and moment of inertia.

CLO-3: Estimate the error in measurement of time.

CLO-4: Understand the concept of propagation of error for different measurements.

CLO-5: Understand the conservation principles by implementing Newton's second law.

CLO-6: Handle the equipment with care and understand the advantages and limitations of a given equipment.

Syllabus:

Unit 1. Verification of Newton's second law using an Air Track

Unit 2. Verification of conservation principles (momentum and energy) using a friction free metal track.

Unit 3. Estimation of the value of "g" using the principle of free fall.

Unit 4. Estimation of the spring constants of spring using the principle of Simple Harmonic motion

Unit 5. Projectile motion: To predict and verify the range of a ball launched at an angle and determine its initial velocity.

Unit 6. Estimation of the value of "g" using a Kater's pendulum.

Unit 7. Estimation of the moment of inertia of a Fly wheel.

Unit 8. Estimation of the moment of inertia about the different axes of a bifilar suspension.

Unit 9. Estimation of the Young's modulus of a steel wire using a torsion pendulum.

Reference Books:

1. R K Shukla and A Srivastava (2006), Practical Physics, New Age International (P) Ltd., New Delhi, India.

2. Hugh D. Young and Roger A. Freedman, (2015), Sears and Zemansky's University Physics with Modern Physics, 14th Edition, Pearson Education Limited, Essex, UK.

Course Code: IPH 151
Title of the Course: Vibrations and Waves
Number of classes: 56, Lectures: 42 ,Tutorials: 14, Credits: 3

Prerequisite Course / Knowledge (If any): Physics and Mathematics at +2 (Intermediate level) and problem-solving skills in Mechanics, Algebra, Trigonometry, Calculus.

Course Learning Outcomes (CLOs) (5 to 8)

After completion of this course successfully, the students will be able to……

CLO-1: Apply complex notation of vectors to solve harmonic motion problems.

CLO-2: Set up equations and solve for the solutions to describe the behaviour of a simple, damped oscillator.

CLO-3: Set up equations and solve for the solutions to describe the behaviour of a forced oscillations

CLO-4: Set up equations and solve for the solutions to describe the behaviour of coupled harmonic oscillators.

CLO-5: Construct travelling and standing solutions to the wave equation.

Syllabus:

Unit-1: Simple harmonic motion: Physical Characteristics of SHO, Mass on a spring (vertical and horizontal) - displacement, velocity, acceleration and energy, Simple pendulum, Physical pendulum, Nonlinear oscillator, Superposition principle.

Unit-2: Damped harmonic oscillator: Physical characteristics of DHO, Equation of motion – Light, heavy and critical damping, Rate of energy Loss, Q factor.

Forced oscillators: Physical characteristics of FHO, Equation of motion, Undamped oscillations, forced oscillations with damping, Power absorbed, Resonance, Transient phenomena, Complex representation.

Unit-3: Coupled oscillators: Physical characteristics of coupled oscillators, Normal modes, Superposition of normal modes, Oscillating masses coupled by springs, Forced oscillations of coupled oscillators, Transverse and longitudinal oscillations

Unit-4: Traveling waves: Physical characteristics of waves, travelling waves, travelling sinusoidal waves, Wave equation, Equation of a vibrating String, Energy in a wave, Transport of energy by a wave

Standing waves: Standing waves on a string, standing waves as superposition of two travelling waves, Energy in a standing wave, Standing waves as normal modes of a vibrating string, Superposition of normal modes, Energy of vibration of a string. Fourier analysis, Dispersion of waves

Unit-5: Unit-5: Superposition of waves, Wave packets, Fourier analysis, Dispersion – phase and group velocities.

Recommended books:

1. Vibrations and waves, George King, Wiley, 2009
2. Oscillations and waves, Richard Fitzpartick
3. Waves, Frank Crawford, Berkeley Physics, Vol. 3
4. Physics of waves, Howard Georgi, Harvard University
5. Introduction to vibrations and waves, J. Pain and P. Rankin
6. Vibrations and waves, A.P. French
7. Waves and oscillations – A prelude to quantum mechanics, W.F. Smith

Course Code: IPH 152
Title of the Course: Vibrations and Waves lab.
Number of classes: 40, Lectures 0, Tutorial: 0, Practical: 40, Credits: 1.5

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge (If any): Basic knowledge of periodic motion, conservation principles, moment of inertia

Course Learning Outcomes (CLOs):
At the end of this course, the students should be able to

CLO-1: Perform experiments to prove the theories with respect to Simple Harmonic Oscillator.

CLO-2: Validate theoretical concepts of forced harmonic oscillator

CLO-3: Measure damping constant of two different liquids such as water and oil.

CLO-4: Show the performance of coupled pendulum and normal modes.

CLO-5: Perform studies of shallow water and deep water waves and compute velocity of waves in them.

CLO-6: Find the resonance situation in air column.

CLO-7: Build a new experiment based on all the understanding.

Syllabus:

Unit-1: Addition of Oscillations

Unit-2: Normal modes and beats

Unit-3: Coupling Constant

Unit-4: Damped Harmonic Oscillator

Unit-5: Resonance in a Forced Oscillator

Unit-6: Waves in 2 Dimensions

Unit-7: Melde's apparatus

Unit-8: Sonometer

Unit-9: Resonance in Air column

Unit-10: Design and develop an additional experiment about waves and oscillations, which is not in above list.

Reference Books:

1. Halliday, Resnick and Walker (2015), "Fundamentals of Physics" – 10th ed. Wiley, New York
2. Young and Freedman (2017), "Sears and Zemansky's University Physics" – Pearson, UK

Course code: IPH-201
Title of the course: Electricity and Magnetism
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Pre Requisite: Vector Analysis and basic knowledge on charges, Coulomb forces, electric field, current, insulator and conductors, capacitor, inductor, resistor, magnetic lines of force and types of magnetic materials etc..

Course Learning Outcomes (CLOs):

At the end of this course, the students should be able to

CLO-1: Use vector analysis to understand the mathematical physics of electric and magnetic forces, fields, potentials, and their divergence and curls.

CLO-2: Explain electric and magnetic fields, forces, potentials originating from charges and currents

CLO-3: Compute electric fields and electric potentials from stationary charges, charge distributions and magnetic fields and vector potentials from stationary currents flowing through straight line segments and loops)

CLO-4: Solve boundary value problems inside and outside dielectric, conducting and magnetic materials and calculate electric and magnetic energy stored in capacitors and inductors.

CLO-5: Able to describe origin of magnetism at atomic level, distinguish materials based on the magnetic dipoles, their alignment and response to external fields and compute magnetic fields within and outside a magnetic material.

CLO-6: Identify the response of different materials under electric and magnetic fields and discover the relationship between materials response through polarization, dielectric constant and electric field in dielectric media and magnetization, permeability and magnetic field in magnetic materials, respectively.

CLO-7: Discuss Faraday's laws of induction, electromotive force (emf), self and mutual induction and calculate energy in magnetic fields and magnetic fields in different geometries of current carrying loops.

CLO-8: Analyze circuits consisting of capacitor, C, resistor, R, CR; inductor, L and resistor, LR and LCR circuits for understanding charging and discharging time constants and resonance. Apply Kirchhoff's s laws to analyze AC circuits to describe the graphical relationship of R, C and L.

CLO-9: Discuss the physical meaning of Maxwell's equations in free space and in matter and solve for different boundary conditions

Syllabus:

Unit-1: General Introduction and Vector Calculus

Unit-2: Charges and fields, Coulomb's law, Superposition principle for force and field, Field due to a discrete charge distribution, Dirac's delta function, Field due to a continuous charge distribution, Introduction of potential and potential energy, Divergence and curl of the electrostatic filed, Consequence of the irrational behaviour of the electrostatic field.

Calculation of potential and field due to different charge distributions, finite and infinite line charge, uniformly and non-uniformly charged rings, charged disks, charged spherical shell, charged solid sphere, charged cylinder

Unit-3: Gauss's law in integral form, Connection between Gauss's law and Coulomb's law; Gauss's law in differential form, Application of Gauss's law to determine the field and potential due to line and plane charges, charged spherical shell and solid sphere, and cylinder; Electrostatic energy. Multipole expansion; Electrostatic energy; Energy of a charge distribution in an electrostatic field. Capacitors: Parallel plate, cylindrical and spherical. Conductors in an electrostatic field, Induced charge, Field inside a conductor, Field inside a cavity, Boundary conditions, Uniqueness theorem

Unit-4: Electric field inside a dielectric medium, Displacement vector, Polarization, Dielectric constant, Electric susceptibility and polarizability, Clausius-Mossotti equation, Capacitors with dielectric materials

Unit-5: Lorentz force; Continuity equation; Biot-Savart law; Magnetic field due to a long straight wire; Force between current carrying parallel wires and current loops; Differential equations of magnetostatics, Ampere's law, Vector potential, Magnetic induction of a circular current loop. Magnetic field due to (i) long solenoid, (ii) toroidal coil, (iii) long cylindrical conductor; Magnetic dipole

Unit-6: Faradays Law of induction, Energy in a magnetic field, Induction of a current in a conducting loop, Induction in a coil by a time-varying magnetic field; Conductor moving in a magnetic field, Conductor at rest in a varying magnetic field, Self-inductance of long solenoid and toroidal coil, Mutual inductance between two co-axial coils and a solenoid with secondary windings.

Unit-7: Electric Currents, A.C. Circuits, Kirchhoff's law, LCR circuits; Induction motor, Dynamo, AC generator, Eddy currents

Unit-8: Magnetic field in matter; Macroscopic magnetization M; Magnetic intensity H; Susceptibility and Permeability, Relation between B, M and H, Magnetic Energy, B - H loop; Magnetic materials. Nonstationary case, Displacement current, Maxwell's equations.

References:

1. D.J. Griffiths, (2013), Introduction to Electrodynamics, (4th Edition), Pearson Education, UK
2. E.M. Purcell (1985) Electricity & Magnetism: Berkeley Physics Course, Vol. 2, (2nd Edition), McGraw-Hill Book Company (New York, USA).
3. Daniel A. Fleisch (2008) A students Guide to Maxwell's equations, (1st Edition), CAMBRIDGE UNIVERSITY PRESS, (Cambridge, UK)

Course Code: IPH 202
Title of the Course: Electricity and Magnetism Lab
Number of classes: 40, Lectures 0, Tutorial: 0, Practical: 40, Credits: 1.5

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge (If any): Basic knowledge of electricity, electrical components, AC and DC voltage sources.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to

CLO-1: Explain how a combination of electrical components work in storing/discharging electrical charges, time constants involved, and apply the knowledge to find out unknown values of components in the circuit.

CLO-2: Analyze the LCR circuit for its resonance and factors that influence Q-factor and damping of an LCR circuit.

CLO-3: Apply the knowledge of charging/discharging of a capacitor and electrical resonance to demonstrate the Faraday's law of induction.

CLO-4: Use the Wheatstone principal and null point of a circuit and determine the value of unknown resistance, emf of a unknown cell or compare emfs of two cells.

CLO-5: Demonstrates hysteresis exhibited by a ferromagnetic material and uses it for estimating the coercivity and retentivity of the ferromagnetic material.

CLO-6: Applies two types of magnetometers to determine horizontal component of earths' magnetic field and the magnetic moment of a bar magnet.

CL0-7: Apply laws of Electricity and Magnetism and assembles an electric motor to demonstrate its functioning.

Syllabus:

Unit 1: Charging and Discharging a Capacitor

Unit 2: Resonance in LCR Circuits

Unit 3: Electromagnetic Induction (Faraday's law)

Unit 4: Measurement of Average Resistance of a Wire by Carey-Foster method and to determine the value of unknown resistance

Unit 5: Measurement of EMF of unknown cell with the Help of Potentiometer

Unit 6: Hysteresis loop for a Ferromagnetic material

Unit 7: Determination of the Moment of a Bar Magnet and the horizontal component of Earth's Magnetic Field by deflection and vibration Magnetometers using (a) Deflection magnetometer and (b)Vibration magnetometer

Unit 8: Design and assemble an electric motor

Reference Books:

1. Prakash & Ramakrishna, A.K. Jha, (2011), A Text Book of Practical Physics, 11th Edition, Kitab Mahal, New Delhi, India

2. Michael Nelson and Jon M. Ogborn, (1985) Advanced Level Physics Practicals, 4th Edition, Heinemann Educational Publications, UK

3. D.J. Griffiths, (2013), Introduction to Electrodynamics, (4th Edition), Pearson Education, UK

Course Code: IPH 203
Title of the Course: Biophysics
Number of classes: 56, Lectures 42, Tutorials 14, Credits: 4

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Understand the role of physical mechanisms in biological processes

CLO-2: Apply the principles and concepts of physics in analysing cell structure and function

CLO-3: Apply the principles and physics concepts in analysing biomolecular structure and function of proteins and nucleic acids and their function

CLO-4: Enable application of the systems approach in developing understanding of complex mechanisms in vision, auditory and olfactory processes

Syllabus:

Unit-1: Introduction to the scope of Biophysics, Overview of Cell structure and interactions, Forces and energies at biological length scales- electromagnetic interactions and screening, Entropic forces, Chemical forces and Self-assembly , Tools and techniques- Optical forces, Atomic force microscopy,

Unit-2: Proteins: Structure and function: Structural organization-primary, secondary, tertiary and quaternary; varieties of proteins, protein folding, stability of proteins

Nucleic acids and genetic information-Structure of DNA, DNA as information storage molecule, Replication, Transcription and translation.

Unit-3: Cells and biological membranes: Cell components, role of macromolecules-proteins, nucleic acids, surface tension and mechanical properties of cell membranes, Brownian motion, viscosity in the cell and its influence on particle motion, Molecular machines; Architecture and transport across cell membranes

Unit-4: Neuron Biology- Nerve signals, generation and propagation of action potentials, Role of channels and pumps, Biophysics of the synapse. Examples from System Biology-physics of vision, physics of audition, olfaction

Books Recommended:

1. Biophysics: An introduction R. Cotterrill, Cambridge Press

2. Biological Physics: Energy, Information, Life, Philip Nelson, Freeman

3. Physical Biology of the Cell, Rob Philips and Jane Kondev Garland Science

4. Newton rules Biology: a physical approach to biological problems,
C.J. Pennycuick

Course code: IPH-251
Title of the course: Modern Physics Including Special Theory of Relativity

Number of classes: 56, Lectures 42, Tutorials 14, Credits: 4

Course Learning Outcomes (CLOs)

At the end of this course, the students should be able to

CLO-1: Explain the limitations of classical Physics

CLO-2: Explain the photoelectric effect and Compton Effect and apply the quantum nature of light to understand.

CLO-3: Describe Atomic structure, various atom models (success/failures) and atomic spectra, experimental evidence to understand the spin of an electron through Stern Gerlach experiment

CLO-4: Recognize the wave particle duality and uncertainty principle

CLO-5: Explain the Schrodinger equation (Time dependent & Time in dependent) and applying the same to compute the energy eigen value of particle in a box

CLO-6: Explain the Galilean covariance of Newton's second law and describe Michelson-Morley experiment and applications

CLO-7: Explain the Lorentz transformation, length contraction and time dilation. Use the relationship between mass & energy, energy & momentum to explain the equivalence.

Syllabus:

Unit-1: Thermal radiation and Planck's postulate; Classical and Planck's theory of black body radiation; Use of Planck's radiation law in thermometry; Planck's postulate

Unit-2: Photoelectric effect- Einstein's quantum theory of photoelectric effects; Compton effects Dual nature of electromagnetic radiation.

Unit-3: Thomson's and Rutherford's model; Bohr's model; Atomic spectra; Sommerfeld's model Franck Hertz Experiment

Unit-4: Discovery of spin; Stern-Gerlach experiment, Anomalous Zeeman effect.

Unit-5: Wave Particle Duality**:** de Broglie's hypothesis; Davison's Experiment, Matter waves; Heisenberg Microscope, Double- Slit experiment with electrons;

Uncertainty principle; some consequences of uncertainty principle.

Unit-6 : Time-independent and time-independent Schrödinger equation; Stationary states; Born's interpretation of wave functions; Expectation values, Free particle and particle in a box, Normalization of Eigen function.

Unit-7: Special Theory of Relativity: Inertial frame, Galilean covariance of Newton's second law, Inconsistency with electromagnetic theory; Michelson-Morley experiment, Interpretation of null results of Michelson-Morley experiment, Postulates of special theory of Relativity.

Unit-8: Lorentz transformation, Relativity of simultaneity, Length contraction and time dilation and their consequences, Transformation of velocity and acceleration, Fizeau's experiment, Relativistic momentum, Equivalence of mass and energy. Energy and Momentum, Four vectors, Relativistic dynamics.

References:

1. Concept of Modern Physics, Arthur Beiser, Shobit Mahajan and S. Rai Choudhury, 7^{th} edition, Mc Graw Hill, 2017
2. Introduction to Special Relativity, Robert Resnick, Wiley Student edition India, 2007

Course Code: IPH 252
Title of the Course: Mathematical Methods for Physics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite Course / Knowledge (If any): Basic Mathematics calculus and vector algebra

Course Learning Outcomes (CLOs)

At the end of this course, the students should be able to

CLO-1: Apply calculus, vectors, and vector calculus tools for problem solving various branches of Physics.

CLO-2: Determining the Eigen values and Eigen vectors using matrix formulation. Application to vector spaces.

CLO-3: Apply ODE of eigenvalue type. Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings.

CLO-4: Apply the special functions, such as Gamma functions and error functions in solving physics problems.

CLO-5: Apply tensors, and tensor calculus in solving physics problems.

CLO-6: Analyze theorems in Group theory and apply Matrix representation of groups for solving physics problems.

Syllabus:

Unit 1: Overview of Elementary Calculus and Vector Calculus.

Unit 2: Matrices, Vector spaces, Basis, Eigenvalues and Eigenvectors, Schur's Lemma, Cayley- Hamilton theorem, Matrix diagonalization

Unit 3: Sturm Liouville Theory- Orthogonal Functions, Self Adjoint ODE's, Gram Schmidt Orthogonalization; Completeness of Eigen functions; Fourier series and Fourier integrals; Special functions; Gamma function

Unit 4: Introduction to Tensors: Covariant and Contravariant tensors, Tensor calculus, Symmetric and anti-symmetric tensors. Applications of tensors to physical problems

Unit-5: Group theory: Definition of a group, Group table, Theorems for finite group, Examples of groups (Ex – Cyclic group, group, Four-group, Dihedral group, Permutation group, Conjugate elements and classes, Invariant subgroup; The Factor group, Isomorphismand Homomorphism; Matrix Representations; Continuous groups, Rotation Group, physical applications

Books recommended:

1. Group theory and Quantum Mechanics, Tinkham

2. Mathematical methods for Physicists, Arfken, Weber and Harris (Academic Press)

3. Group Theory and Its Physical Applications, L. M. Falicov (University of Chicago Press)

4. Tensor Analysis for Physicists, J.A. Schouten (Dover)

5. Schaum Outline Series, "Calculus", "Linear Algebra" and "Group Theory"

6. Tensor analysis, James D. Simmonds (Springer 1994)

Course Code: IPH 253
Title of the Course: Heat & Thermodynamics Lab
Number of classes: 40, Lectures 0, Tutorial: 0, Practical: 40, Credits: 1.5

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge (If any): Basic knowledge about Heat, Temperature, and Gas laws, etc.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to

CLO-1. Practice the measurement of Temperature, Pressure, thermal conductivity and specific heat.

CLO-2: Illustrate a constant volume gas thermometer.

CLO-3: Relate the temperature, pressure and volume of a gas.

CLO-4: Show the measurement of thermal conductivity and specific heat.

CLO-5: Estimate the error in measurement of thermodynamic quantities.

CLO-6: Use the equipment with care and understand the advantages and limitations of a given equipment.

CLO-7: Discover the working principle of a calorimeter.

Syllabus:

Unit 1: Gas laws: Boyles law

Unit 2: Gas laws: Charles law

Unit 3: Constant volume gas thermometer

Unit 4: Electric Joule heating

Unit 5: Thermochromic affect

Unit 6: Thermal conductivity of a poor conductor (Lee's method)

Unit 7: Thermal conductivity of a good conductor (Searle's method)

Unit 8: Specific heat capacity – Method of mixtures

Unit 9: Phase change – Latent heat

Reference Books:

1. Hugh D. Young and Roger A. Freedman (2016), Sears & Zemansky's University Physics with Modern Physics, Fourteenth Edition, Pearson Education Limited, Essex, England.
2. H C Verma, (2011), Concepts of Physics Vol .II, 2nd Edition, Bharathi Bhawan, New Delhi, India.

Course Code: IPH 254

Title of the Course: Optics of Gadgets

Number of classes: 56, Lectures: 46, Tutorials: 10, Credits: 4

Prerequisite Course / Knowledge (If any): Oscillations and waves

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Understand the working of different optical gadgets used in daily life.

CLO-2: Understand the working principle of different optics based scientific equipment.

CLO-3: Apply the principles of geometrical and wave optics to design optical gadgets.

CLO-4: Analyze differences between ordinary light sources and lasers.

CLO-5: Understand the impotence of optical gadgets in daily life.

Detailed Syllabus:

Unit-1: Basics of optics – Geometrical and wave optics; Amplitude, phase and polarization and their manipulation

Unit-2: Optical phenomena – Basics of interference, diffraction and polarization; explanation and understanding based on day-to-day experience / experiments

Unit-3: Optical sources – Lamp to LED and Laser; Optical detectors – Diode to CCD / CMOS and CCD array

Unit-4: Some common gadgets: Introduction, working principle, technology and uses of some gadgets (not limited to) Motion sensors; Compact Disc, Digital Video Disc, Blue-ray disc; Liquid Crystal, Light Emitting displays; Projectors, camera.

Unit-5: Scientific Instruments: Working principle and applications of various instruments like Telescope, Microscope, Spectrometer, LIDAR, Optical Gyroscope.

Reference Books:

1. F. S. Crawford Jr (2017), *Waves,* Volume 3, Berkeley Physics Course, McGraw Hill Education, New York, United States.
2. R.S. Longhurst (1999), *Geometrical and Physical Optics,* Orient Longman, India.
3. F.A. Jenkins and H. E. White (2017), *Fundamentals of Optics*, Fourth edition, McGraw Hill Education, New York, United States.
4. Hecht and A.R. Ganesan (2019), *Optics*, Fifth edition, Pearson Education, Bengaluru, India.
5. K.K. Sharma (2006), *Optics: Principles and applications*, Academic Press, Netherlands.

a. Ghatak (2017), *Optics*, Sixth edition, McGraw Hill Education, New York, United States.

6. Young Hugh D., Freedman Roger A. *Sears and Zemansky's University Physics, Addison -Wesley,1-455.*

Course Code: IPH501
Title of the Course: Analytical Dynamics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Pre-requisites: Basic mechanics, vector calculus, different coordinate systems.

Course Learning Outcomes (CLOs):
A student completing the course will be able to:

CLO-1: Apply Newton's laws of motion to various mechanical systems in two- and three- dimensions.

CLO-2: To analyze various mechanical systems in a central potential.

CLO-3: Write equations of motion in non-inertial frames for various mechanical systems.

CLO-4: Apply rigid body dynamics to analyze simple rigid bodies.

CLO-5: Employ Lagrangian and Hamiltonian formulation to solve simple mechanical systems.

Syllabus:

Unit-1: Inertial and non-inertial frames, Pseudo force; Galilean transformation; Motion under time-dependent and resistive forces, Projectile motion in viscous air; Motion of a charged particle in an electromagnetic field; Motion in two and three dimensions, Exact solution of the motion of the simple pendulum by means of elliptic integrals, the isochronous problem, Spherical pendulum.

Unit-2: Motion under a central force, Conservation of angular momentum, Equation for the orbital equation, Nature of orbits, Detailed discussion for the case of an attractive inverse-squared force field, Kepler's laws of planetary motion, Stability of orbits; Rutherford scattering

Unit-3: Motion in a non-inertial frame, Translation of the coordinate System, General motion of the coordinate system, Dynamics of a particle in a rotating coordinate system, Effects of the earth's rotation, Coriolis and centrifugal forces, Simple examples, Foucault's Pendulum.

Unit-4: Dynamics of a rigid body, Gyroscope, Euler's equation of motion for a rigid body, Simple applications. Motion of a symmetrical top.

Unit-5: Mechanics of a system of particles, Conservation theorems; Constraints, Holonomic and non-holonomic constraints, Time-dependent and time-independent constraints, Generalized coordinates and degrees of freedom, D'Alembert's principle, Derivation of Lagrange's equation for conservative, holonomic systems from D'Alembert's principle; Calculus of variations, Hamilton's variational principle, Generalized momentum, Cyclic coordinates and conservation principle. Hamiltonian and a brief introduction to Hamiltonian mechanics.

Recommended Books:

1. Classical mechanics: **R. Douglas Gregory, 1st edition, CUP (2006)**

2. Classical Dynamics of Particles and Systems: **Stephen T. Thornton and Jerry B. Marion, 5th edition, Cengage Learning (2004)**

3. Introduction to Classical Mechanics: **A. P. Arya, 2nd edition, Pearson (1997)**

Course Code: IPH502

Title of the Course: Electronics

Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite Course / Knowledge (If any): Nil

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to

CLO-1: Learn the concepts of electronics devices and circuits.

CLO-2: Apply network theorems to reduce any two-terminal series-parallel circuit.

CLO-3: Learn the concepts of semi-conductor devices including diodes, transistors, CMOS etc.

CLO-4: Able to Solve/analyze/design the basic circuits utilizing BJT/FET/MOSFET.

CLO-5: Formulate and employ a Karnaugh Map to reduce Boolean expressions and logic circuits to their simplest forms.

CLO-6; Apply logic to design combinational circuits to solve practical problems

Syllabus:

Unit-1: Electronic Devices and Circuits : Voltage and current sources, Kirchhoff's voltage and current law, superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem.

Unit-2: Electronic Devices and Circuits: Voltage and current sources, Kirchhoff's voltage and current law, c, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem.

Unit-3: Diodes : Semiconductor, p-n junction diode, working principles and characteristics of p-n junction diode, Zener diode, LED, phot—diode, half-wave and full-wave rectifier, efficiency, ripple factor, voltage regulation, clipping, clamping, voltage doublers and multipliers.

Unit-4: Transistors : pnp and npn transistors, CE, CB and CC configuration, input and output characteristics, cut off and active and saturation region, biasing and bias stability, load line and Q point, transistor as an amplifier (CE), transistor as a switch, types of FET, construction of junction FET, output characteristics, biasing, operation region, pinch off voltage, MOSFET : enhancement and depletion type, construction, principle of operation and characteristics, elementary idea on CMOS, MOS inverter.

Unit-5: Amplifiers: Voltage and current amplifier, RC coupled amplifier, concepts of feedback, multistage amplifier, frequency response, gain and bandwidth, Introduction to Op-Amp.

Unit-6: Digital Electronics : Decimal, binary and hexadecimal numbers, binary arithmetic, Boolean algebra, logic gates : OR, NAND, NOT, NAND, NOR and exclusive-OR, universal gate, de-Morgan's theorem, 1's and 2's complement, Boolean simplifications, sum-of-product and product-of-sum form, Karnaugh map.

Books Recommended:

1. Introductory Circuit Analysis, Robert L. Bolyestad, Pearson, Global Edition
2. Semiconductor Devices : Theory and Application, James M. Fiore, **ISBN-13:** 978-1796543537,2017
3. Digital principles and Applications, Leach, Malvino and Saha, Tata Mc Graw Hill, 7^{th} Edition

Course Code: IPH503
Title of the Course: OPTICS
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite Course / Knowledge (If any):

Course Learning Outcomes (CLOs): (5 to 8)

After completion of this course successfully, the students will be able to……

CLO-1: Explain different optical phenomenon observed in daily life

CLO-2: Select the right optical component for a specific purpose

CLO-3: Illustrate most commonly occurring optical phenomenon

CLO-4: Choose the right optical phenomenon

CLO-5: Contrast different optical phenomenon

CLO-6: Describe the working of simple optical devices based on interference, diffraction and polarization

CLO-7: Set up simple optical devices based on interference, diffraction and polarization

Syllabus:

Unit-1: Review of oscillations, oscillation of systems with many degrees of freedom, Waves in two and three dimensions, Reflection, Modulation, Pulses and Wave Packets

Unit-2: Wave theory of light: Superposition principle, Coherence etc.

Unit-3: Interference of two beams – Division of wave front – Young's experiment, Fresnel bi-prism, Llyod's mirror etc.

Unit-4: Interference of two beams – Amplitude division – Thin films, wedge film, Newton's rings.

Unit-5: Interferometers – Michelson, Mach-Zehnder, Jamin etc., multiple beam interferometer – Lummer-Gehrcke, Fabry – Perot etc.

Unit-6: Polarization: Superposition of polarized light, polarized, Unpolarized and partially polarized light, waves in anisotropic media, double refraction in uniaxial crystals, Nicol prism, wave plates,

Unit-7: Optical activity, Polarimeters, Faraday Effect, Introduction to Jones vectors, Stokes vectors and Poincare sphere

Unit-8: Scalar theory of diffraction, Fraunhofer diffraction patterns, diffraction gratings

Unit-9: Fresnel diffraction patterns, resolving power of optical systems – Rayleigh criterion

Reference Books:

F. S. Crawford Jr (2017), Waves, Volume 3, Berkeley Physics Course, McGraw Hill Education, New York, United States.

1. H.J. Pain (2006), Physics of vibrations and waves, Sixth Edition, John Wiley & Sons, Hoboken, New Jersey, United States.

2. A.P. French (2003), Vibrations and Waves, First edition, The MIT Introductory Physics Series, CBS Publishers & Distributors, India.

3. R.S. Longhurst (1999), Geometrical and Physical Optics, Orient Longman, India.

4. F.A. Jenkins and H. E. White (2017), Fundamentals of Optics, Fourth edition, McGraw Hill Education, New York, United States.

5. Hecht and A.R. Ganesan (2019), Optics, Fifth edition, Pearson Education, Bengaluru, India.

6. K.K. Sharma (2006), Optics: Principles and applications, Academic Press, Netherlands.

7. Ghatak (2017), Optics, Sixth edition, McGraw Hill Education, New York, United States.

8. M. Born & E. Wolf (2019), Principles of Optics, Seventh edition, Cambridge University Press, United Kingdom.

Course code: IPH 504
Title of the course: Quantum Physics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites: Mechanics, Electricity and magnetism, waves and oscillations, Mathematical methods, basics of the experiments around 1900 that revolutionized the field

Course Learning Outcomes (CLOs):

At the end of the course the student will be able to

CLO-1: To distinguish between phenomena at classical and quantum level

CLO-2: To apply basic formalism to simple problems

CLO-3: Describe the postulates of quantum mechanics

CLO-4: Discuss Schrodinger time dependent and time independent wave equations

Syllabus:

Unit-1: Review of inadequacies of classical physics and development of quantum mechanics.

Unit-2: Dynamical variables as Hermitian operators, Position and momentum operators, Fundamental commutation relation, Compatible observables and simultaneous measurements

Unit-3: Wave function and its probabilistic interpretation, Wave packets, Classical velocity of a particle and the group velocity of the wave representing the particle.

Unit-4: Postulates of quantum mechanics, Coordinate and momentum representation

Unit-5: Time evolution of the wave function and the Time-dependent Schrodinger equation, Expectation values, Ehrenfest theorem, Probability current and conservation of probability

Unit-6: Properties of eigenvalues and eigen functions of a Hermitian operator, Closure property

Unit-7: Time-independent potential and time-independent Schrodinger equation, Stationary states, Normalization of wave function

Unit-8: Free particle problem, Continuous eigenvalues, Normalization of eigen function, Spreading of wave packet

Unit-9: Particle in a box (in one and three dimensions), Concept of degeneracy, Particle in a one-dimensional finite potential well, potential barrier and tunnelling, linear harmonic oscillator

Books Recommended:

1. A textbook on quantum mechanics – P. M. Mathews and Venkatesan (TMH Publisher)
2. Introduction to quantum mechanics – D. Griffith (Prentice Hall)
3. Physics of atoms, nuclei, molecules, Eisberg and Resnick (Wylie)
4. Concepts of modern physics, Beiser (TMH)

Course Code: **IPH 505**

Title of the Course: A.C. Circuit Lab

Number of classes: 90, Lectures 14, Tutorial: 6, Practicals: 70, Credits: 4

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge (If any): Basic knowledge of electricity, electrical components, AC and DC voltage sources.

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Apply the knowledge of current electricity to design simple AC circuits using components such as R, L and C, diode, transistor on breadboard. Determine the values of unknown R, L and C.

CLO-2: Analyse the circuits using Argand diagrams to and understand the input and output signals of the designed AC circuits using function generator and Oscilloscope.

CLO-3: Apply basic laws such as Ohm's law, Thevenin's theorem to analyse the circuits.

CLO-4: Evaluate the performance of several AC circuits such as rectifiers, filters, AC bridges designed on breadboard.

CLO-5: Create a prototype device such as a rectifier using step-down transformer, R, C, and diodes.

Syllabus:

Unit 1: Measurement of capacitance

Unit 2: Measurement of Self-inductance

Unit 3: Passive Filters: Low pass, High pass, Band-pass

Unit 4: AC Wheatstone Bridges: Maxwell's, D. Sauty's and Anderson bridges

Unit 5: Thevenin's Theorem

Unit 6: Diode Characteristic: Forward and Reverse bias

Unit 7: Half-wave and Full-wave Rectifiers

Unit 8: Diode clipping and clamping circuits

Unit 9: Characteristic of Bipolar Junction Transistors

Reference Books:

1. R. Srinivasan, (2008) Modern Physics KIT, Indian Academy of Sciences, Bangalore
2. Samir Kumar Ghosh, (2017), A Text Book of Practical Physics, New Central Book Agency (P) Ltd. 4th edition, Kolkata(India)

Course Code: IPH 506
Title of the Course: Optics Lab
Number of classes: 90, Lectures 14, Tutorial: 6, Practical: 70, Credits: 4

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge (If any): Basic knowledge of optics and mathematics

Course Learning Outcomes (CLOs):

CLO-1: Use a glass prism to understand the laws of reflection of prism and measure the refractive index of the given glass. Operate traveling microscope and measure the apparent depth of the water and estimate the refractive index the given solvent

CLO-2: Use quarter wave plate, half wave plate and polarizer to generate different states of polarized light. Test the validity of Malus-Law by measuring the intensity of light beam as a function of angle of rotation of the polarization.

CLO-3: Construct the experimental setup for measuring reflectivity's of different polarization of light. Discriminate the S and P polarization dependent reflectivity from a glass surface and measure their absolute values experimentally. From the obtained graphs they predict the Brewster's angle of that given sample.

CLO-4: Recognise the division of amplitude interference, by Fabry Perot interferometer method. Practice the alignment to get the best fringe pattern. Estimate the spacing between the etalon and wavelengths of different lasers.

CL0-5: Recognize the division of wavefront interference, by Frenels Bi-prism experiment. Practice the alignment of getting the best fringes. Estimate the distance between the two virtual sources by conjugate foci method and wavelength of the light source from fringe width.

CL0-6: Calculate the radius of the Plano convex lens and refractive index of water using Newton's rings experiment.

CL0-7: Use diffraction grating and single silt for calculation of the periodicity/spacing of slit. Calculate the different wavelengths in mercury vapour lamp.

Syllabus:

Unit-1: Snells law: Measure the refractive index of glass and water.

Unit-2: Malus Law: Transmission of polarized light.

Unit-3: Wave Plates: Characterise quarter wave plate and half wave plate

Unit-4: Brewster's Angle: Polarization of reflections from glass.

Unit-5: Fabry Perot interference: calculate the spacing between two flat mirrors and find unknown wavelength.

Unit-6: Fresnel Bi-prism interference: conjugate foci method and find wavelength of sodium vapour lamp

Unit-7: Newton's rings: find the radius of a Plano-convex lens and refractive index of water

Unit 8: Single slit diffraction- Find the wavelength of laser.

Unit 9: Diffraction grating with white light: find the wavelengths of different lines of mercury vapour lamp

Reference Books:

1. Eugene Hect (2017), Optics, 5^{th} Edition, Pearson education India.
2. Frank K. Pedrotti, Leno M. Perdotti (2019), Introduction to Optics by, 3^{rd} edition, Cambridge University Press, UK.
3. Subhasish Dutta Gupta, Nirmalya Gosh, Ayan Banerjee,(2016), Wave optics: Basic concepts and contemporary trends, 1^{st} Edition, CRC press, India.

Course code: IPH-601
Title of the course: Statistical Thermodynamics

Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Course Learning Outcomes (CLOs):

At the end of this course, the students should be able to

CLO-1: Apply entropy postulates and laws of thermodynamics to given problems to determine the equilibrium configuration of systems.

CLO-2: Compute fundamental relation of a system given equations of state.

CLO-3: Compute Legendre transform for a given function.

CLO-4: Relate C_p to C_v for any real gas using Maxwell's relations.

CLO-5: Illustrate the design of heat engines and refrigerators.

CLO-6: Review Liouville's theorem and generalised equipartition theorem.

CLO-7: Analyze a one-dimensional random walk using probability theory, and its connection with the diffusion problem.

CLO-8: Apply the concept of phase space to the microcanonical and canonical ensemble approaches to study equilibrium systems

Syllabus:

Unit-1: Micro-world described by classical and quantum mechanics; Nature of microscopic laws; Determinism; Time reversal invariance; Macro world described by thermodynamics; Time's arrow.

Unit-2: Thermodynamic variables, Thermal equilibrium; Temperature; Zero-th law of thermodynamics; Mechanical equilibrium; Pressure; Adiabatic work; Internal energy; Heat; First law of thermodynamics; Exact and inexact differentials; Second law of thermodynamics; Entropy; Fundamental relation of a thermodynamic system; Euler equation; Gibbs-Duhem relation; Determination of fundamental relation; Legendre transform; Helmholtz free energy; Enthalpy; Gibbs free energy; Maxwell's relations; Chemical potential; Third law of thermodynamics. Quasistatic and reversible processes; irreversibility. Carnot engine.

Unit-3: Thermodynamic description of phase transitions; Condition of phase coexistence; Ehrenfest's classification of phase transition; Claussias-Clapeyron equation; van der Waal's equation of state, Critical point. Random walk in one dimension. Kinetic theory of gases. Phase space; Distribution function; Liouville's theorem; Generalised equipartition theorem.

Unit-4: Statistical ensemble; Boltzmann entropy; Equal a priori probability; Ergodicity; Microcanonical ensemble; Ideal classical gas; Gibbs paradox; Sackur-Tetrode equation; Canonical ensemble; Canonical partition function; Free energy; Fluctuations of energy and specific heat; Maxwell demon.

Books Recommended:

1. Thermodynamics and an introduction to thermostatistics, H B Callen, 2nd Ed., Wiley India, Delhi, 2006.
2. Fundamentals of statistical and thermal physics, F Rief, Levant Kolkata, 2010.
3. Statistical Mechanics, Kerson Huang, 2nd ed., Wiley India, Delhi, 2009.
4. Heat and Thermodynamics, M W Zemansky and R H Dittman, 7th Ed., McGraw Hill, New York, 1997.

Course Code: IPH 602

Title of the Course: Structure and Properties of Matter

Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite Course / Knowledge (If any):

(1) Basic understanding of general physics, chemistry and mathematics at 10+2 level.

(2) High motivation to learn new physics principles of physical properties and crystal structures.

Course Learning Outcomes (CLOs) :

After completion of this course successfully, the students will be able to

CLO-1: Understand (quantitatively) the force of attraction/repulsion, and interaction potential between the two neutral atoms, including the equilibrium condition of molecules.

CLO-2: Classify and differentiate the different bonding solids (qualitatively) with suitable examples.

CLO-3: Classify the different crystal structures, Bravais lattices, symmetry elements, crystal planes, etc. and explain the concept of the reciprocal lattice.

CLO-4: Apply Bragg's condition to the crystals and interpret it for reciprocal lattice, thereby evaluates/construct the first and second Brillouin zones boundaries in 2D.

CLO-5: Explain how bands are formed in solids, based on that, able to analyze the distinction between metals, semiconductors, and insulators.

CLO-6: Classify different stress & strains relations, elastic moduli, and then evaluate the mechanical strength of cylindrical bodies.

CLO-7: Calculate the various material parameters and access these materials for suitable device applications.

Syllabus:

Unit-1: Bonding in Solids: Crystals of inert gases, Hydrogen, Ionic, Covalent and metallic bonding.

Unit-2: Crystal structure of Solids : Periodic array of atoms; Two and three dimensional lattices, Index systems for crystals, Simple crystal structures, Crystal symmetry, Bravais Lattices, Reciprocal lattice, Miller indices, Diffraction of waves by crystals, Bragg's law of diffraction, Introduction to Brillouin zones.

Unit-3: Electronic properties: Free electron theory of metals, Relaxation time, Mean free path, Drude-Lorentz Model of electrical conductivity, Mobility, Sommerfeld model, Electrons in an electric and magnetic field, Hall Effect
Periodic potential in a crystalline solid, Qualitative explanation of the formation of bands, Bloch Theorem, Kronig- Penney Model, Concept of effective mass, Electrons and Holes, Introduction to metals, semiconductors and insulators

Unit-4: Elastic properties of matter: Introduction (elastic properties of matter, stress, strain), Hooke's law, Different types of moduli of elasticity for isotropic homogeneous bodies, Interrelations of elastic moduli, Torsion of a cylinder, Internal bending moment, Cantilever, Bending of beams, Difference between strength, hardness and toughness of materials.

Unit-5: Surface Tension and Viscosity: Introduction (origin of surface tension forces and applications), Surface tension and surface energy, Molecular theory (property of surface layer), Equation of continuity, Energy of a liquid in flow, Bernoulli's theorem, Critical velocity, Reynold's number, Poiseuille's equation, Motion in a viscous medium: Stoke's law, Streamline and turbulent flow.

Unit-6: Thermal properties of matter (an introduction): Phonons, Specific heat of solids, Dulong-Petit's law, Thermal conductively, Widemann-Franz law.

Reference Books:

1. Steven H. Simon (2013), The Oxford Solid State Basics, 1st Edition, Oxford University Press, Oxford, UK.

2. M. A. Wahab, Solid State Physics (Structure and Properties of Materials), 3rd Edition, Narosa Publishing House Private Limited, New Delhi, India.

3. C. Kittel, Introduction to Solid State Physics (2012), 8th Edition, John Wiley & Sons, Inc. New Jersey, USA.

4. J. R. Hook & H. E. Hall, Solid State Physics (1991), 2nd edition, John Wiley & Sons, Inc. New Jersey, USA.

5. C. J. Smith, General Properties of Matter (1960), 2nd edition, Edward Arnold, London, UK.

6. D. S. Mathur, Elements of Properties of Matter, (1985) 10th edition, S. Chand, New Delhi, India.

Course Code: IPH603
Title of the Course: Atomic and Molecular Physics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite: Only those who have completed Modern Physics course can opt for this course.

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Explain the different atomic models explaining the structure of atoms and the origin of the observed atomic spectra.

CLO-2: Explain the spectra of single and multiple electron atoms of hydrogen like atoms, spin and relativity correction.

CLO-3: Explain LS coupling and JJ coupling, atomic electronic terms, selection rules for multi electron atoms in LS coupling.

CLO-4: Interpret the spectra of alkaline earth elements and interaction energies in LS and JJ couplings.

CLO-5: Explain the origin of spin-orbit interaction, and be able to undertake simple calculations.

CLO-6: Describe the effect of magnetic field on the atomic spectrum. Calculate the Zeeman shift in simple atomic systems and use of the Lande g-factor.

CLO-7: Describe the types of molecular potentials and analyse the spectra of diatomic molecules such as electronic, rotational, vibrational spectra.

CLO-8: Explain the difference between stimulated, spontaneous emission and basic working principle of laser systems.

Syllabus:

Unit-1**: Structure of atom:** Overview of early experiments – cathode ray tube and measurement of e/m by J. J. Thompson, Millikan oil drop experiment to measure charge of electron; Compton Effect, Hertz experiment of photoelectric effect. Source of electron and Photo multiplier tube; Rutherford-Geiger-Marsden experiment – calculation of scattering cross section; Bohr model of atom and Frank – Hertz experiment, Hydrogen spectra, Lyman, series, Balmer series etc. X- ray emission and Moseley's law; Sommerfeld model and angular momentum.

Unit-2: **Vector Atom Model:** Magnetic moment of an electron for orbital motion, Space quantization, Stern – Gerlach experiment, Electron spin, Vector model, Lande g factor, Interpretation of Stern – Gerlach, Doublet lines of alkali spectra, Spin – orbit interaction, Zeeman effect (normal & Anomalous).

Unit-3: **Schrodinger Equation:** Schrodinger equation for one electron atoms, Solution in spherical polar co-ordinates and bound states; Expectation values; Selection rules and transition probabilities; Special hydrogenic systems – positronium, muonium, anti-hydrogen and Rydberg atoms.

Unit-4: **Many electron atoms;** Helium spectra, LS and JJ coupling, Pauli's exclusion principle, Hund's rule, Equivalent and non-equivalent electrons

Unit-5: **Molecular Spectra:** Hydrogen molecule; Potential energy for molecules – Morse and Lennard- Jones Models, Diatomic molecules – rotational and vibrational levels, Basic ideas about molecular spectra, Raman spectra. Lectures:

Unit-6: **Laser Physics**: Interaction of atoms with light – transition probabilities, A & B coefficients, Spontaneous & Stimulated emission, Population inversion, Feedback of energy in a resonator, three level and four level systems.

Reference Books:

1. W. Demtroder 'Atoms, Molecules and Photons' Springer-Verlag Berlin and Heidelberg GmbH & Co. KG 3rd edition (2018)

2. Bransden & Joachim 'Physics of Atoms & Molecules' Pearson Education India; 2nd Edition (2003)

3. C.J. Foot 'Atomic Physics' Oxford University Press 1st edition (2005)

Course Code: IPH604
Title of the Course: Introduction to Nuclear and particle physics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite Course / Knowledge (If any): Nil

Course Learning Outcomes (CLOs):
After completion of this course successfully, the students will be able to

CLO-1: Analyze the properties of nuclei and reason the factors that govern the structure and stability of nuclei.

CLO -2: Identify the properties of nuclear forces. Understand nuclear models and predict nuclear spins by applying Shell model.

CLO-3: Describe the concepts of radioactivity, nuclear fission and fusion. Apply barrier penetration techniques to analyse alpha decay.

CLO -4: Understand the classification of elementary particle physics and the conservation laws

CLO -5: Explain the four basic interactions in nature

CLO -6: Discuss the old and present generation particle accelerators

Syllabus:

Unit-1: Nuclear Structure & Properties: Rutherford scattering, Kinetics and Scattering cross-section. N-Z chart of nuclei and abundance of nuclei. Nuclear mass, charge, size, shape, binding energy, spin and electric/magnetic moments; Nuclear stability and nuclear binding, Liquid drop model. Introduction to Shell Model (qualitative discussion). Nucleonic configuration and prediction of nuclear spins.

Unit-2: Unstable Nuclei: α, β & γ – decay; Geiger-Nuttal law; Alpha particle spectra; Nature of beta ray spectra, the neutrino; Gamma ray spectra and Nuclear energy levels.

Unit-3: Nuclear Fission and Fusion: Energetics Fission and Fusion in terms of liquid drop model. Spontaneous and induced fission. Energy and Mass distribution of fission fragments. Chain reaction and basic principle of nuclear reactors. Fusion as a source of energy production in Stars. Challenges in realizing viable fusion reactors for power generation (qualitative discussion).

Unit-4: Elementary particles: Four basic interaction in nature and their relative strengths; Quantum Numbers: Mass, charge, spin, Isotopic spin, strangeness, hypercharge, Conservation laws.

Unit-5: Classification of elementary particles: Hadrons and leptons, Baryons and mesons, Elementary ideas about quark structure of hadrons; Particle accelerators: Cyclotron, basic theory, Synchrotron, linear accelerator, Hadron colliders

Books Recommended:

1. Introduction to Nuclear and particle physics by A.Das and T.Ferbel
2. Introduction to elementary particle by David Griffiths, JOHN WILEY & SONS, INC.

Course Code: IPH 605

Title of the Course: Computer Programming Lab
Number of classes: 90, Lectures: 14, Tutorials: 6, Practicals: 70, Credits: 4

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge: Basic computer literacy, knowledge of linear algebra and calculus

Course Learning Outcomes (CLOs):
After completion of this course successfully, the students will be able to:

CLO-1: Write simple programs in the language of FORTRAN.

CLO-2: Solve simple computational problems in physics.

CLO-3: Set up numerical methods for obtaining numerical solutions to algebraic equations and differential equations.

CLO-4: Apply numerical methods to obtain approximate solutions to simple physics problems.

CLO-5: Prepare Plots for the results of the programs using an open source software Gnuplot.

CLO-6: Write efficient, well-documented FORTRAN codes and present numerical results in an informative way.

Syllabus:

Unit-1: Recapitulation - Basic computer architecture, CPU, RAM etc, Introduction to different operating systems (Linux/Windows/MAC); basics of programming logic – Flowcharts.

Unit-2: Introduction to programing in FORTRAN - variables and constants, Different data types such as integer floating point, complex etc. If-then-else conditions, Do loops, Arrays, Reading and writing data into files, Subroutines and functions.

Unit-3: Simple programing examples from physics, Matrix addition/multiplications. Handling data into arrays.

Unit-4: Simple numerical methods: Solution of polynomials - Bisection method, Regula -Falsi method and Newton Raphson method. Euler method for solving differential equation. Simpson's method of integration.

Unit-5: Introduction to plotting programs such as Gnuplot - Plotting 2D and 3D data, Density plots and surface plots. Plotting multiple data and multiple plots. Simple curve fitting using Gnuplot.

Reference Books:

1. V. Rajaraman, (1999), Computer programming in Fortran 90 and 95, Prentice Hall of India Pvt. Ltd. New Delhi
2. A. Greenbaum and T. P. Chartier, (2012), Numerical Methods, First Edition, Princeton University Press, New York.
3. William H. Press, (1999), Numerical Recipes in FORTRAN 90, First Edition, Cambridge University Press, UK.

Course Code: **IPH 606**
Title of the Course: **Modern Physics Lab**
Number of classes: 90, Lectures: 14, Tutorials: 6, Practicals: 70, Credits: 4

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge: Basic knowledge of Modern physics, electrical components, heat and thermodynamics.

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Use Differential amplifier to measure extreme low voltages in micro volts.

CLO-2: Demonstrate Si diode and Cu- Constantan thermocouple as temperature sensors. Use them in different sensitivities and response conditions.

CLO-3: Determination of the temperature coefficient of resistance of Copper. Design the experiment about how to measure the resistance variation with change in temperature.

CLO-4: Estimate the ratio of electrical and thermal conductivity of Cu to determine Lorentz Number.

CLO-5: Design an experiment to measure the capacitance with different dielectric media. Estimate Dielectric constant of a polar and non-polar liquids.

CL0-6: Testing the quantization of energy levels in an gaseous atom by Franck-Hertz experiment

CL0-7: Estimate the Planck's constant using photoelectric effect and Stefan's constant using black body radiation.

CL0-8: Estimation of the value of Boltzmann constant from the variation of resistance of an intrinsic semiconductor with temperature. Use four probe method for measuring the voltage and resistant simultaneously with best accuracy. Estimate the band gap of the given semiconductor.

Syllabus:

Unit-1: The use of a differential amplifier in modern physics experiments.

Unit-2: Demonstrate the use of a Si diode as a temperature sensor

Unit-3: Determination of the temperature coefficient of resistance of Copper

Unit-4: Measurement of Lorentz number

Unit-5: Dielectric constant Benzene

Unit-6: Dipole moment Acetone

Unit-7: Franck-Hertz experiment

Unit-8: Planck's constant experiment

Unit-9: Estimation of the value of Boltzmann constant.

Unit-10: Estimation of the value of Stefan's constant.

Reference Books:

1. A C Mellisinos and J Napolitano Experiments (2003), Modern Physics, 2nd edition, Academic Press.

2. Arthur Beiser (2014) Concepts of Modern Physics, 6th edition, Mc Graw Hill, India.

School of Physics

M.Sc. Programs

Course Code: PH401
Title of the Course: Mathematical Methods-1
Number of classes: 56, Lectures: 40, Tutorials: 16, Credits: 4

Pre-requisite: Notion of set theory, mapping between sets and invertibility of maps. Definition of group. Differential equations with constant coefficients, partial differentiation.

Course Learning Outcomes (CLOs):

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

CLO-1: Learn notions of vectors spaces needed to understand and apply postulates of Quantum Mechanics and calculate various quantities of interest in QM, taught at MSc level.

CLO-2: Should be able to calculate the period of a given a function and express it as a Fourier series, obtain its Fourier transform.

CLO-3: Solve ordinary differential equations (ODEs) using different methods. Primarily derive solutions to ODEs that students come across in courses such as Classical Mechanics, Electro-magnetic theory, etc.

CLO-4: Understand the Definition and properties of Laplace transform and use them to solve ODEs with given boundary conditions.

CLO-5: Solve PDE by applying separation of variable method in the cases with rectangular and circular boundaries in 1, 2 and 3 dimensions.

Syllabus

UNIT -1: Linear vector space, subspace, linear dependent and independent vectors, basis, dimensions, Linear functional, dual space, Linear Operators, commutator, inverse of operators, rank, eigen values and eigen vectors of operators, Matrix representation of operators, Change of basis, norm and inner product, Cauchy-Schwarz inequality, ortho-normal basis, Gram-Schmidt procedure, linear operators in inner product space, Hermitian and Unitary operators, Direct sum, direct product and quotient spaces.

UNIT- 2: Fourier series and Fourier transforms, their properties & applications. Definition and properties of Dirac delta function.

UNIT-3: Linear ordinary differential equations with constant coefficients and the Euler equation. Power series method of solving ODE. Extended power series methods (Frobenius method) obtaining Indicial equations and their roots; classification of the ODE based on the nature of roots of indicial equations and obtaining linearly independent solutions. Fuch's theorem and its application

UNIT-4: Definition and properties of Laplace transform, various identities involving Laplace transform, and using them to solve ODEs with boundary conditions

UNIT- 5: Solution of PDE by separation of variable method in the cases with rectangular & circular boundaries in 1, 2 and 3 dimensions. Fixing coefficient using Fourier transform and Parseval's relation.

Recommended Books

1. Linear Vector Spaces, R. R. Halmos, Springer (1987).

2. Outline of Fourier Analysis including problems with step-by step solutions, Hwei P. Hsu, Associated Educational Services Corp. (1967).

3. Operational Mathematics, V A Churchil,McGraw-Hill Book Company; Third Edition,(1972).

4. Ordinary Differential equations R. L. Rabenstein, Academic Press (1972).

5. An Introduction to Ordinary Differential Equations, E. A. Coddington, Prentice-Hall of India PVt LTD, (1992).

6. An introduction to partial differential equations for science students, G. Stephenson, Longman, (1970).

7. Mathematics for Physicists, Dennery & Kryzywicki,Dover Publications, INC,NY, 1996.

8. Mathematical Physics with Applications, Problems and Solutions, V. Balakrishnan, Ane Books Pvt. Ltd (2020)

9. Advances Engineering Mathematics, E Kreysizg, Wiley Estern Ltd. (1992)

Course Code: PH-402

Title of the Course: Classical Mechanics

Number of classes: 42, Lectures: 32, Tutorials: 10, Credits: 3

Prerequisites:

- Classical Mechanics (or Mechanics) at the Undergraduate Level

- Mathematical Physics (or Mathematics) at the Undergraduate Level

Course Learning Outcomes (CLOs):

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

CLO-1: Review Newtonian mechanics in depth

CLO-2: Apply variational principle, Euler-Lagrange equation of motion and symmetries for analyzing the mechanical systems

CLO-3: Analyze different kind of 1-particle and 2-particle systems within the Lagrangian formalism

CLO-4: Analyze motion of a rigid body (for example symmetrical top) within the Lagrangian formalism

CLO-5: Determine normal modes of various interacting systems of particles

CLO-6: Analyze different kinds of mechanical systems within the Hamiltonian formalism

CLO-7: Review Hamilton-Jacobi formalism as the closest approach from Classical Mechanics to Quantum Mechanics

CLO-8: Analyze stability of dynamical systems

Syllabus:

Unit-1: A brief and quick review of Newtonian mechanics of a particle and a system of particles

Unit-2: Variational principle and Hamilton's least action principle, Lagrangian formalism, Euler-Lagrange equation of motion, Arbitrariness of Lagrangian, Integrals of motion, Conservation theorems and symmetry properties – Noether's theorem

Unit-3: Solution to Euler-Lagrange equation of motion and determination of the conserved quantities: Double pendulum, two body central force problems -- orbit-equation, Kepler's problem and determination of orbit from Laplace-Runge-Lenz vector, Charged particle in an electromagnetic field

Unit-4: Rigid-body dynamics from Lagrangian point of view: Infinitesimal rotations, Symmetric top, Euler's equation of motion for rigid body, Euler's angles, Precession and nutation of a symmetric top, Rigid bodies in contact: d'Alembert's principle

Unit-5: Theory of small oscillations, normal modes of the system

Unit-6: Hamiltonian formalism, conjugate momenta, conservation laws, Hamiltonian of a charged particle in electromagnetic field, Poisson brackets and their properties, equation of motion. Canonical transformation.

Unit-7: A brief introduction to the Hamilton-Jacobi's Theory and action angle variables

Unit-8: Dynamical Systems: Phase-Space Dynamics, Stability Analysis

Recommended Books:

1. Mechanics, ed. 3, L.D. Landau and E.M. Lifshitz, Butterworth Heinemann, Oxford (1980)
2. Classical Mechanics, ed. 2, H. Goldstein, Narosa Pub., New Delhi (2001)
3. Theoretical Mechanics, SI Metric ed., M.R. Spiegel, McGraw-Hill, Singapore (1982)
4. Introduction to Classical Mechanics, D. Morin, Cambridge Univ. Press, Cambridge (2007)
5. Classical Mechanics, A.K. Raychaudhuri, Oxford Univ. Press, Oxford (1983)
6. Theory of Orbits (Vol. 1: Integral Systems and Non-perturbative Methods), ed. 3, D. Boccaletti and G. Pucacco, Springer-Verlag, Berlin (2010)
7. Nonlinear Dynamics and Chaos, ed. 2, S.H. Strogatz, Westview Press, Boulder (2015)
8. Theoretical Mechanics of Particles and Continua, A.L. Fetter and J.D. Walecka, Dover Pub., New York (1980)

Course Code: PH-403

Title of the Course: Electromagnetic Theory-I

Number of classes: 42, Lectures: 32, Tutorials: 10, Credits: 3

Course Learning Outcomes (CLOs):

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

CLO-1: Explain Coulomb's law, Gauss's law, and Green's Theorem and use them in nding electrostatic potential and electrostatic eld due to charge distributions.

CLO-2: Apply to Boundary value problems and nding their solutions by separation of variables method, Method of images, and Green's functions.

CLO-3: Explain about dielectric materials, polarization, Maxwells equations for electrostatics in presence of dielectric materials and apply to Boundary value problems in presence of dielectrics.

CLO-4: Describe about Biot-Savart law, Ampere's law, and calculate magnetic eld and vector potential for simple steady current con gurations and force and torque on current carrying conductors.

CLO-5: Explain about stored energy in electrostatic eld and magnetic eld, electric and magnetic multipole expansion and calculate electric and magnetic dipole and quadruple moments.

CLO-6: Describe about dia, para and ferro-magnetic materials, and Maxwells equations in presence of magnetic materials.

CLO-7: Explain about time varying elds, Faradays Laws of induction, and Maxwells equations of electrodynamics, and derive self and mutual inductance.

Syllabus:

Unit-1: Coulomb's law, Electric eld, Gauss's law, Poisson's and Laplace's equations, and Green's Theo-rem.

Unit-2: Electrostatic potential and electrostatic eld due to discrete charges and continuous charge distributions, Electrostatic eld energy, Multipole expansion, and Electric dipole and quadupole moments

Unit-3: Boundary value problems and their solutions by separation of variables, Method of images, and Green's functions

Unit-4: Dielectric materials, Polarization, Maxwells equations for electrostatics in presence of dielectric materials, and Boundary value problems in presence of dielectrics

Unit-5: Biot-Savart law, Ampere's law, Magnetic eld and vector potential for simple steady current con gurations, Force and torque on current carrying conductors, and Magnetic multipole expansion

Unit-6: Dia, para and ferro-magnetic materials, and Maxwells equations in presence of magnetic ma-terials

Unit-7: Time varying elds, Faradays Laws of induction. Maxwells equations of electrodynamics, Magnetic eld energy, and Self and mutual inductance

Recommended Books:

1. Classical Electrodynamics, J. D Jackson
2. Introduction to Electrodynamics, D. J. Gri ths
3. Introduction to the Principles of Electromagnetism, Walter Hauser(Addison-Wesley Educa-tional Publishers Inc)
4. Classical Electromagnetic Radiation, M A Heald and J B Marion
5. Classical Electromagnetic Theory, Jack Vanderlinde
6. Classical Electricity and Magnetism, W. K H Panofsky and M Phillips
7. Classical Electrodynamics, W. Greiner
8. Classical Electrodynamics, J. Schwinger, L L DeRaad Jr, K A Milton,W-y Tsai
9. Electrodynamics of Continuous Media, Landau and Lifshitz
10. Classical Fields, Landau and Lifshitz

Course code: PH404
Title of the course: Electronics Devices and Circuits
Number of Classes: 56, lectures: 44, Tutorials 12, Credits: 4

Pre Requisite: Basic course on Electronics or Electric circuits

Course Learning Outcomes (CLOs):

At the end of this course, the students should be able to

CLO-1: Explain the structure and operation principles of transistors (Bipolar Junction and Unipolar devices).

CLO-2: Analyze BJT and FET based Amplifier circuits. Analyze small signal models and frequency response of amplifier circuits.

CLO-3: Appreciate the concept of feedback. Analyze Amplifier and Oscillator circuits.

CLO-4: Describe the ideal characteristics of Operational Amplifiers and Evaluate Op-Amp based circuits for various applications.

CLO-5: Design Op-Amp based Instrumentation amplifiers and other Op-Amp circuits.

CLO-6: Describe the operation of logic gates. Apply Boolean algebra to design and/or analyze logic circuits.

Syllabus:

Unit-1: Review of semiconductors and p-n diodes.

Unit-2: Transistor Amplifiers: Structure and operational principles of BJT. CE, CB and CC configurations. Load line, operating point, Transistor biasing, transistor as switch, Transistor as amplifier, AC small signal models, Analysis of CE,CB and CC amplifiers, Concept of feedback. Significance of Positive and negative feedback circuits.

Unit-3: Low-frequency amplifiers. The transistor hybrid model and the h-parameters for a transistor. Conversion formulae for the h-parameters of the different transistor configurations. Analysis of a transistor CE amplifier at low frequencies using h-parameters.

Unit-4: The field effect transistor (FET): Structure and Operation principles, Biasing methods and Small signal model. The CS and CD amplifiers at low frequencies. Introduction to MESFET and MOSFET: Structure and operation principles.

Unit-5: Operational Amplifiers: Differential Amplifiers, Characteristics of an ideal Operational amplifier. Inverting and Non-inverting amplifiers. Summing circuits, integration and Differentiation. Applications of operational amplifiers – zero crossing detector, voltage level detector, smoke detector, phase shifter, instrumentation amplifier, Oscillators and Waveform generators.

Unit-6: Introduction to Digital Electronics: Binary system, Boolean algebra, Karnaugh maps. Logic Gates (OR, AND, NOT, NAND, NOR, XOR and XNOR). Realization of gates (OR, AND and NOT) using diodes and transistors. TTL NAND gate and CMOS inverter. Applications of logic gates: Half Adder, Full Adder and simple combinational circuits. Flip-flops: Latch, SR and JK flip-flops. Analog to Digital and Digital to Analog converters: Concepts of ADC and DAC. Examples of Op-Amp based DAC and DAC circuits.

Recommended books:

1. "Integrated Electronics" by Millman and Halkias, 2nd Ed., McGraw Hill Education (2017).

2. "Electronics Devices and Circuit theory" by R Boylestad and L Nashelsky, 11th Ed., Pearson Education India (2015).

3. "Digital Logic and Computer Design", M. Morris Mano, 1st Ed., Pearson Education India (2016).

Other suggested books:

1. "Electronic Devices" by Thomas L. Floyd, 9th Ed., Pearson Education India (2015).

2. "Electronic Principles" by Albert Malvino, 7th Ed., McGraw Hill Education; (2017).

Course Code: PH405
Title of Course: Quantum mechanics-I
Number of classes: 56, Lectures: 44, Tutorials: 12, Credits: 4

Pre requisite: Quantum physics of I.M.Sc. third year course/ knowledge on Old quantum theory, wave function, Schrodinger equation.

Course Learning Objective (CLOs):

At the end of the course, students will be able to

CLO-1: Compute expectation values, probability of measurement given wave function

CLO-2: Convert from wave function formalism to Ket –Bra notation,

CLO-3: Calculate the energy spectrum for particle in one-dimensional potentials

CLO-4: Apply LHO, central potential and hydrogen atom spectrum to physical problems

CLO-5: Apply QM to two level systems

CLO-6: Apply addition of angular momentum techniques to physical systems.

Syllabus:

Unit -1: Formalism of quantum mechanics:

Postulates of quantum mechanics-discussion: Dirac Notation: Linear vector space, operators; properties of Hermitian operators; projection operator, Uncertainty relation, Different pictures of time evolution.

Unit-2: One dimensional problems: Particle in a box, step -wise potentials delta function potentials: step potential; barrier penetration

Unit-3: LHO: quantisation of energy: series method, abstract operator method.

Unit-4: Central potential: Angular momentum: Raising and Lowering operators, Eigen value problem L^2, L_z. Spherical harmonics. Hydrogen atom: Energy spectrum.

Unit-5: N-Particle system: N- particle Hamiltonian, Identical particles. Pauli principle; ground state energy of N free Fermions

Unit-6: Spin: Nature of spin, Kinematics: Pauli matrices and properties; Dynamics of spin. Quantum mechanics of two-level systems.

Unit-7: Addition of angular momentum: C-G coefficients, Irreducible tensor operators-Wigner-Eckart theorem (No proof); singlet-triplet states

Unit-8: Symmetry: Symmetry and conservation: space translation, time translation, rotation and consequences

Books for reference:

1. Quantum Physics: S Gasiorowichz Second edition John Wiley & Sons, (2000)
2. Principles of quantum mechanics: R.Shankar Second edition Springer (2014)
3. Modern Quantum mechanics: J Sakurai : Second edition , Pearson (2013)
4. Introduction to quantum mechanics: D.Griffith second edition Pearson –(2015)
5. Quantum mechanics- Non-relativistic theory: Landau& Lifshiz3rd edition- Elseiver (India)-(2004).

Course Code: PH 406
Title of the Course: Electronic Circuits Lab.
Number of classes: 90, Lectures 14, Tutorial: 6, Practical: 70, Credits: 4

For Lab Course Tutorial hours can be used for analysis of the data obtained by.

Prerequisite Course / Knowledge (If any): Knowledge of Ohm's Law, Kirchhoff's laws, Diode circuits and its applications. Knowledge of basic GATES in digital electronics.

Course Learning Outcomes (CLOs):

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

CLO-1: Operating CRO for measuring DC, AC measurements and triggering. Attenuation of signals.
CLO-2: Measure the characteristics of BJT from biasing circuits.

CLO-3: Designing and building of CE-amplifier for a required gain and stability factors.

CLO-3: Obtaining the JFET characteristics and apply it as a voltage amplifier.

CLO-4: Use IC742 Op-amp and designe circuits for various applications.

CLO-5: Design combinational logic circuits using basic logic gates

Syllabus:

Unit-1: Operate Digital multimeters, oscilloscopes and function generators. Calibration of CRO; AC and DC measurements with and without attenuation and obtaining the Diode characteristics.

Unit-2: Obtain the characteristics of a BJT from biasing circuits. Finding the difference between 2N2218 and BC107 transistors.

Unit-3: Design the CE amplifier for a given gain with the parameters obtained from Lab 2.

Unit-4: design the RC phase shift oscillator

Unit-5: Obtain the JFET characteristics and building a JFET amplifier.

Unit-6: Operation of IC741 Op-amp and building inverting, non-inverting and differential amplifiers. Building functional circuits: integrator, differentiator, adder and subtractor using IC741.

Unit-7: Smoke detector, Zero crossing detector, Voltage level detector, Waveform generator.

Unit-8: Building AND, NOR, NOT, XOR, XNOR, half adder and full adder with NAND gate.

Unit-9: Designing combinational logic circuits using K-maps.

Unit-10: *Open ended experiments. Group projects demonstration and presentation.

*Groups can choose any one of the following or they can propose a new one with the available sources in the lab.
a) Using a transistor as a switch, and building a square wave generator pulse width modulator.
b) Designing and Building a DC power supply of certain watts. (Designing using LT-spice)
c) Designing and building a wave (Sine and Square) generator

Reference books:

1. Millman and Halkias, (1991), Integrated Electronics, Tata Mc Graw Hill (India)

2. R Boylestad and L Nashelsky, (2009), Electronics Devices and Circuit theory, 10th edition. Pearson, (UK).

3. M. Morris Mano, (2008), Digital Logic and Computer Design, 10th edition, Pearson Prentice-Hall India Pvt. Ltd. (India.)
4. Thomas L. Floyd (2015) 9th Edition, "Electronic Devices" Pearson (UK).
5. Albert Malvino (1970) "Electronic Principles" 7th Edition, Mc Graw Hill (India)
6. R. Coughlin and F. Driscoll (2003) "Operational Amplifiers and linear Integrated circuits" International Edition, Pearson (UK).

Course code: PH451
Title of the course: Mathematical methods -II
Number of classes: 56, Lectures: 44, Tutorials: 12, Credits: 4

Pre-requisites: Basic notion of complex variables. Knowledge of vector spaces and matrix operations.

Course Learning Outcomes (CLOs):

At the end of the course, the student should be able to:

CLO-1: Learn the notions of complex variables and apply them in Advanced Electromagnetic theory, Quantum Field Theory and other advanced courses taught in the final semester of M.Sc.

CLO- 2: Analyze functions of a complex variable using series expansions, using line integrals and geometry.

CLO-3: Explain the major theorems and should be able to prove the basic results of complex analysis.

CLO-4: Apply the methods of complex analysis to evaluate definite integrals and infinite series and they should be able to apply contour integrals and residue theorem to analyze simple problems in theoretical physics.

CLO- 5:.Analyze symmetries in group theory and their implications in a systematic and unified way, including solving or simplifying different problems in atomic and molecular physics, solid state and particle physics for which symmetry plays a role.

CLO- 6: Learn Irreducible representation of symmetry groups and be able to analyze their applications in molecular spectra.

Syllabus:

Unit-1: Geometrical representation of complex numbers. Functions of complex variables. Properties of elementary trigonometric and hyperbolic functions of a complex variable. Differentiation, Cauchy-Riemnann equations. Properties of analytical functions.

Unit-2: Contours in complex plane. Integration in complex plane. Cauchy theorem. Deformation of contours. Cauchy integral representation. Taylor series representation. Isolated and essential singular points. Laurent expansion theorem. Poles. Residues at an isolated singular point. Cauchy residue theorem. Applications of the residue theorem.

Unit-3: Definitions and examples of physically important finite groups. Point groups, multiplication table, subgroups, cyclic groups, center, classes, cosets, Lagrange Theorem.

Unit-4: Representations of finite groups, Irreducible representation characters, orthogonality theorem, Schur's character table. Simple applications to small oscillations and selection rules in molecular spectra.

References:

1. Complex Variables and Applications by J. W Brown and R. V. Churchill, published by McGraw - Hill Higher Education in 2013.

2. Complex Variables: Principles and Problem Sessions by A. K. Kapoor, published by Cambridge University Press India Private Limited (16 July 2011) **ISBN-10:** 8175968982 ISBN**-13:** 978-8175968981

3. Theory of Finite Groups: Applications in physics by L. Jansen and M. Boon, published by North-Holland Pub. Co., 1967.

Course Code: (PH 452)
Title of the Course: Electromagnetic Theory-II
Number of classes: 42, Lectures: 42, Tutorials: 14, Credits: 4

Pre-requisite: Notion of set theory, mapping between sets and invertibility of maps. Definition of group. Differential equations with constant coefficients, partial differentiation.

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to……

CLO-1: Derive the wave equation from Maxwell's equations and re-express it in terms of scalar and vector potentials,

CLO-2: Derive the solution to wave equation in terms of electric and magnetic fields as well as in terms of potentials, and able to apply retarded potential in finding solution,

CLO-3: To derive Poynting Theorem, prov} conservation of energy, linear momentum and angular momentum, and construct EM Stress tensor,

CLO-4: Use plane wave solution to construct solutions describing polarized light and describe and construct state of polarization using Poincare Sphere,

CLO-5: Analyse propagation of EM waves in linear media and conductors and apply these results to phenomena such as reflection, dispersion, skin effect. They should be able to set up and solve wave equation for wave guides,

CLO-6: Analyse the Lineard-Wiechert Potential and calculate fields due to moving charges,

CLO-7: Analysis and calculate the radiation from an accelerating charge and oscillating dipole. Use these to derive life time of classical Hydrogen atom,

CLO-8: Use 4-vector notation to analyse and discuss Lorentz transformation and prove invariance of Maxwell's equations under Lorentz transformations. They should be able to write down Maxwell's equations in tensor form and {\it derive} its component form.

Syllabus:

UNIT- 1: Maxwell's equations in differential and integral form in free space and matter. Derive the wave equation from Maxwell's equations and re-express it in terms of scalar and vector potentials. Explain Coulomb and Lorentz gauge conditions and use them in finding solutions to Maxwell's equations. Derive solution to wave equation in terms of electric and magnetic fields as well as in terms of potentials, use of retarded potential

UNIT- 2: Derive Poynting Theorem, conservation of energy, linear & angular momentum, EM stress tensor, Derivation of transformation properties of the fields.

UNIT- 3: Using plane wave solution and polarization, Poincare Sphere.

UNIT-4: Analysis of EM waves in linear media and conductors (reflection, dispersion, skin effect, wave guide)

UNIT-5: Analysis of Lineard-Wiechert Potential, fields due to moving charges. Analysis of radiation from an accelerating charge, oscillating dipole, life time of classical Hydrogen atom

UNIT-6: Use 4-vector notation to analyses discuss Lorentz trans- formation and Maxwell's equations.

Recommended Books

1. Classical Electrodynamics, J. D Jackson, Wiley India

2. Introduction to Electrodynamics, D. J. Griffths, Pearson, (2014)

3 Introduction to the Principles of Electromagnetism, Walter Hauser, Addison-Wesley Educational Publishers Inc, (1971).

4. Classical Electromagnetic Radiation, M A Heald and J B Marion, Academic Press, NY (1980)

5. Classical Electromagnetic Theory, Jack Vanderlinde, Springer (2007)

6. Classical Electricity and Magnetism, W. K H Panofsky and M Phillips, Addison-Wesley Educational Publishers Inc (1962).

7. Classical Electrodynamics, W. Greiner, Springer (1991)

8. Classical Electrodynamics, J. Schwinger, L L DeRaad Jr, K A Milton,W-y Tsai, Perseus Books (1998)

9. Electrodynamics of Continuous Media, Landau and Lifshitz, Pergamon Press (1984)

10. Classical Fields, Landau and Lifshitz, Butterworth-Heinemann (1975)

Course Code: PH 453
Title of the course: Quantum Mechanics-II
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Pre requisites: CM, QM-I,

Course Learning Outcomes (CLOs):

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

CLO-1: Compute shift in energy for non-degenerate and degenerate levels from perturbation theory.

CLO-2: Apply perturbation methods to study the behaviour of atoms in electric - magnetic field using perturbation.

CLO-3: Calculate transition probabilities from Fermis Golden rule.

CLO-4: Apply non perturbative methods to simple quantum system

CLO-5: Calculate scattering amplitude from born approximation and partial wave analysis.

CLO-6: Use the Dirac equation for the relativistic electron energy spectrum.

Pre requisite: Quantum mechanics-I

Syllabus:

Unit-1: Time independent Perturbation theory

Time independent perturbations: non –degenerate, degenerate upto second order perturbation theory; Stark effect Alkali atoms- Zeeman effect- weak and strong magnetic field.

Unit-2: Time dependent perturbation theory: Fermis Golden rule. Harmonic perturbation- selection rules; Semi classical theory of radiation with matter: electric dipole transitions, forbidden transitions, quantum theory of radiation field

Unit-3: Other approximation methods: Variational method-Helium atom, JWKB approximation, Sudden, adiabatic approximation

Unit-4: Scattering theory: Scattering amplitude; born approximation, partial wave approximation, Phase shift analysis,

Unit-5: Relativistic quantum mechanics: Klein-Gordon equation, Dirac equation: Plane wave solution, spin, g-factor, Dirac Sea and interpretation.

Books for reference:

1. Quantum Physics: S Gasiorowichz Second edition John Wiley & Sons, 2000
2. Principles of quantum mechanics: R.Shankar Second edition Springer 2014
3. Modern Quantum mechanics: J Sakurai : Second edition , Pearson (2013)
4. Introduction to quantum mechanics: D.Griffith second edition Pearson –(2015)
5. Quantum mechanics- Non-relativistic theory: Landau& Lifshiz3rd edition- Elseiver (India)-(2004)

Course code: PH 454
Title of the course: Statistical Mechanics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites: Knowledge of thermodynamics and probability theory.

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to……

CLO-1: Compute the moments and convolutions of probability distribution functions.

CLO-2: Compute the partition function, the thermodynamic quantities, and the correlations functions of systems in thermodynamic equilibrium, using microcanonical, canonical, and grand canonical ensemble approaches.

CLO-3: Analyse the low-temperature thermodynamic behaviour of quantum ideal gases, and the one-dimensional Ising spin system.

CLO-4: Analyze the liquid-gas phase equilibrium using van der Waals equation of state, and the low-temperature behaviour and the long-ranged order in magnetic systems using the mean-field theory.

CLO-5: Compute the critical exponents using the Landau theory of phase transitions, and the concepts of scaling and universality in critical phenomena.

Syllabus:

Unit-1: Review of Thermodynamics, Kinetic Theory of Gas, Liouville's Theorem for KTG, Boltzmann's H Theorem, Equipartition Theorem and Virial Theorem

Unit-2: Probability theory, cumulants, Random walk,

Unit-3: Principles of equilibrium systems, Boltzmann's Hypothesis, Statistical Ensembles: Microcanonical, Canonical, Grand Canonical ensembles.

Unit-4: Quantum statistical mechanics, diagonal and off-diagonal correlation functions, Free Fermi Gas and Bose gas, Sommerfeld asymptotic expansion, cluster expansion

Unit-5: Ising model of magnetism, transfer matrix method, mean field theory, Van der Waals equation of state and liquid-gas phase transition

Unit-6: Phase transitions, Landau theory, Scaling and critical point phenomena, the renormalisation group and universality.

References:

1. F. Reif, Fundamentals of Statistical and thermal physics, Levant Kolkata, 2010.
2. K. Huang, Statistical Mechanics, 2nd ed., Wiley India, Delhi, 2009.
3. R. K. Pathria and P. D. Beale, Statistical Mechanics, 3rd Edition., Elsevier, Oxford, 2011.
4. M. Karder, Statistical Physics of Particles, Cambridge University Press, Cambridge, 2007.
5. S. K. Ma, Statistical Mechanics, World Scientific, Singapore, 1985.
6. L. D. Landau and E. M. Lifshitz, Statistical Physics Part 1, Volume 5, Pergamon Press, New York, 1980.
7. L. E. Reichl, A modern Course in Statistical Physics, Edward Arnold, Great Britain, 1980.
8. L. P. Kadanoff, Statistical Physics, World Scientific, Singapore, 2000.

S. K. Ma, Modern Theory of Critical Phenomena, Levant, Kolkata, 2007.

Course code: PH 455

Title of the course: Numerical methods theory and lab

Number of classes: 42, Lectures:14, Tutorials: 0, Practicals: 28; Credits: 2

One Lecture hour + one lab Session (2hrs)

For Lab Course Tutorial hours can be used for analysis of the data obtained by

Course Learning Outcomes (CLOs):

At the end of this course, the students should be able to

CLO-1: Be able to write simple FORTRAN programs to solve numerical methods

CLO-2: Write programs to solve transcendental equations, perform interpolation, numerical integrations etc. on computer.

CLO-3: Numerically solve differential equations.

CLO-4: Write computer program to solve linear equations using Matrix operations.

Syllabus:

Unit-1: Roots of algebraic and transcendental equations: One point and two-point iterative methods Such as bisection method, inverse interpolation and Newton Raphson methods.

Introduction to programming in FORTRAN

Solving transcendental equations using FORTRAN

Unit-2: Interpolation: Linear interpolation, Lagrangian interpolation, Newton's interpolation (different forms).

Unit-3: Integration: Newton-Cotes formulae, Gauss quadrature.

Unit-4: Ordinary Differential equations : Initial value problem Taylor's algorithm,

Euler's methods, Runge-Kutta, and Predictor-corrector methods.

Unit-5: Matrix operations and simultaneous linear equations: Matrix addition, multiplication and inversion. Solution of simultaneous linear equations by matrix inversion methods.

Recommended books:

1. T. R. McCalla, Introduction to Numerical Methods and Fortran Programming, John Wiley 1967 1st ed.

2. F. S. Acton, Numerical Methods that work, The Mathematical Association of America; 1st Ed (1997)

3. K. E. Atkinson, an Introduction to Numerical Analysis, John Wiley, 2nd ed. (1988)

4. William H. Press, Saul A. Teukolsky, Brian P. Flannery, William T. Vetterling et.al, Numerical Recipes in FORTRAN, Cambridget Univ. Press 2nd Ed. 1992

Course Code: PH 456
Title of the Course: Modern Physics Lab
Number of classes: 70, Lectures: 10, Tutorials: 4, Practicals: 56, Credits: 3

For Lab Course Tutorial hours can be used for analysis of the data obtained by

Prerequisite Course / Knowledge (If any): Basic knowledge on elementary electromagnetic theory, quantum physics, semiconductor physics, Solid state and atomic physics.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

CLO-1: Explain basic theories and concepts of some topics of modern physics through hands on experiments

CLO-2: Analyse all the experimental data from the theoretical perspectives

CLO-3: Evaluate some fundamental constants such as Planck’s constant, Rydberg constant etc from the experiments applying basic theories

CLO-4: Apply relevant basic theories to measure specific heat of solids, Brewster's angle, energy band gap and charge of an electron

Syllabus:

Unit 1: Determination of Planck's constant and work function of metals using photoelectric effect Franck-Hertz Experiment [Quantum Physics]

Unit 2: Brewster angle (Polarization) [Electromagnetic Theory]

Unit 3: Frank-Hertz Experiment [Quantum Physics]

Unit 4: Experiments on Solar Cells [Semiconductor Physics]

Unit 5: Emission spectra of Hydrogen (Balmer series) and determination of Rydberg's constant [Atomic Physics & Quantum Physics]

Unit 6: Measurement of resistivity and determination of band gap using Four- Probe method [Solid State Physics]

Unit 7: Measurement of Specific heat of solids [Solid State Physics]

Unit 8: Charge of an electron (Millikan Oil drop) [Classical Physics]

Reference Books:

1. Quantum Physics, Eisberg abd Resnick, John Wiley & Sons, Second Edition
2. I.Prakash & Ramakrishna, A.K. Jha, (2011), A Text Book of Practical Physics, 11th Edition, Kitab Mahal, New Delhi, India
3. Solid State Electronics Devices, B. G. Streetman, Prentice-Hall of India Private Limited, Third Edition, 1993.

Course Code: PH 501

Title of the Course: Solid State Physics

Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite Course / Knowledge (If any):

(3) Basic knowledge of Quantum mechanics.

(4) Basic knowledge of Statistical Mechanics

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Appreciate the differences in nature of bonding in solids and its relevance to physical properties.

CLO -2: Relate the scattering from planes of a crystal to form factor, structure factor and the crystal structure of the materials

CLO-3: Interpret the Phonon dispersion curves of solid-state systems in 3-D in first Brillouin zone

CLO-4: Calculate thermal and electrical properties in the free-electron model.

CLO-5: Discuss the origin and significance of Band formation in contrasting various properties of metals, insulators and semiconductors

CLO-6: Explain the significance of different interactions and energies involved that explain the phenomena and properties of different types of magnetic materials

CLO-7: Knowledge of developments in the field of superconductivity and describe the
basic properties of Type I and Type II superconductors

CLO-8: Analyze the use of theoretical fundamentals of symmetry groups, quantum mechanics and statistical physics for application in solid state systems.

Syllabus:

Unit-1: Crystal structure, X-ray diffraction, reciprocal lattice and Brillouin zones

Unit-2: Nature of Bonding in solids

Unit-3: Lattice vibrations, phonons, thermal properties.

Unit-4: Free electron gas, Band theory of solids, Semiconductors, Transport properties

Unit-5: Magnetism: Dia-para-, ferro-, antiferro and ferrimagnetism.

Unit-6: Superconductivity: Experimental survey, Thermodynamics of superconductors, London's equations.

Reference Books

1. C. Kittel, Introduction to Solid State Physics (2012), 8th Edition, John Wiley & Sons, Inc. New Jersey, USA.

2. A. J. Dekker, Solid State Physics, McMillan India, 2000

3. Neil. W. Ashocroft & N. David Mermin, Solid State Physics, Holt, Rinehart and Winston, 1976.

4. Steven H. Simon (2013), The Oxford Solid State Basics, 1st Edition, Oxford University Press, Oxford, UK

5. J. R. Hook & H. E. Hall, Solid State Physics (1991), 2nd edition, John Wiley & Sons, Inc. New Jersey, USA.

6. J. S. Blakemore, Solid State Physics, Cambridge University Press (2012).

Course Code: PH 502
Title of the Course: Introduction to Particle Physics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

PREREQUISITES:

Mathematical Methods-2(PH 451), Electromagnetic Theory-2(PH 452), Quantum Mechanics 2(PH 452)

Course Learning Outcomes (CLOs):

A student completing the course will be able to:

CLO-1: Explain the basics of particle physics.

CLO-2: Discuss the use of relativistic kinematics in particle decays and illustrate the manifestation of the Einstein mass-energy relation.

CLO-3: Discuss the application of the Dirac equation to the electron and neutrino.

CLO-4: Explain the relation between Symmetry, conservation laws and conserved quantum numbers.

CLO-5: Illustrate the use of symmetry in the classification of elementary particles.

CLO-6: Discuss the components and design of a modern accelerator experiment.

Syllabus:

Unit-1: Units and introduction to classification of particles, Relativistic kinematics, Energy- momentum four vector, kinematics of two-body decay, Center of Mass transformation and reaction thresholds, Transformation from center of mass to lab system

Unit-2: Breif review of KG equation, Brief review of Dirac eqn, Dirac Eqn in 4 vector notation, Dirac Eqn in momentum space and anti-particle, Majorana basis and Dirac eqn for neutrinos, helicity, bilinear covariants

Unit-3: Symmetries and Conservation Laws in Classical and Quantum Mechanics

i) Noether's theorem in classical mechanics, (ii) continuous space-time symmetries and associated conservation laws of momentum, energy, angular momentum (iii) Invariance and operators in quantum mechanics. Iv) Discrete Symmetries, Parity, Tests of parity, Charge conjugation and time reversal, CP symmetry. Parity, Charge Conjugation and Time reversal operators in terms of Gamma Matrices**.**

Unit-4: Violation of discrete symmetries, Parity non-conservation in weak interactions, CP violation and neutral Kaon system.

Unit-5: Charge independence of nuclear forces, isospin and strangeness. Application of isospin invariance to pion -nucleon scattering, (vi) Strangeness, charm and other additive quantum numbers, (vii) Resonance and their quantum numbers with special reference to pion-nucleon scattering. Gellman Nishijima formula. Introduction to Lie Algebra of SU(2) and SU(3) Multiplets, Gell-Mann-Okubo Mass formula.

Unit-6: Experimental techniques: Cyclotron, synchrotron, linear accelerators, colliding beam experiments, intersecting storage rings and stochastic cooling. Detectors for photons, leptons and hadrons.

Recommended Books:

1. Introduction to High Energy Physics (Cambridge) by D. H. Perkins (4th edition)
2. Particle Physics by B. R. Martin, G. Shaw (Manchester)((3^{rd} edition).
3. Introduction to elementary particles (Wiley) D.Griffiths (2nd edition)

4. Introduction to Nuclear & Particle Physics (World Sc.) T. Ferbel and A. Das (2nd edition)
5. Introduction to Particle Physics (PHI Learning), M.P.Khanna (1st edition)

Reference Articles

1. Notes from Sidney Coleman's Physics 253a, arXiv:1110.5013.

Course code: PH 503
Name of the course: LASER PHYSICS
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites: Quantum Mechanics, Classical Electrodynamics and Mathematical Methods in Physics.

CLO-1: After completion of module 1, the student will be able to understand how a laser source is very distinct from a blackbody source. Apply the knowledge to compare the brightness of conventional sources with that of a laser.

CLO-2: Apply the knowledge of complex analysis to beam propagation problems

CLO-3: Understand the density matrix formalism which is a very unique and important mathematical tool for laser theory

CLO-4: To understand the operating principles of any advanced laser system.

CLO-5: Acquire familiarity with construction and application of different laser systems

Unit-1: Idea of a LASER: Spontaneous and stimulated processes, pumping and relaxation. Einstein's A and B coefficients. Heuristic description of a single mode laser based on Statz and de Mars equation. Optical feedback, pumping, steady states and threshold. Mention of different types of lasers and their properties. Comparison of blackbody radiation with laser radiation.

Unit-2: Optical resonators. Ray and beam optics. Paraxial wave equation and fundamental Gaussian beams. Higher order Hermite-Gauss and Laguerre-Gaussian beams. Mobius transformation applied to fundamental Gaussian beams through linear optical elements. Longitudinal and transverse modes of a resonator. Stable and unstable resonators. Losses and Quality factor.

Unit-3: Density matrix formalism. Pure and mixed cases, examples. Interaction of a two-level system with monochromatic light. Incorporation of losses. Reduction of density matrix equations to NMR Bloch equations. Dynamics on the Bloch sphere. p and 2p pulses

Unit-4: Semiclassical theory of single mode operation. Self-consistency. Maxwell-Bloch equations. Steady state operation. Susceptibility and dispersion. Lasing frequency, frequency pushing and pulling. Homogeneous and inhomogeneous broadening. Mode-locked and Q-switched operation.

Unit-5: Specific laser systems. Few recent applications (optical tweezers, EIT, EIA etc.). Comments on the quantum theory of laser fluctuations.

Books:

1. MSargent, MO Scully andWE Lamb Jr., Laser Physics (Addison-Wesley, New York)

2. A E Siegman, Lasers (University Science Books, California, 1986)

3. A Yariv, Quantum Electronics, Third Edition, (John Wiley, New York, 1989)

4. Stephen C Rand, Lectures on Light: Nonlinear and Quantum Optics using the Density Matrix, (Oxford University Press, Oxford, 2010)

Course: PH 504

Title of the course: Atomic and Molecular Physics

Number of classes: 42, Lectures: 31, Tutorials: 11, Credits:3

Course description: This course addresses the structural aspects of atoms and molecules and the interaction of these with electromagnetic radiation. It assumes a background in quantum mechanics, particularly in perturbation theory, angular momentum algebra, and some elementary aspects of groups.

- Acquire an in depth understanding of the structure of atoms and molecules, the interaction of them with external radiation, and the phenomena that results from this interaction, to apply them in problem solving in this area

- Gain proficiency in applying the tools and techniques of quantum mechanics, mainly quantum perturbation theory to predicting the resultant spectra upon interaction with electromagnetic fields

- Apply the knowledge of the structure and dynamics in predicting the spectra of atoms and molecules in different situations.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1: Apply perturbation theory to predict atomic spectra for spin orbit interactions, Zeeman and Stark (up to 2^{nd} order), Hyperfine interactions

CLO-2: Gain a basic understanding of approximation methods in solving many electron systems; predict the spectra of Helium; Develop the LS and jj coupling schemes and predict the term values of multi electron states

CLO-3: Understand the use and validity of the Born Oppenheimer separation in treating electronic, vibrational and rotational structure of molecules

CLO-4: Predict the vibration and rotation spectra, rovibronic structure of diatomic molecules

CLO-5: Gain an understanding of electronic transitions; Hund's classification; molecular electronic term values and apply this given the angular momentum state of the molecule

CLO-6: Apply point group theory to analyzing the Infrared and Raman spectra of polyatomic molecules

Syllabus:

Unit-1: Atoms:

Absorption and emission of radiation: A review of semiclassical theory of Einstein A and B coefficients, Beer-Lambert's law, Spectral Line shapes (Natural, Doppler) (3)

Structure and spectrum of Hydrogen atom, alkali atomic spectra: Relativistic corrections and spin-orbit interaction, perturbation theory estimates of energy shifts (2); Helium: electronic states and spectra (2)

(Tutorials: Problems and exercises on spin orbit coupling, Helium states) (1)

Interaction with external fields: Zeeman, Paschen Back, Stark effect (5)

Hyperfine structure and 21cm line of Hydrogen, Isotope shifts, (2)

(Tutorials: Strong and weak field Zeeman splitting-problems and exercises, hyperfine interaction problems) (1)

Many electron atoms: Central Field Approximation, LS and JJ coupling, Optical spectra of atoms, Hund's rule for electronic states, Radiative transitions and selection rules (4)

(Tutorials: Applying Wigner Eckhart theorem and derive selection rules; enumerating term values in LS coupling) (2)

Unit- 2: Molecular Physics and Spectroscopy (1):

The Born Oppenheimer approximation (2), Electronic states of the Hydrogen molecular ion and molecule (1), Angular momentum coupling cases in diatomics (1)

(Tutorial session with problems recommended at this stage) (1)

Rotational structure and spectra- Rigid rotator, Centrifugal distortions, Microwave spectroscopy (2); Vibrational spectra in diatomics, dissociation (2);

Unit- 3: Molecular Physics and Spectroscopy (2)

Electronic spectra- Franck Condon principle, Progressions and Sequences, Rotational fine structure in electronic spectra (3);

(Tutorial session with problems recommended at this stage) (2)

Symmetry elements and groups (3), polyatomic molecules: Vibrational states and normal mode analysis-Examples (2), Inversion doubling in Ammonia (1), Infrared and Raman spectroscopy: Instrumentation, Applications to vibrational and rotational states (4)

(Tutorial session with problems recommended at this stage)

Texts and References:

1. I.Sobelman: Atomic Spectra and Radiative Transitions, Springer 1979
2. Bransden and Joachain: Physics of Atoms and Molecules, Pearson Education
3. Topics in Atomic Physics, Burkhardt and Leventhal, Springer
4. Demtroeder: Atoms, Molecules and Photons, Springer 2005
5. Hollas J.M: Modern Spectroscopy, Wiley 2004
6. Jeanne L. McHale: Molecular Spectroscopy, Pearson Education, 2008
7. P. Bernath, Spectra of Atoms and Molecules(3^{rd} Ed.), Oxford University Press, 2016
8. Banwell and McCash: Fundamentals of Molecular Spectroscopy, Tata McGraw Hill 2006

Course code: PH 505
Title of the course: Nuclear Physics
Number of Classes: 28, Lectures: 28, Credits:2

Pre Requisite: Quantum Mechanics

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to……

CLO-1: Learn basic concepts of Nuclear Physics, including the concepts of scattering cross-section, properties of nuclei etc.

CLO-2: Analyze the deuteron problem and n-p scattering to study two nucleon bound states. Identify the properties of nuclear forces.

CLO-3: Understand nuclear models and predict nuclear spins and electromagnetic moments by applying Shell model.

CLO-4: Apply quantum mechanical techniques to evaluate radioactive decay processes. Analyze Nuclear reactions and understand the concepts of Nuclear reactors.

Syllabus:

Unit -1: Review of i) Rutherford scattering, Scattering Cross-section, ii) Properties of nuclei, iii) Liquid drop model.

Unit-2: Properties of Nuclear forces-deuteron problem, n-p scattering, Nuclear Shell Model and Collective Model. Shell model predictions (Nuclear spins and electromagnetic moments).

Unit-3: Alpha Decay-Systematics and theory, Beta Decay-Fermi Theory, Selection Rules, Gamma Decay and Internal Conversion, Selection rules.

Unit-4: Nuclear Reactions-Cross Sections, Compound Nucleus, Nuclear Fission and Fusion, Concepts of Nuclear reactors.

Recommended books:

1. "Introductory Nuclear Physics" by Kenneth S. Krane, Wiley (2008).
2. "Nuclear Physics, Principles and Applications" by John Lilley, 2^{nd} Ed. Wiley India Pvt. Limited, (2013)
3. "Elements of Nuclear Physics" by W. E. Burcham, Longman Inc. (1986).

Course Code: PH 506;
Title of the Course: **Solid State Physics Lab**
Number of classes: 70, Lectures: 10, Tutorials: 4, Practical: 56, Credits: 3

For Lab Course Tutorial hours can be used for analysis of the data obtained by

Prerequisite Course/Knowledge (If any): Knowledge of Solid State Physics Theory course

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Determine crystal structure of solids by analysing diffraction patterns.

CLO-2: Determine charge carriers mobility, resistivity, optical constants of solids.

CLO-3: Demonstrate the phase transition in ferroelectrics.

CLO-4: Prepare thin films using thermal evaporation technique.

CLO-5: Determine resistivity of Ni samples using four probe method

CLO-6: Operate temperature controllers, vacuum pumps, pressure gauges, furnaces and other scientific Equipment

CLO-7: Analyse, interpret and represent data with error analysis.

Syllabus:

Unit-1: X-ray powder diffraction

Unit-2: Hysteresis of ferri/ferromagnetic materials

Unit-3: Electrical resistivity of ferromagnetic Nickel

Unit-4: Study of Hall Effect

Unit-5: Magnetic levitation over a super conductor

Unit-6: Thin film deposition and characterization

Unit-7: Phase transition in ferro-electrics through study of dielectric constant

Note: New units may be added in place of the existing ones in some semesters.

References:

1. Charles Kittel, (2012), Introduction to solid state physics, 8th Edition, Wiley (USA).
2. R. P. Prasankumar, A. J. Taylor, (2011), Optical Techniques for Solid-State Materials Characterization, 1st Edition, CRC Press..
3. Y. Leng , (2013), Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd Edition, Wiley-VCH (USA)
4. J. A. Venables, (2000), Introduction to Surface and Thin Film Processes. 1st Edition, Cambridge University Press (USA).

Course Code: PH 507
Title of the Course: Laser Physics Lab.
Number of classes: 70, Lectures: 10, Tutorials: 4, Practicals: 56, Credits: 3

For Lab Course Tutorial hours can be used for analysis of the data obtained by

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students should be able to

CLO-1: Demonstrate measuring laser beam characteristics using a knife-edge for power distribution with in the beam, Young's double slit for spatial coherence, and Michelson interferometer for temporal coherence

CLO-2: Use an interference between plane laser and focussed laser beam to determine the acquired Gouy's phase

CLO-3: Evaluate the Pancharatnam phase due to interference of two different states of polarizations on Poincare's sphere.

CLO-4: Use a laser Doppler anemometry to determine the velocity of flow of water.

CLO-5: Demonstrate electro-optic effect using anisotropic materials like a potassium dihydrogen phosphate (KDP) crystal.

CLO-6: Demonstrate Faraday Effect using magnetic field induces circular birefringence in medium.

CLO-7: Evaluate the speed of light using a Foucault Method.

CLO-8: Demonstrate acousto-optic effect through sound wave modulated the refractive index of the medium.

Syllabus:

Unit-1: Laser Beam Parameters or Laser Characteristics

Unit-2: Measurement of Gouy's Phase

Unit-3: Pancharatnam Phase or Berry's Phase

Unit-4: Laser Doppler Anemometry

Unit-5: Electro-optic effect

Unit-6: Faraday Effect

Unit-7: Speed of Light (Foucault Method)

Unit-8: Acousto-Optic Effects

Reference Books: (to be given in the Format: Authors (year), Title of the Book, Edition, Publishers, Place of Publication)

1. O'Shea, Callen & Rhodes, (1977), An Introduction to Laser & their Applications, 1st edition, Addison-Wesley, Boston, USA.
2. K. Shimoda, (1984), Introduction to Laser Physics, Springer-Verlag Berlin and Heidelberg GmbH, New York City, USA.
3. K. K. Sharma, (2006), Optics: Principles and Applications, 1st Edition, Academic Press, Amsterdam, Netherlands.
4. R.S. Sirohi, (1991), A Course of Experiments with He-Ne Lasers, 2nd edition, New Age International (P) Ltd, New Delhi, India.

School of Physics
Name of the Academic Program ... MSc

Semester-1V

Course Code: PH 551
Title of the Course: Digital Electronics Lab.
Number of classes: 70, Lectures:10, Tutorials: 4, Practicals: 56, Credits: 3

For Lab Course Tutorial hours can be used for analysis of the data obtained by

Prerequisite Course / Knowledge (If any): Analog Electronics Theory and Lab can opt for this course.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to

CLO-1: Conceptualize Boolean algebra and apply it in analysis of logic circuits.

CLO-2: Analyze and design combinational logic circuits using ICs.

CLO-3: Implement Boolean functions using decoder/encoder and mux/demux circuits.

CLO-4: Analyze and design sequential logic circuits using ICs.

CLO-5: Design and construct logical circuits in lab.

CLO-6 Develop fault detection techniques for troubleshooting digital logic circuits.

CLO-7 Develop digital logic for solving problems in projects (open ended).

Syllabus:

Unit-1: Verification of TTL ICs

Unit-2: Universal Gates

Unit-3: Adders and Multipliers

Unit-4: Encoder, Decoder and their application in Binary Arithmetic operations with 7-Segment Display

Unit-5: MUX and DEMUX and their application in combinational circuits

Unit-6: Flip-Flops (SR, JK, MS-JK)

Unit-7: Application of Flip-Flop in counters (Ripple Counters and Synchronous counters (up/down/random)

Reference Books:

1. M. Morris Mano, (2016), Digital Logic and Computer Design, Pearson India Eductaion Pvt. Ltd.-Noid (India).
2. C. E. Strangio, (1980), Digital Electronics: Fundamental Concepts and Applications, Prentice Hall, Inc., NJ (USA).
3. P. Horowitz and W. Hill, (1989), The Art of Electronics, Cambridge University Press, (India).

Course Code: PH 552

Title of the Course: Microwave and Nuclear Physics lab

Number of classes: 70, Lectures: 10, Tutorials: 4, Practicals: 56, Credits: 3

For Lab Course Tutorial hours can be used for analysis of the data obtained by

Prerequisite Course/Knowledge (If any): Basic understanding of electromagnetic (EM) theory, Transmission theory of EM waves in a rectangular waveguide and Nuclear physics.

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Explain how microwave is generated from a simple klystron tube, tuning and modulation, power mode characteristics and analyse microwave radiation power patterns of anisotropic antenna in different planes.

CLO-2: Describe the microwave power transmission in rectangular waveguides and apply it to predict material impedance to predict the power transmission characteristics.

CLO-3: Evaluate the dielectric constant of given dielectric material by von Hippel's method based on the microwave power generation, transmission and detection process.

CLO-4: Evaluate the dielectric constant of given liquid by using the liquid plunger method based on the microwave power absorption.

CLO-5: Analyze the different types of nuclear radiations and Sources.

CLO-6: Operate the Nuclear Instrumentation modules (NIM) used in radiation detector system.

CLO-7: Explain the functioning of the GM counter and measure the counting curve and determine the operating point of the GM counter.

CLO-8: Interpret the unknown nuclear source with the Single channel analyser or Multichannel analyser.

Syllabus:

Microwave Lab

Unit-1: Klystron: Microwave power modes

Unit-2: Voltage Standing Wave Ratio (VSWR) + Smith chart

Unit-3: Directional Coupler + Magic Tee

Unit-4: Horn Antenna (radiation power patterns)

Unit-5: Dielectric constant of solids (von Hippel's method)

Unit-6: Dielectric constant of liquids (liquid plunger method)

Nuclear Lab

Unit-1: NIM Module: Monitor and study the output of Tail pulse generator, study usage of linear amplifier for fixed gain, varying output and varying gain for fixed input, check SCA in 3 different modes: integral mode, window mode, normal mode

Unit-2: Geiger Muller Counter-Counting Curve. Verification of Inverse Square Law. Dead time of detector using Split Source Method. Counting Statistics and Error prediction. Half Life.

Unit-3: Gamma Spectroscopy using Single Channel Analyser-Differential and Integral Pulse Height Spectra of Cs-137. Detector Resolution

Unit-4: Gamma Spectroscopy using Multichannel Analyser-Energy Calibration and Identification of unknown source. Resolution. Spectrum Analysis. Determination of Activity. Peak Integration. Stripping and Background Subtraction

Reference Books:

1. Max Sucher and Jerome Fox, (1963), (Ed.) Handbook of microwave measurements (vol. I, II, and III), 3rd Edition, John Wiley & Sons Inc. New Jersey, USA.
2. David M. Poze,r (2011), Microwave engineering, 4th Edition, John Wiley & Sons, Inc. New Jersey, USA.
3. Peter A. Rizzi, (1987), Microwave engineering: passive circuits, Pearson, London, UK
4. G. F. Knoll, (1988), Radiation Detection and Measurement, John Wiley
5. W. Nicholson,(1974), Nuclear Electronic, Wiley, London

Course Code: PH 553(Optional Course)

Title of the Course: Advanced Computational Methods

Number of classes: 90, Lectures :14, Tutorials: 6, Practicals: 70, Credits: 4

For Lab Course Tutorial hours can be used for analysis of the data obtained by

Pre-requisites:

Basic course on numerical methods. Knowledge of standard numerical methods for integration and solution of ordinary differential equations, interpolation etc. Any programming language.

Course Learning Outcomes:

At the end of the course, the student should be able to:

CLO-1: Solve ordinary differential equations, linear, coupled and non-linear equations numerically.

CLO-2: Analyze the numerical errors associated with the different techniques.

CLO-3: Apply Monte Carlo methods to solve some physics problems.

CLO-4: Learn the basics of largescale hydrodynamic simulations and modelling.

CLO-5: Learn new integrated programming environments used in physics simulations.

Syllabus:

Unit-1: Numerical Solution of Ordinary differential equations, linear, coupled and non-linear equations. Stiff equations, error analysis and other challenges.

Unit-2: Introduction to Monte Carlo methods in physics (lattice algorithms, event generators simulation tools etc.). Error analysis.

Unit-3: Basics of largescale hydrodynamic simulations and modelling.

Modelling of systems based on fluid dynamics equations such as continuity equations, Navier Stokes etc. Justifications and limitations of this method for different systems.

Unit-4: Introduction to new programming environments such as ROOTS, R etc. These are integrated development environments used for numerical calculations.

References:

1. Computational Methods for Physics, Joel Franklin Published by Cambridge University Press,
   Online publication date: July 2013 Online ISBN: 9781139525398

2. Computational Physics, Mark Newman Published by CreateSpace Independent Publishing Platform (November 7, 2012) **ISBN-10:** 1480145513

3. Monte Carlo Simulation in Statistical Physics, Binder, Kurt, Heermann, Dieter, Published by Springer 2010 ISBN 978-3-030-10758-1

Course Code: PH 554
Title of the Course: Magnetism and Superconductivity
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisite Course / Knowledge (If any):

(5) Basic knowledge of Quantum mechanics.
(6) Basic knowledge of Statistical Mechanics
(7) Basic Knowledge of Solid-State Physics

Course Learning Outcomes (CLOs):
After completion of this course successfully, the students will be able to

CLO-1: Explain the different mechanisms and energies involved that explain the Phenomena and magnetic properties of materials with non-interacting moments in Localized picture. Discuss the quantum phenomena of Magnetism.

CLO -2: Relate the observed magnetism in metals to the itinerant model and band Picture and describe the quantization of Landau levels and explain the magneto Oscillatory behaviour.

CLO-3: Explain the collective magnetism using both the localized and Itinerant Models. Discuss the Phase transitions observed in different Physical phenomena.

CLO-4: Calculate the total energy of the magnetic system by considering different Contributions and explain the significance of domain formation.

CLO-5: Discuss different types of (direct &) indirect interactions responsible for Ferro, antiferro and ferri magnetic order.

CLO-6: Knowledge of developments in the field of superconductivity and quantum Phenomena of Superconductivity. Explain type-I and type-II superconductivity based on thermodynamic calculations of the Gibbs free energy for a superconductor

CLO-7: Apply London theory, modified London theory and Ginzburg-Landau theory
for superconductivity for both derivations and numerical calculations

CLO-8: Derive equations for Josephson junctions and relate this to different applications within superconducting electronics, describe various applications of superconductivity

Syllabus:

Unit-1: Langevin Diamagnetism and Paramagnetism; Van vleck Paramagnetism, Crystal-field effects; John-Teller effects; Adiabatic demagnetization

Unit-2: Magnetism in metals: Landau diamagnetism, Pauli paramagnetism, The De Haas-Van Alphen effect

Unit-3: Molecular field theory of ferromagnetism; Heisenberg-exchange interaction;

Spin Waves; Slater-Puling Curve, stoner criterion for ferromagnetism, additionally, brief introduction also to concepts of order broken symmetry and phase transitions (Landau theory)

Unit-4: Shape, magneto-crystalline and other types of anisotropy; Origin and observation of ferromagnetic domains

Unit-5: Brief introduction to antiferromagnetism & Ferrimagnetism, Different types of magnetic interactions.

Unit-6: Basic properties of superconductors. Phenomenological thermodynamic treatment. Two fluid model; Magnetic behavior of superconductors, intermediate state, London's equations and penetration depth, quantized flux

Unit-7: Pippard's non-local relation and coherence length. Ginzburg-Landau theory, variation of the order parameter and the energy gap with magnetic field, isotope effect.

Unit-8: Electron-phonon interaction and cooper pairs, brief discussion of the B.C.S. Theory, its results and experimental verification; (p- and d- wave pairs). Dc and ac Josephson effects, SQUID; Brief introduction to High temperature superconductors.

Reference Books

1. C. Kittel, Introduction to Solid State Physics (2012), 8^{th} Edition, John Wiley & Sons, Inc. New Jersey, USA.
2. Stephen Blundell, Magnetism in Condensed Matter (Oxford University Press)
3. A.H.Morrish, The Physical Principles of Magnetism (IEEE Press 1980)
4. J.M.D.Coey, Magnetism and Magnetic Materials (Cambridge University Press 2009)
5. B.D.Cullity, C.D.Graham, Introduction to Magnetic Materials (IEEE Press 2009)
6. Tinkham, Introduction to Superconductivity (McGraW-Hill Ltd)
7. J.B.Ketterson, S.N.Song, Superconductivity (Cambridge University Press 1999)
8. C.P.Poole Jr., H. A. Farach, R.J. Creswick, R. Prozorov, Superconductivity (Academic Press)
9. A C Rose-Innes and E H Rhoderick, Introduction to Superconductivity (Pergamon)

Course Code: PH555

Title of the Course: Many-Body Theory

Number of Credits: 4

Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

<u>Prerequisites</u>:

Quantum Mechanics-I (PH-405), Quantum Mechanics-II (PH-453), Statistical Mechanics (PH-501)

<u>Course Learning Outcomes (CLOs)</u>:

CLO-1: Describe the many-body states in terms of symmetries for identical bosons and fermions.

CLO-2: Review the density matrix formalism for Statistical Mechanics of many-particle systems connecting Quantum Mechanics, and analyze off-diagonal long-ranged order for a Bose system.

CLO-3: Review the connection of Statistical Mechanics with the Non-relativistic Quantum Flied Theory in terms of the 2^{nd} quantization for Bose and Fermi gases of identical particles.

CLO-4: Analyze quantum correlations in thermodynamic systems.

CLO-5: Describe Hamiltonian and other physical operators in terms of annihilation and creation operators, and apply them in the Fock space.

CLO-6: Analyze non-linear Schrodinger equation in approximate form for interacting many-particle system.

CLO-7: Review the interaction picture for many-particle system

CLO-8: Analyze the Green's functions for interacting many-body systems

CLO-9: Apply the perturbation techniques for interacting many-body systems within the interaction picture, and describe Feynman diagrams for different fundamental processes for the interacting many-body systems

Syllabus:

Unit-1: Systems of identical particles, Symmetric and anti-symmetric wave functions

Unit-2: Density matrix formalism for statistical mechanics, Quantum cluster expansion for Bose and Fermi gases in the language of density matrices

Unit-3: Second quantization and correlation functions for Bose and Fermi gases, Fock space and operators in the Fock space

Unit-4: Interacting electron gas, Hartree and Hartree-Fock Approximations:

Unit-5: Time-dependent operators-Schrodinger, Heisenberg and interaction representations, Perturbative treatment of interacting electron gas problem, Random phase approximation.

Unit-6: Green function, self-energy, Dyson equation

Unit-7: Diagrammatic perturbation theory, Wick's theorem, Feynman diagrams, applications to: electron gas, and many boson systems with condensed phase

Recommended Books:

1. Statistical Mechanics, R.P. Feynman, Westview Press, Boulder (1972)
2. Quantum Theory of Many-Particle Systems, A.L. Fetter and J. D. Walecka, Dover Pub., New York (1971)
3. Methods of Quantum Field Theory in Statistical Mechanics, A.A. Abrikosov, L.P. Gorkov and I.E. Dzyaloshinski, Dover Pub., New York (1963)
4. Many-Particle Physics, ed. 3, G.D. Mahan, Plenum Pub., New York (2000)
5. Introduction to Many-Body Physics, P. Coleman, Cambridge Univ. Press, Cambridge (2015)
6. Condensed Matter Field Theory, ed. 2, A. Altland and B. Simons, Cambridge Univ. Press, Cambridge (2010)
7. Green Functions in Solids, ed. 3, E.N. Economou, Springer-Verlag, Berlin (2006)
8. Theory of Interacting Fermi Systems, ed. 3, P. Nozieres, Westview Press, Boulder (1997)
9. Quantum Many-Particle Systems, J.H. Negele and H. Orland, Levant Books (Indian Ed.), Kolkata (2006)
10. Solid State Physics, N.W. Ashcroft and N. D. Mermin, Hartcourt Pub., Singapore (1976)

Course Code: PH556

Probes of Condensed Matter

Course Level: Elective MSc (IV sem); IMSc (X sem), Ph.D

No. of Credits: 4; No. of Contact Hours: 56

Pre requisite: Solid state physics

Course Learning Outcomes (CLO):

After completion of this Course the student will be able to:

CLO-1: Analyze binary Phase diagrams, assess phase formation and amounts of different phases present

CLO-2: Interpret microstructures and determine composition of phases from EDAX data

CLO-3: Identify methods to determine crystal structure, atom positions, lattice parameters, magnetic moments

CLO-4: Apply resonance techniques to determine Lande g-factor, hyperfine and other interactions from multiple nuclei and neighbourhood

CLO-5: Identify phase transitions and critical temperatures, and magnetic ordering in materials

CLO-6: Select suitable techniques to determine various physical properties to suit a chosen application.

Syllabus:

Investigation of structural and physical properties of solids using the following experimental techniques:

Unit-1: Binary Phase diagrams, Phase formation and microstructures.

Unit-2: Structural properties: X-ray diffraction & Neutron scattering Techniques.

Unit-3: Spectroscopic techniques: ESR/EPR/NMR/ Pulsed NMR/ FMR.

Unit-4: γ–ray spectroscopy: Mossbauer and Positron Annihilation.

Unit-5: Electrical, Thermal and Magnetic properties of materials and Phase transitions.

Note: Some Topics under Item 5 are given for Seminars/Projects by the Students.

Recommended books:

1. "X-ray Diffraction" by H.P Klug and L.E. Alexander; "Neutron Diffraction" by G.E. Bacon

2. "Techniques of Materials Research" edited by R.F. Bunshah
3. "Electron Spin Resonance" by J.E.Wertz and J.R.Bolton; "Electron Paramagnetic Resonance" by J.W.Orton; "Electron Spin Resonance of Paramagnetic Crystals" by L.A. Sorin and M.V. Vlasova
4. "Solid State: Nuclear Methods" Methods of Experimental Physics; Vol 21 edited by J.W.
5. Mundy et.al. "Applications of Mossbauer Spectroscopy" first edition by Richard L. Cohen
6. "Positron Annihilation Spectroscopy" by Hans Kuzmany
7. Other Physical Properties and techniques
8. Thermal Properties of Solids by Ventura G and Perfetti M; "Thermal Expansion "R E Taylor;
9. "Thermal conductivity" Ed. Terry Tritt;
10. "Magnetism and Magnetic Materials" by JMD Coey (2009) ;and by David Jiles (2015)

Course code: PH557.
Title of the course: Soft Condensed Matter
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Pre Requisite: Knowledge of introductory condensed matter physics, optics and light and statistical mechanics is desirable.

Course Learning Outcomes (CLOs):

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

CLO-1: Identify materials are classified as soft condensed matter (in other words soft matter), recognize the importance of scaling of length and times scales with respect to hard matter (i.e. matter made of atoms/molecules) and can list commonalities and differences that exist with hard matter.

CLO-2. Select novel experimental techniques that give insight to soft matter and review experimental techniques that are common to both hard and soft matter.

CLO-3: Explain about different types of colloidal systems and interparticle interactions and identify phases that have commonality with hard matter in structure but differ in dynamics. Prepare novel materials and discover and interpret their novel properties.

CLO-4: Describe different phases of liquid crystals and understand their structures, optical and physical properties.

CLO-5: Describe different types of topological defects. Understand the effects of external electric and magnetic fields and the resulting optical effects. Apply the concept to understand the operation of LCD displays.

CLO-6: Explain self-assembly of surfactants leading to novel phases and discover several emerging properties and learn the ability to modify the properties by altering thermodynamic conditions, concentration and type of surfactants.

CLO.7: Describe different type of polymer solutions and relate the properties to different configurations of polymer molecules in solvent and also to polymer-solvent interactions.

CLO.8: Categorize different soft materials into solutions, colloids, physical gels versus cross-linked gels through structural studies and rheological behavior.

Syllabus:

Unit-1**: Introduction to Soft matter:** Forces, energies, length and time scales and in soft matter. Soft mater systems (colloids, surfactant/micellar systems, gels, polymer solutions, polymers, Polyelectrolytes, microemulsions, membranes, biological macromolecules (DNA and RNA, Proteins, Polysaccharides, membranes), Interactions (electrostatic, van der Walls, hydrophilic and hydrophobic interactions, depletion interaction). Soft matter in nature, some aspects of Industrial and Technological applications.

Unit-2**: Experimental techniques to investigate structure, dynamics, flow and deformation in soft matter:** Scattering techniques (Small-angle X-ray scattering (SAXS), Ultra-small-angle- X-ray scattering (USAXS), Small-angle neutron scattering, Static and Dynamic light scattering (SLS & DLS), Digital video microscopy, confocal laser scanning microscopy, Atomic Force Microscopy (AFM), Optical Tweezers, Dielectric Spectroscopy and Rheology.

Unit-3: **Colloids:** Sterically stabilized and Charge stabilized colloids, Colloidal interactions, Synthesis of monodisperse colloidal particles, characterization, Structural ordering, Dynamics, Phase Transitions [Gas-liquid, Melting/Freezing, Glass Transition, Crystal-Amorphous], Magnetic colloids, Core-shell particles, Colloids under confinement, Colloidal alloys, Colloidal epitaxy, Rheology of colloids, Bio-colloids; Applications of colloidal crystals.

Unit-4: **Liquid Crystals:** Nematic, Cholesteric and Smectic phases of thermotropic liquid crystals, phase transitions, Optical, dielectric and viscous properties of liquid crystals, Continuum elastic theory, Topological defects, Effects of electric and magnetic fields on liquid crystals; Electro-optic effects; Applications of liquid crystals.

Unit-5: **Surfactants**: Types of surfactants, self-assembled phases in solutions, Micellization and critical micelle concentrations (CMC), Langmuir-Blodgett films, Monolayer, Bilayers and Vesicles, Lyotropic liquid crystalline phases, Complex phases in surfactant solutions and micro emulsions, lipids.

Unit-6: **Polymer Solutions, Polyelectrolytes & Polymer hydrogels:** a single ideal chain; mean-square end to-end distance, radius of gyration. Gaussian chain. Freely jointed chain. Worm-like chain, Stretching and confinement, Excluded volume, solvent quality, theta-temperature. Polymer solutions: Flory-Huggins Theory, osmotic pressure, scaling laws for good solvents, Size of a polymer in semi-dilute solutions, poor solvents and phase separation, Measurements of polymer sizes in solution: osmotic pressure, intrinsic viscosity, Polyelectrolytes: Debye-Huckle theory, Donnan equilibrium, Manning condensation; Physical gels, chemical gels and photo-polymerized gels, Sol-Gel transition, Swelling and shrinking of polymer hydrogels. Rheology and Characterization of hydrogels, Rheological models: Maxwell model.

Recommended books

1. R.A. Jones, (2002), Soft Condensed Matter, Oxford University Press, (UK)
2. I. Hamley and J. Chichester, (2000), Introduction to Soft Matter, 2nd edition, Wiley (USA)
3. J.N. Israelachvilli, (1992), Intermolecular and Surface Force, Academic Press, London,
4. W. B. Russel, D. A. Saville, W. R. Schowalter, Colloidal Dispersions, Cambridge University Press (USA)
5. A.K.Arora and B.V.R. Tata (Eds.), (1996), Ordering and Phase Transitions in Charged Colloids, VCH, (USA).
6. J.K.G Dhont, G. Gompper and D. Richter (Eds.), (2002), Soft Matter: Complex Materials on Mesoscopic Scales, Forschungzentrum, Julich GmbH, Julich, Germany
7. Iwao Toraoka, (2002), Polymer Solutions: An Introduction to Physical Properties, John Wiley & Sons,(USA).
8. P.G. de Gennes and J. Prost, (2003) The Physics of Liquid Crystals, 2nd Edition, Oxford University Press, NY, USA

9. S. Chandrasekhar, (1992) Liquid Crystals , 2nd Edition, Cambridge University Press, NY, USA
10. J.P.C. Added, (1996), Physical properties of polymeric gels, John Wiley & Sons, USA

Course code: PH558
Title of the course: Quantum Theory of Solids
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites:

Quantum Mechanics- I (PH 405), Solid State Physics (PH 502)

Course Learning Outcomes (CLOs):

At the end of the course, students will be able to

CLO-1: Apply free electron theory and band theory of solids

CLO-2: Apply the concept of second quantization to write down Hamiltonians for various systems

CLO-3: Analyze interacting Hamiltonians using Hartree and Hartree-Fock approximations

CLO-4: Compute phonon dispersion relations for acoustic and optical phonons

CLO-5: Apply Boltzmann transport equation to study transport properties of solids

CLO-6: Analyze resistivity contributions due to electron-phonon, electron-electron and electron-impurity interactions

CLO-7: Review Kubo formalism for quantum transport

Syllabus:

Unit-1: Review of free electron theory and band theory of solids.

Unit-2: Second quantization: Occupation number representation for Fermion and Bosons, Creation and Annihilation operators, Field opeators, Hamiltonian for one and two-particle operators.

Unit–3: Interacting electron gas: Hartree and Hartree-Fock approximations, Lindhard dielectric function.

Unit–4: Lattice dynamics: Quantization of a three-dimensional lattice, Acoustic and Optical phonons, Heat capacity, Phonons in condensed boson gas, roton spectrum, second sound in crystals.

Unit–5: Transport in solids: Boltzmann transport equation, Relaxation time approximation, Electron-phonon interaction, Resistivity due to electron-phonon, electron-electron and electron-impurity interactions, Matthiessen's rule, Kubo formalism.

References:

1. Quantum Theory of Solids - C. Kittel, 2nd Ed., John Wiley and Sons, USA, 1987.
Many Particle Physics - G. D. Mahan, 3rd Ed., Springer, New York, 2000.

Course Code: PH559
Title of the Course: Advanced Statistical Mechanics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites:

Quantum Mechanics-I (PH-405), Quantum Mechanics-II(PH-453), Statistical Mechanics(PH-501)

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1: Review the density matrix formalism for Statistical Mechanics of many-particle systems connecting Quantum Mechanics

CLO-2: analyze off-diagonal long-ranged order for a Bose system.

CLO-3: Review the connection of Statistical Mechanics with the Non-relativistic Quantum Flied Theory in terms of the 2nd quantization for Bose and Fermi gases of identical particles.

CLO-4: Review continuous phase transition and critical phenomena for interacting chain of spins in various dimensions.

CLO-5: Analyze critical phenomena in the language of renormalization group methods

CLO-6: Analyze interacting Bose and Fermi fluids to understand superfluidity (for Bose systems) and superconductivity (for Fermi systems) in quantum field theoretic language.

CLO-7: Analyze time-evolution of speed distribution of a gas in non-equilibrium situation.

Syllabus:

Unit-1: Density matrix formalism for statistical mechanics, Quantum cluster expansion for Bose and Fermi gases in the language of density matrices.

Unit-2: Second quantization and correlation functions for Bose and Fermi gases.

Unit-3: The Ising model: Multicomponent order parameters: The N-vector model: Exactly soluble models: Ising chain and a few other examples.

Unit-4: The renormalization group (RG) approach, Real-space and momentum-space RG methods and application to simple models.

Unit-5: Quantum fluids: BCS theory of superconductivity, liquid helium, Gross-Pitaevskii equation for Bose-Einstein condensate in harmonic trap

Unit-6: Langevin and Fokker-Planck equations, Fluctuation-dissipation theorem, linear response theory

Recommended Books:

1. Statistical Mechanics, R.P. Feynman, Westview Press, Boulder (1972)
2. Statistical Physics (Part-1 and Part-2), ed. 3, L.D. Landau and E.M. Lifshitz, Butterworth Heinemann, Oxford (1980)
3. Equilibrium Statistical Physics, ed. 3, M. Plischke and B. Bergesen, World Scientific, Singapore (2006)
4. Modern Theory of Critical Phenomena, S.K. Ma, Taylor & Francis, New York (1976)
5. Intermediate Statistical Mechanics, J.K. Bhattacharjee and D. Banerjee, World

Scientific, Singapore (2016)
6. A Modern Course in Statistical Physics, ed. 3, L.E. Reichl, Wiley-VCH, Weinheim (2016)
7. Statistical Physics of Fields, M. Kardar, Cambridge Univ. Press, Cambridge (2007)
8. Superconductivity, Superfluids and Condensates, J.F. Annett, Oxford Univ. Press, Oxford (2004)
9. Nonequilibrium Statistical Mechanics, G.F. Mazenko, Wiley-VCH, Weinheim 2003)

Course code: PH 560
Name of the course: QUANTUM OPTICS
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites: Quantum Mechanics, Classical Electrodynamics and Mathematical Methods in Physics.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to

CLO-1: Identify photon with a quantum of quantized radiation field

CLO-2: Prepare the radiation field in different states

CLO-3: Utilize the squeezed states of field in metrology

CLO-4: Characterize the radiation field according to its second order correlation function

CLO-5: Distinguish how to use different nonlinearities to generate states of the radiation field for different applications in measurement

CLO-6: Characterization of single photon source with certainty using the Hong-Ou-Mandel interference technique

Syllabus:

Unit-1: Quantization of radiation fields- second quantization, Harmonic oscillator algebra revisited

Unit-2: Quantum statistical description of the radiation fields; coherent states, squeezed states and a few other nonclassical states; phase space portraits; Applications in quantum metrology

Unit-3: Theory of optical coherence, correlation functions, signatures of nonclassicality: in terms of second order correlation functions and in terms of quasi probability distributions

Unit-4: Atom-field interaction; time evolution operator, various orders of interactions; Examples: SHG, MPA, MPI and OPA (including discussion on experiment)

Unit-5: Passage of light through optical components; a quantum mechanical treatment: Example of beamsplitter. Interferometry with single photons. Hong-Ou - Mandel Interference experiment and its application for detecting single photon source.

Text Books

1. Quantum Optics by G.S. Agarwal, Cambridge University Press (2013)
2. Introductory Quantum Optics by Gerry and Knight, Cambridge (2005)
3. Quantum Optics by Scully and Zubairy, Cambridge, (6th printing 2008)
4. The Quantum Theory of Light by Loudon, Oxford (recent printing 2010)
5. Essentials of Quantum Optics by Ulf Leonhardt, Cambridge (firstpublished in 2010)

Course code: PH 561

Title of the course: NONLINEAR OPTICS

Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites: Quantum Mechanics, Classical Electrodynamics and Mathematical Methods in Physics, Laser Physics

Course Learning Outcome:

CLO-1: Explain different nonlinear optical phenomena

CLO-2: Select the right nonlinear optical process for a specific frequency generation

CLO-3: Illustrate most commonly implemented nonlinear optical phenomena in advanced laser systems.

CLO-4: Compare and contrast different nonlinear optical phenomena.

CLO-5: Prepare students for a wide range of nonlinear optics-based devices and their applications.

Syllabus:

Unit-1 : Introduction to nonlinear optics, Parametric and nonparametric processes, Different nonlinear optical phenomena: Sum and difference frequency generation, Optical rectification, Optical Parametric Oscillator, Third Harmonic Generation, Four Wave Mixing.

Unit-2: Linear Electro optic effect, Quadratic electro optic effect: Kerr effect, Pockel's Effect, third order polarization and wave mixing, Self-focusing, Kramers - Kronig relation

Unit-3: Spatial symmetry of the susceptibility tensors, Saturable absorption, Two photon absorption, Stimulated Raman effect, constitutive relations.

Unit-4: Susceptibility Tensors: classical anharmonic oscillator (Non centrosymmetric crystals) Kleinmann symmetry conditions, Miller's rule, estimation of $\chi(2)$

Unit-5: Centro symmetric media: anharmonic oscillator, Third order polarization terms Estimation of $\chi(3)$

Unit-6: Wave equation description of nonlinear optical interactions, coupled equations and Manley Rowe relation, Phase matching considerations, Quasi phase matching via temperature tuning

Unit-7: Applications of NLO: Optical phase conjugation, Pulse generation, propagation, dispersion and optical solitons, high-resolution multiphoton imaging

Unit-8: Semi classical theory of susceptibilities, Linear and nonlinear term, Density matrix formalism, Response functions for $\chi(2)$ and $\chi(3)$

Recommended Books:

1. Nonlinear optics by Robert W. Boyd

2. Handbook of nonlinear optical crystals, V. G. Dmitriev, G. G. Gurzadyan, D. N. Nikogosyan
3. The principles of nonlinear optics, Y. R. Shen

Course code: PH 562
Name of the course: NONLINEAR SPECTROSCOPY
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Number of classes: 56; Number of Lectures: 44; Number of tutorials: 12; Credits: 4

Prerequisite Course / Knowledge (If any): Fundamentals of atomic and molecular spectroscopy, quantum mechanics

Course Learning Outcomes (CLOs) (5 to 8)

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

CLO-1: Explain the importance of the nonlinear spectroscopy – describe the laser – atom interaction in the density matrix formalism
CLO-2: Select the right spectroscopic technique for material characterization
CLO-3: Illustrate the importance of source-detector combination for a specific application.
CLO-4: Choose the right source and detector for spectroscopic characterization
CLO-5: Describe Raman spectroscopy and microscopy
CLO-6: Compare and Contrast different laser spectroscopic techniques used for characterization of atoms, molecules

Pre-requisites: Understanding of quantum mechanics, Atomic and Molecular Physics, laser physics

Syllabus:

Unit-1: Review of fundamentals of spectroscopy, density matrix approach of two-level systems, Absorption and emission of light, Transition probabilities, and coherence properties of radiation fields, widths and profiles of spectral lines.

Unit-2: Nonlinear Spectroscopy: Saturation spectroscopy, polarization spectroscopy, multiphoton spectroscopy and combination of different nonlinear techniques

Unit-3: Laser Raman Spectroscopy: Stimulated Raman Scattering, Coherent Raman spectroscopy, Hyper-Raman effect, Resonance Raman effect, Surface-Enhanced Raman scattering, Time resolved Raman Spectroscopy and microscopy

Unit- 4: Time resolved spectroscopy and ultrafast spectroscopy

Unit- 5: Advances in laser spectroscopy: Optical cooling and Trapping of Atoms, Atom interferometry, Spectroscopy of single ions, optical frequency measurements

Unit- 6: Applications of Laser Spectroscopy: in environmental monitoring; in material science; in analytical chemistry, coherent control of chemical reactions, femtosecond chemistry; biological and medical sciences

Reference Books:

1. W. Demtroder (2003), 3rd edition, Laser Spectroscopy Basic Concepts and Instrumentation, Springer International Edition of Springer-Verlag Berlin Hiedelberg, New Delhi, India.
2. B.H. Bransden and C.J. Joachain (2003), Physics of atom and molecules, Pearson Education Ltd, Singapore.
3. L. Allen and J.H. Eberly (2012), Optical Resonance and two-level atom, Dover Books on Physics, Courier Corporation.
4. Shaul Mukamel (1995), Volume 6 of Oxford series in optical and imaging sciences Optical and Imaging Sciences Series, Principles of nonlinear optical spectroscopy, Oxford University Press, UK, India.
5. Ahmed H. Zewail (2008), Volume 3 of World Scientific series in 20th century chemistry, Physical Biology: From Atoms to Medicine, Imperial College Press, London, UK.
6. M. D. Fayer (2001), Volume 26 of Practical spectroscopy, Ultrafast Infrared And Raman Spectroscopy, CRC Press.
7. Y.R. Shen (2003), The principles of nonlinear optics, Wiley-Interscience, Singapore
8. R. W. Boyd (2003), 2nd edition, Nonlinear Optics, Elsevier, Singapore.

Course code: PH 563

Title of the course: PHOTONICS AND PHOTONIC DEVICES
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Prerequisites: Quantum Mechanics, Classical Electrodynamics and Mathematical Methods in Physics, Laser physics

Course Learning Outcomes (CLOs):

At the end of this course, the students should be able to

CLO-1: Solve electromagnetic wave equation in any homogeneous-inhomogeneous and isotropic-anisotropic media.

CLO-2: Apply the idea of photons, electromagnetic fields and their interaction with matter.

CLO-3: Analyze propagation of light through confined systems such as optical fibers and optical waveguides.

CLO-4: Apply ideas of semiconductor physics to functioning of optical sources and detectors.

CLO-5: Acquire basic understanding of acousto-optic, electro-optic and magneto-optic devices and their characteristics.

CLO-6: Design a simple optical communication system with optimized functionalities.

Syllabus:

Unit-1: Review of electromagnetic theory of light, Electromagnetic waves in dielectric media, Absorption and dispersion, Propagation of light in dispersive, homogeneous and inhomogeneous, isotropic and anisotropic media.

Unit-2: Polarization of light. Review of reflection and refraction at dielectric / metal interface, Birefringence, Polarization devices, Stokes and Jones formalism, Poincaré sphere.

Unit-3: Optics of guided waves, Modes, Planar dielectric waveguides, Two-dimensional waveguides, optical fibers, Optical coupling in waveguides, Dispersion relation.

Unit-4: Light-matter interaction in semiconductors: Light propagation in periodic potential, Band structure, light emitting sources, optical amplifiers, noise in photodetectors, different types of photodetectors. Single photon sources.

Unit-5: Interaction of light and sound, acousto-optics of anisotropic media, Acousto-optic devices and characteristics, Electro-optics of anisotropic media, Electro-optic devices and characteristics, Non-reciprocity and Faraday effect, Magneto-optic device and characteristics, Modulators – AOM, SLM, EOM.

References:

1. Fundamentals of Photonics, B.E.A. Saleh and M.A. Teich, 2^{nd} edition, Wiley series in pure and applied optics (2007)
2. Fundamentals of optics waveguides, K. Okamoto, 2^{nd} edition, Academic press – Elsevier (2006)
3. Fundamentals of photonics, C. Roychoudhuri, SPIE press (2008)
4. Physics of optoelectronics, M.A. Parker, Taylor and Francis, CRC press (2005)
5. Fundamentals of photonics and physics, D.L. Andrews

Course code: PH 564
Title of the course: _Quantum Field Theory
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Pre requisite: Courses: CM, EMT-I, EMT-II, QM-I, QM-II, Introduction to PP

Course objective:

Student should be able to appreciate the necessity of quantum fields to understand HEP, understand particles as excitations of fields, learn calculational techniques like Feynman Diagrams, to calculate scattering amplitude

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to……

CLO-1: Apply variational principle to obtain Euler Lagrange equation of motion for any given Lagrangian.

CLO-2: Apply Noether's theorem to get the conserved charge and verify the underlying symmetry.

CLO-3: Understand particles as excitations of fields.

CLO-4: Compute Fock -state representation of observables like Hamiltonian

CLO-5: Apply Wicks theorem

CLO-6: Write down expressions for scattering amplitude for different process using Feynman rules

CLO-7: Apply dimensional regularisation to separate divergent and finite part.

Syllabus:

Unit-1: Classical field theory
Discrete N-particle coupled oscillator system to continuous system; Variational principle for fields;
Euler-Lagrangian field equation; Hamiltonian formulation for field system, including Poisson bracket for fields; Examples of scalar field and vector fields.
Proof of Noether's theorem. Apply for space-time translation. U (1) symmetry. Conserved charges.
Symmetry transformation of field from conserved charges. Example of real and complex scalar field.

Unit-2: Quantisation of free scalar field
Plane wave expansion of real scalar field. Canonical quantisation. Field as a system of oscillators: Fock state representation of Hamiltonian, momentum. Plane wave expansion of complex scalar field. Charge operator.
Particles -excitations of field concept
Feynman-propagator for real and complex fields. Particle and anti-particle concept

Unit-3: Quantisation of Dirac and Maxwell field
Dirac field Lagrangian-Plane wave expansion- need for anticommutators, Hamitonian, Charge
In Fock space; Feynman propagator.
Covariant quantisation of Maxwell. Lorentz condition. Gupta-Bleuer method. Feynman propagator

Unit-4: S-matrix expansion to Feynman diagram
Dyson perturbation, S-matrix, Wicks theorem
Example of interacting scalar field. Sample calculation of matrix element- Feynman rules Cross section formula

Unit-5: Quantum electrodynamics

Lagrangian for QED; gauge invariance; Feynman rules- Feynman amplitude for tree level process.
Cross-section formula- cross section for Compton scattering

Unit-6: One-loop QED
Regularization, renormalisation- dimensional regularization. - Electron self-energy photon self-energy, vertex diagram. G-2.

Books for Reference:

1. A first book on quantum field theory: A.Lahiri and P Pal Narosa Publication (2007)
2. An introduction to quantum field theory : M.Peshkin and D. Schroder (second edition), Sarat book distributors (2005)
3. Quantum field theory: Ryder Second edition Cambridge University Press (2008)
4. Relativistic Quantum Fields, J. D. Bjorken and S. D. Drell, McGraw-Hill (1965)

Course code: PH 565
Title of the course: General Theory of Relativity
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Pre requisite: Classical mechanics, Electromagnetic theory, special theory of relativity

Course Learning Outcomes (CLOs):

At the end of the course, the student will be able to

CLO-1: Employ tensor calculus to any physical theories

CLO-2: Interpret gravity as effect of space-time curvature

CLO-3: Analyse the effect of gravity to the universe

Syllabus:

Unit-1 Tensor calculus

Principle of equivalence and general covariance- metric tensor, parallel transport, covariant differentiation, curvature tensor, effects of gravitation: geodesic equation, general covariant form of Maxwell equations.

Unit-2 Einstein equation

Einstein equation, Schwarzschild solution, mercury precession of perihelia, deflection of light, gravitational red shift, gravitational wave and experimental confirmation of gravitational waves.

Unit-3 Cosmology

Cosmological principles, R-W metric, matter dominated, radiation dominated era; early universe.

Text books:

1. Classical theory of fields: L.D.Landau and E.M.Lifshitz Elsevier 1987 4th edition
2. Gravitation and Cosmology: S.Weinberg John Wiley& Sons 2004
3. Gravitation: foundation and Frontiers: T. Padmanaban Cambridge University Press 210 First edition
4. Introduction to Cosmology, J.V.Narlikar Cambridge University Press, 2002 3rd edition.

Course code: PH 566
Title of the course: Lie Groups and Lie algebra
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

CLO-1: Construct infinitesimal Generators and operators Lie groups and derive structure constants

CLO-2: Understand Cartan's criterion for semi-simple Lie algebras

CLO-3: Construction of direct sum, semi-direct sum of algebras

CLO-4: Construction of Casimirs

CLO-5: Calculate Roots, root vectors and Dynkin Diagrams

CLO-6: Construct representations of lie groups

CLO-7: Construct Young tableau

CLO-8: Apply representation theory to Particle Physics

Syllabus:

UNIT-1: Continuous groups, Lie groups, examples like transition and rotation groups.

UNIT- 2: Statements of Lie's theorem, Lie algebra, standard form of Lie algebra. Casimir invariants

UNIT-3: Roots and cartan classification of semi-simple Lie groups. Root diagrams for SU (2), SU (3) and SU (N). Dynkin diagrams

UNIT-4: Basic and irreducible representations of SU (2) & SU (N). Young tableau and its uses for Clebsch-Gordon decomposition.

UNIT-5: Classification of elementary particles in terms of representations of SU (3), SU (4) and SU (6),

Dynamical symmetries, symmetry group of hydrogen atom.

Recommended Books:

1. 1.Classical Groups, B C Wybourne, Wiley-Interscience (1974)
2. 2.Lie Groups & their Lie Algebra and some of their applications, R Gilmore, Dover Publications (006)
3. 3.Continuous Groups of Transformations, P. Eisenhart, Princeton University Press (1933)
4. 4.Lie Groups in Physics, G. 't Hooft, M. J. G. Veltman, Utrecht University (2007)

Introduction to Topology, Differential Geometry and Group Theory for Physicists, Wiley Eastern Ltd (1990).

Course Code: PH 567
Title of the course: Advanced Particle Physics
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

PREREQUISITES:

Mathematical Methods II (PH 451), Electromagnetic Theory II (PH 452), Quantum Mechanics 2(PH 453) and Introduction to Particle Physics (PH 503)

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to……

CLO-1: Explain the basics of quantum field theory and apply and relate it to particle physics phenomenology.

CLO-2: Calculate scattering cross-sections relativistically for electromagnetic and weak processes

CLO-3: Illustrate the basic use of group theory in particle physics.

CLO-4: Explain the standard model of particle physics.

CLO-5: Justify that he/she has learned particle physics at a level sufficient for graduate studies in any other world class university

CLO-6: Extrapolate his/her knowledge to discuss new physics in upcoming experiments

Syllabus:

Unit-1: Review of SU(2) and SU(3) Lie algebra, Quark and Quarkonium states, Justification of color

Unit-2: Relativistic kinematics, Scattering cross-section, Life-times, Introduction to S-matrix, Feynman diagrams and Matrix elements, Compton scattering, Bhabha scattering

Unit-3: Electromagnetic form factors, Basic ideas of parton model and deep inelastic scattering

Unit-4: Weak Interactions, V-A theory, Pion decay, Muon decay, Charged current Neutrino-electron scattering, Neutral current Neutrino-quark scattering, Cabibbo Theory, CKM mechanism

Unit-5: Gauge Symmetries, Ideas about spontaneous symmetry breaking/Higgs mechanism, Salam-Weinberg model and its simple tests

Unit-6: Physics beyond the standard model. Ideas about neutrino oscillations, GUTs.

Recommended Books:

1. Halzen, F., and A. D. Martin, Quarks and Leptons. New York: Wiley Text Books, January 1984. ISBN: 9780471887416.
2. Peskin, Michael, Concepts of Elementary Particle Physics (Oxford Series), November 2019, ISBN 978-0198812197
3. Greiner, W and Muller, B, Gauge Theory of Weak Interactions, (Springer) 2009, Fourth edition. ISBN 9783540878421
4. Cottingham W, Greenwood D, An Introduction to standard model of particle physics, (CUP) 2007 Second edition, ISBN 978-0521852494
5. Palash B Pal, An Introductory Course of Particle Physics, (CRC Press), 2014, First Edition, ISBN 9781482216981.

Course Code: PH 568
Title of the course: Introduction to Quantum Information
Number of classes: 56, Lectures: 42, Tutorials: 14, Credits: 4

Pre requisites: Quantum Mechanics and Statistical Mechanics

Course Learning Outcomes (CLOs):

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

CLO-1: Apply the concept of pure and mixed states for preparing and characterising the electron spin states with Stern-Gerlach apparatus.

CLO-2: Use the concept of generalised measurement and quantum dynamical process for describing the evolution of closed and open quantum systems.

CLO-3: Define the basic ingredients of a quantum computer, and quantum information processing: the density matrix, the entropy and mutual information, the quantum unitary and non-unitary operations, the quantum channels, the quantum entanglement and decoherence.

CLO-4: Compute the von Neumann entropy of a state and Shannon entropy associated with measurement outcomes, the quantum entanglement from Schmidt decomposition of pure states.

CLO-5: Analyse simple simple quantum protocols and algorithms for quantum speedup and quantum advantage.

CLO-6: Use the covariance matrix of multi-mode gaussian states for the entanglement of continuous variable radiation fields.

Syllabus:

Unit-1: Two-level systems, one-qubit pure and mixed states, polarisation, von Neumann Entropy, Unitary transformations, Quantum Gates.

Unirt-2: Classical Information theory, Shannon Entropy, Mututal information, channel capacity and coding theorems.

Unit-3: Many-qubit pure states, Entanglement of pure states, Schmidt decomposition, Entanglement of formation for mixed states, concurrence measure, Negativity under partial transposition, Multipartite entanglement in GHZ and W states, Bell violation, Conditional entropy and quantum discord.

Unit-4: Dynamics of Many-qubit systems, Decoherence due to environment and interaction, Sudershan-Kraus operators, CPTP maps, Quantum channels, Evolution of local and global correlations.

Unit-5: Quantum information and communication protocols, Dense coding, Teleportation, Fidelity, BB84 protocol for quantum secure communication, quantum algorithms.

Unit-6: Continuos-variable systems: Coherent states, Non-classicality, Gaussian states, Unitary transformations and Symplectic Transformations, Covariance matrix, Glauber-Sudarshan representation of mixed states, Entanglement of multi-mode gaussian pure states, Time- reversal and partial transpose transformations, Entanglement of two-mode gaussian mixed states.

Books for reference:

1. Modern Quantum mechanics: J Sakurai : Second edition , Pearson (2013)

2. Quantum Theory: Concepts and Methods: Asher Peres, Kluwer Academic (1995).

3. Quantum Computation and Quantum information: M. A. Nielsen and I. I. Chuang, Cambridge University (2002).

4. Principles of Quantum Computation and Quantum Information Volume I and II: G. Bennett, G. Casati and G. Strini, World Scientific (2007)

5. Quantum Information Theory: M. M. Wilde, Cambridge University (2013)

6. Lecture notes for Physics 229: Quantum Information and Computationon:' J. Preskill (online from Caltech)

7. Classical and Quantum Information Theory: E. Desurvire, Cambridge University (2009)

Foundation Courses

Course Code: FN119
Title of the Course: Electronics for All-Theory and Lab
Lectures-Tutorial-Practical : 32-0-24 Credits: 4

Prerequisite: This course is open for both MSc and IMSc level non-Physics major students who has taken Math courses at higher secondary level.

Course Learning Outcomes (CLOs):

After completion of this course successfully, the students will be able to

CLO-1: Explain the basic concepts of ac signals, semiconductor devices.

CLO-2: Explain basic logic gates and their use in simple logical circuits in digital electronics.

CLO-3: Describe the working principle of sensors like temperature, pressure sensors, and light sensor.

CLO-4: Explain principle of operation of some medical devices.

CLO-5: Operate Analog Oscilloscope to measure voltage, frequency, phase difference etc.

CLO-6: Operate DC power supply and Function Generator.

CLO-7: Construct simple circuits using breadboard and other electronic components

Syllabus:

Unit-1: Introduction to electronics

(i) Evolution of electronics -Vacuum tubes, diode, transistor, ICs, microprocessor, computers; electronics in everyday life

(ii) Concepts of Electricity - current, voltage, resistance, Ohms law, heat and power, conductors and insulators, electric and magnetic field, induction.
(iii) AC and DC signals-Direct and alternating current, line supply- single phase and three phase, transformers, Time and frequency domain representation, adding and multiplying AC signals, ac to dc conversion

(iv) Circuit Analysis-Ohms Law, Kirchhoff's Law

Unit-2: Hands on Electronics

(i) Electronic components - Resistors, resistor color codes, capacitors, inductors, batteries, power supply, supercapacitors, fuses, circuit breakers, bread board, printed circuit board, flexible circuit boards, switches, relays.

(ii) Constructing Circuits-Building circuits using breadboards, troubleshooting circuits

(iii) Measurement Devices - Ammeters, Voltmeters, Ohmmeters, Multimeters, Analog and Digital Oscilloscope, Oscilloscope loading

(iv) Lab safety

Lab-1: Operation of Digital Multimeter and Oscilloscope

measurement of rms voltages of ac signals with multimeter, triggering of oscilloscopes, measurement of ac signals with oscilloscope in circuits, measurement of phase difference using lissajous figures,

Lab-2: Analysis of RC circuits using Oscilloscope

Unit-3: Semiconductor devices

Diodes, LEDs, photoresistor, photodiode, solar cells, transistors, FETs.

Lab-3: Diodes

Unit-4: Digital Electronics

Logic gates, combinational logic, sequential logic, displays, memory devices.

Lab-4: Timer circuit

Unit-5: Sensors

General principles, temperature sensor, motion sensor, pressure sensor, chemical sensor, light sensor, glucose sensor

Lab 5 and 6-smoke detector, automatic light control, heat sensor, digital thermometer, digital clock. (Any two experiments)

Unit-6: Electronics in Medical Physics

Reference Books:

1. P. Horowitz and W. Hill, 'The Art of Electronics,' Cambridge University Press, 3rd Edition (2015).
2. T.C. Hayes and P. Horowitz 'Learning the art of electronics: A hands on Lab course' Cambridge University Press, 1st Edition (2016).
3. Paul Scherz 'Practical electronics for Inventors' McGraw Hill Publication 4th Edition (2016).
4. Encyclopedia of Applied Physics (Wiley Publication)

Study material will also be provided by the instructor in class.

Course code: FN 225

Title of the course: How Things Work: The physics of Everyday Life

4 Lectures per week Number of Credits: 4

Total number of classes: 56, Lecture hours: 56*, Tutorial hours: 0

* Table top experiments are demonstrated in the class room

Pre Requisite: Interest and curiosity to learn physics of things that are around in everyday life and about common appliances and gadgets.

Course Learning Outcomes (CLOs)

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

CLO-1: Recognize the importance of laws of motion, friction and acceleration due to gravity in everyday activities and objects and relate how a ramp helps to lift a very heavy object does.

CLO-2. Describe the between pressure, density, temperature in gases, recognize the role of buoyancy and viscosity of fluids and distinguish differences between fluid flows (e.g. lamellar vs turbulent).

CLO-3: Identify thermal energy, thermal equilibrium, different modes of heat flows in materials, different phases and describe heat and temperature and its connection to phase transitions. Recognize different types of thermal insulations used in different appliances and different surroundings.

CLO-4: Describe different methods to create charges, forces between electrical charges; current, types of currents and voltage, storing electrical energy and converting it to heat and light.

CLO-5: Describe the difference between bar magnets and electromagnets, and identify their applications in different appliances and devices

CLO-6: Describe electromagnetic waves, relate them to light, radio waves, micro waves and X-rays, and to the natural phenomena. Recognize their applications in communication and electronic devices.

CLO-7: Describe different sources of light, order differences light sources with improved light efficiency; identify the differences between house light sources and Lasers. Recognize the spectral differences between light sources (Bulb, Tube light, LED etc...)

CLO-8: Describe different sources of radiation, shielding, nuclear fusion and fission. Recognize the applications of useful radiation in medical diagnostics and health,

Syllabus:

Unit-1: The Laws of Motion: Skating, Falling Balls, Ramps, Seesaws, Wheels, Bumper Cars.

Unit-2**:** Mechanical Objects: Spring Scales, Bouncing balls, Carousels and Roller Coasters, Bicycles, Rockets and Space Travel.

Unit-3: Fluids and Motion: Balloons, Water Distribution, Garden Watering, Balls and Air, Airplanes.

Unit-4: Heat, Thermodynamics and Phase transitions: Woodstove, Water, Steam and Ice, Incandescent light bulbs, Air Conditioner, Automobiles

Unit 5: Resonance and Mechanical Waves: Clocks, Musical Instruments, The sea.

Unit 6: Electricity and Magnetism**:** Static Electricity, Xerographic copiers, Flashlights, Household Magnets, Electric Power Distribution, Electric Generators and Motors.

Unit 7: Electronics**:** Power adapters, Audio Players, TV and Mobile

Unit 8: Electromagnetic Waves and Light: Radio, Microwave Ovens, Sunlight, Discharge Lamps, Lasers and LEDs**.**

Unit 9**:** Optics: Lenses, Microscope, Cameras, Telescope, And Optical recording

Unit 10: Modern Physics and Radiation: Medical imaging and Radiation, Nuclear Reactors and weapons

References:

1. Louis A. Bloomfield, (2016), How Things Work: The Physics of Everyday Life, (6th Edition), John Wiley & Sons (USA)

Course Code: FN211

Name of the Couse: Physics and our World

(4 Credits)

Lectures and tutorials: 54 lectures including tutorial sessions (The number of tutorials to be decided based on class requirements that may vary from time to time)

Objective of the Course:

This is a course that assumes no quantitative background and is meant as an introduction to a Physicist's way of understanding the world we inhabit and how Physics has influenced our lives. An introduction is provided to the major concepts that revolutionized and indeed, form the backbone of the so-called *paradigm shifts* in our understanding of nature. The practical uses of physics and related technologies is also addressed: The modern electronics revolution forms a significant component as a way of illustrating the process of "lab to life" transformation; Electromagnetic forms of energy and their applications are given.

The approach is not, a simplified treatment of the subjects and categories by which the physicist seeks to understand the physical universe. Rather, it is one that takes the participant on a path so as to get a glimpse of the historical events and key ideas that lead to such understanding.

Course Learning Outcomes (CLOs):

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

CLO-1: Understand the major developments in the history of physics that led to current practice in physics

CLO-2: Analyze these key developments through the prevailing worldviews that are contemporaneous with the prevalent theories in physics of the time.

CLO-3: Apply in a basic form, the notions developed from Cartesian dualism, Reductionism, logical positivism to viewing the developments in physical thought.

CLO-4: Use the concept of paradigm and paradigm shift in tracing the evolution of physics

CLO-5: Acquire a basic understanding of quantum mechanics and how it confronts "common sense notions "of reality.

Syllabus:

Unit-1: Space and Time:
A discussion on length scales and dimensions, early conceptions of the sun and planets,
The solar system and planet earth-Kepler's laws of planetary motion,
Rotation and revolution of the Earth- Seasons, Calendars and the recording of time.
The laws of motion: contribution of Galileo and Newton. Laws of nature, Gravitation
Astronomy and mathematics in ancient India, and other non-western cultures

The relationship between space and time: A basic account of the theory of relativity, Size of the universe - Is the universe expanding? Arrow of time.

Unit-2: Evolution of the method of science:

Inductive and deductive theories in science, Descartes and Francis Bacon, Empirical method, A modern perspective on the notion of science, Logical positivism

Structure of Scientific Revolutions- Paradigms and Paradigm shifts according to Kuhn

Unit-3: Matter and Energy:
A brief historical survey of divisibility of matter,

Atoms and molecules: Structure of atoms. The Periodic table of elements, Chemical bonds and molecules,

Large molecules and living matter.

The nucleus, equivalence of matter and energy; Nuclear energy and thermonuclear power. Thermonuclear bombs,

Nuclear energy and related sociopolitics (science and society in context of nuclear energy)

Elementary particles, Unification of forces

Unit-4: Waves and oscillations:

Background of Sound waves, Electromagnetic radiation and spectrum, Matter waves; Propagation of waves; Interaction of Radiation with Matter

Energy in the atmosphere- Wind, Hydel and Solar energy.

Unit-5: From Determinism to Indeterminacy:

The quantum world -- an introduction, Debates on the conceptualization of physical realities – is nature unreasonably mathematical? (Wigner's paper)

Entanglement, Teleportation

Unit-6: Physics and technology in our lives:

Electricity and electrolytic cell, Electromagnetism, Cathode ray tubes and valves, communications, diodes and transistors, logic and digital circuits, Integrated circuits, computers, mobile technology, Opto-electronics

Reading Material:

1.Einstein and L.Infeld, "The Evolution of Physics" (Toughstone 1967).

2.J.Bronowski, "The Ascent of Man". (Liffle and brown company, 1976).

3. Carl Sagan, Cosmos

4.John Losse,"A Historical Introduction to the Philosophy of Science"(Oxford Univ.Press)

5.Hung, Edwin "The Nature of Science: Problems and Perspectives".(Thomson Press)

6.The Structure of Scientific Revolutions, Thomas Kuhn, Chicago University Press

7.D.M.Bose et.al A Concise History of Science in India". (Insa Press)

8."Stanford Encyclopedia On the Philosophy of Science".(Stanford univ.press)

9.John Gribbin, " In Search of Schrodinger's Cat"

10.Spangeburg and Moser "On the Shoulders of Giants" (university press).

11.Robert K. Logan *The Poetry of Physics and The Physics of Poetry* (World Scientific Publishing Company)