CENTRAL UNIVERSITY OF RAJASTHAN

DEPARTMENT OF PHYSICS

INTEGRATED M.Sc. PHYSICS 5 YEARS PROGRAM

We believe that the students at the age of passing their senior secondary level are more vulnerable in terms of their career choices. In this context, our university offers a Five Year Integrated M.Sc. Physics Program that gives an Integrated M.Sc. Physics Degree after successful completion of ten semesters. The prime emphasis is to provide education of advanced topics along with the everlasting fundamental laws of Physics with other science subjects. During the first two years consisting of four semesters, the students are taught basic levels of science subjects like, Physics, Chemistry, Mathematics, Computer Science, Information Technology, and Statistics. The next one year is devoted to the advanced level of undergraduate Physics Courses. In the last two years consisting of four semesters, the students are taught basic and advanced quantum mechanics, analog and digital electronics, classical mechanics, condensed matter physics, mathematical Physics, statistical mechanics, Nuclear Physics, Atomic and Molecular Physics etc. Besides, the students can opt for the elective courses in Materials Sciences, Fiber Optics and Lasers etc. They can also take elective courses form other departments as a part of choice based credit system. In the final semester, the students are required to do a major project in Physics which prepares them for higher studies.

PROGRAM OUTCOMES (PO)

- Appreciation for all natural science subjects (PO-1)
- Learn to carry out experiments in basic as well as in certain advanced areas of physics and to gain hands-on experience to work in applied fields (PO-2)
- Able to communicate topics of physics to peers, experts from other disciplines and the general public essential for collaborative work with a diverse team (PO-3)
- Building foundation for higher studies as well as enhancing capabilities to get science jobs (PO-4)
- Development of scientific attitude, analytical and rational thinking, positive attitudes to realize the importance of hard work, commitment, ethics and excellence (PO-5)
- Unafraid of taking challenging tasks, responsibilities, flexible in dealing with conflicting issues obligatory to become future entrepreneurs and innovators (PO-6)

Int. M.Sc. Physics (5Y) – Proposed Programme Structure

SEMESTER I (18C)	SEMESTER II (18C)	SEMESTER III (18C)	SEMESTER IV (18C)	SEMESTER V (18C)	SEMESTER VI (18 C)
Mechanics PHY 101 (3Credit)	Basic Electronics PHY 103 (3 Credit)	Modern Physics PHY 201 (3 Credit)	Properties of Matter and Waves PHY 203 (3 Credit)	Electricity and Magnetism PHY 301 (3 Credit)	Advanced Modern Physics PHY 305 (3 Credit)
Physics Lab I PHY 102(1Credit)	Physics Lab II PHY 104 (1 Credit)	Physics Lab III PHY 202 (1 Credit)	Physics Lab IV PHY 204 (1 Credit)	Heat and Thermodynamics PHY 302 (3 Credit)	Optics PHY 306 (3 Credit)
Mathematics (4 Credit)	Mathematics (4 Credit)	Basic Courses* (8 Credit)	Basic Courses* (8 Credit)	Mathematical Physics PHY 303 (3 Credit)	Atomic and Nuclear Physics PHY 307 (3 Credit)
Basic Courses* (8 Credit)	Basic Courses* (8 Credit)			Physics Lab V PHY 304 (3 Credit)	Physics Lab V PHY 308 (3 Credit)
		Environmental Science (3 Credit)	Elective Science (3 Credit)	Elective Science (3 Credit)	Elective Science (3 Credit)
English (2 Credit)	English/ICT (2 Credit)	Elective Social Science (3 Credit)	Elective Social Science (3 Credit)	Elective Social Science (3 Credit)	Elective Social Science (3 Credit)

Fitness – at least 2 Credits in three Years

Societal – at least 2 Credits in three Years

Total Credit = 108+ 4 = 112 (for first six semester)

*Basic Courses means students has to choose two courses of four credit each from the basket of subjects viz. Chemistry, Biology, Computer Science, Statistics, and Economics.

Course Structure

SEM I (3+1 Credits)	SEM II (3+1 Credits)
PHY 101: Mechanics PHY 102: Physics Lab I	PHY 103: Basic Electronics PHY 104: Physics Lab II
SEM III (3+1 Credit)	**SEM IV (3+1 Credits)**
PHY 201: Modern Physics PHY 202: Physics Lab III	PHY 203: Properties of Matter and Waves PHY 204: Physics Lab IV
SEM V (18 Credits)	**SEM VI (18 Credits)**
PHY 301: Electricity and Magnetism [3C] PHY 302: Heat and Thermodynamics [3C] PHY 303: Mathematical Physics [3C] PHY 304: Physics Lab V [3C] PHY XYZ Science Elective [3C] PQR XYZ: Elective (other than science) [3C]	PHY 305: Advanced Modern Physics [3C] PHY 306: Optics [3C] PHY 307: Atomic and Nuclear Physics [3C] PHY 308: Physics Lab VI [3C] PHY XYZ Science Elective [3C] PQR XYZ: Elective (other than science) [3C]

- Integrated M. Sc (5Y) AY 2020-21 onwards: Course Curriculum (Physics Component for the first six semesters). After 6th semester, the Int. M.Sc. students join the 2Y M.Sc. students for the rest of the semester and therefore follow the course curriculum of the 2Y M.Sc. program.

- The 5th and 6th semesters structure will also be applicable to the students admitted in the AY 2018-19 onwards

PHY101: MECHANICS [Credits 3, 3-0-0]

Course Outcome:

The students will be able to appreciate that the different types of dynamics they observe all around and are amenable to simple description in terms of Newton's three laws

Program Outcomes (PO): The course covers the program outcomes PO-1, PO-3, PO-4, PO-5 and PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2

Course Level: Introductory

Course description:

The primary aim of this course is to impress upon the students that a lot about nature can be learnt by careful observation and experimentation. Aristotle discovered that earth is round by observing a ship moving away whose mast disappeared first. Galileo found that different masses fall to the ground at the same time by observing the oscillations of chandeliers on a windy sunday in a church. The observation that objects on a smooth surface move farther tells us of the most important law of motion - the law of inertia. We can say Newton's laws of motion provide the starting point for the major enterprise we call now as physics. The course on mechanics teaches the students of inertial frames and of non-inertial frames. The latter gives rise to pseudo forces : centrifugal, coriolis etc. The students get a glimpse of the symmetry symmetry of space and how such symmetries give rise to conservation laws. They learn of linear momentum, angular momentum; rigid body motion, and small oscillations. This course provides the backdrop for all the courses that follow in all the subsequent semesters.

Course Objectives:

- To make the students familiar with Newton's law of motions so that they can later appreciate alternate ways of formulating dynamics in terms of Euler Lagrange equation or Hamilton Jacobi equation.

Syllabus:

Vectors algebra and calculus: Triple and quadruple product of vectors, vector derivatives, scalar and vector fields, gradient, divergence and curl, Gauss and Stokes theorems.

Conservation of energy and linear momentum: Mechanics of a particle, frictional forces, Conservative and non-conservative forces. Elastic potential and energy diagram. Stable and unstable equilibrium. Force as gradient of potential energy. Work energy theorem, Work done by non-conservative forces. Law of conservation of Energy.

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. Fly wheel motion. Motion of top, Coriolis force and Foucault's pendulum

Motion under Central Forces: concept of central force, Kepler's laws of planetary motions, law of gravitation, gravitational potentials, fields and energy, escape velocity, two particle central force problem, reduced mass, relative and center of mass coordinates, planet and satellites, scattering of charged particles.

Pre-requisites : High School mathematics and physics

Reference Books:

- Mechanics, D.S. Mathur. *S Chand* & *Co ltd, India.*
- Physics for scientists and engineers with modern physics, Raymond A. Serway and John W. Jewett. Cengage, India.
- Fundamentals of physics. Resnick, Halliday and Walker, Wiley, India.
- Schaum's outline of vector analysis. Murray R. Spiegel, McGraw Hill education, India.
- The *Feynman lectures on physics* Vol. 1. R.P. Feynman, R. B. Leighton and M. Sands, Pearson education, India.
- *Berkeley physics* course: *mechanics* Vol.1. C. Kittel, W. Knight, et.al., McGraw Hill education.
- Mechanics, Waves and Thermodynamics: An Example-based Approach. Sudhir Ranjan Jain, Cambridge University Press.

Assessment Method: Written and Assignments

Any need for revision of existing rules: No

PHY 102 : PHYSICS LAB-I [Credits 1, 0-0-2]

Course Outcome:

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

- Perform error analysis for an experiment
- Determine the acceleration due to gravity and the comparison between several methods
- Measure the height of building and towers *etc*. which is not physically possible
- Visualize the importance of friction in daily life.

Program Outcomes (PO): The course covers the program outcomes from PO1-PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3

Course Level: Introductory

Course description:

The experiments in this laboratory are designed in such a way that the students can verify the concepts of Physics taught in the Mechanics theory course.

Course Objectives:

To make the students gain deep insights into the concepts like motion of objects and their dynamics; linear and angular simple harmonic motions; conservation laws and so on developed in the Mechanics theory course

Syllabus:

1. Bar Pendulum
2. Kater's Pendulum
3. Flywheel motion
4. Spring Constant
5. Sextant
6. Foucault's Pendulum
7. Coefficient of Friction
8. To determine g and velocity for a freely falling body using Digital Timing Technique
9. To study the random error in observations
10. Compound Pendulum

Prerequisites: 10+2/ intermediate level Physics

Reference Books

- Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint
- Engineering Practical Physics, S. Panigrahi & B.Mallick, Cengage Learning
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, Kitab Mahal
- BSc Practical Physics, Geeta Sanon, R. Chand & Co

Assessment Method: Record writing, viva, EoSE(60%)

Any need for revision of existing rules: No

PHY 103: BASIC ELECTRONICS [Credits 3, 3-0-0]

Course Outcomes:

- The students will learn the operation of diodes and transistors and their basic applications in electronic devices.
- The students can understand the number system and their interconversions.
- They will understand about digital electronics. They will get insights on digital logics theorems and basic combinational logic devices.
- They will develop understanding about the basic electronic instrumentation.

Programme Outcomes: This course covers *PO-1*, *PO-2* and *PO-3*.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**1**	**1**	**1**
CO2	**3**	**1**	**2**	**1**	**1**	**1**
CO3	**3**	**1**	**3**	**1**	**1**	**1**
CO4	**3**	**1**	**3**	**1**	**1**	**1**

Course level: This is an *introductory* course about basic electronics.

Course Description: This course introduces the operation of the principal semiconductor devices: diodes, and bipolar junction transistors (BJTs). The detailed analysis related to diode and BJT circuits will be covered. The second half of the course deals with digital electronics and electronic instrumentation. The number system, their interconversions, Boolean logic theorems, and basic digital logic devices will be covered. In addition to this, the course also covers different bridges used in electronic/electrical parameters measurements.

Course Objective:

- The students will learn about the concepts and theories of diodes and transistors used in almost every electronic device.
- To make the students familiar with simple logic principles used in advanced digital electronics and communication.
- Give introduction to electronic instrumentation used to measure electronic/electrical parameters.

Syllabus:

Module 1: Semiconductors and Diode

Classification of solids, Energy bands in intrinsic and extrinsic silicon; Carrier transport in semiconductor, drift current, mobility and resistivity; Majority and minority carrier, Generation and recombination of carriers; PN junction, Zenner Diode, Avalanche and Zenner Breakdown, Simple diode circuits: rectifiers, Half wave, full wave and bridge rectifier, Voltage regulator.

Module 2: Transistors

BJT construction and characteristics, Configuration of transistors: Common Emitter (CE), Common Base (CB) and Common Collector configurations, Relation between α, β, and γ, Leakage current in Transistor, Thermal runaway, DC and AC load line analysis, Q point.

Module 3: Digital Electronics

Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers, Negative numbers representation, 1's, 2's, Complements, Logic gates including Universal Gates, BCD codes, Excess-3 code, Gray code, Hamming code. Boolean Algebra, Basic Theorems and properties of Boolean Algebra, Boolean Functions, Minimization of Boolean Function, Ex-OR functions, Adder, Subtractor.

Module 4: Electronic Instrumentation

Measurement of resistance (Carey Foster bridge), Capacitance (De Sauty's bridge), and Self-inductance (Anderson's bridge) using different bridges.

Prerequisite: The basic knowledge of Physics/Mathematics (10^{th}/12^{th} Standard) is desirable to take this course.

Reference/Text Books:

1. Integrated Electronics by Millman and Halkias, Tata McGraw-Hill, International student edition.
2. Semiconductor Physics and Devices by Donald A. Neamen (4^{th} Edition).
3. Basic Electronics by B L Thereja, S Chand & Co ltd, India.
4. Principal of Electronics by V.K. Mehta, S Chand & Co ltd, India.
5. Electronic Devices and Circuit Theory by Boylestad / Nashelsky, Pearson Education India.
6. Digital Electronics by S. Salivahanan & S. Arivazhagan Vikas Publishing House Pvt Ltd.
7. Digital Electronics by G.K. Kharate, Oxford University Press.
8. Modern digital Electronics by R.P. Jain, Tata McGraw Hill.
9. Electrical and Electronic Measurements and Instrumentation by A. K Sawhney, Dhanpat Rai & Co.
10. Electronic Measurements & Instrumentation by K. Lal Kishore, Pearson Education.

Assessment Method: Written exam and Term Paper.

Any need for revision of existing rules: No

PHY 104: PHYSICS LAB II [Credits 1, 0-0-2]

Course Outcomes:

1. The students will be able to understand the diode and transistor I-V characteristics.
2. The students will be able to verify the truth table of various logic gates.
3. They will get exposure to basic analog and digital electronic devices as well as electronic instrumentation used to measure electronic/electrical parameters.

Programme Outcomes: This course covers *PO-1*, *PO-2* and *PO-3*.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**

Course Level: This is an *introductory* lab course about basic electronics.

Course Description: This is a lab course that covers diode and transistor I-V characteristics and its related basic devices. The students will get hands on experience on diode and transistor-based circuits. In addition to this, they will get exposure on Boolean logic operations as well as electronic instrumentation.

Course Objective:

1. The students will learn the basic operation of various electronics devices/components and some measurements.
2. To realize the I-V characteristics of Diodes, Transistors, and about simple electronic components/circuits.
3. Develop understanding of digital logic devices and verify digital logics using universal logic ICs.

Syllabus:

1. Study of forward and reverse characteristics of PN junction diode.
2. Zener diode as voltage regulator.
3. Basic Logic gates' truth table verification using ICs.
4. Study of Transistor I-V characteristics.
5. Construct the Half Wave and Full Wave rectifiers using IN4007 diode on Breadboard.
6. Charging and discharging of capacitor.
7. Construct Half Adder and Half Subtractor using the appropriate ICs.
8. Measurements of Capacitance using De Sauty's bridge.
9. Measurements of Self-inductance using Anderson's bridge.
10. Measurements of resistance using Carey Foster bridge.

Prerequisite: The basic knowledge of Physics/Mathematics (10^{th}/12^{th} Standard) is desirable to take this course.

Reference/Text Books:

1. Basic Electronics: A Text-Lab Manual (7^{th} Edition) by Paul Zbar, Tata McGraw Hill Education.
2. Electronics Lab Manual Volume I (5^{th} Edition) by K. A. Navas, PHI.
3. Electronic Instruments & Measurements by M. L. Anand, S. K. Kataria & Sons, India.
4. Electrical and Electronics Measurements and Instrumentation by Prithwiraj Purkait, Budhaditya Biswas, and Chiranjib Koley, McGraw Hill Education.

Assessment Method: Viva and Experimental exam.

Any need for revision of existing rules: No

PHY 201: MODERN PHYSICS [Credits 3, 3-0-0]

Course Outcomes:

At the end of this course, the students will learn about:

- The stability of atoms and different quantization laws
- Elementary Quantum Mechanics
- The size and shape of nucleus
- Basics of Special theory of relativity

Program Outcomes: PO1, PO3, PO4, PO5, PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**1**	**1**	**1**
CO2	**3**	**3**	**3**	**1**	**1**	**1**
CO3	**3**	**3**	**3**	**1**	**1**	**1**
CO4	**3**	**3**	**3**	**3**	**3**	**3**

Course Level: Introductory

Course Description:

Modern Physics usually refers to the developments of physics (e.g, quantum mechanics, atomic and nuclear physics, particle physics and cosmology, special theory of relativity) from the beginning of 20th century which provide fundamentally different prescriptions than long standing Newtonian Physics.

This course introduces the basic concepts and descriptions of broad topics in physics. It discusses the basic formulation and consequences of special theory of relativity. With the basic introduction of elementary quantum mechanics, this course discusses the quantization of atomic spectra; shape, size and radioactivity nucleus.

Course Objectives:

- To students will be taught different models of atoms, spectra and atomic structure
- To impart the knowledge of special theory of relativity
- To teach the wave particle duality of matter
- To impart the idea of elementary particle physics

Syllabus:

Special theory of Relativity: Michelson-Morle experiment, Einstein's postulates, Lorentz transformation equations, length contraction and time dilation, relativistic addition of velocities, relativity of mass, Mass energy and momentum energy relations.

Atomic physics: Problems with Rutherford model-instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; hydrogen like atoms and their spectra.

Origin of quantum physics: Photoelectric effect and Compton scattering. de Broglie wavelength and matter waves; Davisson-Germer experiment. Wave-particle duality, Heisenberg uncertainty principle, estimating minimum energy of a confined particle using uncertainty principle, Two slit interference experiment with photons, atoms & particles, linear superposition principle as a consequence, Matter waves and wave amplitude, Schrodinger equation for non-relativistic particles, Momentum and Energy operators; stationary states, physical interpretation of wave function, probabilities and normalization

Elementary nuclear physics: Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in nucleus. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy, Radioactivity decay, stability of nucleus, Law of radioactive decay, Mean life and half-life.

Pre-requisites: None

Reference Books:

1. Concepts of Modern Physics. Arthur Beiser, McGraw Hill education, India.
2. Modern Physics. R.A. Serway, C.J. Moses, and C.A. Moyer, Cengage Learning India.
3. The *Feynman lectures on physics* vol. 3. R.P. Feynman, R. B. Leighton and M. Sands, Pearson education, India.
4. *Berkeley Physics* Course: *Quantum Physics* Vol.4. E.H. Wichman, McGraw Hill education, India.
5. Six Ideas That Shaped Physics, Unit Q: Particles Behave Like Waves. Thomas A. Moore, McGraw Hill education, India.

Assessment Method: written, viva, seminar, assignment

Any need for revision of existing rules: No

PHY 202: PHYSICS LAB-III [Credits 1, 0-0-2]

Course Outcomes:

- The students will be capable of verifying the law of conservation of charge
- The students will be capable of measuring the Planck's constant
- The students will be capable of determining the e/m ratio
- The students will be understanding the concept of work function of metals
- The students will be able to understand the uncertainty principle

Program Outcomes (PO): This course covers PO1 to PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**2**	**3**	**3**
CO3	**3**	**3**	**3**	**1**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**2**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**

Course Level: Introductory

Course description: The experiments in this laboratory are designed in such a way that the students can verify the concepts of Physics taught in the theory course of Modern Physics.

Course Objectives

- To make the students learn how to verify the conservation of charge
- The concepts developed in the theory course of Modern Physics will be utilized for the measurement of fundamental constant like Planck's constant and verify the uncertainty principle
- To realize the students about the discrete energy levels in atoms through Frank Hertz experiment

- To make the students learn to verify the e/m ratio for electron

Syllabus:

1. Millikan Oil drop experiment
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine the wavelength of H-alpha emission line of Hydrogen atom
4. To determine value of Planck's constant using LEDs of at least 4 different colours
5. e/m by Thomson's method
6. Heisenberg Uncertainty principle
7. Sommerfeld's fine structure constant determination
8. To verify discrete atomic level using the Frank-Hertz experiment
9. To determine work function of material of filament of directly heated vacuum diode
10. Davisson-Germer experiment

Pre-requisites of the course: 12th standard Physics

Text Books and Reference Books:

1. A Text Book of Practical Physics. I. Prakash & Ramakrishna, Kitab Mahal, India
2. B.Sc. Practical Physics. Geeta Sanon, R. Chand & Co., India
3. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, Vani Pub.
4. Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint

Assessment Method: Lab record checking, viva, EoSE (60% weightage)

Any need for revision of existing rules: No

PHY 203: PROPERTIES OF MATTER AND WAVES [Credits 3, 3-0-0]

Course Outcomes: The students will be able to learn about

- Various elastic moduli of material, streamline and turbulent motion
- Simple systems undergoing simple harmonic motion and to derive differential equation of motion
- Frequency shifts arising from Doppler effect

Program Outcomes (PO): This course covers PO1 to PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**

Course Level: Introductory

Course description: The course aims to introduce the basic concepts required to understand the elastic properties, fluids mechanics and simple harmonic motions. The theoretical and experimental methods to determine the different elastic constants are to be introduced. The unit on fluid mechanics introduces fundamental aspects of fluid flow behaviour at steady state. In the last unit, students will get an opportunity to grasp the mathematical description and physical interpretation of oscillations and wave phenomena.

Course Objectives:

- The students will be taught about the elastic properties of matter and fluid dynamics
- To teach about simple harmonic motion and Lissajous figures, Doppler effect

Syllabus:

Elastic properties of solids: Elastic moduli and their interrelations, torsion of a cylinder, bending moment, cantilever, simply supported beam with concentrated load at the center, strain energy, Maxwell's Needle, Searle's method, twisting couple, coupled pendulum.

Mechanical properties of fluids*:*Surface tension and surface energy, molecular theory, angle of contact, elevation and depression of liquid columns in a capillary tube, excess pressure in a spherical bubble and spherical drop, streamline and turbulent motion, Poiseuille's formula, critical velocity, Reynolds number, Bernoulli's theorem, Stokes' law.

Oscillations and Waves*:* Differential equation of oscillatory motion and its solution. Superposition of Simple Harmonic Motion, Lissajous figures, natural, damped and forced vibration, resonance, sharpness of resonance, Plane progressive wave - energy and intensity. Bel, decibel, Superposition of waves, beats. Velocity of longitudinal wave in solid and in gas, velocity of transverse wave in string, Doppler effect.

Pre-requisites of the course: 12th standard Physics

Reference books:

- Mechanics, D.S. Mathur. S Chand & Co ltd, India, 2014.
- Physics for scientists and engineers with modern physics, Raymond A. Serway and John W. Jewett. Cengage, India, 2017.
- Fundamentals of Physics. Resnick, Halliday and Walker, Wiley, India, 11th edition, 2018.
- The Feynman Lectures on Physics Vol. 1. R.P. Feynman, R. B. Leighton and M. Sands, Pearson education, India, 2012.
- Berkeley Physics Course Mechanics Vol.1. C. Kittel, W. Knight, et.al., McGraw Hill education, 2017.

Assessment Method: Two internal assessment examinations of 20% weightage each. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 204: PHYSICS LAB IV [Credits 1, 0-0-2]

Course Outcomes: At the end of this course, the students will be

- capable of determining the Boltzmann's and Plank's constant
- capable of measuring the unknown resistance and capacitance
- able to understand the photoelectric effect phenomenon
- able to determine frequency of sound

Program Outcomes: PO2 -PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**3**	**3**	**3**	**3**	**3**
CO2	**1**	**3**	**3**	**3**	**3**	**3**
CO3	**1**	**3**	**3**	**3**	**3**	**3**
CO4	**1**	**3**	**3**	**3**	**3**	**3**

Course Level: Basic

Course description: The experiments in this laboratory are designed in such a way that the students can verify the concepts of Physics taught in the theory course of Basic Electronics.

Course Objectives:

- To make the students learn about the characteristics of the p-n junction diodes, Zener diode and photoelectric effect
- Students will learn different electronic circuits like RC circuits including Carey Foster's Bridge and De'Sauty's bridge
- Hands on to determine the electronic charge using Millikan oil drop method and e/m using magnetic focusing and bar magnet

Syllabus:

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine the value of Planck's constant using LEDs of at least 4 different colours.
3. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
4. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
5. Velocity of sound determination
6. To study the voltage regulating characteristics of a Zener diode
7. To determine the frequency of the AC mains using a sonometer
8. Millikan Oil Drop Experiment
9. To study the characteristics of a series RC Circuit.
10. To determine an unknown Low Resistance using Carey Foster's Bridge.
11. To compare capacitances using De Sauty's bridge.

Pre-requisites: 12th Standard Physics

Reference Books:

- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal, New Delhi.
- Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint
- BSc Practical Physics, Geeta Sanon, R. Chand & Co.

Assessment Method: Viva-voce and hands on experiment

Any need for revision of existing rules: No

PHY 301: ELECTRICITY AND MAGNETISM [3 Credits, 3-0-0]

Course Outcomes: After going through the course, the students will be equipped with

- the knowledge of different fields and potentials, polarization, magnetic properties
- the concept of resonance in LCR circuits
- the concept of eddy current

Program Outcomes (PO): This course covers PO1, PO3 to PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**
CO2	**3**	**1**	**3**	**3**	**3**	**3**
CO3	**3**	**1**	**3**	**3**	**3**	**3**

Course Level: Introductory

Course description: This course introduces electrical and magnetic phenomena in nature, including the concepts of electric and magnetic fields, the application of Gauss' Law, electric potential, Ampere's law, hysteresis loop, electromagnetic induction, eddy current and resonance in electric circuits having capacitive and inductive components

Course Objectives: The students will be infused with

- the concepts about the static and dynamic behaviour of charges
- the dielectric properties of materials
- the magnetic properties of materials
- the concept of magnetic hysteresis loop
- the concept of eddy current and its applications

Syllabus:

Electric Field and Potential: Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of the system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor.

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics.

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

Electromagnetic Induction: Faraday's Law. Lenz's Law. Concept of eddy current and its applications. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

Pre-requisites: 12th standard Physics

Reference Books:

- Introduction to Electrodynamics, D. J. Griffiths. Pearson Education India
- The *Feynman lectures on physics* Vol. 2. R.P. Feynman, R. B. Leighton and M. Sands, Pearson education, India.
- Electricity and Magnetism, Edward M. Purcell and David J. Morin. Cambridge University Press.
- Sears and Zemansky's University Physics: Electricity and Magnetism, H. D. Young and R. A. Freedman. Pearson Education India

Assessment Method: Two internal assessment examinations of 20% weightage each. One will be in the form of written examination and the other may be like surprise test, quiz, seminar, assignments etc. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 302: Heat & Thermodynamics [Credits 3, 3-0-0]

Course Outcomes:

- The students will learn that heat and work are two methods by which a thermodynamic system transacts energy with another thermodynamic system or with the surroundings.
- They will understand that pressure provides an integrating factor to convert inexact differential work to an exact differential volume; similarly temperature provides an integrating factor to extract an exact differential entropy from the inexact differential heat.
- They will know of laws of thermodynamics and how each law leads to a thermodynamic property.
- They will learn of formulations of thermodynamics based on energy, entropy, free energy, enthalpy, Gibbs potential etc.
- They will know how to calculate entropy in irreversible processes; they will acquire competence to tackle real-life problems in heat and thermodynamics.

Program Outcomes: PO-1, PO-3, PO-4, PO-5 and PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	2	1
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	2	3	3	3

Course Level: Introductory

Course description:

Thermodynamics was born when Nicolaus Leonard Sadi Carnot discovered that heat must fall from hot to cold to produce work. We call this now, the second law of thermodynamics; much later Benjamin Thompson, von Mayer, and Prescot James Joule established mechanical equivalence of heat and this led to the formulation of the first law of thermodynamics; Then came Rudolf Clausius who invented entropy to correctly capture the irreversibility inherent in the behaviour of thermodynamic systems. This course will describe the exciting developments in the subjects of heat and thermodynamics and prepare the students to take off into the larger enterprise we call statistical mechanics.

Course Objectives:

To impart the students with a correct and sound knowledge of heat and thermodynamics so that they are ready to venture into statistical mechanics which they will learn in later semesters.

Syllabus:

Zeroth and First Law of Thermodynamics:

Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, General Relation between C_P and C_V, Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient.

Second Law of Thermodynamics:

Reversible and Irreversible process. Conversion of Work into Heat and vice versa. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics. Carnot's Theorem. Applications of Second Law of Thermodynamics. Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Entropy of a perfect gas, Entropy Changes in Reversible and Irreversible processes.

Third Law of Thermodynamics:

Unattainability of Absolute Zero. Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Their Definitions, Properties and Applications. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations, Derivation of Maxwell's thermodynamic Relations and their applications, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Value of Cp-Cv, (3) Tds Equations, (4) Energy equations.

Kinetic Theory of Gases:

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy. Specific heats of Gases. Mean Free Path. Transport Phenomenon in Ideal Gases. Behavior of Real Gases: Deviations from the Ideal Gas Equation. Andrew's Experiments on CO_2 Gas. Virial Equation. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

Pre-requisites : high school level physics and mathematics

Reference Books:

- Heat and Thermodynamics. M.W. Zemansky, Richard Dittman, McGraw Hill education.
- Thermal Physics. Stephen J. Blundell and Katherine M, Oxford University Press.
- Thermal Physics. S. Garg, R. Bansal and Ghosh, 2nd Edition, McGraw Hill education.
- Heat Thermodynamics and Statistical Physics. Brij Lal & Submhnranyam, S. Chand Publications.
- Thermodynamics and Statistical Mechanics. A. Sommerfeld, Levant Books.
- Mechanics, Waves and Thermodynamics: An Example-based Approach. Sudhir Ranjan Jain, Cambridge University Press.

Assessment Method: Written and Assignments

Any need for revision of existing rules: No

PHY 303: MATHEMATICAL PHYSICS [Credits 3, 3-0-0]

Course Outcomes:

After going through the course, the students will be able to grasp

- different Mathematical techniques for solving the problems in Physical Sciences

Program Outcomes (PO): The course covers the program outcomes from PO-3 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	3	3

Course Level: Mastery

Course Description: Mathematics and Physics are very closely linked subjects. Physicists need mathematical equations to describe the relationships between physical objects and the forces that act on them. Mathematical physics attempts to apply rigorous mathematical ideas to solve problems inspired by physics. Mathematics provides the tools for physics and can also drive physical insights. It is often joked that to unify all of physics, superstring theory also encompasses all of mathematics. Mathematics is the indispensable language of physics.

Course Objectives:

The course essentially introduces to the students about

- Skills about different mathematical tools required for explanation of various Physics phenomena
- the emphasis is on the application of mathematics to solve real life problems

Syllabus:

Vector Analysis: Transformation properties of vectors; Differentiation and integration of vectors; Line integral, volume integral and surface integral involving vector fields; Gradient, divergence and curl of a vector field; Gauss' divergence theorem, Stokes' theorem, Green's theorem - application to simple problems; Orthogonal curvilinear coordinate systems, unit vectors in such systems, spherical and cylindrical coordinate systems.

Matrices: Hermitian adjoint and inverse of a matrix; Hermitian, orthogonal, and unitary matrices; Eigenvalue and eigenvector (for both degenerate and non-degenerate cases); Similarity transformation; diagonalisation of real symmetric matrices.

Special Functions Differential Equations: Solution of second order linear differential equations with constant coefficients and variable coefficients by Frobenius' method (singularity analysis not required); Solution of Legendre and Hermite equations about $x=0$; Legendre and Hermite polynomials - orthonormality properties.

Prerequisites:
Students must have some familiarity with differentiation, integrations, vectors calculus and matrices.

Test Books/ Reference books:

- Mathematical Methods in the Physical Sciences, Boas, Mary, Wiley India, 3rd edition, 2006.
- Mathematical Methods for Physics and Engineering. Ken Riley, Cambridge University Press India , 3rd edition, 2018.
- George Arfken, Mathematical methods for Physicists, Academic Press, 7th edition, 2012.
- Mathematical Physics, Rajput B S., Pragati Prakashan, 2017

Assessment Method: Written examinations and assignments.

Any need for revision of existing rules: No

PHY 304: Physics Lab V [3 Credits, 0-0-6]

Course Outcomes:

At the end of this course, the students will be

- capable to measuring the magnetic field, self- and mutual- inductance
- capable of measuring the resonance, quality factor, band width and anti-resonant frequency using LCR circuit
- capable of verifying the electromagnetic induction
- capable of measuring the speed of light
- capable of measuring Stefan's constant, thermal conductivity of poor conductor, measurement of high resistance

Program Outcomes (PO): This course covers PO1 to PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

Course Level: Introductory

Course description: The experiments in this laboratory course are designed in such a way that the students will understand and perform the experiments based on the concepts taught in theory courses of Electricity and Magnetism, Heat and Thermodynamics.

Course Objectives:

The course essentially introduces to the students about

- the measurement methods of magnetic field strength and self-inductance and mutual inductance
- to learn different characteristics of the LCR circuit
- measurement of speed of light
- Faraday's law of electromagnetic induction
- thermal conductivity of poor conductor
- Stefan's constant and determination of k/e ratio

Syllabus:

1. Verification of the Faraday's law of induction
2. Series and parallel LCR circuits
3. Measurement of mutual inductance by Ballistic Galvanometer
4. Measurement of high resistance by leakage method
5. To determine the self inductance by Rayleigh's method
6. Bio Savart law
7. Speed of light using Hertz experiment
8. Stefan's constant
9. k/e ratio measurement
10. Thermal conductivity of poor conductor by Lee's disc method

Pre-requisites: 12th standard Physics

Reference Books:

5. A Text Book of Practical Physics. I. Prakash & Ramakrishna, Kitab Mahal, India
6. B.Sc. Practical Physics. Geeta Sanon, R. Chand & Co., India
7. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, Vani Pub.
8. Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint

Assessment Method: lab record checking, viva, EoSE (60% weightage)

Any need for revision of existing rules: No

PHY 305: ADVANCED MODERN PHYSICS [Credits 3, 3-0-0]

Course Outcomes: The students will learn about

- different types of matter
- basic aspects of quantum mechanics
- fundamentals of particle physics

Program Outcomes: All listed POs.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**

Course Level: Intermediate

Course Description: This course offers intermediate topics of nonclassical physics covering Quantum Mechanics, Solid-State Physics, and Particle Physics.

Course Objectives: This course facilitates students to give knowledge about

- different states of matter and their properties
- fundamental of quantum mechanics
- elementary particle physics

Syllabus:

Quantum Mechanics: Wave Packets, The Motion of a Wave Packet, The Schrodinger Equation, Applications of the Schrodinger Equation, The Simple Harmonic Oscillator, Steps and Barriers.

Solid-State Physics: Crystal Structures, The Heat Capacity of Solids, Electrons in Metals, Band Theory of Solids, Superconductivity, Intrinsic and Impurity Semiconductors, Semiconductor Devices, Magnetic Materials.

Particle Physics: The Four Basic Forces, Classifying Particles, Conservation Laws, Particle Interactions and Decays, Energy and Momentum in Particle Decays, Energy and Momentum in Particle Reactions, The Quark Structure of Mesons and Baryons, The Standard Model.

Pre-requisites: PHY 201: MODERN PHYSICS

References:

1. Modern Physics (3rd Edition), Kenneth S. Krane, Wiley (2012).
2. Quantum Physics: Of Atoms, Molecules, Solids, Nuclei And Particles (2nd Edition), Robert Eisberg and Robert Resnick, Wiley (1985).
3. Concepts of Modern Physics (6th Edition), Arthur Beiser, McGraw-Hill (2002).
4. Modern Physics (3rd Edition), Raymond A. Serway, Clement J. Moses, and Curt A. Moyer, Cengage (2004).
5. The Feynman Lectures on Physics, Vol. III, Richard P. Feynman, Robert B. Leighton, and Matthew Sands, Addison Wesley (1971).
6. Quantum Physics (Berkeley Physics Course, Volume 4, 2nd Edition), Eyvind H. Wichmann, McGraw-Hill (1971).
7. Modern Physics (2nd Edition), Randy Harris, Pearson (2007).
8. Introduction to Solid State Physics, Eighth Edition, Charles Kittel, Wiley (2012).
9. Introductory Nuclear Physics, Kenneth S. Krane, Wiley (2008).
10. Modern Physics for Scientists and Engineers, Fourth Edition, Stephen T. Thornton and Andrew Rex, Cengage Learning (2013).

Assessment Method: Assignments and written exams.

Any need for revision of existing rules: No

PHY 306: OPTICS [Credits 3, 3-0-0]

Course Outcomes: After going through this course, the students will be able to understand

- the basic principles of wave nature of light and its propagation
- working principles of different optical instruments for the generation of interference and diffraction patterns
- working principles of different optical wave-plates *viz*. quarter and half wave plates and their applications for the generation of different polarized light

Program Outcomes (PO): The course covers the program outcome form PO-1 to PO-4.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**3**	**1**	**1**
CO2	**3**	**3**	**3**	**3**	**1**	**1**
CO3	**3**	**3**	**3**	**3**	**1**	**1**

Course Level: Mastery

Course Descriptions:

This course first introduces the wave nature of light and fundamental laws of light propagation. After that it covers the interference and diffraction phenomenon using the light wave with different optical instruments. At the end it discusses the orientation of electric field vectors such as linear, circular and elliptical orientations and their realization using the wave plates.

Course Objectives: The objective of this course is to

- to communicate the knowledge of propagation of light based on wave nature
- to discuss the orientation of electric field vector with the help of polarizing elements
- to elaborate about the concepts of interference and diffraction

Syllabus:

Wave Optics: Huygens' Principle, laws of reflection and refraction. Temporal and Spatial Coherence.

Interference: *Division of wavefront:* Young's double slit experiment, Lloyd's mirror and Fresnel Biprism. Phase change on reflection.

Division of amplitude: Interference in thin films (parallel and wedge-shaped films), Fringes of equal inclination, Fringes of equal thickness, Newton's Rings, Interferometer: Michelson interferometer and Fabry - Perot interferometer.

Diffraction: *Fraunhofer Diffraction:* Single slit, Rectangular and Circular aperture, Double slit, Multiple slits, Diffraction grating and its Resolving power.

Fresnel Diffraction: Fresnel's assumptions. Fresnel's Half - period zones for plane waves. Explanation of rectilinear propagation of light. Theory of a zone plate and its multiple foci. Fresnel's integral, Cornu`s spiral and its applications. Diffraction at straight edge and a slit.

Polarization: Types of polarization: Linear, circular, elliptical polarized light; Malus's law, Birefringence, Retarders: Quarter wave plate and Half wave plates

Prerequisites: None

Reference Books:

- Principles of Optics, Max Born and Emil Wolf, Cambridge University Press, 7th Edition, 1999.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, McGraw Hill education, 4th Edition, 2011.
- Optics, Ajoy Ghatak, McGraw Hill education, 3rd Edition, 2005.
- Optical Interferometry, P. Hariharan, Academic Press, 2nd Edition, 2003.
- Optics, Eugene Hecht and A R Ganesan, Pearson Education, 5th Edition, 2019.

Assessment Method: Written, Seminar/Assignment

Any need for revision of existing rules: No

PHY 307: Atomic and Nuclear Physics [Credits 3, 3-0-0]

Course Outcomes:

- Students will be enriched with the fundamental knowledge of atoms, nucleus and their properties
- Students will be enshrined in detail about the radiation hazards, peaceful use of nuclear energy and carbon dating for fossil's age determination
- The students will be able to do higher studies in this field. They may get employment opportunities in radiology and medical fields.

Program Outcomes (PO): The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**	**3**

Course Level: Mastery

Course Objectives:

- To familiarize about the essential properties of the atom & nucleus
- Carbon dating, modern medical applications, radio-physics all require the knowledge of radio-activity
- To impart the knowledge of all kinds of interactions viz. gravitational, electromagnetic, weak and strong.

Course Description: The course is designed to develop the basic concepts and theories of nuclear physics as well as an understanding of the applications of nuclear science in all the fields of sciences.

Syllabus:

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of nuclear force. Nuclear Reaction: Conservation principles in nuclear reactions, Q-values and thresholds, nuclear reaction cross sections.

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

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

Particle physics: Classification of fundamental forces, Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model.

Prerequisites: None

Reference Books

1. Introductory nuclear Physics, Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics, Bernard L.Cohen.(Tata Mcgraw Hill, 1998).
3. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
6. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

Assessment Method: Written examinations and assignments

Any need for revision of existing rules: No

PHY 308: PHYSICS LAB VI [Credits 3, 0-0-6]

Course Outcomes:

At the end of this course, the students will be

- able to determine the wavelength of light
- able to visualize the concept of polarization in light
- able to measure numerical aperture of the optical fiber

Program Outcomes (PO): The course covers the program outcomes from PO-2 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	3	3	3	3
CO2	1	3	3	3	3	3
CO3	1	3	3	3	3	3

Course Level: Undergraduate

Course Description: The course is designed for the students to visualize the various properties and phenomena associated with light. It also imparts the technical skills and fine adjustments of the instruments in draw the objective of the experiment

Course Objectives:

The course essentially introduces to the students about

- the measurement of wavelength of monochromatic and polychromatic light sources
- to study the behavior of light when passes through a single, double and grating structure
- Visualization of the concept of polarization through several experiments

Syllabus:

1. To determine the radius of curvature of the given plano-convex lens using Newton’s Rings
2. To determine the wavelength of sodium light by using Fresnel's Bi Prism
3. To determine the wavelength of laser light using single slit Laser Diffraction
4. To determine Cauchy’s constants and dispersive power of prism using spectrometer
5. To find the wavelength of mercury lines by using diffraction grating
6. To determine the specific rotation of sugar solution by using advanced polarimeter
7. To understand and detection linearly, circularly, and elliptically polarized light and verification of Malus law
8. Determination of the numerical aperture of a multi-mode optical fiber
9. Determination of Brewster angle
10. To study the characteristics of laser diode particularly Gaussian nature and diameter of the laser beam
11. To study the intensity distribution by double slit laser diffraction
12. Birefringence measurement by using Babinet compensator

Pre-requisites: Basic level of optics

Reference Books:

1. A Text Book of Practical Physics. I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
2. Advanced Practical Physics for Students. B.L. Worsnop, H.T. Flint.
3. B.Sc Practical Physics. Geeta Sanon, R. Chand & Co.
4. Principles of Optics, Max Born and Emil Wolf, Cambridge University Press, 7th Edition, 1999.
5. Fundamentals of Optics, F.A. Jenkins and H.E. White, McGraw Hill education, 4th Edition, 2011.
6. Optics, Ajoy Ghatak, McGraw Hill education, 3rd Edition, 2005.
7. Optical Interferometry, P. Hariharan, Academic Press, 2nd Edition, 2003.
8. Optics, Eugene Hecht and A R Ganesan, Pearson Education, 5th Edition, 2019.

Assessment Method: Viva-voce and performance in the laboratory examination

Any need for revision of existing rules: No

ELECTIVE COURSES

1.	Electronics	PHY 320	3
2	Fundamentals of solid state physics	PHY 321	3
3	Plasma Physics: Fundamentals and Applications	PHY 322	3
4	Selected Topics in Mathematical Physics	PHY 323	3

PHY 320: ELECTRONICS [Credit 3, 3-0-0]

Course Outcomes: At the end of this course, the students will be able to understand the fundamentals behind analog and digital devices.

Program Outcomes (PO): This course covers PO1,PO3, PO4, PO5 & PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**

Course Level: Introductory

Course Description: This course has been designed keeping in mind the importance of ever increasing usage of electronic devices in our day-to-day life. The course will impart knowledge of the fundamental components and parts used in the electronic devices. This is an ability enhancement (AE) or skill development (SD) course to cater the need of skill India a flagship program of the Government of India.

Course Objectives:

- To make the students familiar about the concepts of components used in various electronic devices
- To make the students learn the basics of digital electronics which will be useful to them in understanding the concept behind Digital India

Syllabus:

Field effect transistors (FET): Classification of various types of FETs, construction of junction FET, drain characteristics, biasing, operating region, pinch-off voltage. MOSFET: construction of enhancement and depletion type, principle of operation and characteristics.

Feedback Circuit and Amplifier*:* Voltage and current gain, principle of feedback, positive and negative feedback, advantages of negative feedback, multistage amplifier, frequency response of a two stage R-C coupled amplifier, gain and band width and their product, amplifier, analysis of single tuned voltage amplifier, requirement of power amplifiers

Operational amplifier: Properties of ideal OP-AMP, differential amplifiers, CMRR, inverting and non-inverting amplifiers, mathematical operations.

Oscillators: Barkhausen criterion for sustained oscillation, L-C, Weinbridge and crystal oscillators, relaxation oscillators-monostable, bistable and astable multivibrators.

Combinational and Sequential logic: Half adder, full adder, digital comparator, decoder, encoder (ROM), multiplexer, Flip-flops- RS, D, JK, JKMS flip-flops, edge triggering. Shift register, ripple counter (binary and decade).

Pre-requisites: None

Reference books:

1. Electronic Devices and Circuit theory, R. L. Boylestad, L. Nashelsky, Pearson publication
2. Electronic Devices Electron flow version, T. L. Floyd, Pearson publication
3. Electronic Principles, A. P. Malvino, McGraw Hill
4. Digital Principles and Applications, A. P. Malvino, D. P. Leach, McGraw Hill publication
5. Digital fundamentals, T. L. Floyd, Pearson publication
6. Digital Electronics: Principles and Integrated Circuits, A. K. Maini, Wiley publication

Assessment Method: Two internal assessment examinations of 20% weightage each. One will be in the form of written examination and the other may be like a surprise test, quiz, seminar, assignments etc. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 321: FUNDAMENTALS OF SOLID STATE PHYSICS [Credits 3, 3-0-0]

Course Outcomes: The students will learn about

- the crystal structures and bond formation in different kinds of material
- various laws of solid state physics
- dielectric, magnetic and superconducting properties

Program Outcomes (PO): This course covers PO1, PO3, PO4, PO5 & PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**
CO2	**3**	**1**	**3**	**3**	**3**	**3**
CO3	**3**	**1**	**3**	**3**	**3**	**3**

Course Level: Introductory

Course description: This course introduces the students various types of solids viz. crystalline and amorphous. During the course, the students will be taught about lattices, crystal structure and its determination, various types of bonding. In the middle of the course, the students will be familiarized with various interesting laws of solid state physics. In the final part, the knowledge of electrical, magnetic and superconducting properties of materials will be covered.

Course Objectives:

- Students will be taught about different crystal structures
- To impart the knowledge of lattice vibrations and x-ray diffraction
- To impart the knowledge of various laws of solid state physics
- To introduce the dielectric, magnetic & superconducting properties of solids

Syllabus:

Crystal Structure and Bonding: Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, f.c.c. and b.c.c. lattices. Laue and Bragg equations. Determination of crystal structure with X-rays. Different types of bonding- ionic, covalent, metallic, van der Waals and hydrogen, Lattice vibration and Elastic constants

Electronic Structure of solids: free electron theory of metals, Band theory of solids, Periodic potential and Bloch theorem, Kronig-Penny model, energy band structure. Band structure in conductors, direct and indirect semiconductors, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law, Hall effect: Phenomenology and application.

Dielectric, Magnetic & superconducting properties of Solids: Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization, molecular field in a dielectric; Clausius-Mosotti relation. Dia, para and ferro-magnetic properties of solids. Langevin's theory of diamagnetism and paramagnetism. Quantum theory of paramagnetism, Curie's law, Ferromagnetism: spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis, Kamerlingh-Onnes experiment, Meissner effect, Critical fields, Type-I and type-II superconductors, Isotope effect.

Pre-requisites: 12^{th} standard Physics

Reference books:

1. Introduction to Solid State Physics: C. Kittel, John Wiley publication
2. Elementary Solid State Physics: M. Ali Omar, Pearson India publication
3. Solid State Physics, N. W. Ashcroft and N. D. Mermin, Cengage Learning publication
4. Solid State Physics and Electronics: R. K. Puri and V. K. Babbar, S. Chand publication
5. Solid State Physics: R. J. Singh, Pearson India publication

Assessment Method: Two internal assessment examinations of 20% weightage each. One will be in the form of written examination and the other may be like a surprise test, quiz, seminar, assignments etc. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 322: Plasma Physics: Fundamentals and Applications [Credits 3, 3-0-0]

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

- Interpret the basics of the plasma parameters and related fluid equations
- Analyze the behaviour of electromagnetic waves and electron beam with plasma
- Introspect the particle motions under the influence of external electric and magnetic field
- Apply knowledge of physics as a basic science in solving real life and scientific problems
- Engage in research in the field of Plasma based propulsion technologies

Program Outcomes: (PO): The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

Course Level: Mastery

Course Description: The course gives the opportunity to acquire a basic knowledge of plasma physics. Plasma, the fourth state of matter, is the most abundant form of known matter in the universe. Study of plasma physics is essential to explain important astrophysical phenomena applications in industries, medical sciences, achieving fusion energy on Earth, etc.

Course Objectives:

- To grasp the concept of Debye length, Debye shielding and plasma oscillations
- To impart the theoretical and analytical knowledge in the field of plasma waves
- T0 introduce plasma phenomena relevant to plasma thrusters for spacecraft propulsion

Syllabus:

Introduction

Basic concepts of plasma, concept of temperature, Debye length, plasma frequency, criteria for plasmas, Fluid equations, Response of plasma to the fields, DC conductivity, AC conductivity, RF conductivity, collisions.

Waves in Plasma

Plasma in relation with electromagnetic waves, electromagnetic wave propagation, propagation in inhomogeneous plasma, electrostatic waves in plasma, energy flow

Physics of Plasma Propulsion

momentum & energy transport in collisional plasmas, wall effects, & collective (wave) effects, generalized Ohm's law, plasma thruster concepts, acceleration & dissipation mechanisms in Hall thrusters, magnetoplasmadynamic thrusters and & derivation for the propulsive efficiencies.

Prerequisites: Students must have the understanding of mechanics and mathematics.

Test Books/ Reference books:

1. Introduction to Plasma Physics and Controlled Fusion by F. F. Chen, 3rd edition (2016), Springer International Publishing
2. Interaction of electromagnetic waves with electron beams and plasmas by C.S. Liu and V.K. Tripathi, (1994) World Scientific.
3. Textbook of plasma physics, Suresh Chandra, CBS publisher

Assessment Method: Two internal assessment examinations of 20% weightage each. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 323: Selected Topics in Mathematical Physics [Credits 3, 3-0-0)]

Course Outcomes:

After going through the course, the students will be able to

- Know the applications of complex analysis and their role in physics and engineering.
- Define continuity and differentiability for complex function
- Know the uses of Fourier series and Fourier transformations
- Solve wave, diffusion and Laplace equations using the separation of variables

Program Outcomes (PO): The course covers the program outcomes from PO-3 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**1**	**3**	**3**	**3**	**3**
CO2	**1**	**1**	**3**	**3**	**3**	**3**
CO3	**1**	**1**	**3**	**3**	**3**	**3**
CO4	**1**	**1**	**3**	**3**	**3**	**3**

Course Level: Mastery

Course Description: The course gives an understanding of complex analysis, Fourier series, Fourier transformations and differential equations and their role in physics, engineering and mathematics.

Course Objectives: The objective of the course is to

- Identify and construct complex-differentiable functions.
- Grasp the concepts of Fourier transforms and Fourier series along with its usages
- Find the solution of the wave, diffusion and Laplace equations.

Syllabus:

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Analyticity and Cauchy-Riemann Conditions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy’s Integral formula. Laurent and Taylor’s expansion. Residues and Residue Theorem.

Ordinary and Partial Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of wave equation for vibrational modes of a stretched string.

Fourier Series and Fourier Transform: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity Fourier integrals and transform, FT of delta functions.

Prerequisites: Students must have some familiarity with differentiation, integrations, vectors calculus and matrices.

Reference books:

1. Mathematical Methods in the Physical Sciences, Boas, Mary, Wiley India, 3rd edition, 2006.
2. Mathematical Methods for Physics and Engineering. Ken Riley, Cambridge University Press India, 3rd edition, 2018.
3. George Arfken, Mathematical methods for Physicists, Academic Press, 7th edition, 2012.
4. Mathematical Physics, Rajput B S., Pragati Prakashan, XXX edition, 2017

Assessment Method: Two internal assessment examinations of 20% weightage each. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

ELECTIVE COURSES

UG level

1.	Electronics	PHY 320	3
2	Fundamentals of solid state physics	PHY 321	3
3	Plasma Physics: Fundamentals and Applications	PHY 322	3
4	Selected Topics in Mathematical Physics	PHY 323	3

PHY 320: ELECTRONICS [Credit 3, 3-0-0]

Course Outcomes: At the end of this course, the students will be able to understand the fundamentals behind analog and digital devices.

Program Outcomes (PO): This course covers PO1,PO3, PO4, PO5 & PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3

Course Level: Introductory

Course Description: This course has been designed keeping in mind the importance of ever increasing usage of electronic devices in our day-to-day life. The course will impart knowledge of the fundamental components and parts used in the electronic devices. This is an ability enhancement (AE) or skill development (SD) course to cater the need of skill India a flagship program of the Government of India.

Course Objectives:

- To make the students familiar about the concepts of components used in various electronic devices
- To make the students learn the basics of digital electronics which will be useful to them in understanding the concept behind Digital India

Syllabus:

Field effect transistors (FET): Classification of various types of FETs, construction of junction FET, drain characteristics, biasing, operating region, pinch-off voltage. MOSFET: construction of enhancement and depletion type, principle of operation and characteristics.

Feedback Circuit and Amplifier*:* Voltage and current gain, principle of feedback, positive and negative feedback, advantages of negative feedback, multistage amplifier, frequency response of a two stage R-C coupled amplifier, gain and band width and their product, amplifier, analysis of single tuned voltage amplifier, requirement of power amplifiers

Operational amplifier: Properties of ideal OP-AMP, differential amplifiers, CMRR, inverting and non-inverting amplifiers, mathematical operations.

Oscillators: Barkhausen criterion for sustained oscillation, L-C, Weinbridge and crystal oscillators, relaxation oscillators-monostable, bistable and astable multivibrators.

Combinational and Sequential logic: Half adder, full adder, digital comparator, decoder, encoder (ROM), multiplexer, Flip-flops- RS, D, JK, JKMS flip-flops, edge triggering. Shift register, ripple counter (binary and decade).

Pre-requisites: None

Reference books:

1. Electronic Devices and Circuit theory, R. L. Boylestad, L. Nashelsky, Pearson publication
2. Electronic Devices Electron flow version, T. L. Floyd, Pearson publication
3. Electronic Principles, A. P. Malvino, McGraw Hill
4. Digital Principles and Applications, A. P. Malvino, D. P. Leach, McGraw Hill publication
5. Digital fundamentals, T. L. Floyd, Pearson publication
6. Digital Electronics: Principles and Integrated Circuits, A. K. Maini, Wiley publication

Assessment Method: Two internal assessment examinations of 20% weightage each. One will be in the form of written examination and the other may be like a surprise test, quiz, seminar, assignments etc. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 321: FUNDAMENTALS OF SOLID STATE PHYSICS [Credits 3, 3-0-0]

Course Outcomes: The students will learn about:

. the crystal structures and bond formation in different kinds of material
i. various laws of solid state physics
ii. dielectric, magnetic and superconducting properties

Program Outcomes (PO): This course covers PO1, PO3, PO4, PO5 & PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3

Course Level: Introductory

Course description: This course introduces the students various types of solids viz. crystalline and amorphous. During the course, the students will be taught about lattices, crystal structure and its determination, various types of bonding. In the middle of the course, the students will be familiarized with various interesting laws of solid state physics. In the final part, the knowledge of electrical, magnetic and superconducting properties of materials will be covered.

Course Objectives:

iii. Students will be taught about different crystal structures
iv. To impart the knowledge of lattice vibrations and x-ray diffraction
v. To impart the knowledge of various laws of solid state physics
vi. To introduce the dielectric, magnetic & superconducting properties of solids

Syllabus:

Crystal Structure and Bonding: Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, f.c.c. and b.c.c. lattices. Laue and Bragg equations. Determination of crystal structure with X-rays. Different types of bonding- ionic, covalent, metallic, van der Waals and hydrogen, Lattice vibration and Elastic constants

Electronic Structure of solids: free electron theory of metals, Band theory of solids, Periodic potential and Bloch theorem, Kronig-Penny model, energy band structure. Band structure in conductors, direct and indirect semiconductors, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law, Hall effect: Phenomenology and application.

Dielectric, Magnetic & superconducting properties of Solids: Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization, molecular field in a dielectric; Clausius-Mosotti relation. Dia, para and ferro-magnetic properties of solids. Langevin's theory of diamagnetism and paramagnetism. Quantum theory of paramagnetism, Curie's law, Ferromagnetism: spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis, Kamerlingh-Onnes experiment, Meissner effect, Critical fields, Type-I and type-II superconductors, Isotope effect.

Pre-requisites: 12th standard Physics

Reference books:

1. Introduction to Solid State Physics: C. Kittel, John Wiley publication
2. Elementary Solid State Physics: M. Ali Omar, Pearson India publication
3. Solid State Physics, N. W. Ashcroft and N. D. Mermin, Cengage Learning publication
4. Solid State Physics and Electronics: R. K. Puri and V. K. Babbar, S. Chand publication
5. Solid State Physics: R. J. Singh, Pearson India publication

Assessment Method: Two internal assessment examinations of 20% weightage each. One will be in the form of written examination and the other may be like a surprise test, quiz, seminar, assignments etc. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 322: Plasma Physics: Fundamentals and Applications [Credits 3, 3-0-0]

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

- Interpret the basics of the plasma parameters and related fluid equations
- Analyze the behaviour of electromagnetic waves and electron beam with plasma
- Introspect the particle motions under the influence of external electric and magnetic field
- Apply knowledge of physics as a basic science in solving real life and scientific problems
- Engage in research in the field of Plasma based propulsion technologies

Program Outcomes: (PO): The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

Course Level: Mastery

Course Description: The course gives the opportunity to acquire a basic knowledge of plasma physics. Plasma, the fourth state of matter, is the most abundant form of known matter in the universe. Study of plasma physics is essential to explain important astrophysical phenomena applications in industries, medical sciences, achieving fusion energy on Earth, etc.

Course Objectives:

- To grasp the concept of Debye length, Debye shielding and plasma oscillations
- To impart the theoretical and analytical knowledge in the field of plasma waves
- To introduce plasma phenomena relevant to plasma thrusters for spacecraft propulsion

Syllabus:

Introduction

Basic concepts of plasma, concept of temperature, Debye length, plasma frequency, criteria for plasmas, Fluid equations, Response of plasma to the fields, DC conductivity, AC conductivity, RF conductivity, collisions.

Waves in Plasma

Plasma in relation with electromagnetic waves, electromagnetic wave propagation, propagation in inhomogeneous plasma, electrostatic waves in plasma, energy flow

Physics of Plasma Propulsion

momentum and energy transport in collisional plasmas, wall effects, & collective (wave) effects, generalized Ohm's law, plasma thruster concepts, acceleration & dissipation mechanisms in Hall thrusters, magnetoplasmadynamic thrusters and & derivation for the propulsive efficiencies.

Prerequisites: Students must have understanding of mechanics and mathematics.

Text Books/ Reference books:

1. Introduction to Plasma Physics and Controlled Fusion by F. F. Chen, 3rd edition (2016), Springer International Publishing
2. Interaction of electromagnetic waves with electron beams and plasmas by C.S. Liu and V.K. Tripathi, (1994) World Scientific.
3. Textbook of plasma physics, Suresh Chandra, CBS publisher

Assessment Method: Two internal assessment examinations of 20% weightage each. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 323: Selected Topics in Mathematical Physics [Credits 3, 3-0-0)]

Course Outcomes:

After going through the course, the students will be able to

- Know the applications of complex analysis and their role in physics and engineering.
- Define continuity and differentiability for complex function
- Know the uses of Fourier series and Fourier transformations
- Solve wave, diffusion and Laplace equations using the separation of variables

Program Outcomes (PO): The course covers the program outcomes from PO-3 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	3	3
CO2	1	1	3	3	3	3
CO3	1	1	3	3	3	3
CO4	1	1	3	3	3	3

Course Level: Mastery

Course Description: The course gives an understanding of complex analysis, Fourier series, Fourier transformations and differential equations and their role in physics, engineering and mathematics.

Course Objectives: The objective of the course is to

- Identify and construct complex-differentiable functions.
- Grasp the concepts of Fourier transforms and Fourier series along with its usages
- Find the solution of the wave, diffusion and Laplace equations.

Syllabus:

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Analyticity and Cauchy-Riemann Conditions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Integral formula. Laurent and Taylor's expansion. Residues and Residue Theorem.

Ordinary and Partial Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of wave equation for vibrational modes of a stretched string.

Fourier Series and Fourier Transform: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity Fourier integrals and transform, FT of delta functions.

Prerequisites: Students must have some familiarity with differentiation, integrations, vectors calculus and matrices.

Reference books:

1. Mathematical Methods in the Physical Sciences, Boas, Mary, Wiley India, 3rd edition, 2006.
2. Mathematical Methods for Physics and Engineering. Ken Riley, Cambridge University Press India, 3rd edition, 2018.
3. George Arfken, Mathematical methods for Physicists, Academic Press, 7th edition, 2012.
4. Mathematical Physics, Rajput B S., Pragati Prakashan, 2017

Assessment Method: Two internal assessment examinations of 20% weightage each. The EoSE will be of 60% weightage.

Any need for revision of existing rules: No

PHY 401: MATHEMATICAL METHODS IN PHYSICS [Credits 4, (L-T-P: 3-1-0)]

Course Outcomes (CO):

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

- To use the fundamental concepts of complex analysis and their role in physics, engineering and mathematics.
- To define continuity and differentiability for complex functions
- To compute determinants, eigenvalue problems, diagonalization of matrices in several areas of physics, Taylor, power, Laurent series, singularities and poles, residues, complex integrals.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**
CO2	**3**	**1**	**2**	**3**	**3**	**3**
CO3	**3**	**1**	**3**	**3**	**3**	**3**

Course Level: Mastery

Course description:

Mathematics, as the saying goes, is the queen of all sciences. For a physicist, mathematics provides his mother tongue. Of late, we have realized that thorough knowledge of mathematics is a must not only in physics discipline but also in all other disciplines like chemistry, biology, economics *etc*. The mathematical physics course is so designed that a student learns mathematics and acquires enough practice and skills to apply what he has learnt to problems in all other subjects in physical sciences. More importantly this course trains a student into a mathematical way of thinking involving rigour and precision. What a student learns in this course will stand him in good stead in whatever vocation the student takes up in future, be it research, or teaching or science jobs.

Course Objectives:

To explain the basic concepts of vectors, scalars and tensors

- To expose the students to the fascinating world of real and complex numbers
- To introduce the special functions essential in solving physics problems
- To model and solve physical phenomena using differential equations
- To find power series solutions of differential equations

Syllabus:

Brief Introduction to Vectors and Tensors

Review of the properties of scalars, vectors and tensors, vector multiplication and geometrical Applications, Linear independence and orthogonality of vectors, Equations of lines and planes, Kronecker delta symbol, Levi-Civita symbol, Physical interpretation of 'div' and 'curl', Integrals over Fields, Coordinate transformations, simple applications of tensors in non-relativistic physics, Ohm's law in an anisotropic medium, Angular momentum and the inertia tensor, Transformation properties of tensors, Directional derivative, electrical conductivity, tensors, stress and strain tensors, generalized Hook's law.

Vector Spaces

Linear vector spaces, subspaces, Bases and dimension, Gram-Schmidt orthogonalisation procedure. Linear operators. Matrix representation.

Matrices

The algebra of matrices, Special matrices, Rank of a matrix, Elementary transformations, Elementary matrices, Equivalent matrices, Solution of linear equations, Linear transformations, Change of basis, Eigenvalues and eigenvectors of matrices, The Cayley-Hamilton theorem, Diagonalization of matrices, Principal axis transformation, Functions of matrices.

Analysis of Complex Variables

Geometrical representation of complex numbers, Functions of complex variables, Properties of elementary trigonometric and hyperbolic functions of a complex variable, Differentiation, Cauchy-Riemann equations, Properties of analytical functions, Contours in complex plane, Integration in complex plane, Cauchy theorem, Deformation of contours, Cauchy integral representation, Taylor series representation, Isolated and essential singular points, Branch Point and branch Cut, Riemann sheets, Laurent expansion theorem, Poles, Residues at an isolated singular point, Cauchy residue theorem, Application of residue theorem to the evaluation of definite integrals and the summation of infinite series, Integrals involving branch point singularity.

Ordinary and Partial Differential Equation

Ordinary differential equations, separation of variables, Laplace and Poisson's equation in cartesian, cylindrical and spherical polar coordinates, wave equations, heat equation and diffusion equation, boundary value problems.

Frobenius Method and Special Functions

Singular points of second order linear differential equations and their importance, Frobenius method, Legendre differential equations, properties of Legendre polynomials, orthogonality, recurrence relations, Rodrigues formula, generating function. Bessel functions of first and second kind, Hermite and Laguerre differential equations and their generating functions.

Prerequisites: Students must have some familiarity with differentiation, integrations, infinite series, differential vector calculus, matrices and complex numbers.

Text Books:

1. K. F. Riley, M. P. Hobson and S. J. Bence. Mathematical Methods for Physics and Engineering. 3rd edition, Cambridge University Press India,.

2. George B. Arfken, Hans J. Weber and Frank E. Harris. Mathematical Methods for Physicists, Academic Press, 7th edition.

3. Mary Boas. Mathematical Methods in the Physical Sciences, 3rd edition, Wiley India.

4. V. Balakrishnan, Mathematical Physics with Applications, Problems and Solutions, Ane Books.

5. Robert W. Fuller, The mathematics of classical and quantum physics, Dover publications.

6. R. K. Jain and S. R. K. Iyengar. Advanced engineering mathematics, 5th edition, New age international.

7. A. W. Joshi. Elements of group theory for physicists, New age international.

8. A. W. Joshi. Matrices and Tensors, New Age International, Daryaganj, New Delhi.

9. P K. Chattopadhyay, Mathematical Physics, 3rd edition, New Age International, New Delhi.

10. Jon Mathews and Robert L. Walker. Mathematical Methods of Physics, Pearson Education.

Assessment Method: First CIA (20 %), second CIA/assignments (20 %) and EOSE (60 %).

Any need for revision of existing rules: No

PHY 402: CLASSICAL MECHANICS [Credits 4, 3-1-0]

Course Outcome:
This course prepares the students for taking up work in nonlinear dynamics and chaos.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	1	1
CO2	3	1	3	3	1	1
CO3	3	1	3	3	1	1

Course Level: Mastery

Course description:
How and why things move the way they do? For a long time, we believed that for an object to move we require an agent. For example, our ancestors told us that the sun's chariot was drawn by seven horses tied by snakes. However, now we know that things moving with a constant velocity are natural and do not require any external agent. We call it inertia. One needs the help of a force when one wants to change the velocity. Inertia is enshrined in the first law of Newton.

Course Objectives

The course on classical mechanics deals with Newton's laws of motion and several of its later metamorphoses like Euler Lagrange formulations, Hamilton Jacobi equations, Poisson brackets *etc*. It imparts knowledge on different formulations of mechanics; more importantly the Hamiltonian formulation with Poisson bracket prepares the students for quantum mechanics which is taught in two courses each of four credits. Besides, knowledge of classical mechanics is a must for studying nonlinear dynamics and chaos. The subject of nonlinear dynamics and chaos has enormous scope for both basic and applied research.

Syllabus

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

Two-Body Central Force Problem
Equation of motion and first integrals, classification of orbits, Kepler problem, scattering in the central force field.

Small Oscillations
Linearization of equations of motion, free vibrations and normal coordinates, forced oscillations.

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

Prerequisites: B.Sc with Mathematics and Physics papers

Text Books and Reference Books:

1. Classical Mechanics (3rd Edition), Herbert Goldstein, Poole Jr., Charles P., and John L. Safko, Pearson (2001).
2. Mechanics (3rd edition, Course of Theoretical Physics), L. D. Landau and E. M. Lifshitz, Butterworth-Heinemann (1976).
3. Introduction to Dynamics, I. C. Percival and D. Richards, Cambridge University Press (1983).
4. Classical Dynamics: A Contemporary Approach, Eugene J. Saletan and Jorge V. José, Cambridge University Press (CUP) (1998).
5. A Treatise on the Analytical Dynamics of Particles and Rigid Bodies (4th edition), E. T. Whittaker, CUP (1989).
6. Mechanics: From Newton's Laws to Deterministic Chaos (6th Edition), Florian Scheck, Springer (2018).
7. Theoretical Mechanics of Particles and Continua, Alexander L. Fetter and John Dirk Walecka, Dover (2003).
8. Analytical Mechanics, Louis N. Hand and Janet D. Finch, CUP (1998).
9. Classical. Mechanics, N. C. Rana and P. S. Joag, Tata-McGraw Hill(1994).
10. Foundations of Classical Mechanics, P. C. Deshmukh, CUP (2019).

Assessment Method: Written examination and assignments

Any need for revision of existing rules: No

PHY 403: QUANTUM MECHANICS I [Credits 4, 3-1-0]

Course Outcomes: After completing this course, students will

- Feel comfortable in the process of solving the quantum mechanical eigenvalue problems (CO-1).
- Digest the connection between measurement results and the uncertainty relation (CO-2).
- Realize the meaning of wave function in quantum mechanics (CO-3).
- Appreciate the amazing power and surprises of quantum mechanics in problems like free particle and particle in a potential (CO-4).
- Recognize the applicability of angular momenta in several branches of physics (CO-5).

Mapping of Course Outcomes (COs) with Program Outcomes (POs):

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	**3**	**1**	**3**	**1**	**1**	**3**
CO-2	**3**	**1**	**3**	**2**	**2**	**3**
CO-3	**3**	**1**	**3**	**3**	**2**	**3**
CO-4	**3**	**1**	**3**	**2**	**3**	**3**
CO-5	**3**	**1**	**3**	**3**	**3**	**3**

Course description:
In the beginning few years of the last century, it was realized that the well profound classical mechanics fails to explain many experimental outcomes. To overcome such limitations and difficulties, an alternative theory of what we call Quantum Mechanics was proposed. This theory is essential to study a variety of modern physics subjects such as atomic, molecular, nuclear, particle physics. It has broad and rich applicability in condensed matter physics and also in chemistry.

Course Objectives: The course covers the program outcomes from PO-1 to PO-4.

This course facilitates students to

- Learn mathematical tools needed to develop the formal theory of quantum mechanics.
- Understand the measurement process in quantum mechanics.
- Study time-independent and time-dependent Schrodinger wave equations.
- Solve a one-dimensional Schrodinger equation for simple problems.
- Develop theory of angular momenta and to learn to add them.

Syllabus

Vector Spaces in Quantum Mechanics

Dirac notation, Vector Spaces, Bases, Dimension, Subspaces, Dual spaces, Inner product spaces, Orthonormality and Completeness. Linear operators, Matrix representations, Change of basis, Eigenvalues and Eigenkets, Degeneracy, Complete sets of commuting observables.

Fundamental Concepts

Measurement, compatible and incompatible observables, uncertainty relation. Position operator and position eigenkets, momentum operator and momentum eigenkets. Wave functions in position and momentum space. Wave packets.

Quantum Dynamics

Time-Evolution and the Schrodinger Equation, the Schrodinger versus the Heisenberg Picture. Simple harmonic oscillator-energy eigenkets and energy values, time development, coherent state. Schrodinger's Wave Equation, interpretations of the wave function, the classical limit.

Solutions to Schrodinger Wave Equation

Free Particles, Piecewise Constant Potentials in One Dimension (one-dimensional box, square-well potential, potential barrier, potential step, symmetrical double-well potential, periodic potentials), Transmission and Reflection, Central potential: spherical harmonics, radial solution, hydrogen-like atoms.

Theory of Angular Momentum

Rotations and angular momentum, eigenvalues and eigenstates of angular momentum, spin and orbital angular momenta, addition of angular momenta, Tensor operators and Wigner-Eckart theorem, Pauli matrices and spinors.

Prerequisites: B.Sc level knowledge of quantum mechanics is required.

Text Books and Reference Books:

1. F. W. Byron and R. W. Fuller, The Mathematics of Classical and Quantum Physics, Dover.
2. J. J. Sakurai, Modern Quantum Mechanics, Second Edition, Pearson.
3. R. Shankar, Principles of Quantum Mechanics, Second Edition, Springer.
4. E. Merzbacher, Quantum Mechanics, Third Edition, Wiley.
5. K. Gottfried, Quantum Mechanics, Second Edition, Springer.
6. A. Messiah, Quantum Mechanics (Vol. I & II), Dover Publications Inc.
7. Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe, Quantum Mechanics (Vol. I & II), Wiley.
8. Richard P. Feynman, The Feynman Lectures on Physics (Vol. III), Pearson.

9. L. D. Landau and E.M. Lifshitz, Quantum Mechanics, Third Edition, Butterworth-Heinemann.
10. Leonard I. Schiff, Quantum Mechanics, Fourth Edition, McGraw Hill Education.
11. Weinberg, Lectures on Quantum Mechanics, Second Edition, Cambridge University Press.
12. P. A. M. Dirac, The Principles of Quantum Mechanics, Fourth Edition, Oxford University Press.

Assessment Method: Written examination and assignments.

Any need for revision of existing rules: No

PHY 404: General Physics Lab [Credits 4, 0-0-4]

Course Outcomes:

At the end of this laboratory course, the students will be capable of handling sophisticated instruments besides learning the Physics concepts behind these experiments

Course level: Introductory

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**3**	**2**	**3**	**3**	**3**

Course Description:
The aim of this laboratory course is to make the students understand the usage of basic laws and theories to determine various properties of the materials and gain knowledge regarding the underlying Physics to pursue solutions for various problems.

Course Objectives

The aim of this laboratory course is to make the students perceive some of the fundamental laws of Physics through experiments.

Syllabus:

1. To determine the wavelength of sodium light using Michelson Interferometer.
2. Solar cell
   a. Recording the current-voltage characteristic point by point and measuring the open-circuit voltage U_o and the short circuit IS for various values of the irradiance
   b. Determine the power P supplied as a function of the load resistance R for various values of the irradiance
   c. Determine the maximum power P_{max}, the associated load resistance R_{max} and the fill factor.
3. Study of Hall Effect in a semiconductor and determination of all its parameters.
4. Curie-Weiss Law Experiment
   a. Temperature dependence of the capacitance of a ceramic capacitor
   b. Verification of Curie-Weiss Law for the Electrical susceptibility of a Ferroelectric material.
5. To Study the BH curve in ferromagnetic material.
6. Dielectric Constant & Dipole Moment:
   a. To determine dielectric constant of a nonpolar liquid
   b. Dipole moment of an organic molecule Acetone
7. Electron diffraction
   a. Determine the wavelength of the electrons.
   b. Verification of de Broglie's equation.

Prerequisite to take the course: BSc with Physics as one of the subjects

Text Books:

1. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
2. Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint
3. BSc Practical Physics, GeetaSanon, R. Chand & Co
4. Advanced Practical Physics vol.1 – SP Singh (Pragati prakashan).

Assessment Method: Record writing, viva and final exam

Any need for revision of existing rules: No

PHY 405: Classical Electrodynamics [Credits 4, 3-1-0]

Course Outcomes:

- The students will be capable of understanding the underlying Physics behind telecommunication
- This course will lay the foundation for the modern optics and photonics, ionosphere
- The students will be able to analyze different radiative systems such as electric dipole, magnetic dipole, electric quadrupole and their importance and dominance over each other.
- The students will havebasic understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration.
- Students will be prepared enough to understand advances courses relativistic quantum field theory

Course Level: Mastery

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

Course Description:

This course covers the basic principles and phenomenon involved of electric and magnetic fields and their combined time varying effects. The equations of Maxwell that condense elegantly the vast experimental findings of Michael Faraday, his predecessors, and contemporaries, on electricity and magnetism constitute the course on electrodynamics. Further, it covers the propagation of electromagnetic waves under different media such as dielectric, metal, etc. and study their behavior during reflection and refraction coefficients at the interface and waveguides. The invariance of Maxwell's equations under Lorenz transformation provided the key to the special theory of relativity of Albert Einstein.

Course Objectives

- To make the students learn about the unification of forces
- To give students the insights of Maxwell equations and their importance for the development of Electromagnetic theory.
- To make students learn how to solve different complex numerical problems based on Maxwell's equation and Electromagnetic waves.
- To make the students understand the propagation behavior of electromagnetic radiation in different media

Syllabus:

Review of Electrostatics and Magnetostatics:
Coulomb's law, concept of fields, electrostatic energy, Poisson and Laplace equations, formal solution for potential with image method and Green's function method, boundary value problems, multipole expansion, Biot-Savart law, differential equation for static magnetic field,vector potential, magnetic field from localized current distributions, Faraday's law of induction, energy densities of electric and magnetic fields.

Maxwell's Equations
Maxwell's equations in different mediums, Vector and Scalar potentials in electrodynamics, gauge invariance and gauge fixing, Coulomb and Lorenz gauges. Displacement current. Electromagnetic energy and momentum, Poynting Theorem. Conservation laws.

Electromagnetic Waves
Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces. Fresnel's Formula, Change of phase on reflection, Polarization on reflection and Brewster's law, Total Internal reflection. Wave equation in conducting medium, reflection and transmission at metallic surface, skin effect and skin depth. Frequency dispersion in dielectrics and metals. Dielectric constant and anomalous dispersion. Wave propagation in one dimension, group velocity. Wave guides, propagation modes in waveguides, resonant modes in cavities. Dielectric waveguides.
Radiation
EM Field of a localized oscillating source. Fields and radiation in dipole and quadrupole approximations. Antenna; Radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.

Prerequisites: Knowledge about Vector Algebra, Differential equations, Optics

Text Books and reference Books:

1. Classical Electrodynamics, by J.D. Jackson, Wiley India Pvt. Ltd (2007)
2. Introduction to Electrodynamics, byD.J. Griffiths, Cambridge University Press, 4th Ed. (2017)
3. Electromagnetic Fields and Waves, by P. Lorrain, and D. Corson, CBS Publishers (2003)
4. Principles of Electromagnetics, by Matthew N. O. Sadiku, S.V. Kulkarni, Oxford University Press;Sixth edition
5. Electromagnetic Waves, by R K Shevgaonkar, McGraw Hill Education; first Edition
6. Foundations of Electromagnetic Theory, by J.R. Reitz, F.J. Milford and R.W. Christy, Addison Wesley Publisher; 4 edition (1992)

Assessment Method: Written and Assignments

Any need for revision of existing rules: No

PHY 406: QUANTUM MECHANICS II [Credits 4, 3-1-0]

Course Outcome:

After completing this course, students will

- Know the connection between symmetries, degeneracies, and conservation laws.
- Differentiate between classical and quantum identical particles.
- Appreciate the profound strength of approximate methods in problems like Stark effect, Zeeman effect, etc.
- Understand the scattering processes that take place in atomic, subatomic, and molecular systems.
- Get basic information needed for advanced courses like quantum field theory.

Mapping of Course Outcomes (COs) with Program Outcomes (POs):

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	**3**	**1**	**3**	**3**	**3**	**3**
CO-2	**3**	**1**	**3**	**3**	**3**	**3**
CO-3	**3**	**1**	**3**	**3**	**3**	**3**
CO-4	**3**	**1**	**3**	**3**	**3**	**3**
CO-5	3	1	3	3	3	3

Course Description:
In the beginning few years of the last century, it was realized that the well profound classical mechanics fails to explain many experimental outcomes. To overcome such limitations and difficulties, an alternative theory of what we call Quantum Mechanics was proposed. This theory is essential to study a variety of modern physics subjects such as atomic, molecular, nuclear, particle physics. It has broad and rich applicability in condensed matter physics and also in chemistry.

Course Objectives

This course facilitates students to

- Study continuous and discrete symmetries and their consequences.
- Know about identical quantum particles and their wavefunctions.
- Learn various approximation techniques of solving the quantum mechanical problems.
- Develop the theory of scattering processes.
- Learn elementary aspects of relativistic -quantum mechanics.

Syllabus

Symmetry in Quantum Mechanics
Symmetries, conservation laws, and degeneracies. Space-translation, Time-translation, Parity (or space inversion), and Time-Reversal symmetries.

Identical Particles
Permutation symmetry, symmetrization postulate, two-electron system, the Helium atom, permutation symmetry and Young tableaux.

Approximation Methods
The variational and WKB methods, time-independent perturbation theory (non-degenerate and degenerate).Dirac-picture, time-dependent perturbation theory. Sudden and Adiabatic approximations.

Scattering Theory
Lippmann-Schwinger equation, Born approximation, optical theorem. Free-particle states: plane wave versus spherical waves. Method of partial waves, low-energy scattering and bound states, resonance scattering.

Relativistic Quantum Mechanics
Klein-Gordon equation, Dirac equation, Symmetries of the Dirac equation, Dirac's equation for a Central Potential.

Prerequisites: Quantum Mechanics **I**

Text Books and Reference Books:

1. F. W. Byron and R. W. Fuller, The Mathematics of Classical and Quantum Physics, Dover.
2. J. J. Sakurai, Modern Quantum Mechanics, Second Edition, Pearson.
3. R. Shankar, Principles of Quantum Mechanics, Second Edition, Springer.
4. E. Merzbacher, Quantum Mechanics, Third Edition, Wiley.
5. K. Gottfried, Quantum Mechanics, Second Edition, Springer.
6. A. Messiah, Quantum Mechanics (Vol. I & II), Dover Publications Inc.
7. Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe, Quantum Mechanics (Vol. I & II), Wiley.
8. Richard P. Feynman, The Feynman Lectures on Physics (Vol. III), Pearson.
9. L. D. Landau and E.M. Lifshitz, Quantum Mechanics, 3rd Edition, Butterworth-Heinemann.
10. Leonard I. Schiff, Quantum Mechanics, Fourth Edition, McGraw Hill Education.
11. Weinberg, Lectures on Quantum Mechanics, Second Edition, Cambridge University Press.
12. P. A. M. Dirac, The Principles of Quantum Mechanics, 4th Edition, Oxford University Press.

Assessment Method: Written examination and assignments

Any need for revision of existing rules: No

PHY 407: CONDENSED MATTER PHYSICS [Credits 4, (L-T-P: 3-1-0)]

Course Outcome: At the end of this course, the students will be able to

- learn about various crystal structures and how we determine a crystal structure by X-Ray diffraction experiments
- explain the thermal properties of solids, specifically the heat capacity
- understand general mechanisms to study electronic properties in crystalline materials (metals and semiconductors)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**
CO2	**3**	**1**	**3**	**3**	**3**	**3**
CO3	**3**	**1**	**3**	**3**	**3**	**3**

Course Description:

Condensed matter physics (CMP) is undoubtedly the most important area of research which often uncover the phenomena that are converted to technology, in particular solid-state device technology used in various fields of sciences. The theoretical basis for CMP comes from quantum mechanics and statistical mechanics. This course introduces the basic concepts of crystal structure analysis and how X-ray diffraction patterns helps us to determine the lattice structure of various crystalline materials. It also discusses how the electrons move in these crystalline solids to give rise to the metallic, semiconducting and insulating behavior. Moreover, the dynamic behaviour of the electron and lattice is presented.

Course Objectives:

- To use quantum mechanics in explaining the peculiar behaviour of materials
- To describe how X-Ray diffraction experiments help us to determine the crystal structures
- To make the students understand various exotic properties of materials under different length scales
- To give basic formalism of how electrons behave in crystalline materials to give rise various electronic (e.g, conductivity) and thermal properties (e.g, heat capacity)

Syllabus

Metals

Drude theory, DC conductivity, Hall effect and magneto-resistance, AC conductivity, thermal conductivity, thermo-electric effects, Fermi-Dirac distribution, thermal properties of an electron gas, Wiedemann-Franz law, critique of free-electron model.

Crystal Lattices

Bravais lattice, symmetry operations and classification of Bravais lattices, common crystal structures, reciprocal lattice, Brillouin zone, X-ray diffraction, Bragg's law, Von Laue's formulation, diffraction from non-crystalline systems.

Classification of Solids

Band classifications, covalent, molecular and ionic crystals, nature of bonding, cohesive energies, hydrogen bonding.

Electron States in Crystals

Periodic potential and Bloch's theorem, weak potential approximation, energy gaps, Fermi surface and Brillouin zones, Harrison construction, level density.

Electron Dynamics

Wave packets of Bloch electrons, semi-classical equations of motion, motion in static electric and magnetic fields, theory of holes.

Lattice Dynamics
Failure of the static lattice model, harmonic approximation, vibrations of a one-dimensional lattice, one-dimensional lattice with basis, models of three-dimensional lattices, quantization of vibrations, Einstein and Debye theories of specific heat, phonon density of states, neutron scattering.

Semiconductors
General properties and band structure, carrier statistics, impurities, intrinsic and extrinsic semiconductors, p-n junctions, equilibrium fields and densities in junctions, drift and diffusion currents.

Prerequisites: Basic quantum mechanics

Reference Books:

1. C. Kittel, Introduction to Solid State Physics, Wiley; Eighth Edition (2012)
2. N.W. Ashcroft and N.D. Mermin, Solid State Physics, Brooks/Cole, New Edition (1976)
3. J.M. Ziman, Principles of the Theory of Solids, Cambridge University Press; Second Edition (2018)
4. A.J. Dekker, Solid State Physics, Laxmi Publications (2008)
5. G. Burns, Solid State Physics, Academic Press Inc; Illustrated Edition (1985)
6. M. P. Marder, Condensed Matter Physics, Wiley; 2nd Edition (2015)

Assessment Method: written, viva, seminar, assignment

Any need for revision of existing rules: No

PHY 408: COMPUTATIONAL PHYSICS LAB [Credits 4, 0-0-4]

Course Outcome:

At the end of this laboratory, the students will be capable to use numerical ideas in diverse areas such as biological systems, economics, nonlinear dynamics

Course Level: Mastery

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3

Course Description: To make the students learn essential aspects of a programming language, numerical techniques and their applications in a variety of Physics problems.

Course Objectives:

- To acquire the proficiency in effectively using the GUI Windows, the LINUX operating system and also in using the LaTeX software for writing a text file.
- To highlights the use of computational methods to solve physical problems
- Uses of computer languages (Fortran/C/C++/Python)
- Hands on training on Problem solving on Computers.
- To find the roots of a polynomial equation.

Syllabus

An essential introduction to a programming language
Introduction to any one of the programming languages in Fortran/C/C++/Python.

Root-finding and numerical integration
Root-finding methods: bisection method, Newton's method, Newton's method and shooting, steepest descent. Basic integration schemes, stochastic methods for multi-dimensional integrals.

Numerical solutions of differential equations
The Verlet method, Runge–Kutta methods, classical equation of motion, systems with chaotic dynamics.

Monte-Carlo simulations and Molecular Dynamics in statistical mechanics
The Metropolis algorithm for equilibrium statistical mechanics, studies of the phase transition in the Ising model of magnetism, cluster algorithms, molecular dynamics.

Numerical solutions of quantum mechanical problems
Eigenstates of the Schrodinger equation, time-evolution of wave-packets, quantum spin systems (ground state and finite-temperature properties).

Prerequisites: Knowledge of any computer languages

Text Books and Reference Books:

1. Michael Metcalf, John Reid, and Malcolm Cohen, Modern Fortran Explained: Incorporating Fortran 2018, Oxford University Press.
2. Bjarne Stroustrup, The C++ Programming Language (4th Edition), Addison-Wesley.
3. John M. Stewart, Python for Scientists (2nd Edition), Cambridge University Press
4. W. H. Press and S. A. Teukolsky, Numerical Recipes (3rd Edition), Cambridge University Press.
5. Werner Krauth, Statistical Mechanics: Algorithms and Computations, Oxford University Press.

6. J. M. Thijssen, Computational Physics (2nd Edition), Cambridge University Press.
7. Joel Franklin, Computational Methods for Physics, Cambridge University Press.
8. N. J. Giordano and H. Nakanishi, Computational Physics (2nd Edition), Addison-Wesley.
9. R. H. Landau et al., Computational Physics: Problem Solving with Computers, Wiley-VCH.
10. D. P. Landau and K. Binder, A Guide to Monte Carlo Simulations in Statistical Physics (4th edition), Cambridge University Press.

Assessment Method: Written examinations and assignments

Any need for revision of existing rules: No

PHY 409: ADVANCED PHYSICS LAB [Credits 4, 0-0-4]

Course Outcome:

At the end of this laboratory course, the students will be capable of handling sophisticated instruments besides learning the Physics concepts behind these experiments

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**3**	**3**	**3**	**3**

Course Description:

The aim of this laboratory course is to make the students perceive some of the fundamental laws of Physics through experiments and gain knowledge regarding the underlying Physics to pursue solutions for various problems. This course introduces some advanced experiments related to Optics, Condensed Matter, Atomic and Nuclear Physics.

Course Objectives

The aim of this laboratory course is to make the students perceive some of the advanced laws of Physics through experiments.

Syllabus

1. Light Runner
   a. To study the length dependence of attenuation in the given optical fiber at different wavelengths.
   b. To determine the relationship between the laser current and output power and hence find out the threshold laser current.
   c. To check the linearity between laser optical power and its monitor diode.
2. Measurement of magnetic susceptibility of paramagnetic solution by Quincke's method.
3. To investigate the attenuation of x-rays as a function of the absorber thickness and absorber material.
4. Solar (V-I)
   a. To demonstrate the I-V and P-V characteristics of PV modules with varying radiation and temperature level.
   b. To demonstrate the I-V and P-V characteristics of series and parallel combination PV modules.
   c. To demonstrate the working of diode as bypass diode and blocking diode.
5. Zeeman Effect
   a. Using the Fabry–Perot interferometer and a self made telescope and the splitting up of the central line into two sigma lines is measured in wavenumber as a function of the magnetic flux density.
   b. Bohr magneton
6. To determine the wavelength of the most intense spectral lines of Helium and calculation of Rydberg Constant.
7. To find the resistivity and energy band gap of silicon semiconductor using four probe method.
8. Frank Hertz Experiment.
9. Radioactivity using Geiger-Muller counter
   a. G.M. Counter - characteristics, Inverse square law.
   b. Measurement of dead time of a Geiger-Muller counter
   c. End point energy and Absorption coefficient using G.M. tube.
   d. G.M. Counter - Absorption coefficient.
10. Determination of Lande-g factor of a paramagnetic sample using electron spin resonance
11. Millikan's oil drop experiment for the determination of specific charge
12. Study the dependence of magneto-resistance on the applied magnetic field for a given sample
13. Calibrate a given thermocouple & determine the melting point of Sn-Pb (60:40) alloy
14. Ionic conductivity

Prerequisite to take the course: B.Sc with Physics as one of the subjects or PHY404 course

Text Books:

1. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
2. Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint
3. BSc Practical Physics, GeetaSanon, R. Chand & Co.
4. Advanced Practical Physics vol.1 – SP Singh (Pragati prakashan).

Assessment Method: Record writing, viva and final exam

Any need for revision of existing rules: NO

PHY 501: ATOMIC AND MOLECULAR PHYSICS [Credits 4, 3-1-0]

Course Outcome:

- To make the students understand Quantum mechanical phenomenon at the atomic and molecular level
- To make the students understand various couplings effects and selection rules
- To make the students understand about various absorption/emission spectroscopic transitions
- To make the students understand importance of Einstein coefficient for the development of LASER
- Understand the quantum based description of atomic and molecular systems.
- Understand the interaction of atomic and molecular energy level with electric and magnetic fields
- Acquire the basic understanding of ultraviolet-visible-infrared spectroscopy
- Justify the selection rules for various optical spectroscopies in terms of the symmetries of molecular vibrations
- Understand the spectroscopy of non-polar molecules using Raman effect
- Understand the phenomenon of spontaneous, stimulated emission and absorption in the two level system

Course Level: Mastery

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	1	3	3	3	3
CO6	3	2	3	3	3	3
CO7	3	2	3	3	3	3
CO8	3	2	3	3	3	3
CO9	3	2	3	3	3	3
CO10	3	2	3	3	3	3

Course Description: This course has been divided in two parts: (i) Atomic Physics and (ii) Molecular Physics. The first part deals principle of atomic structure, different energy levels in single and multi-electron atoms, coupling based atomic transitions, interaction of atomic spectra under the presence of different fields, while second parts deals with different degrees of freedom that includes rotational, vibrational and electronic, selection rules, Raman spectra and Einstein A and B coefficients.

Syllabus:

Atomic structure

Bohr's model, Bohr's correspondence principle, Wilson - Sommerfeld's quantization rules, energy level & spectra, Stern-Gerlach experiment for electron spin, Revision of quantum numbers, Pauli exclusion principle, electron configuration, Hund's rule.

Many-electron Atoms

Spin-orbit interaction- Hydrogen fine structure, Review of He atom, ground state and first excited state, Hartree and Hartree-Fock method, Periodic table and atomic properties: ionization potential, electron affinity.

Atomic spectra

Spectroscopic terms: L-S and J-J couplings, Many electron atoms, Spectra of Alkali and Alkaline earth elements, Hyperfine structure of spectral lines, selection rules, Zeeman effect, Stark effect, X-ray Spectra.

Molecular Spectroscopy

Types of molecular energy states, pure rotational spectra: rigid rotator, non-rigid rotator, vibrational-rotational spectra for diatomic molecules: harmonic oscillator, anharmonic oscillator, vibrating rotator, role of symmetry, selection rules, Raman spectra, Electronic spectra- Franck Condon principle.

Many-electron Atoms

Review of He atom, ground state and first excited state, quantum virial theorem, Thomas-Fermi method, determinantal wave function, Hartree and Hartree-Fock method, periodic table and atomic properties: ionization potential, electron affinity, Hund's rule.

Interaction of Atoms with Radiation

Atoms in an electromagnetic field, absorption and induced emission, spontaneous emission and line-width, Einstein A and B coefficients, two-level atoms in a radiation field.

Prerequisites:

Students must have done the course of Quantum Mechanics

Text Books:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, by Robert Eisberg &Robert Resnick, Wiley India, 2^{nd} Edition
2. Introduction to Atomic Spectra ,by H. E. White, McGraw Hill.
3. Perspectives of Modern Physics,by Arthur Beiser,McGraw Hill.

4. Molecular Spectra and Molecular Structure, by Gerhard Herzberg, KriegerPub Co.
5. Fundamentals o fMolecular Spectroscopy, by C. N. Banwell,TataMcGraw Hill, Fourth Edition (2017)
6. Physics of Atoms and Molecules, byB.H. Bransden and C.J. Joachain, Pearson, Second Edition, (2003)
7. Quantum Chemistry, byI.N. Levine, Pearson, Seventh Edition (2013)
8. Atoms and Molecules: An Introduction for Students ofPhysical Chemistry, byM. Karplus and R.N. Porter,
9. Quantum Theory of Many-Particle Systems, byL. Fetter and J. D. Walecka

Assessment Method: Written & Assignment

Any need for revision of existing rules: No

PHY 502: NUCLEAR AND PARTICLE PHYSICS [Credits 4, 3-1-0]

Course Outcome:

- Students will be enriched with the fundamental knowledge of the nucleus and its properties
- The principles behind the modern medical instruments such as nuclear magnetic resonances will be clear to the students
- Students will be enshrined in detail about the radiation hazards, peaceful use of nuclear energy and carbon dating for fossil's age determination
- The students will be able to do higher studies in this field. They may get employment opportunities in radiology and medical field

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	2	3	3	3	2	3
CO3	2	2	3	3	3	3
CO4	3	3	3	3	3	3

Course Description:

The nuclear and particle physics course is the fundamental course of physics. In the quest of knowing about the fundamental building blocks of the matter, scientists have gone through a sequence from atoms to nuclei, from nuclei to hadrons and from hadrons to quarks. The course, designed here for the M.Sc. Physics students incorporate several properties of the nucleus and their detailed deliberations.

Course Objectives

The objectives of the course are as under:

- To familiarize about the essential properties of the nucleus such as its shape, size, radius, density, magnetic moment, electric quadrupole moment etc.
- In order to probe these properties several models have been proposed such as liquid drop model, shell models, collective models
- The most useful part of this knowledge is nuclear energy which has immense applications. The concept behind this energy was first given by Hans Bethe in the form of a semi-empirical mass formula which is in the course content.
- Carbon dating, modern medical applications, radio-physics all require the knowledge of radio-activity. One complete unit is dedicated for this purposes
- It is a well-known fact that all kinds of interactions which we perceive in our life are essentially four in number viz. gravitational, electromagnetic, weak and strong. The ultimate aim of particle physics is to unify these interactions.

Syllabus

Size, shape, charge distribution, spin and parity, magnetic moments, Nuclear binding energy, Semi empirical mass formula, Liquid drop model, collective model, shell model, magic numbers and the independent particle model, Fermi gas model.

Characteristics of the force between two nucleons, Deuteron Problem, Nucleon Nucleon interaction, Meson theory of nuclear forces, Nucleon nucleon scattering, spin dependence of the nuclear forces, charge independence and charge symmetry of the nuclear forces,O-values and thresholds, nuclear reaction cross sections, examples of different types of reactions and their characteristics.

Alpha decay, Gamow theory of alpha decay, range of alpha particles, alpha spectra, Beta Decay, Pauli’s neutrino hypothesis, Fermi theory of beta decay, Detection and properties of neutrino, Gamma decay, Multipole Transition in nuclei- angular momentum and parity selection rules.

Classification of fundamental forces, Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, iso spin, strangeness; Gell Mann-Nishijima formula;negative energy solution and the concept of antiparticle.quark model,quark model interpretation, colour quantum number, C, P, and T invariance and applications of symmetry arguments to particle reactions, parity non conservation in weak interaction standard model.

Prerequisite:

It is expected from the students that they should have done a basic course on Atomic Physics, Quantum Physics/Modern Physics at undergraduate level.

Text Books:

1. Introduction to nuclear physics by K.S. Krane, John Wiley and Sons Publication, II Edition
2. Nuclear Physics by S. N. Ghoshal, S. Chand Limited Reprint Edition 2008
3. Nuclear physics by R Prasad Pearson, Pearson Edition India 2014
4. G.D. Coughlan and J.E. Dodd, The Ideas of Particle Physics, Cambridge University Press
5. D. Griffiths, Introduction to Elementary Particles, 3rd Edition, Wiley VCH
6. D.H. Perkins, Introduction to High Energy Physics Cambridge University Press 4th Edition 2000
7. R.R. Roy and B.P. Nigam, Nuclear Physics New Age Publishers 1996
8. M.A. Preston and R.K. Bhaduri, Structure of the Nucleus Avalon Publishing 1993
9. M.G. Bowler, Nuclear Physics, Elsevier, 1st Edition 1993

Assessment Method: Written & Assignment

Any need for revision of existing rules: No

PHY 503: STATISTICAL MECHANICS [Credits 4, 3-1-0]

Course Outcome:

At the end of the course a student would be able to competently employ a whole host of formalisms of statistical mechanics to a variety of problems in physics, chemistry, biology, computer science, economics and several other disciplines.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	3

Course Level: Reinforce

Course Description:

The time asymmetry in the behavior of macroscopic bodies is captured in thermodynamics by the property called entropy; we have the inevitable entropic arrow of time. Contrast this with the time reversal invariance of microscopic laws be it classical or quantum mechanics, or electrodynamics. In the synthesis of macroscopic objects from its microscopic ingredients when and how does time asymmetry emerge? Ludwig Eduard Boltzmann answered this question by interpreting entropy, completely in terms of probabilities. After all, irreversibility is natural to a probabilistic evolution. Thus was born the subject of statistical mechanics which developed quickly and acquired certain robustness with the work of Josiah Willard Gibbs, James Clerk Maxwell and Albert Einstein.

Course Objectives

The methods of statistical ensembles and partition sums are very specific to the subject of Statistical Mechanics. An aim is to introduce the methodologies to the students so that they can apply it to the problems not only in statistical mechanics but in other fields also. A case in point is the method of ensemble which has been carried over to Quantum Mechanics to provide an *Ad hoc* description of Quantum measurements

Syllabus

Brief review of thermal Physics

Extensive and intensive variables, laws of thermodynamics, entropy and Gibbs paradox, Legendre transformation, thermodynamic potentials, chemical potential, Jacobian determinant, Maxwell's relations and their applications.

Statistical description of many-particle systems

Binomial, Gaussian, and Poisson distributions, central limit theorem. Phase space, Liouville's theorem. Microstates and macrostates, statistical ensemble, statistical postulates, probability calculations, accessible states, constraint, equilibrium, irreversibility.

Equilibrium statistical mechanics

Microcanonical ensemble. Canonical ensemble: Boltzmann factor, Boltzmann distribution, canonical partition function and thermodynamic quantities, energy fluctuations, applications of canonical ensemble. Grand canonical ensemble: Gibbs factor, Gibbs distribution, grand partition function and thermodynamic quantities, particle number fluctuations, applications of grand canonical ensemble. Equipartition theorem: proof of the theorem, applications, specific heat of solids. Maxwell–Boltzmann statistics.

Quantum statistics
Bosons: occupation number, Bose-Einstein statistics, specific heat of solids (Einstein model and Debye theory), black-body radiation, Bose-Einstein condensation. Fermions: occupation number, Fermi-Dirac statistics, degenerate Fermi gas.

Phase equilibria and phase transitions (Qualitative treatment)
Equilibrium condition, phase diagrams of some simple systems, Clausius-Clapeyron equation, critical point, first order and second order phase transitions, Ising model.

Prerequisite to take the course: B.Sc. with Physics as one of the subjects

Text Book and Reference Book:

1. Frederick Reif, Fundamentals of Statistical and Thermal Physics, McGraw-Hill (1965).
2. Mehran Kardar, Statistical Physics of Particles, Cambridge University Press (2007).
3. Daniel V. Schroeder, An Introduction to Thermal Physics, Addison Wesley Longman (2000).
4. R. K. Pathria and Paul D. Beale, Statistical Mechanics, Academic Press (2011).
5. L. D. Landau and E. M. Lifshitz, Statistical Physics, Third Edition, Part 1: Volume 5, Pergamon Press (1980).
6. Kerson Huang, Statistical Mechanics (Second Edition), Wiley India (2011).
7. Harvey Gould and Jan Tobochnik, Statistical and Thermal Physics: With Computer Applications, Princeton University Press (2010).
8. James P. Sethna, Statistical Mechanics: Entropy, Order Parameters and Complexity,Oxford University Press (2006) .
9. S. K. Ma, Statistical Physics, World Scientific Publishing, Singapore, (1985).

Assessment Method: Written, assignments and final exam

Any need for revision of existing rules: No

PHY 504 ELECTRONICS [Credit 3 (L T P: 3-0-0)]

Course Outcome:

- At the end of this course, the students will be able to understand the fundamentals behind analog and digital devices.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**2**	**3**	**3**	**3**

Course Description:

This course has been designed keeping in mind the importance of ever increasing usage of electronic devices in our day-to-day life. The course will impart knowledge of the fundamental components and parts used in electronic devices. This is an ability enhancement (AE) or skill development (SD) course to cater the need of skill India, a flagship program of the Government of India.

Course Objectives:

- To make the students familiar about the concepts of components used in various electronic devices
- To make the students learn the basics of digital electronics which will be useful to them in understanding the concept behind digital world

Syllabus:

Semiconductor devices: p-n junction diodes and its I-V characteristics, p-n-p-n devices, clipper and clamper circuits, Optoelectronic devices: light-emitting diodes, solar cells, photo-detectors,

Field effect devices: JFET and MOSFET transistors, Bipolar Junction transistor: transistor as an amplifier, stability factor, different gain stabilizing circuits, emitter follower, switching action of a transistor, multivibrators using transistors: astable, monostable and bistable multivibrators, oscillators devices using transistors: Colpitt, Hartley phase shift, Wein bridge oscillators.

Differential amplifier: its structure and working, common mode- and differential-gain, common mode rejection ratio, Operational amplifier (OP-amp): OP-amp characteristics, inverting and non-inverting amplifiers, OP-amp feedback parameters, OP-amp applications including summer, subtractor, multiplier, divider, integrating and differential circuits, voltage follower, Instrumentation amplifier, log and antilog amplifiers, op-amp as comparator, Schmitt trigger, voltage to current and current to voltage conversions, filters using OP-amp. Basic D to A conversion: weighted resistor, DAC binary R-2R ladder, basic A to D conversion, 555 timer IC and its applications

Number systems-binary, octal, decimal, hexadecimal and their conversion from one to another, Boolean algebra, de-Morgan's theorem, Karnaugh mapping, multiplexers, combinational and sequential circuits, flip-flops, Counters, Registers, introduction to microprocessors and microcontrollers

Assessment Method:

The course consists of two continuous internal assessments (C.I.A.) and one end of semester examination (EoSE). Each C.I.A. would be of 20 marks and the EoSE would be of 60 marks. First C. I.A. will be in the form of written examination while the second C.I.A. will be in the form of a surprise test, quiz or classroom presentation as decided by the course instructor.

Any need for revision of existing rules: No

PHY 505 ELECTRONICS LAB [Credit 2 (L T P: 0-0-2)]

Course Outcome:

- The students are trained enough in handling various electronic equipments

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**2**	**3**	**3**	**3**

Course Description:

This course has been designed keeping in mind the importance of ever increasing usage of electronic devices in our day-to-day life. The course will provide hands-on practice of various components and parts used in electronic devices. This is an ability enhancement (AE) or skill development (SD) course to cater the needs of skill India, a flagship program of the Government of India.

Course Objective:

- To train the students to perform hand-on experiments in the laboratory

Syllabus:

1. Transistor as a feedback amplifier
2. Learning of various OP-amp applications
3. Learning of various Flip flops
4. Learning of counters
5. Learning of registers
6. Multiplexers and demultiplexers
7. Multivibrators using transistor and 555 timer IC
8. Learning operation of multimeter, digital oscilloscope etc.

Prerequisite of the Course: Graduation level knowledge of electronics

Text Book and Reference Book:

1. Electronic Devices and Circuit theory, R. L. Boylestad, L. Nashelsky, Pearson publication
2. Electronic Devices Electron flow version, T. L. Floyd, Pearson publication
3. Principles of electronic materials and devices, S. O. Kasap, McGraw Hill publication
4. Electronic Principles, A. P. Malvino, McGraw Hill
5. Physics of Semiconductor Devices, S. M. Sze, Wiley publication
6. Digital Principles and Applications, A. P. Malvino, D. P. Leach, McGraw Hill publication
7. Digital fundamentals, T. L. Floyd, Pearson publication
8. Digital Electronics: Principles and Integrated Circuits, A. K. Maini, Wiley publication

Assessment Method:

The course consists of performing 8 experiments by the students. Each student will have to give a viva examination to the instructor at the completion of each practical along with the complete lab record of the practical. The instructor will judge the performance of the student and will give marks out of 5. Thus eight practicals will carry 40 marks. The EoSE of the practicals will consist of performing one practical and giving viva to the examiner. This will consist of 60 marks.

Any need for revision of existing rules: No

PHY 507: D-Internship/Summer P/PBL [2 credits]

Course Outcome:

Internship will provide the insights of the research field, uses of research methodologies and interpretation of research data to a learner. The successful completion of the internship work will lead the students in future research work.

Course Outcomes: The course covers the program outcomes from PO-2 to PO-4

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**3**	**3**	**3**	**3**	**3**

Level: Introductory

Course Description: The internship enables the students to use the theoretical knowledge /concepts to solve the real world problems. The internship enables the students to learn new ideas and research methodologies in a particular field.The technical writing skills can be improved by doing an internship.

Course Objective

- The aim of the internship is to develop analytical skill and critical thinking in the fields of Physical sciences.
- Study the basic concepts of programming
- To conduct a literature survey on a preferred field of study.
- To get familiar with software and hardware used for research

Prerequisites: Students must have completed the first two semesters.

Assessment Method: As per university Ordinance

Annexure-II

DISCIPLINE SPECIFIC ELECTIVES (DSE)
M.Sc. and Pre-PhD

1.	Materials Science	PHY 601	3
2	Advanced Computational Physics	PHY 602	4
3	Fundamentals of Semiconductor	PHY 603	3
4	Fiber Optics: Fundamentals And Applications	PHY 604	3
5	Introduction to Dynamical Systems	PHY 605	3
6	Science & Technology Of Thin Films	PHY 606	3
7	Ferroelectric Materials and Devices	PHY 607	3
8	Magnetic and Superconducting Properties of Solids	PHY 608	3
9	Introduction to Fourier Optics	PHY 609	3
10	Monte Carlo-Theory And Practice	PHY 610	3
11	Semiconductor Devices and Technology	PHY 611	3
12	Nonlinear Dynamics And Chaos	PHY 612	3
13	Concepts of Laser Physics and Fiber Optics	PHY 613	3
14	Introduction to Plasma Physics	PHY 614	3
15	Introduction to Nanomaterials and Nanotechnology	PHY 615	3
16	Quantum Many-Body Physics	PHY 616	4
17	Theory Of Complex Networks And Applications	PHY 617	3
18	Computational Condensed Matter Physics	PHY 618	3
1.	Phase Transitions and Critical Phenomena	PHY 619	3
2.	Special Topics in Mathematical Physics	PHY 620	3
3.	Advanced Plasma Physics	PHY 621	3
4.	Concepts of Laser Physics and Fourier Optics	PHY 622	3
5.	Solid State Magnetism	PHY 623	3
6.	Functional Nanomaterials	PHY 624	3

PHY 601: MATERIALS SCIENCE [3 Credits (L T P: 3-0-0)]

Course Outcomes:

At the end of this course, the students will

- appreciate fascinating electrical properties of materials
- be equipped with the knowledge of synthesis and characterization of materials
- comprehend the applications of various applications

Program Outcome: The course covers the program outcomes from PO-2 to PO-6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	3	3
CO2	1	1	3	3	2	3
CO3	1	1	3	3	3	3

Course Level: Mastery

Course Description:

This course has been designed keeping in mind the importance of new materials synthesis and their applications. The course will impart knowledge of the different synthesis and characterization methods.

Course Objectives:

- To disseminate knowledge various electrical properties viz. dielectric, ferroelectric, piezoelectric and piezoelectric
- To impart knowledge of the synthesis and characterization of materials and their applications

Syllabus

Electrical Materials: Static dielectric constant, electronic, ionic and orientation polarizations, Internal or local fields in solid and liquids. Lorentz field in cubic materials, Clausius-Mosotti equation, complex dielectric constant, determination of dipole moment for polar substances, dielectric losses, frequency dependence of electronic, ionic, orientation polarizabilities, Ferroelectric and piezoelectric materials, classification of ferroelectric materials, dipole theory of ferroelectricity, ferroelectric domains, phase transitions, piezoelectric, pyroelectric materials and applications, responsivity, figures of merit. Temperature/infrared light sensors. Infrared image sensors.

Synthesis Methods: Physical Methods: Thermal evaporation deposition, pulsed laser deposition, sputtering, Chemical methods: sol-gel technique, hydrothermal and solvothermal technique, microwave synthesis.

Materials characterization techniques: scanning electron microscopy, transmission electron microscopy, atomic force microscopy, scanning tunneling microscopy, atomic absorption spectroscopy, differential scanning calorimetry, X-ray diffractometry,

Prerequisite of the Course: Graduation level Physics and basic knowledge of Chemistry

Text books and Reference books:

1. Principles and Applications of Ferroelectrics and Related Materials: M. E. Lines and A. M. Glass, Clarendon Press
2. Principles of Electronic materials and devices: S. O. Kasap, McGraw Hill publication
3. Ferroelectric Devices: K. Uchino, CRC Press
4. Electroceramics – Materials properties and Applications: A. L. Moulson and J. M. Herberh, Chapman & Hall
5. Materials Science and Engineering : An Introduction: W. D. Callister, Wiley publication
6. Introduction to Solid State Physics: C. Kittel, Wiley publication
7. Solid State Physics: A. J. Dekker, S. Chand publication
8. Electronic Processes in Materials: Azaroff and Brophy , McGraw Hill publication
9. Nanomaterials: Synthesis, Properties and Applications: A.S. Edelstein and R.C. Cmmarata, Institute of Physics Publishing, London

Assessment Method:

This course will consist of two continuous internal assessments (C.I.A.) and one End of semester examination (EoSE). Each C.I.A. would be of 20 marks and the EoSE would be of 60 marks. First C. I.A. will be in the form of written examination while the second C.I.A. will be in the form of a surprise test, quiz or classroom presentation as decided by the course instructor.

Any need for revision of existing rules: No

PHY 602: ADVANCED COMPUTATIONAL PHYSICS [Credits 4, 3-0-1]

Course Outcomes:

At the end of this course, the students will be capable to apply these computational algorithms to solve different complex problems in various fields

Program Outcomes: The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3

Course Objectives: Students will learn different computational algorithm to analyze the different computational problems

Syllabus

Monte Carlo Techniques

Basic theory, random number generation, Markov chain, Metropolis Algorithm, Applications to Statistical Mechanics, 1D and 2D Ising Model, Phase transitions.

Exact diagonalization

Large scale diagonalization techniques (Lanczosand Davidson) to calculate the lowest few eigenvalues and eigenvectors for large matrices, Introduction to strongly correlated systems, Hubbard model, t-J model, finite systems.

Optimization techniques

Local optimization techniques: conjugate gradient method, steepest descent method, global optimization techniques, simulated annealing, genetic algorithms, minima hopping method, applications to small systems with model potentials.

Molecular Dynamics

Introduction to classical molecular dynamics, Verlet algorithm, Microcanonical ensemble (NVE), Canonical ensemble (NVT), Isothermal-isobaric ensemble (NPT), calculation of standard averages, errors in measurement.

Parallel Computing

Theory and working principles, simplest coding techniques, algorithms and architectures.

Prerequisites: Knowledge of any computer languages

Text Books and Reference Books:

1. Harvey Gould, Jan Tobochnik, and Wolfgang Christian, Introduction to Computer Simulations Methods, Addison Wesley.
2. Mark E. J. Newman and G. T. Barkema, Monte Carlo Methods in Statistical Physics, Oxford University Press (OUP).
3. Daan Frenkel and Berend Smit, Understanding Molecular Simulations: From Algorithms to Applications, Academic Press.
4. W. H. Press and S. A. Teukolsky, Numerical Recipes (3rd Edition), Cambridge University Press.
5. Werner Krauth, Statistical Mechanics: Algorithms and Computations, OUP.
6. J. M. Thijssen, Computational Physics (2nd Edition), Cambridge University Press.
7. R. H. Landau et al., Computational Physics: Problem Solving with Computers, Wiley-VCH.
8. D. P. Landau and K. Binder, A Guide to Monte Carlo Simulations in Statistical Physics (4th edition), Cambridge University Press.
9. Avella, Adolfo, Mancini, Ferdinando (Eds.), Strongly Correlated Systems: Numerical Methods, Springer.
10. KálmánVarga and Joseph A. Driscoll,Computational Nanoscience: Applications for Molecules, Clusters, and Solids,Cambridge University Press.

Assessment Method: Written examination and assignments

Any need for revision of existing rules: No

PHY 603 FUNDAMENTALS OF SEMICONDUCTOR [Credit 3 (L T P: 3-0-0)]

Course Outcomes:

At the end of this course, the students will

- have sufficient knowledge of the structures and properties of various semiconductors
- appreciate the applications of semiconductors in real-life devices

Program Outcome: This course covers PO1 and PO4

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**1**	**1**
CO2	**2**	**1**	**3**	**3**	**1**	**1**

Course Description: This course is designed to impart knowledge of the semiconductor basics and their applications in devices

Course Level: Masters

Course Objectives:

- To disseminate the conceptual knowledge of the structure and various properties of semiconductors
- To make the students familiar about the differences between semiconductors, insulators and conductors
- To impart the knowledge of applications of semiconductors in various electronic devices

Syllabus

Crystal structure, density of states, basic concepts of energy bands in materials, electron-hole concepts, Intrinsic and extrinsic semiconductors, binary, quaternary and ternary semiconductors, donors and acceptors impurities, compensate doping, concept of forbidden gap, Fermi level and its dependency on doping concentration and temperature, Quasi Fermi levels, direct and indirect band gap semiconductors, wide bandgap semiconductors, degenerate and non-degenerate semiconductors, amorphous semiconductors, magnetic semiconductors, Hall effect in semiconductors

Equilibrium and non-equilibrium conditions, diffusion and drift of carriers, temperature dependence of conductivity of semiconductors, carrier concentration temperature dependence, drift mobility: temperature and impurity dependence, generation and recombination of carriers, minority carrier injection, minority carrier lifetime, optical properties of semiconductors, Einstein's relations, continuity equations and its solution, diffusion lengths, Ohmic and non-Ohmic contacts, different semiconductor contacts, metal-semiconductor contacts.

Growth techniques for semiconductors, p-n junction diode, depletion layer, I-V characteristics, reverse bias breakdown: Avalanche and Zener Breakdown; diode resistance, capacitance, Zener diode, tunnel diode, Schottky diode, bipolar junction transistors,; Optoelectronic devices: photodiodes, solar cells, light emitting diodes (LEDs), semiconductor laser diodes, pin diodes, impact avalanche and transit time (IMPATT) diodes; Bipolar Junction transistor (BJT): low frequency and high frequency transistor behaviour

Prerequisite of the Course: Graduation level Physics

Text Books and Reference Books:

1. Principles of Electronic materials and devices: S. O. Kasap, McGraw Hill publication
2. Principles of Semiconductor devices, B. Van Zeghbroeck, Internet Resources
3. Semiconductor Devices (Basic Principles): Jasprit Singh, Wiley Publisher
4. Semiconductor Devices (Physics and Technology): S. M. Sze and M. K Lee, Wiley Publisher
5. Semiconductor Physics and Devices: D. A. Neamen and D. Biswas, McGraw Hill Publication

6. Semiconductor Physics and Devices: S. S. Islam, Oxford Higher Education Publisher
7. Solid State Electronic Devices: B. G. Streetman and S. K. Banerjee, Pearson Education Publisher
8. Solid State Electronic Devices: D. K. Bhattacharya and R. Sharma, Oxford Higher Education Publisher

Assessment Method:
This course will consist of two continuous internal assessments (C.I.A.) and one End of semester examination (EoSE). Each C.I.A. would be of 20 marks and the EoSE would be of 60 marks. First C.I.A. will be in the form of written examination while the second C.I.A. will be in the form of surprise test, quiz or classroom presentation as decided by the course instructor.

Any need for revision of existing rules: No

PHY604: FIBER OPTICS: FUNDAMENTALS AND APPLICATIONS

[Credit 3 (LTP: 3-0-0)]

Course Outcomes:

- Students will have adequate knowledge of different characteristics of the optical fiber
- Beam guidance, numerical aperture, spot size will be conceptualized
- Students will learn the application of Maxwell's equations in the communication

Program Outcomes: PO 1- PO 5

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	1
CO2	2	1	3	3	3	1
CO3	2	1	3	3	3	1

Course description: This course is designed keeping in mind the important application of light in communication. It is believed that the course will infuse the basic knowledge of optical fiber and also develop the understanding of practical applications.

Course Objectives:

- To impart the knowledge of the fundamental concepts of fiber optics
- To familiarize about the application of optical fibers in optical communication techniques
- Generation and propagation of different fiber optic laser modes

Syllabus:
Fiber numerical aperture, Sources of signal attenuation and dispersion Step and graded index multimode fibers, including plastic fibers
LP modes in optical fibers: Single-mode fibers, mode cutoff and mode field modes in optical fibers: Single-mode fibers, mode cutoff and mode field diameter,
Pulse dispersion in single-mode fibers: dispersion-tailored and dispersion-compensating fibers Birefringent fibers and polarization mode dispersion.
Fiber bandwidth and dispersion management, Erbium-doped fiber amplifiers and lasers

Prerequisite:
It is expected from the students that they should have done a basic course on Optics at undergraduate level

Text Books and Reference Books:
1. Introduction to fiber optics: A. K. Ghatak and Thyagarajan, Cambridge University Press
2. Essentials in fiber optics: K Thyagarajan and A.K. Ghatak, Wiley Publication
3. Fiber Optics: J. C. Palice, 4th Edition, Pearson
4. Fiber Optics and optoelectronics: Gerd Keiser, McGraw Hill, 4th Edition
5. Fundamentals of Photonics: Saleh and Teech, Wiley
6. Fiber Optics Edited: B.P. Pal, Jonh Wiley, Newyork
7. Lasers: Theory and Applications K. Thyagarajan and A.K. Ghatak, Springer
8. Optical Electronics: A.K. Ghatak and K. Thyagarajan, Cambridge University Press

Assessment Method:
This course will consist of two continuous internal assessments (C.I.A.) and one End of semester examination (EoSE). Each C.I.A. would be of 20 marks and the EoSE would be of 60 marks. First C. I.A. will be in the form of written examination while the second C.I.A. will be in the form of surprise test, quiz or classroom presentation as decided by the course instructor.

Any need for revision of existing rules: No

PHY 605 INTRODUCTION TO DYNAMICAL SYSTEMS [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

At the end of the course, students will be

- Able to grasp the fundamentals concepts of nonlinear dynamics
- Capable to implement such phenomenon in society, science and engineering

Program Outcomes (PO): The course covers the program outcomes from PO-1 to PO-4.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	1	1
CO2	2	1	3	3	1	1

Course Level: Mastery

Course description:

This interdisciplinary course provides an introduction to nonlinear dissipative and Hamiltonian systems. The course concentrates on simple models of dynamical systems, and their relevance to natural phenomena. The content is structured to be of general interest to graduates in science and engineering.

Course Objectives:

- The main goal of the course is to introduce and describe the non-linear and chaotic phenomena in natural and engineering systems using a minimum background in physics and mathematics
- Understanding the applications of nonlinear phenomenon in society, science and engineering

Syllabus

Introduction: Physics of nonlinear systems, dynamical equation and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classifications, Poincare section and iterative maps

Dissipative Systems: One-dimensional noninvertible maps, iterative maps, period-doubling and universality, intermittency. Simple and strange attractors. Invariant measure, Lyapunov exponents, fractal geometry, generalized dimension and examples of fractals. Higher- dimensional systems: Henon map, Lorenz equations.

Hamiltonian Systems: Integrability, Liouville's theorem, action-angle variables, introduction to perturbation techniques, KAM theorem, Smale Horseshoes, area-preserving maps, concepts of chaos, and stochasticity

Prerequisite: students must have completed a course of classical mechanics.

Text and Reference Books:

1. Chaos in Dynamical Systems by E. Ott, Cambridge University Press, 2nd edition, 2002.
2. Nonlinear Dynamics and Chaos by S. H. Strogatz, CRC press; 2018.
3. Regular and Stochastic Motion by A. J. Lichtenberg and M. A. Lieberman, Springer; 2nd edition, 1992.
4. Chaos and Integrability in Nonlinear Dynamics by M. Tabor, Wiley-Blackwell, 1989.
5. Nonlinear Dynamics by M. Lakshmanan and S. Rajasekar, Springer, 2003.

Assessment Method: As per University Ordinance

Any need for revision of existing rules: No

PHY 606: SCIENCE & TECHNOLOGY OF THIN FILMS [Credit 3 (LTP: 3-0-0)]

Course Outcome:
At the end of this course, students will understand essential aspects of science and technology of thin film growth, advanced characterization techniques and their applications.

Program Outcomes: PO1-PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3

Course Descriptions:
Thin film technology is pervasive in applications like microelectronics, optics, magnetic, hard resistant coatings, micromechanics, etc. These applications need selective and controlled deposition thin films with desired physical properties. There are a vast number of deposition methods with their specific merits and demerits in terms of involved processes, film quality, substrate material limitations, expected film properties, scalability and cost.
This course will introduce a variety of thin film deposition methods and their limitations from applications points of view. Fundamentals related to nucleation and growth of thin films as well as characterization and applications are outlined.

Course Objectives:

- To impart the knowledge of thin films in modern technology
- To understand different physical and chemical fabrication approach of thin film
- To give the flavor of use of thin films in various potential applications

Syllabus

Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law;
Electron-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering - mechanisms and yield, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD- Ion plating, reactive evaporation, ion beam assisted deposition, Chemical Vapor Deposition - reaction chemistry and thermodynamics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, Sol-Gel and LB Techniques,

Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films, Epitaxy - homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors, Scope of devices and applications.

Prerequisites:
BSc with Physics as one of the subjects or a course on Materials Science or Nanotechnology

Text Book and Reference Book:

1. Milton Ohring, The Materials Science of Thin Films, academic Press Sanden, 1992
2. Kasturi L. Chopra, Thin Film Phenomena, McGraw Hill (NewYork), 1969
3. Donald L. Smith, Thin – Film Deposition: Principles and practice, Mc. Grow Hill, Inc. 1995
4. Kigotakawasa, MokotaKitabatke and HineakiAdadi,Thin Film Materials Technology, Shurtting of Compound Materials, Elsevier Science and Technology Book, (2004)
5. Renald M. Matten, Handbook of Physical Vapor Deposition (PVP) Processions,Norses Publication, 1998
6. John E. Mahan, Physical Vapor Deposition of Thin Film, John Wiley & Sons, 2000
7. D. M. Dolokin, M.K. Zwrow, Principles of Chemical Vapor Deposition, Kluwer Academic Publisher, Natterlande, 2003
8. Pradeep George, Chemical Vapor Deposition, VDM Verles Dr. Mueller E.K., 2007

Assessment Method: Written, assignments, seminar/term paper and final exam

Any need for revision of existing rules: No

PHY 607: FERROELECTRIC MATERIALS AND DEVICES [Credit 3 (L T P: 3-0-0)]

Course Outcomes: At the end of this course, the students will have sufficient knowledge of the fundamentals of various electric materials and their usage in devices

Program Outcomes: This course covers PO1 and PO4

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**1**	**1**

Course Description: The course is intended to impart the knowledge about various electric materials like dielectrics, ferroelectrics, piezoelectric and pyroelectrics, which are integral part of many modern devices.

Course Level: Masters

Course Objectives:

- To impart the basics of electric polarization and related phenomena
- To disseminate the knowledge of electric devices

Syllabus

Polarization, Macroscopic electric field, Local electric field at an atom, Dielectric constant and polarizability, Structural phase transitions, Classification of ferroelectric crystals, Displacive transitions, Soft optical phonons, Landau theory of the phase transition, Antiferroelectricity, Ferroelectric domains, Ferroelectric memory devices, Piezoelectricity, High permittivity dielectrics: Ceramic capacitors, Relaxor ferroelectrics, High permittivity, Diffuse phase transition, Dielectric relaxation.

Piezoelectric materials and properties, Figures of Merit, Pressure sensors, accelerometers, gyroscopes, Piezoelectric vibrators, piezoelectric resonance, equivalent circuits, ultrasonic transducers, Resonators/filters, Surface acoustic wave devices, Piezoelectric transformers, Piezoelectric actuators Pyroelectric materials, pyroelectric effect, responsivity, figures of merit. Temperature/infrared light sensors, Infrared image sensors.

Prerequisite of the Course: Graduation level Physics

Text Books and Reference Books:

1. Ferroelectric Devices: Kenji Uchino, CRC Press publication
2. Electrets: R. Gerhard, Springer
3. Electroceramics-Materials properties and Applications: A. L. Moulson and J. M. Herberh, Wiley publication

4. Principles and Applications of Ferroelectrics and Related Materials: M. E. Lines and A. M. Glass, Clarendon Press publication

Assessment Method:
This course will consist of two continuous internal assessments (C.I.A.) and one End of semester examination (EoSE). Each C.I.A. would be of 20 marks and the EoSE would be of 60 marks. First C.I.A. will be in the form of written examination while the second C.I.A. will be in the form of surprise test, quiz or classroom presentation as decided by the course instructor.

Any need for revision of existing rules: No

PHY 608: MAGNETIC AND SUPERCONDUCTING PROPERTIES OF SOLIDS
[Credit 3 (LTP: 3-0-0)]

Course Outcome:

At the end of this course, the students will
- learn the basic properties of various magnetic materials and their applications
- understand the basic theoretical models to explain the magnetic behaviours
- gain basic knowledge of superconducting materials.

Program Outcomes (PO): PO1, PO2, PO3, PO4, PO5

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	3	1

Course Description: Magnetic materials are one of fertile playground for understanding fundamental physics phenomena as well as tremendous practical applications from data storage to high-tech magnetic levitations. This course introduces the basic types of magnetic behaviours and the microscopic theories to explain these magnetic properties. This course also covers the basic properties of superconducting materials along with its theories (phenomenological and microscopic-BCS) to explain the conventional superconductivity. Finally, it touches upon the phenomena of high-Tc superconductors.

Course Objectives:

- To make familiar various types of magnetic materials and their interesting properties.
- To discuss the basic theoretical models to explain the magnetic properties
- To impart the basic knowledge of the exotic properties of superconducting materials along with the microscopic theory (BCS) to explain the conventional superconductors.

Level: Reinforce

Syllabus:

Magnetism: Free electron in external field: Landau levels, Pauli paramagnetism, Electrons in atoms: Diamagnetism, Larmour precession, atomic magnetic moments, paramagnetism, ideal magnetic gas, classical and quantum mechanical treatment. Magnetism in condensed phase: Ferromagnetic ordering, mean field theory, Electrostatic origin of magnetic interaction, magnetic properties of a two-electron system, Heitler-London theory, Heisenberg Hamiltonian, Ground state, excited states, Weiss Molecular field theory, Antiferromagnetism, Ferrimagnetism.

Magnons and dispersion relation for magnons, origin of domains and domain walls, coercive force, hysteresis, motion of domain walls, experimental methods to determine the magnetic susceptibility. Magnetism in small and nanoparticles, superparamagnetism, Magnetic resonance.

Superconductivity: The Meissner effect, D.C. resistivity, the heat capacity, flux quantization, Superconducting energy gap, coherence length, London penetration depth, (Landau Ginzburg formulation along with) BCs theory, Interacting Cooper pairs, the condensate, Type I and II superconductors. Tunneling, phase and momentum, Dc and Ac Josephson effects, SQUID, Introduction to high TC superconductors.

Prerequisite: Basic Condensed Matter Physics

Text Books and Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, (John Wiley and Sons), 8th Edition, 2012
2. Solid State Physics, N. W. Ashcroft and N. D. Mermin, (CBS Publishing Asia Ltd.).
3. Magnetism in Condensed Matter, S. Blundell (Oxford) 1st Edition, 2001.
4. Introduction to Magnetic Materials, B. D. Culity and C D Grahim (Wiley), 2nd Edition, 2008

Assessment Methods: Written, Seminar/Assignment/Viva

Any need for revision of existing rules: No

PHY 609: INTRODUCTION TO FOURIER OPTICS [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

On completion of this course the students will

- be capable to understand the fundamentals of Fourier optics and to analyze the rigorous theory of different kinds of optical wave propagation theory
- gain the advanced knowledge of the beam propagation theory and diffraction pattern
- understand the principles involved in the different components of optical filters and lenses used in communication systems.
- be trained enough to design different optical holographic masks

Program Outcomes: The course covers the program outcomes from PO-1 to PO-6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3

Course Level: Mastery

Course description:

This is an advanced level course that covers mathematical explanation of wave propagation through different optical elements and their underlying theory. Importance of Fourier theorem for basic understanding of light waves propagation. Designing of different optical apertures and analysis of their diffraction pattern.

Objectives:

- Rigorous understanding of recent intricate theories of Fourier transform, Hankel Transform, Fourier-Bessel Transform
- Physical interpretation of scalar diffraction theory and angular spectrum propagation method
- Fresnel and Fraunhofer diffraction theory and propagation of light beams through different optical systems

Syllabus:

Analysis of Two-Dimensional Signals and Systems

Fourier Analysis in Two Dimensions, Fourier Transform Theorems, Separable Functions, Hankel transforms, Functions with Circular Symmetry: Fourier-Bessel Transforms, Local Spatial Frequency and Space-Frequency Localization, Linear Systems, Transfer Functions, Two-Dimensional Sampling Theory, The Whittaker-Shannon Sampling Theorem.

Foundations of Scalar Diffraction Theory

The Rayleigh-Somrnerfeld Formulation of Scalar Diffraction Theory, The Angular Spectrum of Plane Waves: The Angular Spectrum and Its Physical Interpretation, Propagation of the Angular Spectrum, Effects of a Diffracting Aperture on the Angular Spectrum, The Propagation Phenomenon as a Linear Spatial Filter.

Fresnel and Fraunhofer Diffraction

The Fresnel Diffraction Approximation: Positive vs. Negative Phases, Accuracy of the Fresnel Approximation, The Fresnel Approximation and the Angular Spectrum; The Fraunhofer Diffraction Approximation, Examples of Fraunhofer Diffraction Patterns: Rectangular Aperture, Circular Aperture, Thin Sinusoidal Amplitude Grating, Thin Sinusoidal Phase Grating; Examples of Fresnel Diffraction Calculations: Fresnel Diffraction by a Square Aperture/Sinusoidal amplitude grating-Talbot Images

Wave-Optics Analysis of Coherent Optical Systems

A Thin Lens as a Phase Transformation, Fourier Transforming Properties of Lenses, Image Formation: Monochromatic Illumination, Analysis of Complex Coherent Optical Systems

Prerequisite: Student must have completed Optics Course

Text Books and References Books:

- Introduction to Fourier Optics: Joseph W. Goodman, The McGraw-Hill Companies Inc.
- The Fourier transform and its applications: R. N. Bracewell, McGraw-Hill, NY
- Fourier Optics and Computational Imaging: Kedar Khare, , Wiley Publications
- Linear systems, Fourier transforms, and optics: Jack D. Gaskill, Wiley Publications
- The Fourier transform and its applications to optics: P. M. Duffleux, John Wiley and Sons
- Diffraction, Fourier Optics, and Imaging: Okan K. Ersoy, John Wiley and Sons

Assessment Method:

Written and Assignments

Any need for revision of existing rules: No

PHY 610: MONTE CARLO-THEORY AND PRACTICE [Credit 3 (LTP: 3-0-0)]

Course Outcomes:
Students will acquire skills to simulate complex phenomenon on a computer and make useful inferences. These skills will be useful to them whatever be the career they embark on, after completing their studies in the university.

Program Outcomes: The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3

Course Level: Mastery

Course Descriptions:
Computational science has emerged as an important discipline along with the traditional ones: theoretical and experimental science. Amongst numerous computational methods, the technique of Monte Carlo simulation has gained importance, thanks to the phenomenal developments in computers. This course will teach the students not only of the theory behind Monte Carlo simulation methods but also of how to implement it on a variety of problems.

Course objectives
With the advent of modern computing machines which are fast and which have large memory, Monte Carlo methods have emerged as useful techniques to solve a variety of problems in physics, chemistry, biology, economics and a host of other disciplines. The students will acquire a deeper understanding of a phenomenon when they acquire when they simulate the phenomenon on a computer.

Syllabus

Elements of Probability Theory
Sample Space; events, mutually exclusive events; independent events; probability of events; axioms of probability; conditional probability; Bayes' theorem.
Random variable; probability density function; discrete probabilities: Binomial distribution; Poisson distribution; geometric distribution; moments; moment generating function and its applications; Master equation for Poisson process.
Continuous random variables; probability density functions; uniform, exponential, Gaussian and Caucchy probbility density functions; characteristic functions; moments and cumulants.
Function of many random variables; sum of independent random variables; formal expression for the probability density function of sum of independent random variables; characteristic function of sum of identically distributed independent random variables; Chebyshev inequality; law of large numbers; cumulant generating function; central limit theorem.

Random number generation and testing:
pseudo random numbers; mid-square method; linear congruential method; Testing of random numbers; uniformity test; run down and run up tests; tests based on correlation;

Random Sampling Techniques:

Techniques of random sampling from distributions; inversion - analytical and numerical; rejection algorithms; Metropolis Rejection;

Boltzmann Monte Carlo Methods:
Metropolis algorithm; Markov chains; time homogeneous Markov Chains; balance and detailed balance; reversible Markov chains; Markov matrices; invariant probability vectors; convergence to equilibrium ensemble; canonical ensembles; Boltzmann Monte Carlo methods; simulation of Ising spins systems; second order phase transition; critical slowing down; cluster algorithm; super critical slowing down; first order phase transition

Non-Boltzmann Monte Carlo Method:
Umbrella sampling; flat histogram methods; multi canonical sampling; entropic sampling; Wang-Landau algorithm, Work fluctuations; Jarzynski identity; combining Jarzynski identity and Wang Lan-dau Monte Carlo to calculate equilibrium free energies.

Prerequisite of the Course: Graduation level Physics

Text Books and Reference Books:

1. J. M. Hammersley and D. C. Handscomb, Monte Carlo Methods, Chapman and Hall, London (1964)
2. M. H. Kalos and P. A. Whitlock, Monte Carlo Methods, Vol. 1: Basics, John Wiley, New York (1986).
3. D P Landau and K Binder, A Guideto Monte Carlo Simulations in Statistical Physics, Cambridge University Press (2009.).
4. K P N Murthy, Monte Carlo: Basics, ISRP/TD-3, Indian Society for Radiation Physics, February, 2000. cond-Mat:arXiv:0104215 vi [cond-mat-stat.phy) 12 April 2001
5. K. P. N. Murthy, Monte Carlo Methods in Statistical Physics, Universities Press (India) Private Limited, distributed by Orient Longmann Private Limited (2004)

Assessment Method: Written and Assignments

Any need for revision of existing rules: No

PHY611 SEMICONDUCTOR DEVICES AND TECHNOLOGY [Credit 3 (L T P: 3-0-0)]

Course Outcomes:

At the end of the course, the students will

- Be familiar with the peculiar behaviour of semiconductors
- be equipped the knowledge of different semiconductor devices
- have the knowledge about various fabrication techniques of semiconductors

Program Outcomes: This course covers PO1 and PO4

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	1	1
CO2	3	1	3	3	1	1
CO3	3	1	3	3	1	1

Course Description: The course is intended to disseminate the basic and applied knowledge of various semiconductors, the difference between homo- and hetero-junction based semiconductor devices, provide the knowledge about various fabrication techniques of semiconductors and various applications of semiconductors in devices

Course Level: Mastery

Course Objectives:

- To disseminate the basic and applied knowledge of various semiconductors
- To impart the knowledge about the difference between homo- and hetero-junction based semiconductor devices
- To provide the knowledge about various fabrication techniques of semiconductors
- Applications of semiconductors in devices

Syllabus

Crystal and crystal structures, Common semiconductor crystal structures, Energy bands, Density of states, Carrier distribution functions, Carrier densities, Carrier transport, Carrier recombination and generation Continuity equation the drift-diffusion model, Semiconductor thermodynamics, Growth of semiconductor crystals: silicon crystal growth from the melt, silicon float-zone process, GaAs growth techniques, epitaxial growth technique, structure and defects in epitaxial layers

Structure, principle of operation and electrostatic analysis of p-n diode, Current-Voltage characteristics, Reverse bias breakdown, Depletion capacitance, Charge storage and transient behaviour, Uniformly doped and linearly graded junctions, Hyper-abrupt junctions, Heterojunctions, Optoelectronic devices, Photodiodes, Solar Cells, Light Emitting Diodes (LEDs), Laser diodes; Microwave diodes: Tunnel diode, IMPATT diode, Transferred electron devices

Structure and principle of operation of metal semiconductor contacts: Schottky barriers, Rectifying contacts, Ohmic contacts, Electrostatic analysis, Schottky diode current, Metal- Semiconductor Field Effect Transistors (MESFET), Schottky diode with an interfacial layer, MOS capacitor and MOSFET fundamentals, Heterojunction bipolar transistors, BJT technology, Frequency response and switching of bipolar transistors, High Electron Mobility Transistors (HEMTs)

Prerequisite of the Course: Graduation level Physics

Text Books and Reference Books:

1. Principles of Electronic materials and devices: S. O. Kasap, McGraw Hill publication
2. Principles of Semiconductor devices, B. Van Zeghbroeck, Internet Resources
3. Semiconductor Devices (Basic Principles): Jasprit Singh, Wiley publication
4. Semiconductor Devices (Physics and Technology): S. M. Sze and M. K Lee, Wiley publication
5. Semiconductor Physics and Devices: D. A. Neamen and D. Biswas, McGraw Hill publication
6. Semiconductor Physics and Devices: S. S. Islam, Oxford Higher Education publication
7. Solid State Electronic Devices: B. G. Streetman and S. K. Banerjee, Pearson Education publication
8. Solid State Electronic Devices: D. K. Bhattacharya and R. Sharma, Oxford Higher Education publication

Assessment Method:

This course will consist of two continuous internal assessments (C.I.A.) and one End of semester examination (EoSE). Each C.I.A. would be of 20 marks and the EoSE would be of 60 marks. First C. I.A. will be in the form of written examination while the second C.I.A. will be in the form of surprise test, quiz or classroom presentation as decided by the course instructor.

Any need for revision of existing rules: No

PHY 612: NONLINEAR DYNAMICS AND CHAOS [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

At the end of the course, students will be

- Able to grasp the fundamentals concepts of nonlinear dynamics
- Capable to implement such phenomenon in society, science and engineering

Program Outcomes (PO): The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3

Course Level: Mastery

Course description:

This interdisciplinary course provides an introduction to nonlinear dynamics, chaos and fractals. We will investigate how to determine the qualitative behaviour of the solutions of nonlinear differential and difference equations, without having to determine the actual solutions explicitly. The course concentrates on simple models of dynamical systems, and their relevance to natural phenomena. The content is structured to be of general interest to graduates in science and engineering.

Course Objectives:

- The main goal of the course is to introduce and describe the non-linear and chaotic phenomenon in natural and engineering systems using a minimum background in physics and mathematics
- Understanding the applications of nonlinear phenomenon in society, science and engineering
- Learn an extensive use of computational tools and laboratory experiments to explore chaotic behaviour

Syllabus:

The qualitative analysis of nonlinear dynamical flows: Stability of fixed points, existence of limit cycles, Bifurcations theory

Nonlinear Oscillators: Lorenz and Rossler equations; Iterated maps: Logistic and Henon maps; Period doubling, Intermittency and other routes to Chaos

Fractal geometry; Strange Chaotic and Nonchaotic Attractors; Characterization of Regular and Chaotic motions: Lyapunov exponent, Power spectrum, Autocorrelation, and Dimension

Prerequisite of the Course: Graduation level Physics

Text and Reference Books:

1. S. H. Strogatz, Nonlinear Dynamics and Chaos, Perseus, 2000 (Indian Edition, 2009)
2. K. T. Alligood and *et al*, *Chaos – An Introduction to Dynamical Systems*, Springer, 1996
3. E. Ott, *Chaos in Dynamical Systems*, Cambridge, 2002
4. M. Lakshmanan and S. Rajasekar, *Nonlinear Dynamics*, Springer, 2003
5. S. Lynch, *Dynamical Systems with Applications using MATLAB*, Birkhauser, 2004

Assessment Method:

As per University Ordinance

Any need for revision of existing rules: No

PHY 613: CONCEPTS OF LASER PHYSICS AND FIBER OPTICS [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

At the end of the course, the students will

- appreciates the working principles of laser and their utilities
- get the exposure of techniques underlying optical communication using single and multimode fibers
- be able to apprehend the phenomenon of dispersion, communications wavelengths and transmission losses

Program Objective: The course covers the program outcomes from PO-1 to PO-6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3

Course Level: Mastery

Course Descriptions:

This course is divided in two parts: First part covers the physics of light-matter interaction, stimulated and spontaneous emission, Einstein Coefficients, two level, three level, four level LASER system, Ultrafast Laser and their underlying characteristic properties. Second part covers different types of Optical fibers and their underlying principles and further propagation of LASER through these optical fibers.

Objectives:

- To conceptualize the basics of lasers and light matter interaction
- To ingrain the knowledge of optical communications on utilitarian ground
- To infuse the knowledge of various characteristics of optical fiber and their peculiar properties

Syllabus:

Introduction, Physics of interaction between Radiation and Atomic systems including: Stimulated emission, emission line shapes and dispersion effects Einstein coefficients; Line shape function, Line-broadening mechanisms, Condition for amplification by stimulated emission, the meta-stable state and laser action. 3-level and 4-level pumping schemes. Laser Rate Equations: Two-, three- and four level laser systems, condition for population inversion, gain saturation; Carrier wave communication and necessity of communication at optical frequencies Introduction to optical fibers, concepts of core and cladding, necessity of cladding structure, Total internal reflections, evanescent wave, penetration depth and propagation concept of evanescent waves, type of optical fibers, glass fibers, plastic cladded silica fibers, single mode and multi-mode optical fibers, index Profiles of the optical fibers step index and graded index core optical fibers, Numerical aperture, Experimental technique to measure numerical aperture of the optical fiber Ray paths and pulse dispersion in optical waveguides, Ray paths in homogeneous and square law profiles, calculation of dispersion in terms of relative core cladding refractive index parameter, Transit time calculation in step index and parabolic index waveguide, Material dispersion, material dispersion in pure and doped silica, Zero material dispersion wavelength (ZMDW)

Prerequisite: Atomic Physics and spectra

Reference Books:

1. Principles of lasers by O. Svelto, Springer, Fifth Edition, (2010)
2. Lasers by Anthony ESiegman,University Science Books; Revised Ed. (1986)
3. Lasers and Non-linear optics: B. B. Laud, Wiley
4. Lasers: Theory and Applications: K. Thyagarajan and A.K. Ghatak, Springer, First Edition (1981)
5. Introduction to fiber optics: A. K. Ghatak and Thyagarajan
6. Essentials in fiber optics: K Thyagarajan and A.K. Ghatak
7. Introduction to Fiber Optics by John Crisp, Newnes, Third Edition (2007)
8. Fiber Optics: J. C. Palice
9. Fiber Optics and optoelectronics: G. Keiser
10. Fundamental of Photonics: B.E.A.Saleh and Teich, John Wiley & Sons; 1st edition

11. Fiber Optics Edited: B.P. Pal

Assessment Method: Written examinations and assignments

Any need for revision of existing rules: No

PHY 614: INTRODUCTION TO PLASMA PHYSICS [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

On completion of the course, the students will be able

- To understand the basic properties of plasma state and the motion of charged particles in the electromagnetic fields
- To understand the nonlinear effects in plasma and their inswing applications
- To realize the application of ionospheric plasma used for telecommunications

Course Outcomes (PO): The course covers the program outcomes from PO-1 and PO-5-PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	1	3	3
CO2	3	1	1	1	3	3
CO3	3	1	1	1	3	3

Level: Mastery

Description: The course is planned to introduce the basic knowledge and various applications of plasma . Plasma, the most common state of ordinary matter in the universe, is fascinating and has importance in lightning, microelectronics, nano science, polymer, textile processing and medicine.This course is recommended for students who have strong interests in electrodynamics.

Course Prerequisites: Students must have some basic understanding of mathematical tools and have studied electrodynamics.

Objectives:

- To impart the theoretical and analytical knowledge in the field of plasma physics
- To introduce plasma phenomena relevant to energy generation by controlled thermonuclear fusion
- To grasp the concept of Debye length, Debye shielding, plasma sheath and plasma oscillation

Syllabus:

Introduction to Plasmas and Particle Dynamics: Definition and general properties of plasma, plasma oscillations, Debye shielding and criteria for plasma, motion of charged particles in electromagnetic field and non-uniform magnetostatic field, electric field drift, gradient B drift, parallel acceleration and magnetic mirror effect, curvature drift, adiabatic invariants.

Waves and Transport Processes in Plasmas: Fluid description of plasmas, continuity and momentum balance equations of fluid mechanics, electron plasma waves, ion acoustic waves, electromagnetic waves in plasma , magnetosonic and Alfven waves and their dispersion relations and properties, stability of plasmas, ambipolar diffusion, hydromagnetic equilibrium, diffusion of magnetic lines and frozen-in fields, concept of magnetic pressure, plasma confinement schemes.

Nonlinear Effects and Controlled Fusion: Vlasov equation, landau damping, plasma sheath, pondermotive force, wave-wave interaction, nuclear fusion, plasma pinching, toroidal devices.

Text Books:

- Introduction to plasma physics and controlled fusion Chen, Francis F, Springer, 3rd edition, 2016.
- The physics of fluids and plasmas: an introduction for astrophysicists. Choudhuri, ArnabRai. Cambridge University Press, 2015.
- Principles of Plasma Discharges and Materials Processing.Lieberman and Lichtenberg,Wiley-Interscience; 2nd edition, 2008.
- Introduction to dusty plasma physics. Shukla P. K. and Mamun A. A., CRC Press; 2001.

Assessment Method: First CIA (20 %), second CIA/assignments (20 %) and EOSE (60 %)

Any need for revision of existing rules: No

PHY 615: INTRODUCTION TO NANOMATERIALS AND NANOTECHNOLOGY [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

At the end of the course the students will

- Appreciate the unusual properties of materials at nanoscale
- Gain deep insights about modern synthesis and characterization techniques
- Have knowledge of nanomaterials applications in day-to-day life

List of PO that the course covers: PO1, PO3-PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3

Level: Mastery

Course Description:

The physical properties change drastically as the material size shrinks towards the atomic scale. Nanomaterials have a much greater surface area to volume ratio than their conventional forms and quantum effects become important. They can be engineered to possess unique composition and functionalities. In this course, many key concepts related to nanomaterials and nanotechnology will be discussed. Fundamental aspects and applications of nanotechnology in the areas of Physics, Chemistry, materials science, biology, energy and electronics will be outlined.

Course Objectives:

Introduction of various physical properties at nanoscale

- To impart the knowledge of synthesis and characterization techniques of nanomaterials
- To familiarize the fascinating application of nanomaterials

Syllabus:

Classification of nanomaterials, effect of nanometer length scale on system total energy, structure and properties. Hydrothermal Synthesis, Solvothermal Method, Chemical Vapor Deposition (CVD), Thermal Decomposition and Pulsed Laser Ablation, Templating, Microwave Synthesis, Conventional Sol-Gel Method. Scanning electron microscope (SEM), transmission electron microscope (TEM), atomic force microscope (AFM), X-ray photoelectron spectroscopy (XPS), X-ray diffraction, UV-Vis and FTIR, Raman spectroscopy and Network analyzer.

Fabrication of metallic, magnetic, carbon-based nanomaterials (Carbon nanotube, graphene, fullerene and nano-diamond), other inorganic nanomaterials. Electrical, Magnetic, Thermal, Mechanical and Optical properties of thin films, foam, layered materials, nanofiber, nanowire, nanocrystals and composite nanomaterials. Viscoelastic and liquid crystalline properties.

Examples of potential applications in biomedical; drug delivery, tissue engineering, opto-electronic, thermal management, electromagnetic interference shielding, solar cells, fuel-cells, batteries, supercapacitors, hydrogen storage, catalysis, aerospace, military, High-Sensitivity Sensors, water desalination and composites.

Prerequisite of the course: Graduation level Physics and Chemistry

Text Books and Reference Books:

1. Massimiliano Ventra, Stephane Evoy and James R. Heflin (Editors), Introduction to Nanoscale Science and Technology, Springer, Boston, 2004.
2. Guozhong Cao and Ying Wang, Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, 2nd edition, World Scientific Publishing Company, 2010.
3. A.S. Edelstein and R.C. Cammarata (Editors), Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Publishing, London, 1996.
4. E. L. Wolf, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, 2nd edition, Wiley VCH, 2006.

Course Assessment: Assignments: 20 %, Presentation: 20 %, End of semester exam: 60 %

Any need for revision of existing rules: No

PHY 616: QUANTUM MANY-BODY PHYSICS [Credits 4, 3-1-0]

Course Outcomes:
This course will help the learners in modeling and understanding the real world problems contained in transport phenomenon, magnetic properties, superconductivity, quantum hall effect, etc. which have numerous relevance in industrial applications and research.

Program Outcomes (PO): The course covers the program outcomes from PO-1 to PO-5.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	1	3	3	3	1

Level: Mastery

Course Description:
Most of the condensed matter systems are interacting ones. In such systems, the experimental outcomes cannot be understood at the level of a single body. Nobel Laureate Philip Warren Anderson is famously quoted as saying “More is different." In other words, condensed matter systems are challenging to deal with due to many-body interactions. This course offers several quantum many-body techniques which are essentially devised for such complex systems.

Objectives:

- To give the exposure of second quantized world
- To learn the Feynman diagrams and their importance in interacting quantum many-body systems where either exact solutions do not exist or hard to find

Syllabus

Second Quantization

Fock space, creation and annihilation operators, one-body operators, two-body operators, field operators, electron gas.

Green's Functions at Zero Temperature

Interaction representation, Green's functions, Wick's theorem, Feynman diagrams, Dyson's equations, linear response theory, examples.

Green's Functions at Finite Temperatures

Imaginary-time representation, Matsubara Green's functions, Wick's theorem, Feynman diagrams, Dyson's equations, linear response theory, examples.

Green's Functions and Phonons

Green's function for free phonons, electron-phonon interaction and Feynman diagrams, combining Coulomb and electron-phonon interactions, phonon renormalization by electron screening in random phase approximation, Cooper instability and Feynman diagrams.

Superconductivity

Cooper instability, Bardeen–Cooper–Schrieffer (BCS) ground state, microscopic BCS theory, BCS theory with Matsubara Green's functions, Nambu formalism of the BCS theory, gauge symmetry breaking and zero resistivity, Josephson effect.

Prerequisite of the course: course on quantum mechanics

Text Books and Reference Books:

1. A. A. Abrikosov et al., Methods of Quantum Field Theory in Statistical Physics, Dover.
2. L. D. Lifshits et al., Statistical Physics (Part 2: Volume 9; 3rd Edition), Pergamon Press.
3. A. L. Fetter and J. D. Walecka, Quantum Theory of Many-Particle Systems, Dover.
4. G. D. Mahan, Many-Particle Physics (3rd Edition), Springer.
5. R. D. Mattuck, A Guide to Feynman Diagrams in the Many-Body Problem (2nd Edition), Dover.
6. A. Zagoskin, Quantum Theory of Many-Body Systems (2nd Edition), Springer.
7. Xiao-Gang Wen, Quantum Field Theory of Many-body Systems, Oxford University Press.
8. H. Bruus and K. Flensberg, Many-body Quantum Theory in Condensed Matter Physics, Oxford University Press.
9. P. Coleman, Introduction to Many-Body Physics, Cambridge University Press (CUP).
10. J. W. Negele, Quantum Many-particle Systems, Perseus Books.
11. R. A. Jishi, Feynman Diagram Techniques in Condensed Matter Physics, CUP.
12. D.J. Thouless, The Quantum Mechanics of Many-Body Systems (2nd Edition), Dover.

Assessment Method: Written examinations and assignments

Any need for revision of existing rules: No

PHY 617: Theory of Complex Networks and Applications [Credit 3 (LTP: 3-0-0)]

Course Outcome:

Students who successfully complete this course will gain a broad conceptual and technical introduction to the modern theory and applications of complex networks. Specifically the students will learn fundamentals of graph and network theory well as a dynamical system based approach to large scale networks and they will be able to analyze real world networks empirically and generate network models to study their collective behaviour on a computer.

Program Outcomes (PO): The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3

Course Level: Mastery

Course description:

This interdisciplinary course provides an introduction to complex network theory and its applications in physics, biology, technology and social sciences. Basic graph theory and the statistical physics foundations as well as applications to real world networks will be covered. A hands-on approach to analytical and computational techniques for real world networks will be provided.

Course Objectives

A complex network is a graph (network) with non-trivial topological features - features that do not occur in simple networks such as lattices or random graphs but often occur in real graphs. In this course, we investigate the topology and dynamics of such complex networks, aiming to better understand the behavior and properties of the underlying systems. The applications of complex networks cover physical, informational, biological, cognitive, and social systems.

Prerequisite: students must have completed a course of classical mechanics.

Syllabus

Introduction to Networks, basic concepts of graph theory: Properties of real networks: small- world and scale-free networks, community structure, hierarchies, Centrality measures, Clustering, assortativity, Motifs, Characteristics of weighted networks.

Network Models: Erdős Rényi, Watts-Strogatz, and Barabási-Albert. Analysis and stability of networks.

Random Graphs, Community Structures, Modular networks, Processes on networks, Growth models, Random walks on networks.

Network Examples: Social network, The Internet as a complex network, Complex networks in economy and finance, Cellular networks, Networks of neurons and ecosystems, Epidemics.

Text and Reference Books

1. Networks: An Introduction, Oxford University Press, Oxford, 2010.
2. Networks, Crowds and Markets by D Easley and J Klienberg, Cambridge Univ Press, 2010.
3. Dynamical Processes on Complex Networks, A. Barrat *et al*, Cambridge Univ Press, 2008.

Assessment Method: As per University Ordinance

Any need for revision of existing rules: No

PHY 618: Computational Condensed Matter Physics [Credit 3 (L-T-P: 2-1-0)]

Course Outcomes:

At the end of the course, the students should:

- Learn the basics of the formulation of various theoretical models in condensed matter physics
- Learn the basics of at least one programming language (Fortran90, C++, Python)
- Be able to write the basic simulation codes for Condensed Matter Physics Models
- Gain general understanding of how computational physics works.

Program Outcomes: PO1, PO3, PO4, PO5, PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**
CO2	**3**	**1**	**3**	**3**	**3**	**3**
CO3	**3**	**1**	**3**	**3**	**3**	**3**
CO4	**3**	**1**	**3**	**3**	**3**	**3**

Level: Mastery

Course Description: Condensed Matter Physics (CMP) is the fundamental science of solids and liquids. It is undoubtedly one of the fast moving and very active research fields which often uncovers phenomena (superconductivity, magnetism, topological insulators etc) that are technologically important. Nowadays, computational methods are well established in studying various phenomena in all branches of science. Indeed, very often the computer simulation is the only route for systematic studies and improved understanding.

This course introduces some of the numerical techniques applied to the models in CMP covering phenomena of metal-insulating transitions, magnetism, topological insulators etc. The pedagogical approach of the lecture will be to start from a model description of a phenomena and then develop a numerical approach starting from there. The practical implementation of the basic code writing (e.g. with Fortran 90/95) would be monitored.

Course Objectives:

Students will learn the basics of various condensed matter physics models and how to solve these models by computer simulation.

Syllabus:

Matrix formulation of Quantum Mechanics, Exact diagonalization, Illustrations by Heisenberg spin models, Hubbard models, Lanczos diagonalization for large systems, tight binding bands and density of states calculations for various lattice systems: square, triangular, honeycomb etc, band structure of Su-Schrieffer-Heeger (SSH) model as the simplest case for topological insulator

Monte Carlo methods, Basic theory, random number generations, Markov Process, Metropolis algorithm, Applications to Ising model, Heisenberg models in various lattices, Frustrated magnetic systems, magnetic phase transitions, itinerant magnetic systems (localized spin and electron systems), hybrid Monte Carlo method

Willson's numerical Renormalization Group (RG) method, Particle in a box problem, Basics of Density Matrix and Density matrix RG method, Matrix product states, Basis Truncation in DMRG method, Infinite system algorithm, finite system algorithm, Application to Heisenberg, Hubbard and t-J models

Pre-requisites of the Course: Basic solid-state physics, basic quantum mechanics

Text Books and Reference books:

1. Computational Physics, Nicholas J. Giordano, Hisao Nakanishi, Pearson Addison-Wesley; 2 edition (July 2005)
2. Monte Carlo Simulation in Statistical Physics: An Introduction, Kurt Binder, Dieter Heermann (Springer, 6th Edition)
3. The density-matrix renormalization group, U. Schollwöck, Reviews of Modern Physics, 77, 259 (2005)
4. Fortran 90/95 2nd Ed.: For Scientists And Engineers by Chapman S J, Tata McGraw Hill

Assessment Method: written, tutorials, viva, seminar, assignment

Any need for revision of existing rules: No

PHY 619: Phase Transitions and Critical Phenomena [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

The student is expected to gain a good understanding of various types of phase transitions and their description. Obtain a considerable insight of the modern theory of critical phenomena and of the behavior of canonical theories and models, and the skills required to solve problems useful for future professional activity

Program Outcomes: PO1, PO3-PO6

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**

Level: Mastery

Course Description: Thermodynamic systems exist in various stable homogeneous states (phases) which differ in their structure, symmetry, order or dynamics. At certain (critical) values of the thermodynamic variables the system undergoes an abrupt change from one phase to another phase which is called a phase transition. Critical phenomena investigates the relevant observable physical properties exhibiting singularity or discontinuity in the vicinity of a critical point. It is often the existence of phase transitions that give materials the properties that are exploited in technological applications and therefore, forms an important subject of interest to physicists, chemists, and material scientists.

This is an advanced course on Statistical Physics, with a particular emphasis on Phase Transitions and Critical Phenomena, exploring a wide range of phase transitions like magnetic transitions, liquid-gas transition, ferroelectric, atomic ordering transitions and other displacive phase transitions.

Course Objectives:

(1) to provide insights into the Physics of phase transitions and critical phenomena through a systematic presentation of the formalism and the models

(2) to train students in the analytical and numerical methods of modern statistical mechanics to solve the exercises proposed during the course.

(3) to enable the student to recognize the nature and type of the phase transitions that occur in

nature and to study the main implications of critical phenomena in various branches of Physics independently.

Syllabus:

Phase equilibrium and phase transition. Examples. Critical point exponents, inequalities and universality classes. Overview of simple models. Mean field Approximation, Landau theory, Beyond mean field, correlations and fluctuations, Scaling hypothesis, Renormalization Group and Crossover Phenomena, Dynamics of phase transitions (nucleation, spinodal decomposition, critical slowing down, mode-coupling)

Prerequisites of the Course: Statistical Mechanics

Text Books and Reference Books:

1. H E Stanley, Introduction to Phase transitions and Critical Phenomena, Oxford Science Publications (1987).
2. S. K. Ma, Modern Theory of Critical Phenomena, Westview Press, Oxford (2000).
3. N. Goldenfeld, Lectures on Phase Transitions and the Renormalization Group, Addison & Wesley (1992)
4. J. M. Yeomans, Statistical Mechanics of Phase Transitions, Oxford University Press, New York, NY (1992).
5. J. J. Binney, N. J. Dowrick, A. J. Fisher and M. E. J. Newman, The Theory of Critical Phenomena: An Introduction to the Renormalization Group, Oxford University Press, Oxford (1992).
6. J. Zinn-Justin, Quantum Field Theory and Critical Phenomena, Oxford University Press (2002)
7. I. Herbut, A Modern Approach to Critical Phenomena, Cambridge, University Press (2006)
8. H. Nishimori, G. Ortiz, Elements of Phase Transitions and Critical Phenomena, Oxford University Press (2011).

Course Assessment: Assignments: 20 %, Presentation: 20 % (on a subject chosen by the student and validated by the teacher) and End of Semester examination: 60 %

Any need for revision of existing rules: No

PHY 620: Special Topics in Mathematical Physics [Credit 3 (LTP: 300)]

Course Outcomes:

Successful students will be able

- To work with integral transforms
- To work with vectors, tensors, coordinate transformations
- To define the a group, order of a finite group, permutation groups, different types of subgroups such as normal subgroups, cyclic subgroups
- To describe the symmetries in figures
- To construct Green’s functions and use to solve boundary value problems.

Program Outcomes (PO): The course covers the program outcomes from PO-1 and PO-5 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**1**	**1**	**3**	**3**
CO2	**3**	**1**	**1**	**1**	**3**	**3**
CO3	**3**	**1**	**1**	**1**	**3**	**3**
CO4	**3**	**1**	**1**	**1**	**3**	**3**
CO5	**3**	**1**	**1**	**1**	**3**	**3**

Course Level: Mastery

Course description: The purpose of the course is to introduce mathematical skills required to solve problems in quantum mechanics, electrodynamics, condensed matter physics and other fields of theoretical sciences.

Course Objectives:

- To expose the students to the fascinating world of symmetry in physics and chemistry
- To make the students learn about tensor calculus special functions essential in solving physics problems
- To model and solve physical phenomena using Green's functions

Syllabus:

Integral Transforms

Definition and properties of Dirac delta function. Fourier and inverse Fourier transform, Fourier Series, development of the Fourier integral from the Fourier Series, simple applications of Fourier and inverse Fourier Transform, Finite wave train, Wave train with Gaussian amplitude, Fourier transform of derivatives, solution of wave equations and application. Convolution theorem. Laplace transforms and their properties, Laplace transform of derivatives integrals, derivatives and integrals of Laplace transform. Impulsive function, Application of Laplace transform in solving linear, differential equations with constant coefficient with variable coefficient and linear partial differential equation.

Introduction to elements of Group theory

Introduction to group theory, representation of groups, symmetry in physics, Discrete groups, Continuous groups, Lorentz groups, space groups

Green's functions

Dirac-delta function, three-dimensional delta function, definition of Green's functions, Green's function for one dimensional equations, Green's functions for two and three dimensional equations, Symmetry property of Green's function, eigenfunction expansion of Green's functions, Green's function for Poisson's equation.

Tensors in Physics

Scalar, vector and tensor quantities, Coordinate transformations, simple applications of tensors in non-relativistic physics, moment of inertia tensor, electrical conductivity, electrical polarizability and magnetic susceptibility tensors, stress and strain tensors, generalized Hook's law, Maxwell's equations in tensor form, Lorentz covariance of Maxwell's equations.

Prerequisites:

Students must have some familiarity with differentiation, integrations, infinite series, differential vector calculus, matrices and complex numbers.

Text Books and Reference Books:

1. K. F. Riley, M. P. Hobson and S. J. Bence. Mathematical Methods for Physics and Engineering. 3rd edition, Cambridge University Press India,.
2. George B. Arfken, Hans J. Weber and Frank E. Harris. Mathematical Methods for Physicists, Academic Press, 7th edition.
3. Mary Boas. Mathematical Methods in the Physical Sciences, 3rd edition, Wiley India.
4. V. Balakrishnan, Mathematical Physics with Applications, Problems and Solutions, Ane Books.
5. Robert W. Fuller, The mathematics of classical and quantum physics, Dover publications.
6. R. K. Jain and S. R. K. Iyengar. Advanced engineering mathematics, 5th edition, New age international.
7. A. W. Joshi. Elements of group theory for physicists, New age international.
8. A. W. Joshi. Matrices and Tensors, New Age International, Daryaganj, New Delhi.
9. P K. Chattopadhyay, Mathematical Physics, 3rd edition, New Age International, Daryaganj, New Delhi.
10. Jon Mathews , Robert L. Walker. Mathematical Methods of Physics, Pearson Education(US).

Assessment Method: First CIA (20 %), second CIA/assignments (20 %) and EOSE (60 %)

Any need for revision of existing rules: No

PHY 621: Advanced Plasma Physics [Credit 3 (LTP: 300)]

Course Outcomes:

After completing the course the students will be able

- To analyze the motion of charged particles in electric and magnetic fields
- To discuss plasma resistivity and diffusion in plasma
- To linearize equations describing plasma and derive differential equations for various types of waves in plasma and their dispersion relation
- To explain the concept of plasma instability and analyze the instabilities based on the dispersion relation
- To explain the use of plasma in thermonuclear fusion for energy production and future directions of research.

Course Outcomes (PO): The course covers the program outcomes from PO-1 and PO-5 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**1**	**1**	**3**	**3**
CO2	**3**	**1**	**1**	**1**	**3**	**3**
CO3	**3**	**1**	**1**	**1**	**3**	**3**
CO4	**3**	**1**	**1**	**1**	**3**	**3**
CO5	**3**	**1**	**1**	**1**	**3**	**3**

Course Level: Mastery

Course Description: The course is designed to provide the advance understanding of physical processes that govern by ordinary plasmas, space plasmas, laboratory plasmas and dusty plasmas. This course is recommended for students those have research interests in plasma physics and electrodynamics.

Course Objectives:

The objectives of course are

- To study the interactions of charged particles with electromagnetic fields.
- To study the various instabilities in plasma medium
- To study the different applications of plasma physics
- To study the nonlinear effects in plasma physics

Syllabus:

Plasma Generations a**nd Transport Processes**: Plasma oscillations, Debye shielding and criteria for plasma, ionization of atoms and molecules, AC and DC discharges, conduction in ionized gases, Low temperature plasma generation, motion of charged particles in electromagnetic field and non-uniform magnetostatic field, fluid description of plasmas, continuity and momentum balance equation of fluid mechanics, ambipolar diffusion, hydromagnetic equilibrium, diffusion of magnetic lines and frozen-in fields, concept of magnetic pressure.

Nonlinear Effects in Plasmas: Vlasov equation, landau damping, Plasma Sheath, pondermotive force, solitary waves and solitons, Kortewegde Vries (kdv) equation, wave-wave interaction.

Plasma Waves and Instabilities: Electron plasma waves, ion acoustic waves, electromagnetic waves in plasma, magnetosonic and Alfven waves, Rayleigh-Taylor instability, Resistive instability, Two stream instability, Waveguide modes in the presence of plasma, Dusty plasma, Current flow in dust grains, Waves in dusty plasma. Absorption of EM waves in plasmas, Radiation by coulomb collisions.

Dusty Plasmas: definitions of the dusty plasma, dusty plasmas in the solar system and earth, The charge on a dust grain in a plasma, The forces on a dust grain in a plasma, Weakly vs. strongly coupled dusty plasmas, Formation and growth of dust particles in a plasma, Dusty plasmas in the solar system and on earth, Spokes in Saturn’s B ring, Dust streams from Jupiter, Dusty plasmas in industry, Dust contamination in plasma processing devices, Applications of dusty plasmas, Dedicated dusty plasma experiments, Dusty plasma devices, Coulomb crystals, Dust in fusion devices.

Applications of Plasma technology: Plasma based terahertz radiation generation, Hall thrusters, Plasma production & characterization, Laser driven fusion, plasma furnace in steel making, plasma cutting, plasma pinching, toroidal devices, sputtering, plasma enhanced chemical vapor deposition, plasma nitriding and surface cleaning.

Course Prerequisites: Students must have some basic understanding of mathematical tools, basic plasmas physics and electrodynamics.

Text Books:

1. Introduction to plasma physics and controlled fusion Chen, Francis F, Springer, 3rd edition, 2016.
2. The physics of fluids and plasmas: an introduction for astrophysicists. Choudhuri, ArnabRai. Cambridge University Press, 2015.

3. Principles of Plasma Discharges and Materials Processing.Lieberman and Lichtenberg,Wiley-Interscience; 2nd edition, 2008.
4. Introduction to dusty plasma physics.Shukla P. K. and Mamun A. A, CRC Press, 2001.

Assessment Method: First CIA (20 %), second CIA/assignments (20 %) and EOSE (60 %)

Any need for revision of existing rules: No

PHY 622 Concepts of Laser Physics and Fourier Optics [Credit 3 (LTP: 3-0-0)]

Course Outcomes:

On completion of this course the students will

- be capable to understand the fundamentals of Laser Physics and Fourier optics
- be able to analyse the rigorous theory behind the Laser and their applications,
- be capable to understand the fundamentals of Fourier optics and to analyze the rigorous theory of different kinds of optical wave propagation theory
- gain the advanced knowledge of the beam propagation theory and diffraction pattern
- understand the principles involved in the different components of optical filters and lenses used in communication systems.
- be trained enough to design different optical holographic masks

Program Objective: The course covers the program outcomes from PO-1 to PO-6.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**3**	**3**
CO2	**3**	**1**	**3**	**3**	**3**	**3**
CO3	**3**	**1**	**3**	**3**	**3**	**3**
CO4	**3**	**1**	**3**	**3**	**3**	**3**
CO5	**3**	**1**	**3**	**3**	**3**	**3**
CO6	**3**	**1**	**3**	**3**	**3**	**3**

Course Level: Mastery

Course Descriptions:

The first part covers the basic concepts of Laser physics that includes the different phenomena involved for the generation of laser radiation, their components, and types of LASER. Second part of the course covers mathematical explanation of wave propagation through different optical elements and their underlying theory. Importance of Fourier theorem for basic understanding of light waves propagation. Designing of different optical apertures and analysis of their diffraction pattern.

Course Objective:

A detailed exposition of the course for the student, opting for physics is so vitally important for a clear understanding of recent intricate theories of Laser Physics and Fourier optics.

- Understand the different phenomenon involved for the generation of Laser
- Different types of Lasers and their applications
- Rigorous understanding of recent intricate theories of Fourier transform, Hankel Transform, Fourier-Bessel Transform
- Physical interpretation of scalar diffraction theory and angular spectrum propagation method
- Fresnel and Fraunhofer diffraction theory and propagation of light beams through different optical systems

Syllabus:

Introduction, Physics of interaction between Radiation and Atomic systems including: Stimulated emission, emission line shapes and dispersion effects Einstein coefficients; Line shape function, Line-broadening mechanisms, Condition for amplification by stimulated emission, the meta-stable state and laser action. 3-level and 4-level pumping schemes. Laser Rate Equations: Two-, three- and four level laser systems, condition for population inversion, gain saturation; Some Laser Systems: Ruby, Nd: YAG, He-Ne, CO 2 and excimer lasers,

Fourier Analysis in Two Dimensions, Fourier Transform Theorems, Separable Functions, Hankel transforms, Functions with Circular Symmetry: Fourier-Bessel Transforms, Local Spatial Frequency and Space-Frequency Localization, Linear Systems, Transfer Functions, Two-Dimensional Sampling Theory, The Whittaker-Shannon Sampling Theorem, The Rayleigh - Somrnerfeld Formulation of Scalar Diffraction Theory, The Angular Spectrum of Plane Waves: The Angular Spectrum and Its Physical Interpretation, Propagation of the Angular Spectrum. The Fresnel Approximation and the Angular Spectrum; The Fraunhofer Diffraction Approximation, Examples of Fraunhofer Diffraction Patterns: Rectangular Aperture, Circular Aperture, Thin Sinusoidal Amplitude Grating, Thin Sinusoidal Phase Grating; A thin Lens as a Phase Transformation, Fourier Transforming Properties of Lenses.

Prerequisite: Student must have completed Optics Course

Reference Books:

1. Lasers: Theory and Applications, K. Thyagarajan and A.K. Ghatak.
2. Optical Electronics, A.K. Ghatak and K. Thyagarajan, Cambridge University Press
3. Laser Fundamentals, W. T. Silfvast, Cambridge Publications
4. Laser and Non-linear Optics, B.B. Laud, New Age International Publishers
5. Introduction to Fourier Optics, Joseph W. Goodman, The McGraw-Hill Companies Inc.
6. The Fourier transform and its applications, R. N. Bracewell, McGraw-Hill, NY
7. Fourier Optics and Computational Imaging, Kedar Khare, Wiley Publications
8. Linear systems, Fourier transforms, and optics, Jack D. Gaskill, Wiley Publications
9. The Fourier transform and its applications to optics, P. M. Duffleux, John Wiley and Sons

Assessment methods: Written examinations and Assignments

Any need for revision of existing rules: No

PHY 623: Solid State Magnetism (Credit: 3, L-T-P: 3-0-0)

Course outcomes: After the successful completion of this course, students are expected to:

- explain the atomic origins of magnetism and describe various kinds of magnetic materials and interactions
- understand major experimental techniques that are employed in the investigation of magnetism

Program Outcomes: This course covers PO1 and PO4

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**3**	**3**	**1**	**1**
CO2	**3**	**1**	**3**	**3**	**1**	**1**

Course Description: This course is about magnetism in condensed form of matter. It connects the phenomenon of magnetism and its various manifestations to atomic and electronic systems and their interactions. The electronic systems could be localized or itinerant. During the course discussion, we shall find the origins of magnetism within angular momentum and start exploring the magnetism of isolated systems. We shall then assemble these angular moments into crystal structures and shall begin exploring the impact of crystal environments and interactions. We shall spend considerable time on various exchange interactions and how the interplay of exchange effects and crystal structure leads to long range magnetic order of multiple kinds. We shall also discuss various measurement techniques to investigate magnetism.

Course Level: Mastery

Course objectives:

- connecting macroscopic magnetism with its microscopic origin
- understand various magnetic phenomena and experimental methods to measure them

Syllabus

Concept of electron spin: Stern Gerlach experiment; Pauli's exclusion principal, Hund's rules, Spin-orbit interaction and LS coupling; Crystal electric field: Orbital degeneracy, octahedral and tetrahedral environment, weak- and strong-field ligands, high spin and low spin states, static, dynamic and cooperative Jahn Teller effect; Quenching of orbital angular momentum; Magnetic interactions: Dipole versus exchange magnetic interaction, Direct and indirect exchange interactions, Anisotropic exchange like Dzyaloshinskii-Moriya (DM) interaction, Itinerant exchange interaction, Orbital versus magnetic ordering: GoodenoughKanamori-Anderson rules, Rudermann-Kittel-Kasuya-Yosida (RKKY) interaction; hyperfine interaction

Quantum treatment of diamagnetic and paramagnetic susceptibilities; Orbital Contribution: Landau levels and Landau diamagnetism, Van Vleck susceptibility, Susceptibility of conduction electrons, relation between Pauli and Landau susceptibilities, Ferromagnetism in insulators and metals, Magnetocrystalline anisotropy and domain theory, Barkhausen effect, Stoner model of magnetism, Half metals; Landau theory of ferromagnetism, Critical exponents, Antiferromagnetism and ferrimagnetism, Excitations in magnetic materials; Kondo effect; Magnetoresistance (MR): anisotropic, ballistic, extraordinary, giant, colossal and tunneling MR; Frustrated magnetism; Brief introduction to magnetism at nanoscale.

Measurement techniques: Magnetic Force Microscopy; Vibrating sample magnetometry & SQUID; measurement of susceptibility in A.C. field; Nuclear magnetic resonance; electron spin resonance; Neutron scattering.

Prerequisite of the Course: Graduation level Physics and XII standard Chemistry

Reference books:

1. S. J. Blundell, Magnetism in Condensed Matter (Oxford University Press)
2. A.H. Morrish, Physical principles of Magnetism (John Wiley & Sons)
3. J. M. D. Coey, Magnetism and magnetic materials (Cambridge University Press)
4. J. Stöhr and H.C. Siegmann, Magnetism from Fundamentals to Nanoscale Dynamics (Springer)

Assessment Method:
This course consists of two continuous internal assessments (C.I.A.) and one End of semester examination (EoSE). Each C.I.A. would be of 20 marks and the EoSE would be of 60 marks. First C.I.A. will be in the form of written examination while the second C.I.A. will be in the form of a surprise test, quiz or classroom presentation as decided by the course instructor.

Any need for revision of existing rules: No

PHY 624: Functional Nanomaterials [Credit 3 (LTP: 300)]

Course Outcomes:

After completing this course, the students will

- be able to describe the principles of important methods for the characterization of materials
- be able to describe the preparation and properties of metal alloys, ceramics and polymers of technical importance
- be able to explain how the micro-and nanostructure at different levels affects the properties of materials

Program Outcomes: This course covers PO1, PO3, PO4 and PO5.

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	1
CO2	3	1	3	3	3	1
CO3	3	1	3	3	3	1

Course Descriptions:

The course intends to give fundamental understanding of the properties of different materials, with special reference to the connection to atomic structure, preparation and function.

Course Objectives:

- to provide the student with an overview of inorganic and polymer materials of technical importance, as well as their applications, from an atomic and molecular perspective
- to give examples of applications of materials science in the field of nanotechnology
- to give the student insight into how to manufacture functional materials, i.e. materials, or combination of materials which are designed on the atomic or nanolevel scale for a specific property.

Syllabus

Zero-, One-, Two- and Three- dimensional structure, Size control of metal Nanoparticles, Optical, Electronic, Magnetic properties; Surface plasmon Resonance, Concept of phonon, Thermal conductivity, Specific heat, Exothermic & Endothermic processes. Nano ceramics, Dielectrics, ferroelectrics and magneto ceramics, Magnetic properties; Nanopolymers, Preparation and characterization of diblock Copolymer based nanocomposites, Nanoparticles polymer ensembles; Applications of Nanopolymers, Metal-Metal nanocomposites, Polymer-Metal nanocomposites, Ceramic nanocomposites, Nano Semiconductors, Nanoscale electronic devices (CMOS, sensors) Thermo Electric Materials (TEM),

Prerequisite of the Course: Graduation level knowledge of Physics and Chemistry.

Text Books and Reference Books:

1. D.R. Askeland, D.K. Wright, The Science and Engineering of Materials, (Cengage) 2015,
2. J.R. Fried, Polymer Science & Technology, (Prentice Hall) 2014,
3. Brian Cantor, Novel Nanocrystalline Alloys and Magnetic Nanomaterials (CRC Press) 2004,
4. Guozhong Cao and Ying Wang, Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, 2nd edition, (World Scientific Publishing Company,) 2010.
5. A.S. Edelstein and R.C. Cammarata (Editors), Nanomaterials: Synthesis, Properties and Applications, (Institute of Physics Publishing, London,) 1996.