B.Sc. Programme

B. Sc. Programme in Physics (Honors) (CBCS) Course Outcome

SEM	**PAPER**	**Course TITLE**	**Credits T+P**	**Page No.**
		F. Y. B. Sc.		
I	PYC101	Section 1 :Mathematical methods & Mechanics Section 2 :Electrical circuit theory	2+1 2+1	
I	PYG101	Basic Physics (GE)	4	
II	PYC102	Section 1 :Heat and Thermodynamics Section 2 :Properties of Matter & Acoustics	2+1 2+1	
II	PYG102	Optics and Instrumentation (GE)	4	
		S. Y. B. Sc.		
III	PYC103	Section 1: Waves & Oscillation Section 2 : Electronics	2+1 2+1	
III	PYS101	Network Analysis (SEC)	3+2	
IV	PYC104	Section 1: Optics Section 2: Modern Physics	2+1 2+1	
IV	PYS105	Electrical and Electronic Instrumentation (SEC)	3+2	
		T. Y. B. Sc.		
V	PYC105	Section 1: Classical Mechanics Section 2: Thermal Physics	2+1 2+1	
	PYC106	Analog and Digital Electronics	4+2	
	PYC107	Mathematical Physics &Electromagnetic Theory I	4+2	
	PYD101	Quantum Mechanics	4	
	PYD103	Solid State Physics	3+1	
VI	**PYC108**	Atomic and Molecular Physics	4+2	
	PYC109	Solid State Devices and Instrumentation	4+2	
	PYC110	Electromagnetic Theory II & Theory of Relativity	4+2	
	PYD106	Nuclear Physics	4	
	PYD109	Project	4	

SEMESTER I
PYC101: MATHEMATICAL METHODS, MECHANICS
and
ELECTRICAL CIRCUIT THEORY

SECTION 1: MATHEMATICAL METHODS AND MECHANICS

Course Objectives: The main objectives of the course is..
To introduce the required mathematics in the study of classical mechanics in one and two dimensions, and to be able to solve the problems arising in this study. The basic mathematics introduced is matrices, determinants linear equations, complex numbers and calculus. The classical laws of motion and conservation laws of motion help in studying the motion.

Learning Outcomes: On completion of the course the student ..

- Will be equipped to use matrices, determinants, complex numbers and calculus.
- Will understand the classical laws of motion and conservation laws.
- Be able to derive classical equations of motion in one and two dimensions and to solve problems arising in this study.
- The laboratory component .. as a result of practical activities, the students will be able to acquire knowledge and understanding on the basic measurements techniques.

SECTION 2: ELECTRICAL CIRCUIT THEORY

Course Objectives: The course objectives are:
To impart basic knowledge of electrical quantities such as current, voltage, power and techniques of circuit analysis. To make the student familiar with the basic theory of self and mutual inductance, its application and in problem solving, understand concept of transients in electrical circuits (CR, LR, LCR) and resonance. Provide working knowledge for the analysis of AC circuits, mutually coupled LR circuits (transformers) and AC Bridges.

Learning Outcome: On completion of the course the students will be able to :

- Understand the basic concepts of sources of energy (current and voltage), methods of DC and AC circuit analysis and apply the same for problem solving.
- Understand concept of self and mutual inductance which occurs when flux linked with the coil changes, concept of transients in electrical circuits containing capacitor/ inductor and be able to use this knowledge in application and problem solving.
- Understand phenomena of electrical resonance and its application.
- Analyse AC as applied to mutually coupled LR circuits and the working /use of transformer, working of AC Bridges and its application.
- In the laboratory component the student learn to apply their knowledge and understanding of the course to perform experiments on verification of network theorems, transients and AC circuits and have the ability to gather and interpret data collected.

SEMESTER I

PYC101: MATHEMATICAL METHODS, MECHANICS

and

ELECTRICAL CIRCUIT THEORY

SECTION 1: MATHEMATICAL METHODS AND MECHANICS (Theory 2 Credits)

Mathematical methods **[15 Lectures]**

Matrices and determinants, Linear equations [2]
System of linear equations, matrices and determinants.

Elementary Vector Algebra **[2]**
Scalars and vectors, addition and subtraction of vectors, multiplication by a scalar, basis vectors and components, magnitude of a vector, unit vector, dot and cross product of vectors and their physical interpretation.

Complex numbers **[2]**
Complex numbers, notation of complex number, complex planes, physical meaning of complex quantities, exponential, logarithmic and trigonometric functions, hyperbolic functions. De'Moivre's Theorem, Roots of unity.

Limits and Continuity **[3]**
Definition, intervals and neighborhoods, algebra of limits, limits of trigonometric functions, exponential limits. Concept of continuity, left and right hand limits, graphical representation of continuity.

Differentiation **[3]**
Differentiation from first principles, derivative of polynomials, trigonometric, exponential, logarithmic functions and implicit functions. Rules of differentiation, Leibnitz theorem, higher order derivatives.

Integration **[3]**
Integration from first principles, integration as inverse of derivative, integration by inspection. Standard Integrals: (Algebraic, trignometric, exponential logarithmic), integration by parts, substitution methods, reduction formulae).

Mechanics **[15 Lectures]**

Motion of a particle in one dimension **[10]**
Discussion of the general problem of one dimensional motion. Dependence of force in general on position, velocity and time. Motion under a constant force with illustrations - Atwood's machine, free fall near the surface of the earth. Motion along a rough inclined plane. The equation of motion, momentum and energy conservation theorems. Motion under a force which depends on time-general approach to the solution. Illustration using force of the type $F = F_o \sin(\omega t + \varphi)$. Motion under a conservative force dependent on position, potential energy. Motion under damping force depending on velocity - general dependence of resistive force on velocity. Motion in a medium with resistive force proportional to first power of velocity. Body falling under gravity in a resistive medium near the surface of the earth.

Motion in two dimensions : **[5]**

Equations of motion in plane polar coordinates. Momentum and energy theorems. Plane and vector angular momentum theorems.

Projectile motion in a non-resistive and resistive medium, (resistive force proportional to the first power of velocity).

Text Books & References

1. K. F. Riley, M. P. Hobson and S. J. Bence, Mathematical methods for Physics and Engineering, Cambridge University Press (2006).
2. Robert Stainer and Philip Schmidt, Mathematics for Physics students, Schaum series, 2007.
3. K. R. Symon, Mechanics, Addison Wesley (1962).
4. R. G. Takawale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw-Hill (1997).
5. C. Kittel, W. D. Knight, M. A. Rudderman, A. C. Helmhotz and B. J. Moyer, Berkeley Physics Course, Volume I, Mechanics, McGraw-Hill (1973).
6. Eugine Hecht, College Physics, Schaum Outline Series, 2011.
7. P. V. Panat, Classical Mechanics, Narosa Publishing, (2013).
8. D. S. Mathur, Mechanics, S. Chand & Co. (1981).
9. Gupta, Kumar and Sharma, Classical Mechanics, Pragati Prakashan, Merut (2008).

PYC101

MATHEMATICAL METHODS AND MECHANICS

Practical (any four) (1 credit)

Introduction to measurement techniques:

1. Range and least count of instruments, measurements using various instruments and error analysis (Vernier calipers, micrometer screw gauge, travelling microscope, spherometer, spectrometer) Graphical analysis of one-dimensional motion: Kinematics, plotting and interpretation of displacement, velocity and acceleration versus time graphs. Linear and nonlinear plots, determination of slopes and area under the curves for evaluation of physical quantities such as force, work and energy.
2. Motion in resistive medium (Experimentation/Simulation).
3. Atwood's machine.
4. Fly wheel: Determination of frictional couple and moment of inertia of a flywheel.
5. Projectile Motion (Experimentation/Simulation).
6. Bar pendulum
7. Conical Pendulum
8. Torsional Pendulum
9. Graphical analysis of one-dimensional motion: Kinematics, plotting and interpretation of displacement, velocity and acceleration versus time graphs. Linear and nonlinear plots, determination of slopes and area under the curves for evaluation of physical quantities such as force, work and energy.
10. Motion in resistive medium (Experimentation/Simulation).
11. Atwood's machine.
12. Fly wheel: Determination of frictional couple and moment of inertia of a flywheel.
13. Projectile Motion (Experimentation/Simulation).
14. Bar pendulum
15. Conical Pendulum
16. Torsional Pendulum

PYC101

SECTION 2: ELECTRICAL CIRCUIT THEORY

(Theory 2 Credits)

Circuit Analysis **[7]**

Concept of constant current and constant voltage source, Maxwell’s cyclic current method for circuit analysis, Superposition theorem, Thevenin’s theorem, Norton's theorem, maximum power transfer theorem (with proof) and their application to simple networks.

Inductance **[4]**

Self Inductance, self inductance of two parallel wires carrying equal current in opposite directions, Principle of non-inductive resistance coils, self inductance of co-axial cables, mutual inductance, coefficient of coupling, inductance in series and parallel.

Response of circuits containing L, C and R to DC **[6]**

Growth and decay of current in L-R circuit, Charging and discharging of capacitor in C-R circuit and in a series L-C-R circuit.

AC Circuits **[7]**

AC applied to L-R and C-R circuits, Inductive and Capacitive reactance, impedance and admittance, The j operator and vector or phasor method applied to LR, CR and LCR circuits. Series and parallel resonance. Q factor and Bandwidth. Graphic representation of resonance (Variation of resistance, inductive reactance, capacitive reactance with frequency)

Mutually Coupled L-R circuits **[3]**

AC applied to mutually coupled L-R circuits. Reflected impedance. Transformers, Effect of loading the secondary of a transformer.

AC Bridges **[3]**

General AC bridges, Maxwell's bridge, Maxwell's L/C bridge,De-Sauty's bridge. Wein's frequency bridge.

Text Books & References

1. J. Yarwood and J. H. Fewkes, Electricity and Magnetism. University Tutorial Press (1991).
2. D. N. Vasudeva, Fundamentals of Electricity and Magnetism, S. Chand and Company Ltd. New Delhi.(2012)
3. Brijlal and Subramaniam, Electicity and Magnetism, Ratan Prakashan, New Delhi. (1966).
4. Mahmood Nahvi, Joseph Edminister, Electrical Circuits, Schaum outline Series, (2002).
5. Thereja B.L. Text Book of Electrical Technology, S. Chand and Co Ltd. New Delhi (1990).
6. Sudhakar and Shammohan, Circuits and Networks Analysis and Synthesis, TMH, (2006).

PYC101

SECTION 2: ELECTRICAL CIRCUIT THEORY

Practical (any four) (1 credit)

1. Verification of Thevenin’s Theorem & Maximum Power transfer theorem
2. Verification of Norton’s theorem & Maximum Power transfer theorem
3. Response of LR and CR circuits to AC - phasor diagrams.
4. Step Response of CR circuit / LR Circuit.
5. De Sauty’s Bridge- comparison of capacitance and Maxwells L/C Bridge- determination of mutual inductance
6. LCR Series and parallel resonance –Resonant frequency, Q value and Bandwidth.

PYG 101

BASIC PHYSICS (Generic Elective) (4 credits Theory)

Course Objectives:

This paper is offered to non-Physics students mainly to give exposure on Physics topics to relevant to life sciences with an objective of training the students for any competitive exam. The basic Physics is reviewed in a simplest way.

The techniques of measurement of length, time and mass; from radius of proton to size to astronomical distances, from atomic mass unit to mass of earth, from time for fast elementary particle to pass through nucleus to age of earth, and the International systems of units.

The student can apply the knowledge that she gets from the study and demonstration of concepts of elasticity, surface tension, fluid Statics and fluid dynamics *to life Sciences.*

Acoustics is introduced with an emphasis on loudness, sound absorption, ultrasonic waves, Doppler Effect with their application to life sciences. Design of an auditorium for good hearing of music and speech is also discussed.

Electrostatics having relevance in life sciences, and electricity, magnetism and basic electronics is taught to get a feel of instrumentation used in chemical and Biological Sciences.

Learning Outcome:

- At the end of this basic Physics course, the student gets the basic knowledge of General Physics, Properties of matter, Acoustics, Electricity, Magnetism and basic Electronics.
- Though this course has no practical content, the demonstrations, hands on training and assignments with experiments which are made as a part of classroom teaching makes the student confident in answering questions from Physics in the entrance exams and interviews.

PYG 101

BASIC PHYSICS (Generic Elective) (4 credits Theory)

Measurement of Physical quantities, standards and units. [5]

Length: radius of proton to size to astronomical distances.
Mass: atomic mass unit to mass of earth.
Time: time for fast elementary particle to pass through nucleus to age of earth.
Units in electricity: volts, Amperes, ohms.
Units of Temperature: Celsius scale, Kelvin scale.
International systems and units: Units used to measure physical quantities and their inter-conversion.

Properties of matter [12]

Elasticity: Hook's law, modulii of elasticity, Surface tension: Brief review of molecular theory of surface tension. Relation between surface tension and surface energy. Pressure difference across curved surfaces. Angle of contact. Capillarity. *Application of the phenomenon to life sciences.*

Fluid Statics and fluid dynamics**:** Pascal's Principle, Measurement of pressure. Various units of pressure and their inter-conversion, Concept of pressure energy. Bernoulli's theorem and its applications- Venturi meter and Pitot's tube. Viscosity, Viscosity estimation by Oswald's viscometer. Relevance to life sciences.

Acoustics [12]

Loudness, units of intensity and loudness, Weber Fechner law and sound absorbers.

Production and detection of Ultrasonic waves and its applications. Doppler effect. Calculation of of apparent frequency, (Normal incidence only), application to life sciences. Acoustics of Building Growth and decay of intensity, Reverberation of Sound, Reverberation time, Absorption coefficient, Sabine's formula for reverberation time (discussions only) , Acoustic requirements of a good auditorium,

Basics of Electrostatics and Electricity: [10]

Electric charge. Coulomb's law. Applications of electrostatics in life sciences. Basics of electricity: Current, voltage and resistance and their units, Ohm's law, Conductor, Semiconductor and Insulator.

Transducers: characteristics, classification of transducers-electrical, mechanical, optical. Applications in chemical and biological instruments.

Magnetism [5]

The magnetic field, The definition of B, magnetic dipoles, Units of magnetism, Electromagnetic induction, Faraday's law, Lenz's law.

Basic Electronics [16]

Voltage and current sources, Inductance coils, capacitors and transformers. Rectifiers and voltage regulators: Volt-ampere characteristics of Junction diode, Half wave, Full wave and Bridge rectifiers using Junction diodes, Percentage regulation, Ripple factor and Rectification efficiency. ripple filters, Zener diode characteristics and its use as a simple voltage regulator. Thermistor characteristics and its use in A.C. voltage regulation. Junction Transistor and its characteristics in CE mode, Current gain, Voltage gain, Light Emitting Diodes, Photoiodes and Phototransistors.

References:

1. Haliday, Resnik and Walker, Fundamentals of Physics, 10e, John Wiley and Sons.
2. Elements of Properties of Matter, by D. S. Mathur, S. Chand and Sons, (2013).
3. Text book of Sound by Khanna and Bedi.
4. H.S. Kalsi, Electronic Instrumentation,Tata McGraw Hill Publication.
5. A course in Electrical and Electronic Measurements and Instrumentation by A.K. Sawhney, Dhanpat Rai & Sons.
6. V.K.Metha, Principles of Electronics, S.Chand & Company (2009).
7. A.P.Malvino, Electronic Principles –TMH 5th edition

Semester II
PYC 102 - Section 1: Heat and Thermodynamics

Course Objectives:
This course introduces concepts of thermodynamics. It will give an understanding of Zeroth, First, Second and Third Laws of Thermodynamics which are the foundations of energy conversion processes.

Learning Outcomes: At the end of the course the student will be able to…

- Understand concept of ideal gas, kinetic theory of gases and transport phenomena.
- Understand behaviour of real gases and develop an equation of state.
- Comprehend concepts of thermodynamics and apply the first law to different systems.
- Discuss basic thermodynamic cycles and systems (Heat Engine, Carnot cycle and Refrigeration).
- Gain a better insight to second law of thermodynamics and its applications.
- Understand the concept of Entropy.
- In the laboratory component the student will learn and understand the concept of heat. concept of temperature. Measure Stefan's constant, thermal conductivity of material, and able to use different sensor's for temperature measurements.

PYC 102 - Section 2: Properties of Matter and Acoustics

Course Objectives:
This course introduces concepts of matter. It will enable student to understand different types of matter and their properties. Acoustics is introduced, which provides the student an understanding of different types of wave motion.

Learning Outcomes: At the end of the course the student will be able to

- Understand Elasticity of materials and develop theory for elastic behaviour of different materials by studying different systems.
- Understand surface tension and viscosity.
- Develop differential equation for harmonic oscillator.
- Familiarise with general terms in acoustics like intensity, loudness, reverberation, etc, and study in detail ultrasonic waves.
- Demonstrate a strong understanding of waves in transverse and longitudinal modes and derive various parameters of wave motion.
- Demonstrate knowledge regarding acoustic requirements of an auditorium.
- In laboratory component student will learn to determine the Young's modulus of a material through various experiments. Study capillarity rise and hence determine the surface tension of a liquid. Study phenomena of waves.

SEMESTER II
PYC102: HEAT & THERMODYNAMICS

And

PROPERTIES OF MATTER & ACOUSTICS

SECTION 1: HEAT AND THERMODYNAMICS I

(Theory 2 Credits)

Kinetic theory of gases **[8]**

Three states of matter, concept of ideal gas, postulates of Kinetic Theory of gases, expression of pressure of a gas, relation between rms velocity and temperature, Average kinetic energy of a gas molecule, heat and temperature, kinetic interpretation of temperature, Degrees of freedom, Law of equipartition of energy and its application to specific heats of gases. Brownian motion and its features, Einstein's equation, Determination of Avogadro's number. Mean free path and derivation to calculate MFP, Transport phenomena, transport of momentum (viscosity).

Behavior of real gases **[7]**

Deviation from perfect gas behavior, Discussion of results of Andrew's experiments on CO2 and Amagat's experiment, critical constants, Van der Wall's equation of state, expression of Wan der Wall's constants, Reduced equation of state, Law of corresponding state, relation between Boyle temperature and critical temperature, critical coefficient.

Zeroth and First Law of Thermodynamics **[4]**

Basic concepts of thermodynamics: Thermodynamic system, Thermodynamic variables, Thermodynamic equilibrium, and Thermodynamic processes, Zeroth law of thermodynamics and concept of temperature, Internal energy and First law of thermodynamics, Relation between pressure, volume and temperature in adiabatic process, Work done in isothermal and adiabatic processes, Path dependence of heat and work.

Second Law of Thermodynamics **[7]**

Process-reversible and irreversible, condition of reversibility, Second law of thermodynamics, Carnot's cycle, efficiency of Carnot's cycle, reversibility of Carnot's cycle, Carnot's theorem, coefficient of performance of a refrigerator, Thermodynamic scale of temperature, its identity with perfect gas scale, Clapeyron latent heat equation and its applications.

Entropy **[4]**

Entropy as a Thermodynamic variable, Entropy change in reversible and irreversible processes, Temperature–Entropy diagram of Carnot's Cycle, Entropy of a perfect gas, Physical significance of Entropy: Entropy and Unavailable Energy, Entropy and molecular disorder, Entropy and Second Law of Thermodynamics. Impossibility of attaining Absolute Zero (Third law of Thermodynamics).

Text Books & Reference Books:

1. Treatise on heat, M. N. Saha and B. N. Shrivastava, The Indian Press (1965).
2. Thermal Physics, S.C . Garg, R.M. Bansal and C. K. Ghosh, TMH (1993).
3. Thermodynamics J.K. Roberts and A.R Miller , E.L.B.S. (1960).
4. Text Book of Heat, G.R. Noakes, Mcmilan& Co(1960).
5. Thermodynamics, William C .Reynolds (1968).
6. Heat and Thermodynamics M.W. Zemansky and R.H. Ditman, McGraw Hill (1997).
7. Heat, Thermodynamics and Statistical Physics, BrijLal, N. Subrahmanyam and P. S. Hemne, S. Chand.

PYC102

SECTION 1: HEAT AND THERMODYNAMICS I

Practical (any four) (1 credit)

1. Determination of Stefan's constant.
2. Resistance Thermometry (Cu wire and Pt 100).
3. Thermistor- NTC /PTC
4. Study of thermocouples for temperature measurement
5. Constant volume air thermometer.
6. Constant pressure air thermometer.
7. Calibration of Si diode as a temperature sensor.
8. Measurement of thermal conductivity of good conductors- by any method

PYC102

SECTION 2: PROPERTIES OF MATTER AND ACOUSTICS(Theory 2 Credits)

Elasticity: **[10]**

Brief review of moment of Inertia. Modulii of elasticity, Strain energy, equivalence of shear to compression and extension at right angles to each other, Poisson's ratio and its limiting values, Relationship between the elastic constants. Torsion in a string-couple per unit twist, Torsional Pendulum. Bending of beams-bending moment, flexural rigidity. Cantilever (rectangular bar). Depression of a beam supported at the ends and loaded at the center. Theory of Loaded pillars, Critical load for pillars.

Surface Tension: **[4]**

Brief review of molecular theory of surface tension. Relation between surface tension and surface energy. Pressure difference across curved surfaces. Angle of contact. Capillarity, experimental determination of surface tension and angle of contact.

Flow of liquids and Viscosity: **[3]**

Streamline flow, Turbulent flow, Critical velocity. Coefficient of viscosity, Poiseuille's formula for flow of liquid through a capillary tube. Viscosity of gases – Mayer's formula.

Acoustics: **[10]**

Differential equation for harmonic oscillator, Velocity of longitudinal waves in fluids. Newton's formula for velocity of sound, vibrations in stretched strings. (transverse and longitudinal modes). Vibration in rods. Superposition of two simple harmonic motions, standing waves and beats, Helmholtz resonator.

Doppler effect. Intensity level - Bel and Decibel.

Production and detection of Ultrasonic waves and its applications.

Reverberation of sound **[3]**

Reverberation of Sound, Reverberation time, Absorption coefficient, Sabine's formula for reverberation time, Acoustic requirements of an auditorium.

Text Books and References:

1. Elements of Properties of Matter, by D. S. Mathur, S. Chand and Sons, (2013).
2. Lectures in elementary fluid dynamics, by J. M. McDonough (Lecture Notes available on Net, free download).
3. Fluid Mechanics by R K Bansal, Firewall Media, (2005).
4. Fluid Mechanics by Merle Potter, David Wiggert, Schaum Outline Series, (2008). Continuum Mechanics by George Mase, Schaum Outline Series. (1969).
5. Text book of Sound by Khanna and Bedi, Atma Ram, New Delhi, 1969.

PYC102

SECTION 2: PROPERTIES OF MATTER AND ACOUSTICS

Practical (any four) (1 credit)

1. Bending of beams-single cantilever: determination of Young’s modulus.
2. Bending of beams-double cantilever: determination of Young’s modulus.
3. Velocity of sound by forming stationary waves by using C.R.O.
4. Young’s modulus by transverse vibrations of rods /strips.
5. Capillarity: determination of Surface tension.
6. Viscosity of a liquid by Poiseuilles method.
7. Verification of Bernoulli’s theorem.
8. To measure the velocity of flow using Pitot tube.
9. To determine the viscosity of fluid by viscometer.
10. Frequency of AC cycle using amplitude resonance
11. Kundt’s tube experiment

PYG 102

OPTICS and INSTRUMENTATION (Generic Elective) (4 credits Theory)

Course Objectives:
This course is a continuation of previous basic Physics course. Here, ray optics (Lens optics), wave optics (interference, diffraction and polarization) and modern optics (X-Rays and Lasers) are introduced to the students with demonstration of concepts. Students are also given exposure to Bio-medical Instrumentation with Digital Displays.

Learning outcome: On completion of the Course…

- As the optical concepts are taught with experimental demo in class / lab, the student is able to understand, theories of interference, diffraction and polarization, lasers and X-Rays, principles of Diamagnetism, Paramagnetism and Ferromagnetism, mentioned in this course.
- The student learns various imaging techniques like X-ray diagnostics and imaging, Nuclear and Radiological imaging, tomography, Ultrasound imaging etc

PYG 102

OPTICS and INSTRUMENTATION (Generic Elective) (4 credits Theory)

Image Formation **[8]**

Luminous Intensity And Its Units, Reflection, Refraction. Introduction To Lenses, Optical Properties Of Lenses, Thin Lenses & Thick Lenses, Cardinal Points Of An Optical System, Aberrations; Spherical & Chromatic Aberrations In Lenses (Only Conceptual), Methods Of Minimizing Spherical & Chromatic Aberrations. Kellner's, Ramsden And Huygens Eyepiece- Construction And Image Formation With Optical Ray Diagrams.

Interference: **[3]**

Interference by Division of Wave Front & Division Of Amplitude. One Example Of Each Kind.

Diffraction: **[5]**

Concept of Diffraction, Fresnel and Fraunhoffer Class of Diffraction. Concept Of Fraunhoffer Diffraction At Single Slit, Application Of Fraunhoffer Diffraction To Resolving Power Of Optical Instruments, Raleygh's Criterian For Resolution, Resolving Power Of Telescope And Microscope.

Polarization: **[5]**

Concept Of Polarization, Plane Of Polarization, Polarization By Reflection, Brewster's Law, Polarization By Refraction, Double Refraction. Nicol Prism, Simple Polarimeter

Lasers: **[7]**

Stimulated And Spontaneous Emission, Population Inversion, Lasers, Properties Of Lasers, Different Kinds of Laser, Applications of Lasers In Medicine, And Science. Optical Fibers: Basic Principle and Applications.

X-Rays **[5]**

Coolidge Tube Generator, Continuous X-Ray Spectra and its Dependence on Voltage, Duane And Hunt's Law, Wave Nature Of X-Rays – Laue's Pattern, Diffraction Of X-Rays By Crystal, Bragg's Law, Bragg Single Crystal Spectrometer, Analysis Of Crystal Structure - Simple Cubic Crystal.

LCD And LED Displays:

Types of Liquid Crystals, Principle Of Liquid Crystal Displays, Applications, Led's, Led Displays And Their Advantages.

Instrumentation **[7]**

Simple Microscope, Compound Microscope, Phase Contrast Microscope, Electron Microscope, XRD, UV and IR Spectroscopy.

MEDICAL IMAGING PHYSICS: **[12]**

Molecular field: Diamagnetism, Paramagnetism and Ferromagnetism,
X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR) – NMR imaging – MRI Radiological imaging –Radiography –X-ray film – fluoroscopy –computed tomography scanner – principle function – display – generations –mammography. Ultrasound imaging – magnetic resonance imaging

Demonstration in class/ laboratory. **Any four** **[8]**

1. Luxmeter/Photometer.
2. Construction and image formation of Ramsden /Huygens eyepiece.
3. Interference patters using Fresnel's biprism, Lloyds mirror in Physics Laboratory.
4. Fresnel and Fraunhoffer class of Diffraction, Resolving power of telescope and microscope in Physics Laboratory.
5. Polarization using Polaroid, Double refraction. Nicol prism, simple polarimeter in Physics Laboratory.
6. Some properties of lasers in class.
7. Analysis of x-ray diffraction data for crystal structure determination

References

1. N Subrahmayam and N.Brijlal, Text Book of Optics, S. Chand & Company Ltd,(1991).
2. Arthur Beiser, Concepts of Modern Physics, 5th Edition, McGraw Hill (1985).
3. Banwell, Fundamentals of Molecular Spectroscopy, TMH (2012).
4. K. Thyagrajan and A. Ghatak Laser: Theory and Applications, McMillan (2009).
5. R. S. Khandpur, Handbook of Biomedical Instrumentation, Second Edition. Front Cover. . Tata Mcgraw-hill Pub, 1992
6. Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)

SEMESTER III
PYC103: SECTION 1: WAVES AND OSCILLATIONS

Course Objectives:
To give an understanding of oscillations and waves and an appreciation of their importance in the study of physics; to introduce the mathematical tools used in their analysis.

Course Outcomes: At the end of the course the student will be able to

- Formulate and solve the equations of motions for different physical systems that undergo SHM.
- Apply the principle of superposition for two harmonic motions having different and same frequency respectively.
- Demonstrate knowledge of the fundamental assumptions related to the derivation of the wave equation.
- Derive and solve the equations for the damped oscillator and forced oscillator; understand the concept of resonance.
- In **laboratory component** student will experiment with different types of harmonic systems and will be able to predict the outcome of the experiments using the theory learnt during lectures. Students will be able to demonstrate of undamped, damped and driven oscillations. Analyse two harmonic motions using CRO. Understand and demonstrate the phenomena of resonance. Also, will find different elastic properties of the material used for certain experiments.

PYC103: SECTION 2: ELECTRONICS

Course Objectives: The course main objectives are:
Introduction of semiconductor devices like diodes, thermistors, transistors and operation amplifiers.
Understand the concept and use of Current – Voltage (I-V) characteristics of semiconductor devices, study of required characteristic parameters. Applications using diodes, thermistors in voltage source (rectification and regulation), amplification using transistors. Transistor Biasing -- Stability biasing, Concept of feedback in amplifiers and oscillator circuits. Operation amplifiers characteristics and its use in amplification.

Course Outcomes: On completion of the course the students will be able to:

- Understand the basic behavior/working of the electronics devices like rectifying diodes, zener diodes, thermistors, transistors and operation- amplifiers.
- Apply to a variety of situation and applications in rectification, regulations, amplification, oscillations.
- Understand Operation amplifiers characteristics and its use in amplification.
- Solve problems based on these topics.
- In laboratory component students will experiment with the use of diodes as unregulated and regulated power supplies, Transistors as amplifiers and its properties, transistor in oscillators and operation amplifiers as amplifiers.

SEMESTER III
PYC103: WAVES & OSCILLATIONS

And

ELECTRONICS

SECTION 1: WAVES AND OSCILLATIONS

(Theory 2 Credits)

Waves and Oscillations: **[10]**

Periodic oscillations and potential well, differential equation for harmonic oscillator and its solutions (case of harmonic oscillations), kinetic and potential energy. Examples of simple harmonic oscillations: spring and mass system, simple and compound pendulum, Helmholtz resonator, bifilar oscillations.

Superposition of Waves: **[8]**

Wave equation and solutions, Superposition of two simple harmonic motions of the same frequency along the same line, interference, superposition of two mutually perpendicular simple harmonic vibrations of the same frequency, Lissajous figures, case of different frequencies.

Oscillatory Motion in a Resistive Medium: **[12]**

Damped harmonic oscillator, Damped forced harmonic oscillator. Displacement and velocity Resonance, Sharpness of resonance, Phase relationships, Energy consideration in a forced harmonic oscillator. Harmonic oscillator with an arbitrary applied force.

Text Books and References:

1. Takawale R. G. and Puranik P S. Introduction to Classical Mechanics, TMH, 1997
2. D. R. Khanna and R.S. Bedi, Text book of Sound,Atma Ram, New Delhi (1994).
3. N. K. Bajaj, Physics of Waves and Oscillations, TMH, 2006.
4. A P French, Waves and Oscillations, CBS Publishers, 2003
5. H. J. Pain, Physics of Vibrations and waves, 6th Ed, Wiley, India, 2005
6. Brijlal and Subrahmanyam, Waves and Oscillations and Accoustics, S Chand & Co Ltd.(2009)
7. D. Chattopadhyay and P.C. Rakshit, Waves and Oscillations, Books and Allied Pvt Ltd (2009)
8. M Ghosh and B Bhattacharya, Oscillations and Accoustics, S Chand & Co Ltd. (1976).
9. S.P.Puri, Text book of Vibrations and Waves, Macmillan India ltd, 2nd edition, 2004

PYC103

SECTION 1: WAVES AND OSCILLATIONS

Practical (any 4) (1 credit)

1. Bifilar oscillations Determination of η using Flat spiral spring.
2. Determination of η using Flat spiral spring.
3. Determination of Y using Flat spiral spring.
4. Y by vibrations of cantilever.
5. Superposition of two mutually perpendicular simple harmonic oscillations -Lissajous figures using CRO.
6. Helmholtz resonator.
7. Simulation of Waves
8. Resonance pendulum –study of amplitude resonance and determination of ‘g’
9. Double pendulum.

PYC103

SECTION 2: ELECTRONICS (Theory 2 Credits)

Rectifiers and Regulators **[6]**

Volt-ampere characteristics of Junction diode, Half wave, Full wave and Bridge rectifiers using Junction diodes without and with capacitive filters. Percentage regulation, Ripple factor and Rectification efficiency. Zener diode characteristics and its use as a simple voltage regulator. Thermistor characteristics and its use in A.C. voltage regulation.

Transistors **[3]**

Basic configurations of transistors, Transistor characteristic in CE and CB mode, Current gains α and β and their interrelation, Leakage current in transistors.

Basic Amplifier Characteristics **[3]**

Current gain, Voltage gain, Power gain, Input resistance, Output resistance, Conversion efficiency, Classes of amplifier operations, Decibel, Frequency response, Amplifier bandwidth.

CE amplifier: Class A **[4]**

Graphical analysis, Effect of adding A.C. load, Input and Output resistance, Conversion efficiency, Phase relationship between input and output.

Transistor Biasing **[4]**

Bias stability, Stability factor, Different methods of biasing, biasing compensation.

Feedback **[5]**

Positive and negative feedback, Voltage and current feedback, series and shunt feedback.
Effect on negative feedback on gain, frequency response, input and output resistance and distortion. **Positive feedback,** Barkhausen criterion for oscillations, Phase shift oscillator, Wein bridge oscillator, LC tank circuit, Hartley oscillator and Colpitts oscillator.

Linear IC's and Operation Amplifiers **[5]**

The Differential Amplifier, OP-Amp characteristics, Input and Output impedance, Input bias and offset currents, Input and output offset voltages. Differential and Common mode gains, CMRR, Slew rate, OP-Amp as inverting , Non Inverting amplifier and Difference amplifier.

Text Books and References

1. A.P.Malvino, Electronic Principles –TMH 5th edition (1996).
2. Allen Mottershed, Electronics Devices and Circuits an Introduction- 3rd edition PHI (1997).
3. Millman and Halkias, Intergrated electronics- TMH (1972).
4. Bhargava, Kulshrestha and Gupta, Basic Electronics and Linear Circuits-. TMH (1984).
5. Ramakant Gayakwad, Op-amp and Linear Intergrated Circuits, PHI (2002).

PYC 103

ELECTRONICS

Practical (any four) (1 credit)

1. Half wave and Full wave rectifier using Junction Diode, Load regulation characteristics.
2. Bridge rectifier with capacitor filter- Ripple factor using CRO.
3. Zener Diode Regulation.
4. Colpitts / Hartley oscillator
5. Wein’s Bridge /Phase shift Oscillator.
6. Transistor characteristics- Input and Output (C E mode)
7. C.E. Amplifier. Fequency response with and without negative feedback. Calculation of Gain Bandwidth product.
8. C.E. Amplifier -Determination of Input and Output Impedance, Variation of Gain with load
9. OP-Amp: Inverting and Non-inverting amplifier.
10. Op-Amp : Differential amplifier & adder/subtractor

PYS 101: NETWORK ANALYSIS

Course Objective:

With knowledge of Mathematical Physics, and electrical circuit theory, student studies this problem solving course with advanced techniques for solving network with DC source, using network theorems, Mesh /super mesh/ node/super node analysis for different kinds of networks.

Other objectives are to review Alternating current concept, and study the transient behavior of complex R-L, R-C and RLC circuits, to both DC and AC, and response of mutually coupled circuit to AC, Study of two port network parameters with the interpretation. AC bridges are taught with an emphasis on problem solving.

Learning outcomes: At the end of the course, the student gets additional knowledge of super node technique for solving circuit problems with voltage source common to two nodes, and super mesh technique to solve problems with circuits having constant current source common to two loops.

Also, the students learn to calculate two port network parameters for T, $\boldsymbol{\pi}$,lattice and bridge networks.

In the laboratory component the student learn to apply their knowledge and understanding of the course to perform simple laboratory experiments on verification of network theorems , trasients, Filters, Response of LR, CR circuit to DC and AC. The student acquire the ability to gather and interpret data collected

PYS 101: NETWORK ANALYSIS

Review of BASIC CONCEPTS: **[5]**

Voltage, Current, Power and Energy, Constant voltage and constant current source, The sine wave, RMS value and average value of a sine wave, The Resistance, Inductance and Capacitance, Kirchhoff's Voltage Law, Kirchhoff's Current Law, Principle of non-inductive resistance coils, Mutual inductance, Coefficient of coupling. Self Inductance of co-axial cables, Inductance in series and parallel. Capacitances in series and parallel.

CIRCUIT ANALYSIS AND NETWORK THEOREMS: **[10]**

Mesh analysis, Super Mesh analysis, Nodal analysis, Super Node analysis, Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum power transfer Theorem, Impedance matching. **RESPONSE OF RL, RC and RLC circuits to DC and AC [11]** Transient Response of RL, RC and RLC circuits. Sinusoidal response of RL, RC, RLC circuits, Impedance diagram, Phase angle, series and parallel complex impedance circuits. **POWER AND POWER FACTOR: [3]** Instantaneous power, Average power, Apparent power and Power factor, Reactive power, Power triangle.

COUPLED CIRCUITS: **[3]**

AC applied to mutually coupled L-R circuits. Reflected impedance, Transformers, Effect of loading the secondary of a transformer, Ideal transformer.

RESONANCE: **[3]**

Series resonance, quality factor (Q) and its effect on Bandwidth, parallel resonance, Q factor of parallel resonance.

TWO-PORT NETWORK: **[7]**

Two-port networks, open circuit impedance (Z) parameters, Short circuit admittance (Y) parameter, Hybrid (h) parameter, Interrelationship of different parameters, T & II networks, Lattice networks.

AC BRIDGES **[3]**

General AC bridges, Maxwell's bridge, Maxwell's L/C bridge, De-Sauty's bridge. Wein's frequency bridge.

Text Books & References ;

1. Sudhakar and Shammohan, Circuits and Networks Analysis and Synthesis, TMH, (2006).
2. J. Yarwood and J. H. Fewkes, Electricity and Magnetism. University Tutorial Press (1991).
3. D. N. Vasudeva,Fundamentals of Electricity and Magnetism.S. Chand and Company Ltd. New Delhi.(2012).
4. Brijlal and Subramaniam, Electicity and Magnetism, Ratan Prakashan, New Delhi. (1966).
5. Thereja B.L. Text Book of Electrical Technology, S. Chand and Co Ltd. New Delhi (1990).
6. Mahmood Nahvi, Joseph Edminister, Electrical Circuits, Schaum outline Series, (2002).

Practical: Minimum of 4 experiments.

1. Design of 1 mH inductor.
2. Study of High pass, Low Pass filters using passive components.
3. Band pass and Band stop filters using passive components.
4. Study of passive integrator and differentiator.
5. Thevenin’s Theorem and Norton’s Theorem.
6. Varification of Superposition Theorem.
7. Impedance Matching.
8. Response of LR, circuit to DC and AC.
9. Response of CR circuit to DC and AC.

SEMESTER IV

PYC104: OPTICS AND MODERN PHYSICS

SECTION 1: OPTICS

Course Objectives: The main objective of the course is to
Introduce optical phenomena of Interference, Diffraction and Polarisation. In Interference - methods of production are studied along with the use of interferometry in length measurements, Phenomenon of diffraction with concept of resolving power, concept of Polarisation and optical activity with its applications. Practical component imparts the skills needed to use instruments in measurements and to estimate optical constants.

Course Learning outcome. On completion of the course the student Will have a good grasp of the three major optical phenomena.

SECTION 2: MODERN PHYSICS

Objectives . The main objective of this course is ….
To provide information about motion/trajectory of charged particles under Lorentz force and its application in atomic physics in measurement of e/m of cathode rays, measurement q/m of positive rays, measurement of mass in mass spectrometer. Basic working knowledge of linear accelerator and cyclotron. Bohr's Hydrogen atom- existence of discrete energy levels -Frank-Hertz experiment.

To provide facts of black body radiation and to how classical concept is inadequate in explaining Photoelectric effect and Compton Effect and the use of quantum theory, X-rays, X-ray emission spectra, diffraction of electrons..

Outcomes. On completion of the course the students will.

- Know and understand the application of Lorentz force in controlling the motion of charged particle. Use this knowledge in measuring e/m of cathode rays, q/m of positive rays and in mass spectrometer / spectrographs. Have acquired working knowledge of Linear accelerator and Cyclotron.
- Have understood concept of Quantization of Energy-Existence of discrete energy levels.
- Have acquired knowledge and understanding of Properties of electromagnetic radiation, why classical concept failed in explaining modern experiments, X-ray-- emission spectra, diffraction of electrons.
- Have acquired knowledge of basic crystal structure, and use of x-ray in study of actual crystal structure.
- Be able to express the concept of the subject and problem solving.
- Laboratory component … Learn the skill to perform experiments in modern physics, measuring physics constants using LED's , transistors and learn to interpret basic x-ray diffraction patterns and x-ray emission lines.

SEMESTER IV
PYC104: OPTICS

And

MODERN PHYSICS

SECTION 1: OPTICS

Interference **[9]**
Introduction: Interference by division of wave front & division of amplitude. Fresnel's biprism and Lloyd's mirror.

Formation of colors in thin film- reflected system, Transmitted system, wedge shaped film, Newton's Rings and its application to determine refractive index of liquids (Normal Incidence only).

Interferometry:- Michelson interferometer-its principle, working and its application to determine wavelength and difference between two wavelengths. Fabri Perot Interferometer.

Diffraction **[12]**
Concept of Diffraction, Fresnel and Fraunhoffer Diffraction. Division of cylindrical wave-front into half period strips, Fresnel's diffraction at straight edge and cylindrical wire. Fraunhoffer diffraction at single, double and N slits. Diffraction grating, width of principal maxima of plane diffraction grating. Resolving power of optical instruments- Rayleigh's criterion, Resolving power of telescope, Prism and grating.

Polarization **[9]**
Concept of polarization, Plane of polarization, Polarization by reflection, Brewster's law, Polarization by refraction, Double refraction, uniaxial and biaxial crystals, positive and negative crystals, Nichol's Prism, Circularly and Elliptically polarized light - Theory and analysis, Polaroid, Retardation plates - Quarter wave plate and Half wave plate, Optical activity, specific rotation, simple polarimeter, Laurent's half shade polarimeter.

Text Books and References

1. N Subrahmayam and N.Brijlal, Text Book of Optics, S. Chand & Company Ltd,(1991).
2. Optics, AjoyGhatak, Tata McGraw-Hill Publicashing Company Limited. (1977).
3. Ghatak And Tyagrajan, Contenprary Optics, Mc Millan (2003).
4. R. S Longhurst, Geometrical and Physical Optics, Orient Longman (1976 Indian edition).
5. Francis A Jenkins and Harvey E White, Fundamentals of Optics, (1976).
6. D N VasudevaA textbook of light for B. Sc. students (1962).
7. B.K. Mathur and T P Pandya,Principles of Optics, New Global Printing Press, Kanpur. (1980).

PYC104

SECTION 1: OPTICS

Practical (any four) (1 credit)

1. Spectrometer: Determination of dispersive power of prism..
2. Cardinals points of two lenses.
3. Wedge shaped film – determination of wavelength
4. Fresnel Biprism
5. Newton's rings - determination of radius of curvature of lens
6. Single slit Diffraction using Na source
7. Diffraction Grating.
8. Resolving power of telescope using wire mesh.
9. Verification of Brewster's law.

PYC104

SECTION 2: MODERN PHYSICS
(Theory 2 Credits)

Motion of charged particles in electric and magnetic fields **[6]**

Lorentz force , Motion in a uniform electric field, magnetic field, parallel and crossed fields. Electric discharge through gases, Determination of e/m for cathode rays, Charge and mass of an electron, Atomic masses, Energy and mass units.

Particle Accelerators **[3]**

Linear accelerator and Cyclotron.

Atomic Physics **[6]**

Measurement of Mass: Thomson's positive ray analysis, Dempster's Mass spectrometer, Bainbridge Mass spectrograph. Review of Bohr's Hydrogen atom, Correction due to finite nuclear mass. Frank-Hertz experiment and atomic energy levels.

Properties of electromagnetic radiation **[7]**

Black Body Radiation, Kirchoff's radiation law, Stefan's law, Wien' law, Raleigh - Jean's law, Planck's law. Photoelectric effect and Compton Effect – observation, description, derivations of relevant equations and failure of classical physics to explain the same. Experimental verification of the Photoelectric and Compton effects.

Crystal Structure **[3]**

Crystal lattice,crystal planes and Miller indices, unit cells, typical crystal structures.

X- rays **[5]**

Coolidge tube generator, Continuous X-ray spectra and its dependence on voltage, Duane and Hunt's law, Wave nature of X-rays – Laue's pattern, Diffraction of X-rays by crystal, Bragg's law, Bragg single crystal spectrometer, Analysis of crystal structure - simple cubic crystal.

Text Books and References;

1. Arthur Beiser, Concepts of Modern Physics, 5th Edition, McGraw Hill (1985).
2. S.B. Patel, Nuclear Physics, TMH (1991).
3. Irving Kaplan, Nuclear Physics, Narosa Publishing House,(1997).
4. F.K. Richtmyer, E.H. Kennord, J.N. Cooper Introduction to Modern Physics, McGraw Hill (1997).
5. H.Semat and J.R.Albright, Introduction to Atomic and nuclear Physics, Chapman and Hall (1973).
6. J.B.Rajam, Atomic Physics, S.Chand and Co. Ltd.(1950).

7. K. Thyagrajan and A. Ghatak Laser: Theory and Applications, McMillan (2009).
8. K.Thyagarajan and A.Ghatak, Optical Electronics, Cambridge University Press (1997).
9. B.B.Laud, LASERs and Non-linear optics, Wiley Eastern (1991)

PYC104

SECTION 2: MODERN PHYSICS

Practical (any four) 1 credit

1. Frank Hertz Experiment.
2. Characteristics of photo cell.
3. Measurement of K/e using transistor.
4. Photocell (verification of Photoelectric effect).
5. To determine the Planck's constant using LEDs of at least 4 different colours.
6. Measurement of emissivity of hot bodies (various types of surfaces).
7. X-ray emission (characteristic lines of copper target) – calculation of wavelength and energy and assigning transitions.
8. Calculation of lattice constant by of Copper – x-ray diffraction pattern is given and student calculates, d-spacing, miller indices and lattice constant.

PYS105: ELECTRICAL AND ELECTRONIC INSTRUMENTATION
(3 credits theory and one credit practical)

Course Objectives

Learning Outcomes.

PYS105: ELECTRICAL AND ELECTRONIC INSTRUMENTATION
(3 credits theory and one credit practical)

D.C Indicating Instruments: (6)
PMMC Galvanometer (D'Arsonval movement) - Principle, construction and working, current sensitivity, voltage sensitivity and megohm sensitivity, advantages and disadvantages, conversion of Galvanometer into Ammeter, Voltmeter and Ohmmeter (series and shunt type), Aryton shunt, Loading effect of voltmeter. **A.C Indicating Instruments: (6)** Electrodynamometer-principle, construction and working, merits and demerits, Rectifier type Instruments, thermocouple Instrument (Ammeter), electrostatic voltmeter-principle, construction and working, watt-hour meter.

D.C and A.C Bridges: (6)
Wheat stone bridge-determination of resistance, Kelvin double bridge-determination of resistance, Maxwell's L/C bridge-determination of self inductance, Wien's bridge-determination of frequency, Schering bridge-determination of capacitance.

Power Supplies: (9)
Unregulated D.C power supplies(using full wave, bridge rectifier with C and L-C filter), transistor series and shunt voltage regulators, OP-AMP series and shunt voltage regulators, voltage regulators using IC 78xx series and ICLM317, Switching regulator(step down type).

Oscilloscopes: (9)
Block diagram of basic oscilloscope, CRT, deflection sensitivity, electrostatic deflection, electrostatic focusing (explanation only –no mathematical treatment), vertical amplifier, delay line circuit, sweep generator, measurement of voltage, period, frequency and phase difference, sampling oscilloscope, Digital storage oscilloscope – block diagram and working principle.

Instrumentation Amplifiers and Signal Analyzers: (9)
Instrumentation amplifier, Electronic voltmeters - d.c voltmeter with direct coupled amplifier, a.c voltmeter using rectifiers, ramp type digital voltmeter, digital multimeter, function generator, wave analyzers- audio range wave analyzer, heterodyne wave analyzer.

Books:

1. W. D. Cooper and A. D. Helfrik Electronic Instrumentation and Measurement Techniques - PHI Publication
2. H.S. Kalsi, Electronic Instrumentation,Tata McGraw Hill Publication
3. A course in Electrical and Electronic Measurements and Instrumentation by A. K. Sawhney, Dhanpat Rai & Sons
4. Robert Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory - PHI Publication
5. Ramakant Gayakwad, Op-amps and Linear Integrated Circuits, Pentice Hall, 2000.

Practical: Minimum of 4 practical

1. Use of Analog and Digital Multimeter for components testing and measurements(voltage, current and resistance)
2. Design and construction of multi range Voltmeter
3. Design and construction of series type Ohmmeter
4. Study of Maxwell’s L/C bridge for determination of inductance
5. Study of Schering bridge for determination of capacitance
6. Design and construction of Wien bridge oscillator using OP-AMP
7. Design and construction of Instrumentation amplifier using OP-AMP
8. Series voltage regulator using transistor/OP-AMP.
9. Shunt voltage regulator using transistor/OP-AMP.
10. Design and construction of Function Generator using IC XR2206.
11. Measurement of frequency and phase on a CRO using Lissajous figures
12. Study of SMPS.

SEMESTER V

PYC105 CLASSICAL MECHANICS AND THERMAL PHYSICS

Course Objectives:

The course of classical mechanics introduces the concept of centre of mass of a system and the conservation laws of physics . It also studies in depth the motion under inverse square law force field and the moving co-ordinate system followed by the rigid body dynamics. At every step problems solved help to deepen understanding of concepts mentioned.

The course on Thermal Physics studies two power cycles the Otto and the Diesel ,followed by different methods of producing very low temperatures. The statistics introduced studies the three distributions, the Binomial ,Poisson and Gaussian distributions. This statistical approach is applied to a thermal system to arrive at the most probable distribution or equilibrium at a particular temperature.

Learning Outcomes. On Completion of the course the students will…

- Understand concepts of centre of mass ,conservations laws of motion.
- Gain a good understanding of the moving co-ordinate system and the rigid body dynamics.
- Understand the Otto and Diesel cycle.
- Learn a number of methods of low temperature production.
- Be able to use the different distributions in different applications.
- Be able to arrive at the most probable distribution for a thermal system.
- Solve numerical problems and at every step will help to look deep into the physics involved.
- Laboratory component … Learn skills to perform experiments with the laboratory designed experiments .To obtain the value of the well known physical constants of the materials provided and be able to investigate the system of coupled oscillators.

SEMESTER V

PYC105
CLASSICAL MECHANICS and THERMAL PHYSICS
(Theory 4 credits)

Classical Mechanics:

Motion of a system of particles **[7]**

Center of mass coordinates, applications of conservation laws for linear momentum, angular momentum and energy - rockets, conveyor belts and planets, critique of conservation of laws. The collision problems, the two body problem, reduction to equivalent one body problem.
(Ref: [1,2,3]).

Motion under a central force [**10]**

General features of motion, qualitative discussions of orbits under inverse square law force field. Nature of orbits, elliptical orbits, Kepler's problem, hyperbolic orbits, classical scattering, definition of scattering cross section, impact parameter and scattering angle, Rutherford's scattering cross section. (Ref: [1,2]).

Moving coordinate systems **[7]**

Inertial and non- inertial coordinate frames, rotating coordinate systems, laws of motion on the rotating earth, Coriolis force, Foucault's pendulum, and Larmor's theorem. (Ref: [2,4]).

Rigid bodies **[6]**

Rotation about an axis, moment of inertia tensor, Euler's equations of motion of a rigid body, torque free motion, qualitative discussion of motion of a symmetric top.
(Ref: [1,2,4]).

Thermal Physics:

Power cycles. **[3]**

Internal Combustion Engines – The Otto cycle and its efficiency, Diesel cycle and its efficiency.
(Ref: [6,7]).

Production of low temperature. **[13]**

Cooling by evaporation. Vapour compression machines. Refrigerators based on Vapour absorption. Cooling by sudden adiabatic expansion of compressed gases. Efficiency and performance of refrigerating machines. Enthalpy and heat flow. Joule Kelvin effect. Expression for Joule Kelvin coefficient and inversion temperature. Application to Van der Waals' gas. Principles of regenerative and cascade cooling. Liquifaction of hydrogen and helium. Production of temperatures below 4^{o} K. Properties of He I and He II. Cooling by Adiabatic Demagnetisation of paramagnetic substances. (Ref: [4,6,7,8]).

Probability **[7]**

Random Events, Probability, Probability and Frequency, Some basic rules of Probability theory, Continuous random variables, Mean value of discrete and continuous variables, Variance: Dispersion, Probability Distribution, Binomial distribution: Mean value and fluctuation, Stirling's Approximation, Poisson Distribution: Mean value and Standard deviation, Gaussian Distribution: Standard deviation. (Ref: [9,10]).

Statistical Distributions: **[7]**

Concept of Phase space, Probability of distribution and most probable distribution. Maxwell Boltzmann Statistics. Molecular speeds: mean, most probable and rms speeds. Experimental verification of Maxwell Boltzmann distribution law (Zartman ko experiment). Bose Einstein and Fermi Dirac statistics (qualitative study). (Ref: [4,6,11]).

References

1. K. R. Symon, Mechanics, Addison Wesley (1971).
2. R. G. Takawale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw-Hill (1997)
3. Gupta, Kumar and Sharma, Classical Mechanics, Pragati Prakashan.
4. A.V. Namjoshi, J.A. Rao, Classical Mechanics Thermal and Statistical Physics (T.Y. B.Sc Vol. III), Sheth Publishers Pvt. Ltd.
5. C.L. Arora & P.S. Hemne, Physics for Degree Students, S. Chand
6. Brij Lal & Subrahmaniam, Heat Thermodynamics and Statistical Physics, S. Chand Publications.
7. M.N. Saha and B.N. Shrivastava,Treatise on heat, The Indian Press(1965).
8. M.W. Zemansky and R.H. Ditman, Heat and Thermodynamics, McGraw Hill (1997).
9. B.B. Laud Introduction to Statistical Mechanics, New Age International (2008).
10. N. Joshi, S.G. Chitale, G. Venkat, S.R. Rege, Statistical Techniques,
11. Perspectives of modern physics – Arthur Beiser, McGraw hill (1995).

PYC105

CLASSICAL MECHANICS and THERMAL PHYSICS
(Practical 2 credits)

Minimum of total 8 experiments, but at least 3 experiments from each section

Classical Mechanics

1. Kater's Pendulum.
2. To investigate the motion of coupled oscillators.
3. Surface tension by Quinke's method
4. Y by Koenig's method
5. To determine "Y" by optical lever Viscosity of liquid using Stokes method
6. Verification of parallel & perpendicular axis theorem – using Moment of Inertia
7. Determination of Log decrement & viscosity

Thermal Physics

8. To determine temperature coefficient of Pt_{100}
9. Specific heat of graphite.
10. Measurement of thermal conductivity of poor conductors. –by Lee's method
11. Measurement of thermal conductivity of good conductors – by Searle's method
12. Computer simulation of Maxwell-Boltzmann distribution, Fermi- Dirac & Bose-Einstein

PYC106

ANALOG AND DIGITAL ELECTRONICS

Course Objectives. The course introduces the student to analog and digital electronics.
In analog electronics - Application of transistor as a switch in multivibrators and comparator circuits (astable, monostable bistable and Schmitt Trigger). Application of **Op-amp** in active diode circuits, intergrator, differentiator, multivibrators, comparators, waveform generator, voltage regulators, and IC-555 timer and its application.
The course also introduces the working and operation of another very important electronic device the Field Effect Transistor JFET and MOSFETS and applications.
The course in digital electronics introduces the students to a detailed study of number system logic - binary logic, logic gates, combinational and sequential circuits.

Course Outcomes: On completion of the course the student will **..**

- Understand the working of **transistor** as a switch, and apply this knowledge to explain the principle of operation of multivibrators and Schmitt trigger.
- Understand the working of **Op-amp** as in Active diode circuits, intergrator, differentiator, multivibrators, comparators, waveform generator, IC voltage regulators, and IC-555 timer and applications.
- Understand the working principle and operation of Field Effect Transistors(FET) and MOSFETS in amplifiers, oscillators and VVR dependent devices.
- Understand binary logic, working of logic gates, working of digital circuits like adders, subtracters, multiplexers, demultiplexers, flip flops, counters and digital clock and other combinational and sequential circuits.
- The laboratory component ….. will have developed those learning skills and apply knowledge and understanding of basic electronics to build, analyze and realize simple circuits.

PYC106
ANALOG AND DIGITAL ELECTRONICS
(Theory 4 credits)

Analog Electronics:

Transistors Multivibrators. **[6]**

Transistor as a switch, switching times, Multivibrators – Astable, Monostable, Bistable and Schmitt Trigger.

Field Effect Transistors. **[11]**

Basic structure of the JFET, Principles of operation, Characteristic curves and parameters, Common source amplifiers, Common gate amplifier (only qualitative discussion), The MOSFET Depletion Mode and Enhancement mode, Dual-Gate MOSFET. FET Phase shift oscillator, FET as VVR and its applications in Attenuator, AGC and Voltmeter circuits.

Applications of OP-AMP. **[6]**

Active diode circuits, Intergrator, Differentiator, Comparator, Window comparator, Schmitt Trigger, Waveform generator –Square wave, Triangular and Ramp Generator and monostable.

Voltage Regulation: **[3]**

Fixed voltage regulation using IC-78 & 79 series, adjustable voltage regulators using IC LM-317.

Timers: **[4]**

IC-555 Timer : basic concept, block diagram, Monostable, Astable and Voltage controlled oscillator (VCO).

Digital Electronics:

Number system Logic. **[15]**

Binary number system, Binary to Decimal and Decimal to Binary conversion, Basic logic gates, OR, AND, NOR, NAND, and EX-OR, Bubbled OR and Bubbled AND gates. De Morgan's Law's, Boolean Algebra, NAND and NOR gates as universal building blocks in logic circuits, Sum of Products methods and Product of Sum methods of representation of logical functions. Binary addition and Subtraction, Half adder and Full adder, Multiplexer and Demultiplexer. Encoders and decoders

Logic families – DTL, TTL Standard TTL NAND gate, Schottky TTL, ECL OR and NOR gate, MOS (inverter, NAND and NOR gates) and CMOS (inverter, NAND and NOR gates).

Flip Flops and Counters. **[15]**

Basic RS FF, Clocked RS FF, JK FF, D-type and T-type FF, Master Slave Concept, 3 bit Shift register (shift left, shift right), Applications of FF's in counters, 3 bit count up/count down binary ripple counter, Mod 3, Mod 5, Mod 7 Counters, BCD Decade Counter, Cascade BCD Decade counters, Principle of digital clock.

Books and References:

1. A.P. Malvino, Electronic Principles: TMH.(2007).
2. Allen Mottershed, Electronics Devices and Circuits An Introduction: PHI (1997).
3. Millman and Halkias, Electronic Devices and Circuits, Mc Graw Hill (1967).
4. Millman and Halkias, Intergrated Electronics, TMH (1971).
5. V.K.Metha, Principles of Electronics, S.Chand & Company (2009).
6. Malvino and Leach, Digital Principles and Applications, TMH (1986).
7. R. P. Jain, Modern Digital Electronics, TMH (2003).
8. Ramakant Gayakwad, Introduction to operational amplifier, PHI.

PYC106
ANALOG AND DIGITAL ELECTRONICS
(Practical 2 credits)

Minimum of total 8 experiments, but at least 3 experiments from each section

Analog Electronics

1. Study and analysis of transistorised Multivibrators- Astable, Monostable.
2. Study and analysis of transistorised Multivibrators- Bistable, Schmitt trigger.
3. F.E.T Characteristics & F.E.T Common Source Amplifier.
4. Op-Amp as a differential (Instrumentation) amplifier and its application in temperature measurement.
5. Op-Amp as a square wave generator & integrator
6. Regulated power supply using IC LM 317 with external pass transistor.
7. Study of IC 555 as Astable & VCO / Monostable multivibrator.

Digital Electronics

8. Analog / Digital Multiplexer.
9. Verification of De Morgan Laws and Boolean Identities. (Construction using Gates).
10. Binary addition- Half adder and Full adder using logic gates.
11. NAND and NOR gates as universal building blocks.
12. Study of JK flip flop with JK FF IC's (Ripple counter and Decade counter).

PYC107: MATHEMATICAL PHYSICS & ELECTROMAGNETIC THEORY I

Objective:

The purpose of the course is to provide students the working knowledge of calculus and to develop required mathematical skills to solve problems in electrostatics, magnetic fields in material media, and other fields of theoretical physics.

Learning outcomes:

Upon completion of the course in Mathematical Physics,

- The student is able to understand entire vector calculus, partial derivatives, Solution of Partial differential equations, Legendre's equation, Legendre polynomials, Fourier series, beta and gamma functions, study of electric fields in dielectric media, Microscopic theory of dielectrics, and energy calculations in electrostatic fields.
- The student is able to solve the differential vector identities, partial derivative, solution of partial differential equations and Fourier series

.

Upon completion of the course in Electrostatics,

- The student is able to understand the basic laws of electrostatics, solve electrostatic field equations in rectangular and spherical symmetry in vacuum and dielectric media, acquires in depth knowledge microscopic theory of dielectrics, and Electrostatic energy.
- In the practical component the student will learn to use capacitors to measure dielectric constant and susceptibility of liquid, verify Curie -Weiss law and use ballistic galvanometer for the measurement of high and low resistance and capacitance.

PYC107
MATHEMATICAL PHYSICS & ELECTROMAGNETIC THEORY I
(Theory 4 credits)

MATHEMATICAL PHYSICS

Vector Analysis **[15]**

Vectors and scalar fields, differentiation and integration of scalar and vector fields, directional derivative, gradient, the del operator, divergence and curl, Laplacian operator, Integration of Vector Functions - Line, Surface and Volume Integrals, Gauss Divergence Theorem (without proof), Greens Theorem, Stokes Theorem (without proof), Differential vector Identities, Expression for Laplacian operator in Cartesian, spherical and cylindrical coordinates. Dirac delta function and its application. (Ref: [1,2,3,4,5]).

Differential equations **[10]**

Partial differentiation - definition of the partial derivative, Total differential, Chain rule, Exact and inexact differentials, Useful theorems of partial differentiation, Change of variables, Partial differential equations and separable solutions, Problems (Schaum Series).
(Ref: [1,2,3,4])

Some special functions in Mathematical Physics **[5]**

Introduction to Legendre's equation, Legendre polynomials and Fourier series, Introduction to beta and gamma functions. (Ref: [1,2,3,4])

ELECTROMAGNETIC THEORY I

Electrostatics **[6]**

Coulomb's Law, Electric Field and electrostatic potential, Continuous Charge distribution, field lines, flux and Gauss' law with applications, the electric dipole- field and potential. (Ref: [5]).

Techniques to solve electrostatic problems **[8]**

The electrostatic potential, Poisson's equation, Laplace's equation in one independent variable, solutions to Laplace's equation in spherical co-ordinates (zonal harmonics), conducting sphere in a uniform electric field, method of electrostatic images, point charge in front of grounded conducting plane.
(Ref: [5]).

Electric Fields in matter **[6]**

Polarization, Fields outside a dielectric medium, electric field inside a dielectric, Gauss's law in a dielectric, the electric displacement vector, electric susceptibility and dielectric constant. Boundary conditions on the field vectors, Dielectric sphere in a uniform electric field. (Ref: [5]).

Microscopic Theory of Dielectrics **[5]**

Molecular field in a dielectric, induced dipoles, A simple model, polar molecules, Langevin-Debye formula, permanent polarization, ferroelectricity. (Ref: [5]).

Work and Energy in electrostatics **[5]**

Work and Potential energy of discrete and continuous charge distributions, Energy density of an electric field.

Books and References

1. Charlie Harper, Introduction to Mathematical Physics, PHI, (1976)
2. H.K. Dass & R. Verma, Mathematical Physics, S. Chand.
3. Mary L Boas, Mathematical methods in physical sciences, John Wiley and sons (1983)
4. Arfken & Weber, Mathematical Methods for Physicists, Elsevier.
5. Reitz and Milford, Foundations of Electromagnetic Theory, Addision- Wesley Publishing Company.(2008)
6. David Griffiths, Introduction to Electrodynamics , Prentice Hall of India Ltd, New Delhi (1995)
7. Mahajan and Rangawala, Electricity and Magnetism, Tata McGraw-Hill Publishing Company Ltd., 1988
8. Chatopadhaya and Rakshit, Electricity and Magnetism, New Central Book Agency, (2013)

PYC107

MATHEMATICAL PHYSICS & ELECTROMAGNETIC THEORY I

(Practical 2 credits)

Students must perform minimum 5 experiments from electromagnetic theory and minimum of 3 tutorials from mathematical physics.

Electromagnetic Theory I

1. Measurement of Dielectric constant of solids by using parallel plate capacitor.
2. Measurement of dielectric constant & susceptibility of liquid using two co-axial metal tubes
3. Absolute capacity by ballistic galvanometer.
4. Verification of Curie -Weiss law using a disc capacitor.
5. Equipotential lines & electric field
6. Variation of A.C. Resistance of a coil with frequency.
7. Dielectric constant K and Electric Susceptibility χ_e using series resonance method.
8. Determination of high resistance by leakage using ballistic galvanometer
9. Resistance of ballistic galvanometer by shunting.

Mathematics Physics tutorials

10. Proof of differential vector identities.
11. First order differential equation.
12. Second order differential equation.
13. Partial differential equations
14. Application of Fourier Series to solution of ODF
15. Application of Fourier Series to solution of PDE

PYD101 QUANTUM MECHANICS

Course Objectives.

This course gives a basic introduction to quantum physics, starting with a historical description to a more formal quantum mechanics. This course develops concepts like Heisenberg Uncertainty Principle and its application, wave function and its statistical interpretation, Schrödinger Equation and modelling of simple systems - resulting in explanation of phenomena of tunnelling, alpha decay, tunnel diode, scanning tunneling microscope and zero point energy in oscillators etc. The course provides a basics for further study of quantum mechanics

Course Outcomes: On successful completion of the course the students

- Learn the interesting concepts of quantum physics and the basic formalism of quantum mechanics.
- Students will be familiar with the facets of the historical development of quantum mechanics that reveal the wave properties of matter.
- Understand the concepts and principles in quantum mechanics, such as the Uncertainty Principle, the Schrödinger equation, the wave function and its statistical interpretation, , stationary and non-stationary states.
- The students will be able to solve and give concise physical interpretations of the Schrödinger equation for simple systems.

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PYD101
QUANTUM MECHANICS
(Theory 4 credits)

Waves and particles **[7+2T]**

De Broglie’s hypothesis, Review of the Bohr’s postulate about stationary states in the light of De Broglie’s hypothesis, The concept of quantum (particle) nature of radiation.
Demonstration of wave nature of particles-Davisson Germer experiment, electron diffraction experiment of G.P.Thomson, Dual nature of radiation/matter. Complimentary in Duality.
(Ref: [1,2,3]).

The Wave Function **[5+2T]**

Representation of a De Broglie wave, Velocity of De Broglie wave, Construction of a wave group, Wave packet and its motion in one dimension., Group velocity and particle velocity, Max Born’s interpretation of the wave function, probability concept, Acceptable wave function, Normalization of wave function.
(Ref: [1,2,3]).

Heisenberg’s Uncertainty Principle **[5+2T]**

Limitation of wave mechanics to predict the physical state of a particle/system accurately.
Heisenberg Uncertainty principle. Illustration by thought experiments (γ - ray microscope, single slit diffraction and double slit experiment), Applications of Heisenberg Uncertainty principle.
(Ref: [1,2,3]).

Schroedinger’s Wave Equation **[12+4T]**

Wave equation for De Broglie waves and Schroedinger’s time dependent wave equation, Concept of stationary states. Schroedinger’s time independent equation. Postulates of Quantum mechanics, Definition of operators & their necessity, Expectation values, Extraction of information from solutions in terms of expectation values of physical variables/observable. Eigen value equation, Commutation relations.
(Ref: [1,2,3]).

Applications of Schrödinger’s Time Independent Wave Equation **[16+5T]**

Free particle, Infinite square well potential: Energy eigen functions and eigen values,
One dimensional finite square step potential of height Vo: Comparison of classical and quantum mechanical results for particle energy E>Vo and E<Vo, Rectangular potential barrier and penetration through it, tunnel effect, Qualitative discussion of alpha decay, tunnel diode & scanning tunneling microscope. Simple Harmonic Oscillator – Energy eigen values and eigen functions (Operator method), Calculation of $\langle x \rangle$ and $\langle p_x \rangle$, $\langle x^2 \rangle$ and $\langle p_x^2 \rangle$. Particle in a three dimensional box, Concept of degeneracy.
(Ref: [1,2,3]).

Books and References

1. Arthur Beiser, Concepts of Modern Physics, 5th Edition, McGraw Hill (1995).
2. Arthur Beiser, Perspectives of Modern Physics, 5th Edition, McGraw Hill (1995).
3. P.S. Bangui & others, New Course in Physics, Sheth Publishers.
4. F.K. Richtmayer, E.H.Kennard, J.N. Cooper, Introduction to Modern Physics (1969).
5. H. Semat and J.R.Albright, Introduction to Atomic and nuclear Physics, HRW (1972).
6. Ghatak and Lokanathan, Quantum Mechanics, Theory and Applications, Mc Millan (2004).

Semester V
PYD 103: Solid State Physics

Course Objectives. The main objectives of this course is…
To give an introduction to solid state physics, and to enable the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids.

Course Outcomes: At the end of the course the student will be able to

- Classify and analyse the crystal structures by applying crystallographic parameters.
- Understand X-ray diffraction and it's use in determining crystal structure.
- Formulate classical and quantum free electron theory to solids which describes electronic behaviour.
- Understand periodic potential and its application in the Kronig Penny model, which shows the existence energy of bands.
- Classify materials based on their magnetic properties.
- Formulate and apply classical and quantum theory for different types of magnetic materials, which would help to understand their behaviour.
- Understand different properties of dielectric material and develop theory to explain the experimental observations.
- Understand different types of ferroelectric crystals that exhibit polarization. Describe the domain theory and hysteresis loop for ferroelectric materials.
- In the laboratory component Student will experiment with different materials, which will help the student better understand the concept and theories explaining the behaviour of the solid state materials. Students will also, gain valuable experience in using different types of research instruments.

PYD103
SOLID STATE PHYSICS
(Theory 3 credit course)

Crystal Structure: [10]

Solids - Amorphous and Crystalline Materials, Lattice Translation Vectors, Basis, Unit Cell, Miller Indices, Reciprocal Lattice, Types of Lattices, Brillouin zones, Diffraction of X-rays by Crystals, Bragg's Law. (Ref: [1,3,4,5]).

Free electron theory of metals: [5]

Drude's Free electron model, Fermi Dirac distribution, thermionic emission, Contact potential. (Ref: [2,4,5]).

Band theory of metals: **[7]**

Electrons in periodic lattice, Kronig Penny Model (Qualitative Approach) Effective mass of electron, Concept of hole. Classification of materials based on band structure. Effect of magnetic field on electrons, Hall effect. (Ref: [2,4,5]).

Magnetic Properties of Matter: [9]

Diamagnetic, Paramagnetic, Ferrimagnetic and Ferromagnetic Materials. Classical Langevin Theory of diamagnetic and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. (Ref: [1,4,5]).

Dielectric Properties of Materials: [7]

Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, Tranverse optic modes. (Ref: [1,2,3,4]).

Ferroelectric Properties of Materials: [7]

Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. (Ref: [1,2]).

Books and References:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Solid State Physics, A. J. Dekker, McMillan, 1969
3. Solid State Physics, S.O. Pillai, Mc-Graw Hill.
4. Solid State Physics, Gupta, Kumar & Sharma,
5. New Course in Physics, Gogawale & Lele, Vol. I. Sheth Publishers
6. Millman & Halkias, Electronic Devices and Circuits, Mc-Graw Hill.
7. Principles of Electronic Materials and Devices, S.O. Kasap,
8. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, PHI

9. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
10. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
11. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
12. Solid State Physics, Rita John, 2014, McGraw Hill
13. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
14. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PYD103
SOLID STATE PHYSICS
Practical (any four) 1 credit

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. Measurement of magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. Variation of Dielectric Constant of a dielectric Materials with frequency
5. To study the P E Hysteresis loop of a Ferroelectric Crystal.
6. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
7. To measure the resistivity of a semiconductor (Si/Ge) with temperature by any method (room temperature to 150^{o}C) and to determine its band gap.
8. To determine the Hall coefficient of a semiconductor sample.
9. Energy band gap using PN junction.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

SEMESTER VI

PYC108
ATOMIC AND MOLECULAR PHYSICS

Objectives. The main objective of the course is.

To introduce Schrodinger's equation for the Hydrogen atom and interpret its solutions, concept of orbital, spin magnetic moment and quantum theory of angular momentum, the atomic spectra of one valence electron atoms (Alkali metal type spectra). To be able to understand the effects of external applied magnetic fields on the behaviour of atoms, X-ray spectra (emission and absorption). To equip the students with the knowledge of atomic rotational, vibrational and Raman spectra of molecules.

Outcomes: On completion of the course the students will ….

- Be able to solve Schrodinger's equation for the Hydrogen atom- and interpret solutions in terms of three quantum numbers,
- Have knowledge and understanding of orbital and spin magnetic moment, angular momentum, classification of elements in periodic table, electron configuration, spin-orbit coupling , L-S coupling, J-J coupling.
- Understand the atomic spectra of one valence electron atoms. Alkali metal type spectra.
- Know the effects of external magnetic fields on an atom, space quantization and Zeeman effect.
- Know X-ray spectra (Emission and absorption) on the basis of quantum mechanics. Fluorescence and Auger effect.
- Have knowledge of the basic elements of atomic and molecular spectra, classical – quantum description of electronic, vibrational, rotational spectra and Raman spectroscopy.
- In the laboratory component the students will perform experiments which will verify the atomic and molecular theories as per syllabus content.

SEMESTER VI

PYC108
ATOMIC AND MOLECULAR PHYSICS

Hydrogen Atom **[6]**

Schrodinger's equation for the H-atom, separation of variables, Quantum numbers-n, l, m_l, spin, magnetic moment, J and m_J, Angular momentum, Magnetic moment and Bohr magneton.
(Ref: [1,2,3]).

Many Electron Atoms **[10]**

Pauli exclusion principle and classification of elements in periodic table. Symmetric and Antisymmetric wave functions, Electron configuration, Hund's rule, Spin orbit interaction, Vector atom model, Total angular momentum, L-S coupling, J-J coupling.
(Ref: [1]).

Atomic Spectra **[8]**

Spectroscopic notation, Selection rules (derivation from transition probabilities), Alkali metal type spectra, Principal, Sharp, Diffused and Fundamental series, fine structure in alkali spectra.
(Ref: [1]).

Atoms in a Magnetic Field **[8]**

Effects of magnetic field on an atom, The Stern-Gerlach experiment, Larmor Precession, The Normal Zeeman effect, Lande 'g' factor, Zeeman pattern in a weak field (Anomalous Zeeman effect). (Ref: [1,4]).

X-ray Spectra **[6]**

Characteristic spectrum, Moseley's law, Explanation of X-ray spectra on the basis of quantum mechanics, Energy levels and characteristic X-ray lines, X-ray absorption spectra, Fluorescence and Auger effect. (Ref: [4]).

Spectra of Diatomic Molecules **[14]**

Rotational energy levels, Rotational spectra, Vibrational energy levels, Vibration-Rotation spectra, Fortrat Parabolas and explanation of band structure on its basis, Electronic spectra
(Ref: [5,7,10]).

Raman Effect **[8]**

Raman Effect: Classical and Quantum mechanical explanation, Pure rotational Raman spectra, Vibrational Raman spectra, Rotational fine structure, Experimental set up for Raman spectroscopy.
(Ref: [10])

Books and References:

1. Arthur Beiser, Perspectives of Modern Physics, 5th Edition, McGraw Hill (1995)

2. F.K. Richtmayer, E.H.Kennard, J.N. Cooper, Introduction to Modern Physics (1969)
3. H.E.White H.Semat and J.R.Albright, Introduction to Atomic Physics, McGraw Hill Book Company (2003)
4. H.Semat and J.R.Albright, Introduction to Atomic and nuclear Physics, Chapman and Hall (1972)
5. Barrow, Introduction to Molecular Physics, McGraw Hill (1962)
6. Anne P. Thorne, Spectrophysics, Chapman and Hall(1974)
7. Banwell, Fundamentals of Molecular Spectroscopy, TMH (2012)
8. P.T. Matthews, Introduction to Quantum Mechanics, TMH (1974)
9. Ghatak and Lokanathan, Quantum Mechanics, Theory and Applications, Mc Milan (1967)
10. G. Arhuldas, Molecular Structure & Spectroscopy, PHI.

PYC108
ATOMIC AND MOLECULAR PHYSICS
(Practical 2 credits)

Minimum of 8 experiments

1. To determine the wavelength of H-alpha emission line of Hydrogen atom. Hydrogen source / Rydberg Constant
2. Balmer series & Emission spectra
3. Determination of specific rotation of optically active substances.
4. To determine the value of e/m by helical method.
5. Absorption spectrum of a liquid $KMnO_4$ or KI
6. To determine the charge of an electron using Millikan oil drop apparatus
7. Resolving fine structure of Sodium D lines using Diffraction (reflection/ transmission) grating
8. Determination of Cauchy's constants of a given Flint glass prism using fine structure of Na D lines
9. To determine refractive index of liquid by hollow prism
10. To determine the absorption lines in the rotational spectrum of Iodine vapour.
11. Analysis of Rotational / Vibrational spectra to find bond length and bond strength
12. Zeeman effect
13. GM counter

PYC109

SOLID STATE DEVICES AND INSTRUMENTATION

(Theory 4 credits

Objectives: The main objective of this course is to introduce solid state devices and instrumentation. In solid state devices the working principle / operation and applications of different types two terminal, industrial and image capture solid state devices is studied and in instrumentation the working principle / operation of various electrical and electronic measuring instruments used in physics and various transducers involving different kinds of sensors are studied.

Learning Outcome: At the end of the theory and practical course, the student understand the working and application of

- Different types of diodes including photodiodes and light emitting diodes, photoconductive cell photovoltaic cell, solar cell and LCD.
- Industrial Devices like Silicon controlled rectifier, Silicon controlled switch, Gate turn off switch, Light activated SCR, Shockley diode, Diac, Triac, Unijunction transistor (UJT).
- Phototransistor. Solid State Image scanners (CCD's), Basic LED TV.
- Instruments like DC and AC ammeter/ voltmeter, Ohmmeter Digital voltmeter, multimeter, frequency meter, CRO, Signal Generator,
- Sensors like strain gauges, resistance thermometer, thermister, capacitor, inductor, piezoelectric, and Hall Effect.
- In the practical component of this course - experiments to observe Current –Voltage characteristics and applications of few two and three terminal devices is carried out.

PYC109

SOLID STATE DEVICES AND INSTRUMENTATION

(Theory 4 credits)

Solid State Devices:

Two Terminal Devices **[10]**

Power diodes, Tunnel diodes, Varicap diodes, Schottky Barrier diode, Semiconductor photoconductive cell, Photovoltaic cell, Photodiode, Light emitting diodes (LED), Liquid Crystal display (LCD), Solar cells and Photocouplers. (Ref: [1,3]).

Industrial Devices **[15]**

Silicon controlled rectifier (SCR), SCR characteristics, rating, construction and terminal identification, SCR applications, Silicon controlled switch (SCS), Gate turn off switch (GTO), Light activated SCR (LASCR), Shockley diode, Diac, Triac, Typical Diac-Triac Phase control circuit, Unijunction transistor (UJT), Phototransistor. (Ref: [1,3]).

Image Capture Devices **[5]**

Solid State Image scanners (CCD's), Basic LED TV. (Ref: [2]).

INSTRUMENTATION:

Measuring Instruments **[12]**

Errors in measurement, Basic PMMC, Analog DC ammeter, Multirange ammeter, Universal shunt, DC & AC voltmeter, Multirange voltmeter, Extending voltmeter range, Transistor voltmeter, Ohmmeter – Series and shunt type, Multimeter, Digital voltmeter, Resolution and sensitivity of digital meters, multimeter, frequency meter, Q meter. (Ref: [6,7,8]).

Oscilloscope **[4]**

CRT, CRO block diagram (simple CRO), vertical and horizontal deflection system, Vertical amplifier, sweep generator, Delay line. (Ref: [6,7,8]).

Transducers **[10]**

Introduction, Electrical transducer, selecting a transducer, Resistive transducers, Strain gauges, resistance wire gauge, types of strain gauges, foil strain gauge, semiconductor strain gauge, Resistance thermometer, Thermistor, Inductor transducer, LVDT, Capacitive transducer, Piezo electric transducer and Hall effect transducers. (Ref: [6,7,8]).

Signal Generator **[4]**

Standard signal generator, AF sine and square wave generator, Function generator.
(Ref: [6,7]).

Books and References

Solid State Devices:

1. Robert Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, 11t Ed. PHI (2009)

2. R.R. Gulati Monochrome and Colour TV, 2nd Ed., New Age International, 2005.
3. Allen Mottershed, Electronic Devices and Circuits An Introduction: PHI (1997).
4. Malvino, Electronic Principles, TMH (2007).
5. J. Millman and C. Halkias, Electronic Devices and Circuits , Mc Graw Hill (1972).
6. H. S. Kalsi, Electronic Instrumentation: TMH (2004).
7. William David Cooper, Electronic Instrunentation and Measurement Techniques, PHI (2003).
8. A. K. Sawhney A course in Electrical and Electronic Measurement, Dhanpat Rai and Co.(2001).

PYC109

SOLID STATE DEVICES AND INSTRUMENTATION

(Practical 2 credits)

Minimum of 8 experiments

1. Light emitting diode V-I characteristics, determination of Planck's constant & Energy gap
2. Photodiode /Photo-transistor: Characteristics, Variation of conductivity with Intensity and spectral response,
   Application as a switch
3. UJT characteristics and its use in relaxation oscillator.
4. SCR characteristics and gate-controlled ac half wave rectifier.
5. DIAC& TRIAC Characteristics, Gate triggering application.
6. Design and Construction of analog two range voltmeter & ohmmeter.
7. Solar cell characteristics (V-I at different wavelengths), spectral response, maximum power point
8. Determination of transition capacitance of Varactor diode as function of reverse bias voltage and use as
   a variable/tuning capacitor in any one application. (Type CD91 or Bel 90 or equivalent).
9. Crystal Oscillator: Determination of velocity of ultrasonic waves in a liquid medium, different liquids/ same liquid
   at different temperatures.
10. Study of strain Gauges to determine Young's Modulus.
11. Study of LVDT - calibration and its use in any one application.
12. Signal Generator XR 2206

PYC110
ELECTROMAGNETIC THEORY II & THEORY OF RELATIVITY
(Theory 4 credits)

Steady currents and their magnetic fields **[8]**

Steady currents, current density, Biot-savart's law and its applications, Ampere's circuital law, magnetic vector potential, magnetic field of a distant circuit, magnetic dipoles, dipole moment and the field of a point magnetic dipole, magnetic scalar potential. (Ref: [1]).

Magnetic Field in material media **[12]**

Magnetization, magnetic field produced by magnetized material, magnetic pole density, sources of the magnetic field, magnetic intensity H (Auxiliary magnetic field), The field equations, magnetic susceptibility and permeability, Hysteresis, Boundary conditions on **B** and **H** vectors, current circuits containing magnetic media, Magnetic circuits, Magnetic circuits containing permanent magnets. (Ref: [1]).

Microscopic Theory of Magnetism **[6]**

Molecular field inside matter, Origin of Diamagnetism, Origin of Paramagnetism, theory of Ferromagnetism, Ferromagnetic domains, ferrites. (Ref: [1]).

Magnetic Energy **[5]**

Magnetic energy of coupled circuits, Energy density in the magnetic field, Hysteresis Loss. (Ref: [1]).

Maxwell's Equations **[6]**

Faraday's Law of electromagnetic induction, Generalization of Ampere's Law- Displacement current, Maxwell's equations and their empirical basis, Electromagnetic energy-Poyntings theorem. (Ref: [1]).

Experimental Background of the Theory of Special Relativity **[7]**

Galilean Transformations, Newtonian Relativity, Michelson Morley Experiment, Attempts to preserve the concept of a preferred Ether frame, (Lorentz-Fitzgerald Hypothesis), Einstein's Postulates of Special Relativity. (Ref: [6,7])

Relativistic Kinematics **[6]**

Relativity of Simultaneity , Derivation of the Lorentz Transformations and derivation of its consequences such as Length Contraction and Time dilation, Relativistic Addition of velocities, Aberration and Doppler Effect. (Ref: [6,7])

Relativistic Dynamics **[10]**

Dynamics and relativity, Need to redefine momentum, Relativistic Momentum, Relativistic Force law, and dynamics of a single particle, Longitudinal and transverse mass, Equivalence of mass and energy $E= Mc^2$, Lorentz transformation of Momentum, Energy, Mass and Force, Twin Paradox (qualitative approach). (Ref: [6,7])

Books and Reference Books: -

1. Reitz and Milford, Foundations of Electromagnetic Theory, Addision- Wesley Publishing Company (2008).
2. David Griffiths, Introduction to Electrodynamics , Prentice Hall of India Ltd, New Delhi (1995).
3. Mahajan and Rangawala, Electricity and Magnetism, TMH, , (1988).
4. Chatopadhaya and Rakshit, Electricity and Magnetism, New Central Book Agency, (2013).
5. P. Lorrain, D. Corson, Electromagnetic Fields and Waves, 1988.
6. Robert Resnik, Introduction to Special Relativity Wiley(1968).
7. N.C. Garach, Understanding Relativity, Vol. I, Sheth Publishers

PYC110
ELECTROMAGNETIC THEORY II & THEORY OF RELATIVITY
(Practical 2 credits)

Students must perform minimum 6 experiments and 2 tutorials.

Experiments

1. Measurement of Core losses and copper losses in a transformer
2. Measurement of Hysteresis loss using CRO.
3. Hysteresis by magnetometer
4. To study Hall effect, measurement of hall coefficient and its application as a transducer
5. Self inductance: Rayleigh’s method
6. Mutual inductance by ballistic galvanometer.
7. Mutually coupled tuned series LCR circuits
8. Magnetic circuit – determination of flux and reluctance
9. Helmholtz coil & measurement of Faraday’s number
10. Magnetic susceptibility of paramagnetic substances by Guoy’s Balance

Tutorials

11. Problems on length contraction/ time dilation
12. Problems on relativistic velocity addition
13. Twin Paradox
14. Pole –Barn Paradox

NUCLEAR PHYSICS

OBJECTIVE:

The course starts with study of basics -the nuclear radius ,density, mass defect, Binding energy magnetic and electric dipole and quadrapole moment. The meson theory proposed by Yukawa tries to explain the nature of nuclear force. The nuclear decay processes are studied at length ,with different decay processes being dealt from their energetics to other specifics .The two nuclear models , the Liquid drop model and the Nuclear Shell model try explain the different nuclear properties

LEARNING OUTCOME: On completion of the course the student will …

- Have gained knowledge of the nucleus properties ,like size ,charge ,angular momentum, dipole moment , quadrapole moment etc.
- Have understood the meson theory of nuclear force and estimate mass of meson.
- Have understood the nuclear properties in the light of the two nuclear models, the liquid and the shell model.
- Be be able to use Jenson Mayor scheme in finding nuclear angular momentum and spin.

PYD106
NUCLEAR PHYSICS
(Theory 4 credits)

Nuclear Properties **[5]**

Constituents of nucleus, Isotope, Isotone & Isobar, Radii & Density of nucleus, Definition of a.m.u, Mass of nuclei, Mass defect, Packing fraction, Binding energy, Stability of nuclei, Magnetic and electrical dipole moments.

Nuclear forces **[5]**

Main characteristics of nuclear forces; Deuteron problem that reveals tensor/ non-central nature of nuclear force, meson theory of nuclear forces, estimation of mass of meson using Heisenberg's Uncertainity Principle; Yukawa potential.

Radioactivity **[10]**

Law of radioactive decay; Derivation of expression for exponential decay, half & mean life, statistical nature of radioactive phenomenon, Problems, Successive radioactive transformation (A→B→C type); ideal, transient and secular equilibrium; radioactive series; Radioactive-carbon dating, Applications, Problems

Nuclear Reactions [8]

Artificial transmutation, Definition, Compound nucleus, Types of nuclear reactions, Conservation laws, Energetics of nuclear reactions, Q value, Threshold energy of endoergic reactions, cross sections of nuclear reactions, Discovery of neutron, Determination of neutron mass, Problems

Radioactive Decay **[12]**

Alpha decay: Velocity and energy of alpha particles; Alpha disintegration energy; Geiger-Nuttal law, alpha spectra and fine structure; short range and long range alpha particles; Gamow theory of alpha decay (qualitative treatment);

Beta decay: Types of beta decay; energies of beta decay; the continuous beta particle spectrum; difficulties in understanding the spectrum; Pauli's neutrino hypothesis; Fermi's theory of beta decay (qualitative treatment); K capture

Gamma decay: Origin of the decay; internal conversion and nuclear isomerism.

Nuclear Models **[10]**

Liquid drop model; compound nucleus theory; analogy between liquid drop and the nucleus; Wiezsacker's semi empirical mass formula; mass parabolas; prediction of stability against decay for members of an isobaric family; spontaneous and induced fission; Bohr-Wheeler theory of nuclear fission and condition for spontaneous fission on the basis of Z/A; Estimation of energy released from binding energy curve and from energy – mass equivalence.

Nuclear Shell Model: Experimental evidence for magic numbers; evidences that led to shell model, main assumptions of the single particle shell model; Jensen-Mayer scheme (no derivation); predictions of the shell model- Spin and Parity

Nuclear energy **[7]**

Neutron induced fission; chain reaction; mass yield in an asymmetrical fission; neutron cycle in a thermal nuclear reactor (the four factor formula) Structure of nuclear reactor and it's working; principle of a breeder reactor; Nuclear Program in India- Nuclear Energy , Nuclear test (Pokhran-I & II), Nuclear submarine

Detection of nuclear radiation **[3]**

Ionization chamber; proportional chamber; Geiger Muller counter; Photographic emulsions; Semiconductor detectors

Text Books / References:

1. Irving Kaplan, Nuclear Physics, Narosa Publishing House
2. Atomic and Nuclear Physics, A.B.Gupta and Dipak Ghosh, Books and Allied (P) Ltd
3. Arthur Beiser, Perspectives of Modern Physics, 5th Edition, McGraw Hill (1995)
4. F.K. Richtmyer, E.H. Kennord, J.N. Cooper, Introduction to Modern Physics, (6th Ed.) McGraw Hill (1997).
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