MINUTES OF MEETING OF THE BOARD OF STUDIES IN PHYSICS
HELD ON 7th OCTOBER, 2023 at 10:00 am
Parvatibai Chowgule College of Arts & Science
(Autonomous)
Margao – Goa

Vide Chowgule College notice F.133(C)/717 dated 14th September, 2023) a meeting of this BOS was convened on 7th October, 2023 at 10:00 a.m. through online Google meet, Parvatibai Chowgule College of Arts & Science, Margao – Goa. Since the number of members present represented the Quorum, the BOS began its proceedings.

Members present:
1. Dr. Ashish M. Desai (Chairman)
2. Mrs. Malati Dessai (Member)
3. Mr. Yatin P. Desai (Member Secretary)
4. Ms. Mrunal Shetkar (Member)
5. Ms. Anushka Panjikar (Member)
6. Dr. Bholanath Pahari (Academic Council Nominee)
7. Dr. Sudhir Cherukulappurath (Vice-Chancellor Nominee)

Member Absent with Intimation
1. Dr. Ananya Das (Member)
2. Dr. Tarun Kumar Jha (Academic Council Nominee)
3. Mr. Mangrish Salelkar (Industry Representative)
4. Mr. Harison Cota (Postgraduate Alumni)

Proceedings
The Chairperson welcomed the members of the Board of Studies (BOS). The Chairperson introduced and explained the agenda for the meeting and read out the minutes of the previous B.O.S. meet. The faculty members Ms. Mrunal Shetkar and Ms. Anushka Panjikar were inducted as new members of BoS Physics. The meet continued taking up the following agenda.

Agenda Items:
1. To approve the Under Graduate (UG) syllabus of Department of Physics for Semester III & IV under NEP 2020.
2. To approve the Multidisciplinary, Skill enhancement and Vocational Education &Training Syllabus under NEP 2020.
3. Any Other Business (A.O.B.)

PART A: The BOS passed the resolutions as follows:

1. As the Department of Physics is offering Vocational courses in semesters IV, V, and VI, it was decided to remove separate minor courses for semesters IV (Heat and Optics), V (Statistical and Solid-State Physics), and VI (Atomic and Nuclear Physics). The modified list of courses for all eight semesters is presented in Annexure A.
2. The syllabi of Semester III and IV courses under new course structure were discussed and approved by the BoS during the meeting. The syllabi of the Semester III and IV courses to be offered under NEP 2020 are given in Annexure A.
3. The syllabi of Multidisciplinary, Skill enhancement and Vocational Education & Training courses under new course structure were discussed and approved by the BoS during the meeting. The syllabi of the Multidisciplinary, Skill enhancement and Vocational Education & Training courses to be offered under NEP 2020 are given in Annexure A.
4. Under A.O.B, it was decided to include new practicals in the course Electromagnetic theory-II offered in semester V. The syllabus of Electromagnetic theory-II along with modified list of practicals, is given in Annexure I.

PART B: Important Points/ recommendations of BOS that require consideration / approval of Academic Council:

1. The revised list of courses under the nomenclatures Discipline Core (Major & Minor), Skill enhancement course, and Multidisciplinary course to be offered by the Department of Physics under NEP 2020 presented in Annexure A.
2. The syllabi of the Semester III and IV courses to be offered under NEP 2020 presented in Annexure A.
3. The syllabi of Multidisciplinary, Skill enhancement and Vocational Education & Training courses to be offered under NEP 2020 presented in Annexure A.
4. The syllabus of the course Electromagnetic theory-II offered in Semester V presented in Annexure I.

Mr. Yatin P. Desai
Member Secretary
Board of Studies

Dr. Ashish M. Desai
Chairperson
Board of Studies

Dated: 12th October 2023

PART C: The remarks of the Dean of the Faculty:-

a. The minutes are in order.
b. The minutes may be placed before the Academic Council with remark, if any.
c. Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 12th October 2023

Signature of the Dean:
(Faculty of Science)

Dr. Meghana Devli

PART D: The remarks of the Members Secretary of the Academic Council:-

a. The minutes are in order.
b. The minutes may be placed before the Academic Council with remark, if any.
c. Important points of the minutes which need clear policy decision of the Academic Council to be recorded.

Date: 16/10/2023

Signature of the Member Secretary
Academic Council

Mr. V. C. Kumaresh

Annexure A

COURSE STRUCTURE

SEMESTER	MAJOR CORE	MINOR/ VOCATIONAL	MULTI-DISCIPLINARY COURSE (MDC)	SKILL ENHANCEMENT COURSE (SEC)
I	**UG-PHY-101:** Mechanics-I	**UG-PHY-102:** Mechanics, Sound and Properties of Matter	**UG-PHY-MDC1:** General Physics: Fluids and Heat	**UG-PHY-SEC1:** Introduction to Mathematical Physics-I
II	**UG-PHY-103:** Electricity and Magnetism	**UG-PHY-104:** Electricity, Magnetism and Electronics	**UG-PHY-MDC2:** General Physics: Light and atoms	**UG-PHY-SEC2:** Introduction to Mathematical Physics-II
III	**UG-PHY-201:** Electromagnetic Theory-I	**UG-PHY-205:** Elementary Modern Physics	**UG-PHY-MDC3:** General Physics: Nucleus, Relativity and Beyond	**UG-PHY-SEC3:** Introduction to Error Analysis
	UG-PHY-202: Optics			
	UG-PHY-203: Modern Physics			
	UG-PHY-204: Oscillation, Waves and Sound			
IV	**UG-PHY-206:** Quantum Mechanics	**UG-PHY-VOC1:** Computational Physics		
	UG-PHY-207: Heat and Thermodynamics			
	UG-PHY-208: Electronics-I			
	UG-PHY-209: Properties of Matter and Acoustics			
	UG-PHY-210: Introduction to Astronomy and Astrophysics			
V	**UG-PHY-301:** Electromagnetic Theory-II	**UG-PHY-VOC2:** Basics of Visualization and Scientific word processing		
	UG-PHY-302: Solid State Physics			
	UG-PHY-303: Thermodynamics and Statistical Mechanics			
	UG-PHY-304: Solid State Devices			

VI	**UG-PHY-306:** Atomic and Molecular Physics	**UG-PHY-VOC3:** Instrumentation		
	UG-PHY-307: Mechanics II			
	UG-PHY-308: Nuclear and Elementary Particle Physics			
	UG-PHY-PRJ: Project			
	UG-PHY-309: Introduction to Material Science			
VII	**UG-PHY-401:** Mathematical Physics			
	UG-PHY-402: Classical Mechanics*			
	UG-PHY-403: Electronics-II			
	UG-PHY-404: Laboratory (Electronics and Computer Programming)			
VIII	**UG-PHY-405:** Advanced Electromagnetic Theory			
	UG-PHY-406: Introduction to Special Theory of Relativity*			
	UG-PHY-407: Quantum Mechanics II			
	UG-PHY-408: Laboratory (General Physics)			
	UG-PHY-409: Advanced Solid State Physics			

* Courses maybe offered to the minor students

SEMESTER III

DISCIPLINE SPECIFIC CORE COURSE

Course Title : **Electromagnetic Theory – I**

Course Code : **UG-PHY-201**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : Electricity and Magnetism (UG-PHY-103) and Introduction to Mathematical Physics-II (UG-PHY-SEC2)

Course Objectives : To acquaint students with fundamental principles of Electrostatics part of the Electromagnetic Theory.

Course Learning Outcomes: At the end of this course students will be able to:

CLO1: Apply vector calculus to understand concepts in electrostatics.

CLO2: Comprehend the interaction between charges in vacuum as well as in medium.

CLO3: Calculate the electric field and electrical potential for discrete charges and continuous distribution of charge.

CLO4: Apply suitable techniques to solve various electrostatic problems.

CLO5: Understand how ferroelectric materials can be used as memory devices.

Course content

Theory:

Module I: Vector Analysis **[10 h]**

1. **Vector Analysis** **[10 h]**

   Review of Vector Operations and Vector Algebra

   Position, Displacement and Separation Vectors, Differential Calculus: Ordinary Derivatives, Gradient, The Operator $\vec{\nabla}$, The Divergence and Curl, Product Rules, Second Derivatives, Integral Calculus: Line, Surface and Volume Integrals, The fundamental Theorem for Divergences, The fundamental Theorem for Curls, Different Co-ordinate Systems: Cartesian Co-ordinate System, Cylindrical Co- ordinate System, Spherical Co-ordinate System, Some Useful Vector Identities with Proofs.

Module II: Electrostatics and Techniques to Solve Electrostatic Problems [20 h]

1. **Electrostatics [12 h]**

   The Electric Field: Coulomb's Law, The Electric Field, Continuous Charge Distributions, Divergence and Curl of Electrostatic Fields: Field Lines, Flux and Gauss's Law, The Divergence of E, Applications of Gauss's Law, The Curl of E, Electric Potential: Introduction to Potential, Poisson's Equation and Laplace's Equation, Potential of a Localized Charged Distribution, Summary: Electrostatic Boundary Condition, Work and Energy in Electrostatics: Work Done to Move a Charge, The Energy of a Point Charge Distribution, The Energy of a Continuous Charge Distribution, Comments on Electrostatic Energy, Conductors: Basic Properties of Conductor, Induced Charges, Surface Charge and the Force on a Conductor, Capacitors.

2. **Techniques to Solve Electrostatic Problems [8 h]**

   Poisson's Equation, Laplace's Equation: Laplace's Equation in One Dimension, Laplace's Equation in Two Dimensions, Laplace's Equation in Rectangular Co-ordinates, Solution to Laplace's Equation in Spherical Co-ordinates (Zonal Harmonics), Conducting Sphere in Uniform Electric Field, Electrostatic Images: Point Charge and Conducting Sphere, Line Charge and Line Images.

Module III: Electrostatic Field in Matter and Microscopic Theory of Dielectrics [15 h]

1. **Electrostatic Field in Matter [8 h]**

   Polarization, Gauss's Law in a Dielectric, Electric Displacement Vector, Electric Susceptibility and Dielectric Constant, Boundary Conditions on the Field Vectors, Boundary Value Problems Involving Dielectric, Dielectric Sphere in a Uniform Electric Field

2. **Microscopic Theory of Dielectrics [7 h]**

   Molecular field in a dielectric: Clausius Mossotti Relation, Polar and Non-Polar Molecules, Induced Dipoles, Langevin's Debye Formula, Permanent Polarization, Ferroelectricity.

Praticals: (Minimum Six)

1. Van-de-graff Generator. [Demonstration]
2. Measurement of dielectric constant and susceptibility of liquid using parallel metal plates.
3. Measurement of dielectric constant and susceptibility of liquid using coaxial metal tubes.
4. Measurement and Study of variation of dielectric constant of BaTiO3 ferroelectric and determination of its Curie temperature.
5. E and D measurement for a parallel plate capacitor and calculation of dielectric constant.

6. Law of Capacitance using Dielectric Constant Measurement Kit.
7. Absolute capacity by ballistic galvanometer.
8. C1/C2 by De-Sauty's method using ballistic galvanometer.
9. Dipole Moment and Polarizability of Benzene.

List of books recommended for reference

Mandatory Reading:

1. Griffiths D. J., 2011, *Introduction to Electrodynamics,* 3rd Ed., Prentice Hall of India, New Delhi
2. Harper Charlie, 1993, *Introduction to Mathematical Physics*, Prentice Hall of India, New Delhi
3. Reitz J. R., Milford F. J., Christy R. W., 1979, *Foundations of Electromagnetic Theory*, 3rd Ed. Addison-Wesley Publishing Company

Supplementary Reading:

1. Mukherji U., 2008, *Electromagnetic Field Theory and Wave Propagation*, Narosa Publishing House.

Online resources:

1. https://nptel.ac.in/courses/115101005/
2. https://swayam.gov.in/nd1_noc19_ph08/preview
3. https://ocw.mit.edu/courses/physics/8-07-electromagnetism-ii-fall-2012/lecture-notes/
4. https://www.feynmanlectures.caltech.edu/II_10.html
5. https://www.iiserkol.ac.in/~ph324/ExptManuals/DielectricConstant.pdf

Course Title : **Optics**

Course Code : **UG-PHY-202**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Nil**.

Course Objective: The course aims to enable the students to develop an understanding towards the properties of light, its nature, its propagation and the different phenomena exhibited by light. The whole branch is divided into: (1) Geometrical Optics involving geometrical consideration of image –formation based on the rectilinear propagation of light and (2) Physical Optics considering the wave nature of light, then explaining the optical phenomena such as Interference, Diffraction and Polarization exhibited by light using suitable theories. The primary aim of this course is to emphasize the different fundamental principles and the techniques used for different optical phenomena.

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

CLO1: Understand and apply cardinal points technique and aberration to study the image formation in optical systems and solve numerical problems based on aberration and cardinal points.
CLO2: Apply division by wave front and division by amplitude techniques to study interference patterns and solve numerical problems based on interference in thin films.
CLO3: Derive conditions for Fresnel class diffraction and Fraunhofer class diffraction, and solve numerical problems based on diffraction grating, resolving power of telescope and prism.
CLO4: Apply Huygen's theory of double refraction to study the types of crystal.
CLO5: Analyze the types of polarized light with help of Nicol Prism and retardation plate.
CLO6: Determine optical rotation of sugar solution using Polarimeters.

Course content
Theory:

Module I: Geometrical Optics **[15 h]**

1. **Fundamentals of Reflection and Refraction** **[6 h]**
   Refractive index and optical path, Fermat's Principle of least time, Derivation of the laws of reflection and refraction using Fermat's Principle. Lenses: thin and thick lenses, Lens equation, Lens maker's formula, Cardinal points of an optical system, Combination of coaxially placed two thin lenses (equivalent lenses) (including derivation for focal length and cardinal points).

2. **Lens Aberrations** **[5 h]**

Introduction, Types of aberrations: monochromatic and chromatic aberration, Monochromatic aberration and its reduction: Spherical aberration, Types of chromatic aberration: Achromatism (lenses in contact and separated by finite distance).

3. **Optical Instruments** **[4 h]**

Objective and Eyepiece, Huygen's eyepiece, Ramsden's eyepiece, Telescopes, Refracting and Reflecting type of telescopes and Spectrometer.

Module II: Interference and Diffraction **[20 h]**

1. **Introduction to Interference and Interference in Thin Films** **[6 h]**

Superposition of waves, Interference, Coherence, Conditions for Interference, Techniques of obtaining Interference, Young's Double Slit Experiment, Phase Change on reflection: Stoke's law.

Thin Film, Interference due to reflected and transmitted lights in thin films: Plane Parallel Film, Wedge-shaped Film, Newton's Rings, Types of fringes.

2. **Interferometry** **[3 h]**

Michelson's Interferometer: Principle, Construction, Working, Circular Fringes, Localised Fringes, White Light Fringes, Application of Michelson's Interferometer: Measurement of Wavelength and Determination of the difference in the wavelength of two waves.

3. **Introduction to Diffraction and Fresnel Class Diffraction** **[5 h]**

Difference between Interference and Diffraction, Types of diffraction: Fresnel Class and Fraunhoffer Class.

Diffraction of Light (Fresnel Class): Division of cylindrical wave-front into Fresnel's half period strips, Diffraction at straight edge, Diffraction at a narrow wire.

4. **Fraunhoffer Class Diffraction and Resolving Power of optical Instruments** **[6 h]**

Diffraction at a single slit (Central maximum, Secondary maxima and Secondary minima), Diffraction at double slit, Distinction between single slit and double slit diffraction patterns, Missing orders in a double slit diffraction pattern, Diffraction at N slits(only conceptual), Determination of wavelength of a spectral line using Plane Transmission Grating. Resolving Power, Rayleigh's criterion, Resolving power of telescope and Resolving Power of Prism.

Module III: Polarization **[10 h]**

1. **Production and Analysis of Polarized lights** **[7 h]**

Polarized Light, Natural Light, Production of Linearly Polarised Light, Anisotropic Crystal, Calcite Crystal, Huygens Theory of Double Refraction in Uniaxial crystal, Nicol prism- its fabrication, working and use, Types of Polarized Light, Retardation plates - Quarter wave plate and Half wave plate, Production of Elliptically and Circularly

Polarized Lights, Detection of plane, circularly, elliptically polarized lights, Analysis of polarized light.

2. **Polarimeter** **[3 h]**
Optical activity, Specific rotation, Simple Polarimeter, Laurent's Half-Shade Polarimeter.

Practicals: (Minimum six)

1. Cardinals points of Two lenses
2. Prism Spectrometer: Optical levelling, Angle of Prism
3. Dispersive power of prism
4. Newton's Rings
5. Wedge shaped air film
6. Single Slit Diffraction using LASER/Sodium source.
7. Diffraction Grating using LASER/Sodium source.
8. Malus's Law using LASER source.
9. Brewster's Law using LASER source.
10. Polarimeter (Demonstration)
11. Lloyd's Mirror/Biprism (Demonstration)
12. Cylindrical Obstacle (Demonstration)

List of books recommended for reference
Mandatory Reading:

1. Subramanyam N., Lal Brij, Avadhanulu M. N., 2006, *A Text book of Optics*, First multicolour Edition, S. Chand & Company Ltd., New Delhi
2. Singh S. P., Agarwal J. P., 2001, *Optics*, 8th Edition, Pragati Prakashan, Meerut

Supplementary Reading:

1. Mathur B. K., *Principles of Optics*, New Global Printing Press, Kanpur.
2. Ghatak A., 1977, *Optics*, Tata McGraw-Hill Publishing Company Ltd., New Delhi
3. Jenkins F. A., White H. E., 1981, *Fundamentals of Optics*, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Online resources:

1. https://ocw.mit.edu/courses/mechanical-engineering/2-71-optics-spring-2009/video-lectures/
2. https://www.youtube.com/playlist?list=PLkzOLGQfSuu0L7NRVSxXrMd73NDc48ILb
3. https://www.youtube.com/playlist?list=PL9jo2wQj1WCP2eeRb8UacmKJy850Y9DYQ
4. https://www.youtube.com/playlist?list=PLX2gX-ftPVXWA5TjEhVQSQQzZ-5_5Nui8
5. https://www.youtube.com/watch?v=htSPI7YHnP4&list=PLD707C7AF1A0BC358
6. https://www.youtube.com/watch?v=v1U38n52h9A&list=PLA435953DF9CC6BB9

Course Title **: Modern Physics**

Course Code **: UG-PHY-203**

Marks **: 75 (Theory) + 25 (Practical)**

Credits **: 3 (Theory) + 1 (Practical)**

Pre-requisite **: Nil**.

Course Objectives:

Modern Physics involves the study of radiation and matter at atomic levels and velocities close to the speed of light. This course will focus on the early development of the theory of atomic structure, wave particle duality, mass spectrographs, accelerators and Lasers. Lectures will help you clarify concepts of modern physics through various conceptual questions and problems.

Course Learning Outcomes: At the end of this course students will be able to:

CLO1: Understand constituents of an atom and atomic structure.

CLO2: Understand and interpret experiments that reveal the particle properties of waves and wavelike properties of particle.

CLO3: Apply uncertainty principle to solve numerical problems related to subatomic physics

CLO4: Understand the working of mass spectrographs and accelerators

CLO5: Understand the basic operating principle of the laser and the optical fibre.

Course content

Theory:

Module I: **[15 h]**

1. **Electrons, Nucleus and Atoms:** **[4 h]**
   Determination of e/m for cathode rays. Thomson's model of the atom and qualitative discussion of alpha scattering experiment. Rutherford's model of the atom. Determining upper limit to nuclear dimension. Electron orbits. Failure of Classical Physics.

2. **Brief review of Atomic models:** **[6 h]**
   Atomic Spectra. Frank-Hertz experiment. The Bohr Atom: Quantization of energy. Bohr-Sommerfeld model. Nuclear motion and reduced mass. Bohr's Correspondence Principle.

3. **Particle Properties of waves:** **[5h]**
   Concepts of Black body radiation. The Photoelectric effect. Compton Effect. Experimental verification of the Photoelectric effect.

Module II: **[15 h]**

1. **De Broglie's Postulate - Wavelike properties of Particles:** **[9 h]**
   a. **Dual nature of matter:** Experiments with bullets, waves and electrons. The interference of electron waves. Watching the electrons.

b. **Matter Waves**: De Broglie's postulate. Davisson and Germer experiment. Electron diffraction experiment of G. P. Thomson. Review of the Bohr's postulate about stationary states in the light of De Broglie's concepts.

c. **Properties of Matter waves:** Wave and group velocities. Relation between the group velocity and phase velocity. Velocity of De Broglie wave. Wave packet and its motion in one dimension.

2. **Heisenberg's Uncertainty Principle: [6 h]**
   Uncertainty principle. Elementary proof of Heisenberg's uncertainty relation between position and momentum. Elementary proof of Heisenberg's uncertainty relation between energy and time. Illustration of Heisenberg's uncertainty principle with thought-experiments. Consequences of the uncertainty relation.

Module III: [15 h]

1. **Measurement of Mass and accelerators [6 h]**
   Measurement of Mass: Thomson's positive ray analysis, Dempster's Mass spectrometer, Bainbridge Mass spectrograph.
   Linear accelerator and Cyclotron.
2. **Lasers: [9 h]**
   Attenuation of light in an optical media. Thermal Equilibrium. Interaction of light with matter. Einstein's A and B coefficients and their relations. Population inversion. Principal pumping schemes. Ruby Laser, He-Ne Laser and Semiconductor laser. Applications of Laser.
   Optical fibres: Optical fibre, Total internal reflection, Propagation of light through optical fibre, Losses in optical fibre.

Practicals: (Minimum Six)

1. Determination of e/m of electrons using Thomson's method.
2. Measurement of k/e.
3. Measurement of diameter of Lycopodium powder.
4. To determine wavelength of Laser source by diffraction of single slit.
5. To determine wavelength of Laser source by diffraction of double slit.
6. Frank Hertz Experiment.
7. Photoelectric effect.
8. IV Characteristics of LASER
9. Optical fibre: Numerical aperture
10. Bending loss in optical fibre

List of books recommended for reference

Mandatory Reading:

1. Beiser, A. 1969, *Perspectives of Modern Physics*, McGraw-Hill Book Company, Singapore.
2. Feynman, R. 2012, *Feynman Lectures on Physics: Quantum Mechanics (Volume - 3)*, Pearson Education, India.
3. Murugeshan, R 2009, *Modern Physics*, S. Chand and Company limited, New Delhi.
4. Rajam, J. 2000, *Atomic Physics*, S. Chand and Company limited, New Delhi.
5. Subramanyam, N., Lal, B. and Avadhanulu, M. 2004, *A Textbook of Optics*, S. Chand and Company limited, New Delhi.
6. Singh, K. And Singh, S. 2013, *Elements of Quantum Mechanics*, S. Chand, New Delhi.

Supplementary Reading:

1. Ghatak 2012, *Optics*, McGraw Hill Education, India.
2. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. McGraw-Hill Book Company, New Delhi.
3. Tipler, P. 2012, *Modern Physics*, WH Freeman, New York.

Online resources:

1. https://hcverma.in/QuantumMechanics
2. https://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
3. https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2016/
4. https://www.youtube.com/watch?v=VLU4dntonhE&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1
5. https://phet.colorado.edu/en/simulations/category/physics

Course Title : **Oscillations, Waves and Sound**

Course Code : **UG-PHY-204**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Prerequisite : **Nil**

Course Objectives : Simple harmonic motion is one of the fundamental types of motion that exists in nature. The objective of this course is to cover the fundamental physical concepts of Simple harmonic motion, waves and sound.

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

CLO1: Set up an equation of motion for simple harmonic motion and obtain its solution.
CLO2: Explain how superposition of waves leads to different Lissajous figures.
CLO3: Set and solve the equation of motion for damped and driven damped harmonic oscillators and analyze the nature of oscillations.
CLO4: Understand the dependence of velocity of sound waves on various factors like temperature, pressure, density, humidity.
CLO5: Solve problems for different cases of Doppler effect.

Course content

Theory:

Module I: Undamped free oscillation **[15 h]**

1. **Undamped free oscillation** **[15 h]**

   Different type of equilibria (Stable, unstable and neutral equilibrium). Periodic oscillations and potential well.

   Differential equation for simple harmonic oscillator and its solutions. Energy of the harmonic oscillator.

   Examples of simple harmonic oscillations: spring and mass system, simple and compound pendulum, torsional pendulum, bifilar oscillations, Helmholtz resonator.

   Superposition of two simple harmonic motions of the same frequency along the same line. Superposition of two mutually perpendicular simple harmonic vibrations of the same frequency. Superposition of two mutually perpendicular simple harmonic vibrations and having time periods in the ratio 1:2. Uses of Lissajous' figures.

Module II: Damped Oscillations and Driven Damped Oscillations **[15 h]**

1. **Damped Oscillations** **[5 h]**

   Introduction. Differential equation of damped harmonic oscillator and its solution, discussion of different cases (Strong, weak and Critical damping).Logarithmic decrement. Energy equation of damped oscillations. Power dissipation. Quality factor.

2. **Driven Damped Oscillations** **[5 h]**
Introduction, Differential equation of forced oscillation and its solution (transient and steady state). Resonance. Width of the resonance; the Q factor. The phase at resonance. Velocity resonance.

3. **Coupled Oscillations** **[5 h]**
Coupled oscillations. Normal Coordinates. Energy of coupled oscillations.

Module III: Waves and Sound and Doppler Effect **[15 h]**

1. **Waves and Sound** **[10 h]**
Transverse vibrations in strings. Velocity of longitudinal waves in gases. Newton's formula for velocity of sound. Velocity in a homogeneous medium. Laplace's correction. Kundt's tube-determination of velocity of sound in a gas and in solids. Intensity level and Bel and Decibel.
Production and detection of Ultrasonic waves and its applications
2. **Doppler Effect:** **[5 h]**
Explanation of Doppler effect in sound. Observer in rest and source in motion. Source at rest and observer in motion. When both source and observer are in motion. Effect of wind velocity. Doppler effect in light. Applications of Doppler effect.

Practicals: (Minimum Six)
1. To determine the equivalent length of the Kater's pendulum and the acceleration due to gravity using a resonance pendulum.
2. To determine the damping constant using Damped harmonic oscillator
3. To determine the velocity of Sound using Helmholtz resonator
4. To determine the value of acceleration due to gravity using a bar pendulum.
5. To determine the frequency of AC mains using Sonometer.
6. Bifilar suspension: Dependence of the time period on the geometry of non-parallel bifilar suspension.
7. Log Decrement.
8. Velocity of Sound using CRO.
9. Lissajous Figures (Demonstration).

List of books recommended for reference

Mandatory Reading:

1. Khanna, D., Bedi, R. 1992, *A Textbook of Sound*, Atma Ram and sons, Delhi.
2. Mathur, D. 2012, *Mechanics*, S. Chand, New Delhi.
3. Taylor, J. 2005, *Classical Mechanics,* University Science Books, USA
4. Subrahmanyam, N. and Lal, B. 1994, Waves and Oscillation, Vikas Publishing House, Noida

Supplementary Reading:

1. French, AP 2003, Vibration and Waves, CBS Publisher, India.
2. Halliday, D., Resnick, R. and Walker, J. 2003, Fundamentals of Physics, 6th edition, John Wiley and Sons, USA.
3. Pain, J. 2005, *The Physics of Vibration and Waves*, 6th Edition, Wiley.

Online resources:

1. https://nptel.ac.in/courses/115/106/115106119/
2. https://nptel.ac.in/courses/115/106/115106090/
3. https://ocw.mit.edu/courses/physics/8-03sc-physics-iii-vibrations-and-waves-fall-2016/part-i-mechanical-vibrations-and-waves/
4. http://galileo.phys.virginia.edu/classes/152.mf1i.spring02/OscWavesIndex.htm
5. http://www.qrg.northwestern.edu/projects/vss/docs/communications/3-what-is-the-doppler-effect.html

Course Title: Elementary Modern Physics

Course Code: UG-PHY-205

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Course Objectives:
The course will focus on the two major theories, the special theory of relativity and the quantum mechanics. Course will help the students in clarifying the concepts of Special theory of Relativity and Modern physics.

Course Learning Outcomes: At the end of this course students will be able to:
CLO1: Demonstrate a comprehensive understanding of the consequences of the Michelson-Morley experiment, and the core principles like Lorentz transformations, time dilation, and mass-energy equivalence.
CLO2: Understand and interpret experiments that reveal the particle properties of waves and wavelike properties of particle.
CLO3: Apply uncertainty principle to solve numerical problems related to subatomic physics
CLO4: understand the principles in quantum mechanics, such as the Schrödinger equation, the wave function and its statistical interpretation.
CLO5: Solve the Schrödinger equation for potentials in one and three dimension and interpret the solutions.

Course Content
Theory:
Module I: **[10 h]**

1. **Special Theory of Relativity:** **[7h]**

Postulates of special theory of relativity. The Michelson-Morley experiment. The Galilean transformation. The Lorentz transformation. The Lorentz-Fitzgerald contraction. Time dilation. Simultaneity.

2. **Relativistic Mechanics:** **[3 h]**

Velocity addition. The relativity of mass. Mass and energy

Module II: **[15 h]**

1. **Particle Properties of waves:** **[4 h]**
   Concepts of Black Body Radiation. The Photoelectric effect. Compton effect, Experimental verification of the Photoelectric effect.

2. **Wave Properties of Particles:** **[8 h]**
   De Broglie's hypothesis. Wave function. Wave and group velocities. Davisson-Germer Experiment. Experiments with bullets, waves and electrons. The interference of electron waves. Watching the electrons. The uncertainty principle and its application.Illustration of Heisenberg's uncertainty principle with thought-experiments.

Module III: **[20 h]**

1. **Schrodinger's Wave Equation:** **[7 h]**

   Derivation of the wave equation on a stretched string. Schrodinger's Equation: Time-dependent form. Probability current. Expectation values and operators. Schrodinger's equation: Steady state form. Eigen values and Eigen functions.

2. **Application of Quantum Mechanics** **[13 h]**

   Free particle. Particle in a one-dimensional infinite square well potential. Particle in a three-dimensional rigid box. Degree of degeneracy One dimensional step potential of finite height (Energy less than step height and energy greater than step height). One dimensional potential barrier. Qualitative discussion of alpha decay.

Practicals: (Minimum Six)

1. Measurement of diameter of Lycopodium powder
2. Fraunhoffer diffraction over double slit
3. Frank Hertz Experiment
4. Photoelectric effect.
5. Determination of Boltzmann's constant using transistor.
6. Characteristics of tunnel diode.
7. Michelson Interferometer.
8. Numerically solving the Time Independent Schrödinger equation for the case of Infinite potential well.
9. Numerically solving the Time Independent Schrödinger equation for the case of Step potential.
10. Numerically solving the Time Independent Schrödinger equation for the case of Sloping potential well.

List of books recommended for reference

Mandatory reading:

1. Beiser, A 1969, Perspectives of Modern Physics, McGraw-Hill Book Company, Singapore.
2. Eisberg, R. And Resnick, R. 2010, Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles, 2nd Edition, Wiley India Pvt Ltd.
3. Feynman, RP 2012, Feynman Lectures on Physics: Quantum Mechanics (Volume - 3), Pearson Education, India.
4. Singh, K. And Singh, S. 2013, Elements of Quantum Mechanics, S. Chand, New Delhi.

Supplementary reading:

1. Griffiths, D 2015, Introduction to Quantum Mechanics, Pearson Education, India.
2. Singh, K. 2013, Elements of Quantum Mechanics, S. Chand and Company, New Delhi.
3. Resnick, R. 2010, Introduction to Special Relativity, Wiley India Pvt Ltd, India.
4. Verma, HC 2012, Quantum Physics, TBS, Calicut.
5. Wichmann E 2010, Quantum Physics: Berkeley Physics Course Vol 4, Mcgraw Hill Education, India.

MULTDISCIPLINARY COURSES (MDC)

Course Title: General Physics: Nucleus, Relativity and Beyond

Course Code: UG-PHY-MDC 3

Credits: 2 (Theory) + 1 (Practical)

Marks: 50 (Theory) + 25 (Practical)

Duration: 30 hrs. (Theory) + 30 hrs. (Practical)

Course objectives: The objective of this course is to build up an understanding of the fundamental principles governing nucleus and nuclear energy and to have knowledge of their application to real life problems. This course will help the students to understand the fundamental concepts of special theory of relativity and its postulates and the concepts of semiconductors, microelectronics and superconductors.

Course Learning Outcomes: At the end of this course, students will:
CLO1: Develop an understanding of nuclear science, encompassing the fundamental principles, phenomena, and applications in various contexts.
CLO2: Acquire an understanding of the principles and applications of the special theory of relativity, and comprehend the fundamental concepts of General theory of relativity.
CLO3: Develop insights into the fundamental constituents of matter, including quarks and elementary particles, and the principles governing their interactions.
CLO4: Gain basic knowledge in the field of cosmology, exploring the origins and evolution of the universe, including its mysterious beginnings.
CLO5: Develop an understanding of two crucial aspects of modern materials science and technology: semiconductors and microelectronics, and superconductors and other emerging materials.
Course content

Theory:
Module I: **[10 h]**

1. **The Nucleus and Nuclear energy**

The structure of nucleus. Radioactive decay. Nuclear reactions and nuclear fission. Nuclear reactors. Nuclear weapons and nuclear fusion.

Module II: **[20 h]**

2. **Relativity**

Relative motion in classical physics. The speed of light and Einstein's postulates. Time dilation and Length contraction. Newtons laws and Mass-Energy equivalence. General Relativity.

3. **Beyond everyday phenomena**

Quarks and other elementary particles. Cosmology and the beginning of time. Semiconductors and microelectronics. Superconductors and other new materials.

Practicals: (Minimum six)

1. Energy band of a semiconductor using a diode.
2. Zener diode characteristics
3. Simulation of Doppler effect
4. Hall effect in semiconductor
5. Verify truth tables of logic gates
6. Experiment on Geiger muller Counter
7. V-I characteristics of a P-N junction diode
8. Radioactive dice experiment
9. To identify unknown radiation source using Geiger Muller counter (Virtual Lab)
10. Determine half-life of Ba-137 m (Virtual Lab)

List of books recommended for reference

Mandatory Reading:

1. Griffiths Thomas and Brosing Juliet, 2009, The Physics of Everyday Phenomenon: A conceptual introduction to Physics, 6th Edition. McGraw-Hill Companies.

Supplementary Reading

1. Robert Resnik , Introduction to special relativity wiley (1968)
2. N.C Garach , understanding Relativity ,vol. I, Sheth publishers
3. Atomic and nuclear physics , A.B.Gupta and Dipak Ghosh , Books and Allied(P)Ltd
4. Nuclear physics , K.Ilangovan ,MJP Publishers
5. Boylested R. Nashelsky L,2000 , Electronic devices and circuit Theory , 6^{th} Edition , prentice-Hall of India Pvt ltd , New Delhi

SKILL ENHANCEMENT COURSE (SEC)

Course Title : Introduction to Error Analysis

Course Code : UG-PHY-SEC3

Marks : 50 (Theory) + 25 (Practical)

Credits : 2 (Theory) + 1 (Practical)

Course Objectives: The objective of this course is that the students will be able to comprehend some of the important methods used in estimate uncertainties and should be able to use these methods in estimating uncertainty in laboratory experiments.

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

CLO1: the techniques involved in analyzing measurement data and the errors associated with the measurement system used.

CLO2: the importance of knowing the uncertainty and nature of uncertainty that occurs during measurements

CLO3: the method of propagation of errors and applying it to estimate uncertainties.

CLO4: the method of statistical analysis in applying it to estimate uncertainties.

CLO5: plotting of graphs and estimate the best fit lines through the data points.

Course Content

Theory:

Module I: [15 h]

1. **Preliminary description [7 h]**

   Errors as uncertainty and its inevitability. Importance of knowing the uncertainties. Estimating uncertainties. Significant figures. Discrepancy. Comparison of measures and accepted values. Comparison of two measured numbers. Checking relationship with graphs. Fractional uncertainties. Multiplying two measured numbers.

2. **Propagation of uncertainties [8h]**

   Uncertainties in direct measurements. The square root rule for a counting experiment. Sums and differences; product and quotient. Arbitrary functions of one variable. General formula for error propagation.

Module II: [15 h]

1. **Statistical analysis of random uncertainties [6 h]**

   Random and systematic errors. The mean and standard deviation. The standard deviation as the uncertainty in the single measurement. The standard deviation of the mean. Systematic errors.

2. **Rejection of data [3 h]**

   The problem of rejecting data. Chauvenet’s Criterion. Discussion.

3. **Least-Squares fitting** **[6 h]**
   Data that should fit a straight line. Calculation of slope and intercept. Uncertainty in the slope and intercept. Least-squares fit to other curves.

Practicals: (Minimum Six)

1. Exploring Propagation of uncertainties using programming.
2. Programming-based exploration of Statistical analysis for random uncertainties.
3. Programming-based exploration of least-squares fitting.
4. Application of propagation of errors to experimental data-I.
5. Application of propagation of errors to experimental data-II.
6. Application of Statistical analysis of random uncertainties to experimental data-I.
7. Application of Statistical analysis of random uncertainties to experimental data-II.
8. Application of Least-Squares fitting to experimental data-I.
9. Application of Least-Squares fitting to experimental data-II.

List of books recommended for reference

Mandatory Reading:

1. Taylor J, 1997, *An Introduction to Error analysis*, University Science Books.

Supplementary Reading:

1. Drosg M. 2007, *Dealing with Uncertainties: A guide to error analysis*, Springer.

2. Hughes, I. G., Hase, T. P. 2010, *Measurements and their Uncertainties A practical guide to modern error analysis.* New York: Oxford University Press Inc.

3. Young, H. D. 1962, *Statistical Treatment of Experimental Data.* New York: McGraw-Hill Book Company, Inc.

4. Squires, G. L., 2001, *Practical Physics*, Cambridge University Press, USA.

Online resources:

1. https://www.youtube.com/watch?v=yQsDxOdn1hk&list=PLYdroRCLMg5NTT00m-7ituVGdtY1X680M
2. https://www.youtube.com/watch?v=5XIybCGh4ck&list=RDCMUCCDzHkpuIuD1ZC0wsCXUuPQ&index=1
3. http://web.pas.rochester.edu/~physlabs/manuals/L2C-StatisticsForWeb-AB5-short.pdf
4. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-621-experimental-projects-i-spring-2003/lecture-notes/10_errors03.pdf
5. https://www.physics.utoronto.ca/~jharlow/teaching/summerlab08/Errors.pdf

SEMESTER IV
DISCIPLINE SPECIFIC CORE COURSE (DSC)

Course Title : **Quantum Mechanics**

Course Code : **UG-PHY-206**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1(Practical)**

Pre-requisite : **Nil**

Course Objectives : The objective of this course is to provide an introduction to quantum mechanics and its application.

Course Learning Outcomes: At the end of this course students will be able to:

CLO1: understand the principles in quantum mechanics, such as the Schrödinger equation, the wave function and its statistical interpretation.
CLO2: solve the Schrödinger equation for potentials in one and three dimension and interpret the solutions.
CLO3: grasp the concepts of angular momentum and spin.
CLO4: have an insight into fundamental issues in quantum mechanics like the EPR paradox, Bells theorem and Schrödinger's cat
CLO5: use numerical tools and software to solve the Schrodinger equation for complex problems.

Course Content
Theory:

Module I: Schrödinger's Theory of Quantum Mechanics **[10 h]**

Plausibility argument leading to Schrödinger equation, Born interpretation of wave functions, Operators in quantum mechanics: position, momentum, kinetic energy and Hamiltonian, Expectation values, The time independent Schrödinger equation, Required properties of Eigen functions, Energy quantization in the Schrödinger theory. Postulates of quantum mechanics.

Module II: Applications of Schrödinger's Steady state equation **[20h]**

Free particle. One dimensional infinite rectangular potential well (Particle in a one-dimensional box). Stationary states, Concept of parity, parity operator and its eigen values. Particle in a three-dimensional rigid box. Degree of degeneracy. One dimensional step potential of finite height (Energy less than step height and energy greater than step height) One dimensional potential barrier. Qualitative discussion of alpha decay,
One dimensional finite rectangular potential well (placed symmetric to origin). Parity and parity operators.

One dimensional harmonic oscillator (Algebraic method using raising and lowering operators and analytical method.)

Module III: **[15 h]**

1. **Angular momentum and Spin** **[11 h]**

   Angular momentum operators, Angular momentum Eigen values and Eigen functions. Spin 1/2, Spinors, Pauli spin matrices, Eigen values and Eigen spinors of Spin. Electron in a Magnetic field: Larmor Precession and Stern Gerlach Experiment.

2. **Fundamental issues in quantum mechanics** **[4 h]**

   EPR paradox, Bell's Theorem and Schrödinger's cat.

Practicals: (Minimum six)

1. Introduction to Numerov method.
2. Numerically solving the Time Independent Schrödinger equation for the case of Infinite potential well.
3. Numerically solving the Time Independent Schrödinger equation for the case of finite potential well.
4. Numerically solving the Time Independent Schrödinger equation for the case of Infinite potential well with a cosine bump.
5. Numerically solving the Time Independent Schrödinger equation for the case of Step potential.
6. Numerically solving the Time Independent Schrödinger equation for the case of Sloping potential well.
7. Numerically solving the Time Independent Schrödinger equation for the case of Potential barrier.
8. IV Characteristics of Tunnel Diode.

List of books recommended for reference

Mandatory reading:

1. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles*, 2nd Edition, Wiley India Pvt Ltd.
2. Griffiths, D. 2015, *Introduction to Quantum Mechanics*, Pearson Education, India.
3. Singh, K. And Singh, S. 2013, *Elements of Quantum Mechanics,* S. Chand, New Delhi.

Supplementary reading:

1. Beiser, A. 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.
2. Flugge, S. 2008, *Practical Quantum Mechanics,* Springer (SIE).
3. Rajasekar, S. and Veluswamy, R. 2014, *Quantum Mechanics I: The Fundamentals,* CRC Press, New York.

4. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. Tata McGraw-Hill Book Company, New Delhi.
5. Verma, H. 2012, *Quantum Physics*, TBS, Calicut.
6. Wichmann, E. 2010, *Quantum Physics: Berkeley Physics Course Vol 4*, Tata McGraw-Hill Book Company, New Delhi.
7. Sengupta, K. and Pal, P. B. Qua 2023, *Introduction to Quantum Mechanics*, Cambridge University Press.

Online resources:

1. Verma, P. H. (2016). Retrieved from https://hcverma.in/QuantumMechanics
2. Zwiebach, P. B. (2016). *Quantum Physics I*. Retrieved from MIT OpenCourseWare: https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2016/video-lectures/part-1/
3. PhET Interactive Simulations, University of Colorado Boulder, https://phet.colorado.edu/
4. Adams, A. (2013). Retrieved from MIT OpenCourseWare: https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2013/
5. Greensite, J. (2003). Retrieved from http://stanford.edu/~oas/SI/QM/papers/QMGreensite.pdf

Course Title : **Heat and Thermodynamics**

Course Code : **UG-PHY-207**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Course Objectives **:** To acquaint students with fundamental concepts of Thermal Physics and explain the usefulness of these concepts for wide range of applications that include heat engines, refrigerators and air conditioners.

Course Learning Outcomes : At the end of this course students will be able to:

CLO1: Understand different types of temperature scales and relationship between different scales of temperature.
CLO2: Relate the effects of changes in temperature, pressure and volume on physical systems at macroscopic scale by analyzing collective motion of their particles.
CLO3: Comprehend the first law of thermodynamics to represent the relationship between heat and mechanical work.
CLO4: Comprehend the second law of thermodynamics to depict the manner in which thermodynamic changes take place.
CLO5: Use laws of thermodynamics to understand the working of engines, refrigerators and air conditioners.
CLO6: Comprehend the concept of entropy and calculate the change in entropy when the matter is heated/cooled or when the matter undergoes change in phase.

Course Content

Theory:

Module I: **[15 h]**

1. **Principle of Thermometry** **[6 h]**
   Review of concept of heat and temperature, Thermometry, Types of thermometers, Centigrade, Fahrenheit, Rankine Scales and relations between them, Platinum resistance thermometer, Thermocouple (thermoelectric) thermometers.

2. **Equations of State** **[9 h]**
   Equation of state, Andrew's experiment, Amagat's experiment, Van der Waal's equation of State, Critical constants, Reduced equation of state, Boyle temperature. Joule's Law for a perfect gas, expression for Joule's coefficient, Joule Thomson effect, Joule Thomson porous plug experiment, Joule-Kelvin effect-temperature of inversion.

Module II: **[15 h]**

1. **Laws of Thermodynamics** **[15 h]**
   Thermodynamic system, Thermodynamic variables, Thermodynamic equilibrium, and Thermodynamic processes, Zeroth law of thermodynamics, Concept of work and internal energy, First law of thermodynamics, Isothermal and adiabatic changes, Work done in isothermal and adiabatic changes, Relation between pressure, volume and temperature in

adiabatic process, Reversible and irreversible processes, Carnot Heat engine, Carnot cycle for perfect gas, efficiency, Second law of thermodynamics (Kelvin – Planck Statement, Clausius Statement)

Module III: **[15 h]**

1. **Applications of First and Second Law of Thermodynamics** **[9 h]**

   Otto cycle and Otto engine, Diesel cycle and Diesel engine, Efficiencies, Introduction to refrigeration, Principle and coefficient of performance, Principle of air conditioning, comfort chart A.C. machine, factors affecting size and capacity of A.C. machines.

2. **Concept of Entropy** **[6 h]**

   Changes of entropy during reversible and irreversible process, Temperature – Entropy diagram, Temperature – Entropy diagram of Carnot's cycle, Physical significance of Entropy, Entropy of a perfect gas, Principle of increase of entropy, Third Law of Thermodynamics.

Practicals: (Minimum Six)

1. Latent heat of ice
2. Calibration of Si diode as a thermometer.
3. Constant volume air thermometer.
4. Constant pressure air thermometer.
5. Thermal conductivity by Lee's method.
6. Thermal conductivity of copper.
7. Temperature coefficient of resistance of copper.
8. Temperature coefficient of resistance of Platinum thermometer using PT-100.
9. Callender-Griffith Bridge.

List of books recommended for reference

Mandatory reading:

1. Brij Lal, Subramanyam N., Hemne P.S. 2007, *Heat Thermodynamics and Statistical Physics*, S. Chand & Company Ltd., New Delhi

2. Saha M.N., Shrivastava B.N. 1965, *Treatise on Heat*, 5th Ed., The Indian Press, Allahabad and Calcutta.

Supplementary reading:

1. Roberts J. K., Miller A.R. 1960, *Thermodynamics*, E.L.B.S.

2. Zemansky M.W., Ditman R.H. 2013, *Heat and Thermodynamics*, 8th Ed., McGraw Hill, New Delhi

Online resources:

1. http://www.zytemp.com/infrared/thermometry_history.asp
2. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/video-lectures/lecture-1-state-of-a-system-0th-law-equation-of-state/
3. https://ocw.mit.edu/high-school/physics/exam-prep/kinetic-theory-thermodynamics/laws-of-thermodynamics/
4. https://www.texasgateway.org/resource/124-applications-thermodynamics-heat-engines-heat-pumps-and-refrigerators
5. https://web.mit.edu/2.972/www/reports/compression_refrigeration_system/compression_refrigeration_system.html
6. http://web.mit.edu/16.unified/www/FALL/thermodynamics/notes/node41.html
7. F., R. A Treatise on Heat. *Nature* 137, 554-556 (1936) https://doi.org/10.1038/137554a0

Course Title : **Electronics-I**

Course Code : **UG-PHY-208**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Nil**

Course Objectives : The general goal of this course is to allow the students to understand the fundamentals of semiconductor behaviour and the operation of basic semiconductor devices. This course lays the foundations for the understanding of more advanced semiconductor devices such as those covered in more advanced courses.

Course Learning Outcomes: At the end of the course, students will be able to:

CLO1: Understand the fundamentals of semiconductor behaviour and the operation of basic semiconductor devices.

CLO2: Understand basic circuit laws; semiconductor based analog circuits.

CLO3: Use this knowledge to describe bipolar transistors and its applications.

CLO4: Understand and apply the concept of feedback in operational amplifier and sinusoidal oscillators.

Course Content

Theory:

Module I: **[15 h]**

1. **Basic concepts and resistor circuits** **[7 h]**

   Basics of current and voltages in a circuit, Constant voltage and Constant current source, Conversion of voltage source into current source, Maximum power transfer theorem, Kirchoff's Current and voltage Law, Thevenin's theorem and Norton's theorem, Techniques for solving circuit problems.

2. **Semiconductor Diodes** **[8 h]**

   Semiconductor materials- intrinsic and extrinsic types, Ideal Diode, Terminal characteristics of diodes: p-n junction under open circuit condition, p-n junction under forward bias and reverse bias conditions, Diode I-V characteristic and load line for a simple diode circuit, Diode applications: Voltage dropper, Diode limiter, Variable diode clipper, Diode clamp, Rectification-working of Half wave and Full wave – calculation of efficiency, nature of rectifier output, comparison of rectifiers, Power supply filters (capacitor filter)

Module II: **[20 h]**

1. **Bipolar Junction Transistors (BJTs)** **[12 h]**

   Physical structure and operation modes, Transistor action, Transistor as an amplifier, Basic BJT amplifier configuration: common emitter, common base and common collector connections and their characteristics, comparison of transistor connections, Transistor as an amplifier in C-E mode, Active region operation of transistor, D.C. analysis of transistor circuits, performance of transistor amplifier, cut off and saturation points, power rating of transistor. Biasing the BJT: fixed bias, emitter feedback bias, collector feedback bias and voltage divider bias.

2. Sinusoidal oscillators **[8 h]**

Positive and negative feedback, Voltage and current feedback, series and shunt feedback, Effect of negative feedback on gain, frequency response, input and output resistance and distortion, Positive feedback, Barkhausen criterion for oscillations, Phase shift oscillator, Wein bridge oscillator, Hartley oscillator and Colpitt's oscillator.

Module III: **[10 h]**

1. Operation Amplifier (Op-amps) **[10 h]**

Ideal Op-amp, operation of differential amplifier, differential and common mode signals, common mode rejection ratio (CMRR), d.c. analysis of differential amplifier , parameters of differential amplifier due to mismatch of transistors, bandwidth of an Op-amp, Slew rate limiting, Frequency response, Practical op-amp circuits: inverting amplifier, non-inverting amplifier, integrator, differentiator.

Practicals: (Minimum Six)

1. Half wave rectifier using Junction Diode
2. Full wave rectifier using Junction Diode
3. Bridge rectifier with capacitor filter- Ripple factor using CRO.
4. C.E. Amplifier: Gain v/s Load
5. C.E. Amplifier: Input and Output Impedance
6. C.E. Amplifier. Frequency response. Calculation of Gain Bandwidth product
7. OP-Amp: Characteristics Input and Output impedance
8. OP-Amp: Inverting and Non-inverting amplifier
9. Colpitt's Oscillator
10. Wein's Bridge Oscillator

List of books recommended for references

Mandatory reading:

1. Eggleston D. L., 2011, *Basic Electronics for Scientists and Engineers*, 1st edition Cambridge University Press.

2. Mehta V. K., Rohit Mehta, *Principles of Electronics*, S. Chand and Co. Ltd. New Delhi

Supplementary reading:

1. Kal Saantiram 2006, *Basic Electronics: Devices, Circuits and IT fundamentals*, PHI, New Delhi

2. Malvino A. P, Bates D. J. 2006, *Electronic Principles*, Tata McGraw- Hill, New Delhi

3. Mottershead Allen 2000, *Electronics Devices and Circuits: An Introduction*, Prentice-Hall of India Pvt. Ltd., New Delhi.
4. Bhargava N. N., Kulshrestha D. C., Gupta S. C., 2017, *Basic Electronics and Linear Circuits*, 2nd Edition, Tata McGraw Hill, New Delhi
5. Gayakwad R. A., 2015, *Op-Amps and Linear Integrated Circuits*, 4th Edition, Pearson Education, Delhi

Online resources:

1. http://alan.ece.gatech.edu/ECE3040/Lectures/CircuitReview.pdf
2. https://www.electricaltechnology.org/2019/01/what-is-rectifier-types-of-rectifiers-their-operation.html
3. https://www.elprocus.com/different-types-rectifiers-working/
4. https://www.pitt.edu/~qiw4/Academic/ME2082/Transistor%20Basics.pdf
5. https://nptel.ac.in/courses/115/102/115102014/
6. https://www.electronics-tutorials.ws/oscillator/oscillators.html

Course Title : **Properties of Matter and Acoustics**

Course Code : **UG-PHY-209**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Nil**

Course Objectives **:** This course provides an introduction to dynamics of rigid bodies and calculation of moment of inertia, properties of matter and acoustics of rooms. An objective of this course is to build up an understanding of fundamental physical principles which are required for most of other physical sciences.

Course Learning Outcomes: At the end of this course students will be able to:

CLO1: Gain an introductory knowledge of dynamics of rigid bodies, and its applications to basic physical problems.
CLO2: Familiarize with of acoustics of rooms and musical scales.
CLO3: Explain the concept of elasticity, including its various types and its applications.
CLO4: Explain the concept of surface tension, analyse and explain the role of surface tension in various natural phenomena such as capillary action.
CLO5: Interpret the concept of viscosity and its applications, describe the properties of fluids that determine their viscosity.

Course Content

Theory:

Module I: **[15 h]**

1. **Dynamics of Rigid bodies:** **[15 h]**

   Rigid bodies, Rotational Kinetic energy, Moment of inertia and its physical significance, Angular acceleration, angular moment, law of conservation of momentum, Analogy between translatory and rotatory motion, Theorem of perpendicular axis, Theorem of parallel axis, Moment of inertia of thin uniform bar, Moment of Inertia of a bar about an axis passing through one end and perpendicular to its length, Moment of Inertia of a bar about an axis perpendicular to its at a distance ‘a’ from one end, Moment of inertia of rectangular lamina, Moment of inertia of solid uniform bar of rectangular cross section, Moment of inertia of ring, Moment of inertia of disc, Moment of inertia of Annular disc, Moment of inertia of hollow cylinder, Moment of inertia of solid sphere, Moment of inertia of hollow sphere, Moment of inertia of spherical shell, ,Moment of inertia of a uniform elliptical lamina, Moment of inertia of a uniform triangular lamina, Moment of inertia of a

Module II: **[15 h]**

1. **Elasticity:** **[8 h]**

   Moduli of elasticity, Poisson's ratio and relationship between them. Bending of beams-bending moment, flexural rigidity. Cantilever (rectangular bar). Depression of a beam supported at the ends and loaded at the centre. A vibrating cantilever. Torsion in a string-couple per unit twist, Torsional Pendulum.

2. **Surface Tension:** **[7 h]**

   Brief review of molecular theory of surface tension. Relation between surface tension and surface energy. Excess pressure inside a spherical Liquid drop, difference of pressure across a curved surface, Angle of contact. Capillarity-rise of liquid in a capillary tube.

Module III: **[15 h]**

1. **Viscosity** **[9 h]**

   Equation of continuity: Euler's equation for liquid flow, Bernoulli's theorem and its applications. Streamline flow, Turbulent flow, Critical velocity, Coefficient of viscosity, Poiseuille's formula for flow of liquid through a capillary tube. Criticism of Poiseuille's equation

2. **Acoustics of Rooms and Musical Scales** **[6 h]**

   Reverberation of Sound, Reverberation time, Absorption coefficient, Sabine's formula for reverberation time (discussions only) , Acoustic requirements of an auditorium. Musical interval, harmony, melody. Diatonic scale. Tempered scale. (only concepts)

Practicals: (Minimum Six)

1. Cantilever: Determination of Young's modulus by vertical vibrations of a cantilever.
2. Torsional Pendulum: Determination of Rigidity Modulus of the material of a wire.
3. Jagger's Method: Determination of Surface Tension
4. Viscosity of a liquid by Poiseuilles method
5. Bending of beams: determination of Young's modulus
6. Capillarity: determination of Surface tension
7. Flat Spiral Spring: determination of elastic constants by vertical and torsional oscillations of a loaded spring
8. Young's Modulus of Brass by Flexural Vibrations of Bar.
9. Rigidity Modulus of Brass.

List of books recommended for reference

Mandatory reading:

1. Brij Lal, Subramanyam N., 1999, *Properties of matter*, Eurasia Publishing House New Delhi
2. Mathur D. S., 2010, *Elements of Properties of Matter*, S. Chand and Company, New Delhi.
3. Bedi R.S., Khanna D. R.,1994, *Text book of Sound*. Atma Ram, New Delhi

Supplementary reading:

1. Mee F. G., 1967, *Sound*. Heinemann Ltd., London
2. Newman, Searle, 1957, *General properties of Matter,* 5thedition,Hodder & Stoughton Educational, UK
3. Smith C. J., 2011, *Properties of Matter*, 2nd edition, Edward Arnold, UK

Online resources:

1. https://www.youtube.com/watch?v=ZFEExw-qUSk&list=PLVFqK_9GOGXnSnuU-x2qgX68mWyBqn6O8
2. https://www.youtube.com/watch?v=47bEFVyczLk&list=PLwdnzlV3ogoV-ATGY2ptuLS9mwLFOJoDw
3. https://www.youtube.com/watch?v=fa0zHI6nLUo&list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm
4. https://www.youtube.com/watch?v=yyqhgnc5cWI&list=PLbRMhDVUMngeGSqPVkrc8G_kApltxEEos
5. https://www.youtube.com/watch?v=CIws3dZEHMU&list=PL546CD09EA2399DAB&index=7

Course Title: Introduction to Astronomy and Astrophysics

Course Code: UG-PHY-210

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Prerequisites: Classical Mechanics, Optics, Modern Physics, Quantum Mechanics, Electromagnetic Theory - I

Course Objectives: The course aims to introduce the students to the Exciting World of Extragalactic Universe.

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

CLO1: Understand the various Extra-galactic objects.

CLO2: Understand the construction, working and mounting of modern telescopes.

CLO3: Understand co-ordinate system of Celestial Objects.

CLO4: Understand different spectral classes of stars, galaxies and the very early universe.

CLO5: Locate objects in the sky using coordinate systems.

Course Content

Theory:

Module I: FUNDAMENTALS OF ASTRONOMY [15 h]

1. **The Celestial Sphere and Mechanics: [7 h]**

The Greek tradition: The geocentric universe; The Copernican revolution: Bringing Order to the Planets; Positions on the Celestial Sphere: The Altitude- Azimuth Coordinate system, The Equatorial Coordinate System, Precession, Measurement of time

Elliptical orbits: Kepler's Laws of Planetary Motion, Geometry of Elliptical Motion

2. **Continuous Spectrum of Light [8 h]**

Stellar Parallax; The Magnitude Scale: Apparent Magnitude, Flux, Luminosity and Inverse Square Law, Absolute Magnitude, Distance Modulus; Blackbody Radiation: Connection between color and temperature, Stefan Boltzmann Equation; Planck function and Astrophysics; Color Index: UBV Wavelength filters, Color indices and the Bolometric Correction, The Color-Color diagram; Interaction of Light and Matter: Spectral lines, Kirchoff's laws, Applications of Stellar Spectra Data, Spectrographs.

Module II: ASTRONOMICAL TOOLS, THE SOLAR SYSTEM AND THE NATURE OF STARS [15 h]

1. **Astronomical Instruments: [4 h]**

Optical telescopes: Refracting and reflecting telescopes, Telescope mounts, Large Aperture telescopes, Adaptive optics, Space based observatories, Electronic detectors; Radio telescopes: Spectral flux density, Improving resolution – Large apertures and Interferometry

2. **The Solar System: [6 h]**

Brief survey: General characteristics of the planets, Moons of the planets, Asteroid belt, Comets and Kuiper belt objects, Meteorites, Solar system formation – a brief overview; Tidal forces: Physics of tides, Effects of tides, Synchronous rotation, Additional tidal effects from the sun, Roche limit.

3. **Classification of Stellar Spectra: [5 h]**

Formation of spectral lines: Spectral types of stars, The Maxwell Boltzmann velocity distribution, The Boltzmann equation, Saha equation; The Hertzsprung Russell Diagram: An enormous range in stellar radii

Module III: STAR FORMATION, GALAXIES AND THE UNIVERSE [15 h]

1. **Star formation [6 h]**

Formation of protostars- Jeans criterion; Pre-Main Sequence- Formation of Brown Dwarfs, The Zero Age Main Sequence (ZAMS); Evolution of the Main Sequence- Schönberg-Chandrsekhar limit; Late Stages of Stellar Evolution- Subgiant branch, Red Giant branch, Horizontal branch; Stellar Clusters- Globular and Galactic clusters

2. **The Milky Way and the Nature of Galaxies [5 h]**

Morphology of the Milky Way Galaxy; Galactic Center; The Hubble Sequence: Classification of galaxies

3. The Early Universe [4 h]

Fundamental particles, Hot and Cold Dark matter, Planck’s limits on time, mass and length, Unification and spontaneous symmetry breaking, Problems with the standard theory of the Big Bang, Inflation

Practicals: (Minimum six)

1. Resolving power of telescope
2. Study of scattering of light (Diameter of Lycopodium powder)
3. To find radius of curvature of a convex lens using optical lever
4. Measurement of the solar constant
5. Draw constellation map of a) Orion b) Auriga c) Taurus d) Ursa Major (Big Dipper) marking of pole star.
6. To determine the elements in sun using Frauhoffer spectra
7. To estimate Astronomical Unit using Venus transit data by parallax method
8. Determine the period of revolution of sun using virtual laboratory
9. To become familiar with the astronomical objects visible to naked eye in the night sky using the software Stellarium
10. To become familiar with the Constellations in the night sky using the software Stellarium
11. To identify the retrograde motion of Mars with respect to the Background stars using Stellarium
12. To identify some of the prominent spectral lines in the spectrum of our sun
13. To get familiar with the spectra of different stars using Stellarium
14. To extract coordinates of a star assuming a telescope in equatorial mount using Stellarium
15. To measure astronomical distances using Cepheid variables using Stellarium
16. To measure the Proper Motion of Barnard's Star using Stellarium
17. To identify a Circumpolar Star using Stellarium
18. To determine the distance and age of cluster using Colour Magnitude Diagram using Stellarium
19. To determine orbital inclination of the planet Mars using Stellarium
20. To measure planetary distances using Stellarium
21. To measure distance to Moon using Stellarium
22. To determine observer’s location by means of the stars using Stellarium

List of books recommended for reference

Mandatory reading:

1. Freedman, R. A. & Kaufmann III, W. J., 2008. *Universe*, Eighth Edition. New York: Clancy Marshall

2. Shu, F. H., 1982. *The Physical Universe An Introduction to Astronomy*. Sausalito, California: University Science Books.
3. Kutner, M. L., First published in 2003. *Astronomy A Physical Perspective*. Second ed. New York: Cambridge University Press.
1. Carroll, B. W. & Ostlie, D. A., n.d. *An Introduction to Modern Astrophysics*. Second ed. San Francisco: Addison Wesley.

Supplementary reading:

1. Roy A.E., Clarke D., 1989, *Astronomy structure of the Universe*, Adam Hilger Pub.
2. Glasstone S., 1965, *Source book on the Space Sciences*, Van Nostrand Reinhold Inc., U.S
3. Bhatia V. B., 2001, *Textbook of Astronomy and Astrophysics* with Elements of Cosmology, Narosa Publishers, New Delhi.
4. Narlikar J.V., 1976, *Structure of the Universe*, Oxford Paperbacks.
5. Baidyanath and Basu, 2010, *An Introduction to Astrophysics*, 2nd Edition, Prentice Hall India Learning Private Limited
6. Abhyankar K.D., 2001, *Astrophysics - Stars and Galaxies*, Tata McGraw Hill, New Delhi
7. Sule, A., 2013. *A Problem Book in Astronomy and Astrophysics.* [Online]
8. Palen, S. E., 2002. *Schaum's Outline Series, Astronomy*. United States of America: McGraw Hill.

Online resources:

1. https://youtu.be/QJjT9QPlnJs
2. https://youtu.be/vDv3iSMdYyc
3. https://youtu.be/Upy-jNpQW_0
4. https://youtu.be/nzmFc2gjUo4
5. https://youtu.be/0b7-4tfx3J4
6. https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/
7. https://ocw.mit.edu/courses/physics/8-901-astrophysics-i-spring-2006/
8. https://ocw.mit.edu/courses/physics/8-902-astrophysics-ii-fall-2004/

VOCATIONAL COURSE (VOC)

Course Title : Computational Physics

Course Code : UG-PHY-VOC1

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Pre-requisite : Nil

Course Objectives : The course aims to enable the students to solve problems in Physics which involves numerical methods by using FORTRAN as a programming language.

Course Learning Outcomes: At the end of this course students will be able to:

CLO1: Understand various numerical methods
CLO2: Use FORTRAN language for numerical calculations.
CLO3: Understand various concepts of Physics using numerical methods using FORTRAN as a programming language.
CLO4: Understand least square fitting using computation.

Course Content

Theory:

Module I: Concepts of programming: [5 h]
Definition and Properties of algorithms, Algorithm development, Flow charts- symbols and simple flowcharts.

Module II: FORTRAN Programming [20 h]

1. Evolution of Fortran.

2. Simple Fortran Programs:
Writing a Program, Input statements, Some Fortran program examples.

3. Numerical Constants and Variables:
Constants, Scalar Variables, Declaring Variable Names, Implicit Declaration, Named Constants.

4. Arithmetic Expressions:
Arithmetic Operators and Modes of Expression, Integer Expressions, Real Expressions, Precedence of Operations in Expressions, Assignment Statements, Defining Variables, Some problems due to rounding of real numbers, mixed mode expressions, Intrinsic functions, Examples of Use of Functions.

5. Input-Output Statements:
List-directed input statements, List-directed output statements.

6. Conditional Statements:
Relational Operators, The block IF construct, Example programs Using IF structure.

7. Implementing Loops in Program:
The block DO loop, count control DO loop, Rules to be followed in writing DO loops.

8. Logical expressions and More Control statements:
Introduction, Logical constants, variables and expressions, precedence rules for logical operators, Some examples of use of Logical expressions, The case statements.

9. Functions and subroutines:
Introduction, function subprogram, syntax rules for function subprograms, Generic functions, Subroutines, Internal Procedures.

10. Defining and Manipulating Arrays:
Arrays Variables, Use of multiple subscripts, Do type notation for Input/Output Statements, Initializing arrays, Terminology used for multidimensional arrays, use of arrays in DO loops, whole array operations.

Module III: Computational Physics: **[20 h]**

1. Errors in Computation:
Inherent errors in storing, Numbers due to finite bit representation to use in Computer, Truncation error, round off errors (Explain with the help of examples)

2. Iterative methods:
Discussion of algorithm and flowcharts and writing FORTRAN programs for finding single root of equation using bi-section method, Newton-Raphson method.

3. Least Square Curve fitting:
Discussion of algorithm and flowcharts and writing FORTRAN program for straight line fit with example in physics.

4. Numerical Integration:
Discussion of algorithm and flowcharts and writing FORTRAN program for trapezoidal rule and Simpson's 1/3rd rule.

5. Solution of Differential equations:
Discussion of algorithm and flowcharts and writing FORTRAN program for Euler's method for finding solution of differential equation.
(*Derivation of formula is not expected for all the above numerical methods*)

Practicals: (minimum six)

Following programs may be discussed thoroughly in theory lectures and implemented in the practicals.

1. Sum of digits of an integer
2. To find factorial of a number
3. Checking and printing of prime numbers
4. Generation of Fibonacci numbers
5. To find sin(X), cos(X) using series method
6. Sorting of Numerical data - ascending, descending.
7. Matrix operations – addition, subtraction, multiplication
8. Graphics- line, circle, arc, bar, ellipse.
9. Root of equation-Bisection method, Newton Raphson method
10. Numerical integration- Trapezoidal, Simpson's 1/3rd rule.
11. Least square curve fitting- data for ohm's law.
12. Freely falling body and motion of falling body including air drag. (using Euler's method)
13. Electric field due to a point charge
14. Charging and Discharging of Capacitor in RC circuit/Growth and Decay of current in RL Circuit.

List of books recommended for reference

Mandatory reading:

1. Rajaraman V. 1987, *Computer Programming in Fortran 90 and 95*, 2nd Edition, Prentice-Hall of India, New Delhi,.
2. Rajaraman V. 1999, *Computer Oriented Numerical Methods*, Prentice-Hall of India, New Delhi.

Supplementary reading:

1. Verma P. K. and Ahluwalia and Sharma K. C. 1999, *Computational Physics*, New Age International Publishers, India.

Online resources:

1. https://nptel.ac.in/courses/115/106/115106118/
2. https://www.fortrantutorial.com/
3. https://web.stanford.edu/class/me200c/tutorial_77/
4. https://pages.mtu.edu/~shene/COURSES/cs201/NOTES/fortran.html
5. http://www.ibiblio.org/pub/languages/fortran/index.html

Annexure I

(Summary of changes incorporated in the syllabus)

Semester	Course Title	Existing (Indicate only the unit where the change is proposed)	Changes Proposed	Specify the reason for the change
IV	Heat and Optics	Heat and Optics	Course removed	As the Dept. of Physics is offering vocational courses, separate minor courses are removed.
V	Statistical and Solid-State Physics	Statistical and Solid-State Physics	Course removed	
V	Electromagnetic Theory -II	**Practicals:** 1. Hysteresis by magnetometer. 2. B-H curve in a hard magnetic material and in a soft ferrite. 3. Core losses and copper losses in a transformer. 4. Measurement of mutual inductance using ballistic galvanometer. 5. Calibration of lock-in-amplifier and determination of mutual inductance. 6. Determination of magnetic susceptibility of $FeCl_3$ by Quincke's method. 7. M/C using ballistic galvanometer 8. Helmholtz coils. 9. Verification and application of Biot-Savart law.	**Practicals:** 1.Verification and application of Biot-Savart law.	Addition of one new experiment to foster practical understanding.

VI	Atomic and Nuclear Physics	Atomic and Nuclear Physics	Course removed	As the Dept. of Physics is offering vocational courses, separate minor course is removed.

SEMESTER V

Course Title **: Electromagnetic Theory – II**

Course Code **: PHY-V.C-7**

Marks **: 75 (Theory) + 25 (Practical)**

Credits **: 3 (Theory) + 1 (Practical)**

Pre-requisite **: Electromagnetic Theory – I (PHY-III.C-5)**

Course Objectives **:** To acquaint students with fundamental principles of Magnetostatics part of the Electromagnetic Theory.

Course Learning Outcomes: At the end of this course, students would be able to:
CLO1: Calculate magnetic field induction using Biot-Savart's law and Ampere's law.
CLO2: Interpret bound currents and calculate magnetic fields in matter.
CLO3: Comprehend microscopic theory magnetism.
CLO4: Relate electrostatics and magnetostatics using Maxwell's equations.
CLO5: Develop and solve the wave equation for propagation of electromagnetic waves through material media and vacuum at different angles of incidence.
Theory:

Unit I: Magnetostatics **[15 h]**

1. **Magnetostatics** **[15 h]**

   Lorentz force law: Magnetic fields, Magnetic forces, Currents, Biot-Savart law: Steady currents, Magnetic fields of a steady current, Divergence and Curl of **B**: Straight-line currents, divergence and curl of **B**, applications of Ampere's law, comparison of magnetostatics and electrostatics, Magnetic vector Potential: Vector potential, magnetostatic boundary conditions, multipole expansion of the vector potential.

Unit II: Magnetic Fields in Matter and Microscopic Theory of Magnetism **[15 h]**

1. **Magnetic Fields in Matter** **[11 h]**

   Magnetization: Diamagnets, paramagnets and ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization, the field of a magnetized object: Bound currents, physical interpretation of bound currents, magnetic field inside matter, The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions, Linear and nonlinear media: Magnetic susceptibility and permeability, Energy in magnetic fields.

2. **Microscopic Theory of Magnetism** **[4 h]**

   Molecular field inside matter, origin of diamagnetism, origin of paramagnetism, theory of ferromagnetism, ferromagnetic domains, ferrites

Unit III: Maxwell's Equations and Propagation of Electromagnetic Waves **[15 h]**

1. **Maxwell's Equations** **[5 h]**

   Generalization of Ampere's law, displacement current, Maxwell's equations and their empirical basis, electromagnetic energy, Poynting theorem.

2. **Propagation of Electromagnetic Waves** **[10 h]**

   The wave equation, plane monochromatic waves in non-conducting media, polarization, plane monochromatic waves in conducting media, reflection and refraction at the boundary of two non-conducting media: normal incidence and oblique incidence, Brewster's angle, critical angle.

Experiments: (Minimum Six)

1. Hysteresis by magnetometer.
2. B-H curve in a hard magnetic material and in a soft ferrite.
3. Core losses and copper losses in a transformer.
4. Measurement of mutual inductance using ballistic galvanometer.
5. Calibration of lock-in-amplifier and determination of mutual inductance.
6. Determination of magnetic susceptibility of $FeCl_3$ by Quincke's method.
7. M/C using ballistic galvanometer
8. Helmholtz coils.
9. Verification and application of Biot-Savart law.

References:

1. Griffiths D. J., 2011, *Introduction to Electrodynamics*,3rd Ed., Prentice Hall of India, New Delhi
2. Reitz J. R., Milford F. J., Christy R. W., 1979, *Foundations of Electromagnetic Theory*,3rd Ed., Addison-Wesley Publishing Company.

Additional Reference:

1. Mukherji U., 2008, *Electromagnetic Field Theory and Wave Propagation*, Narosa Publishing House.

Web References:

1. https://nptel.ac.in/courses/115101005/
2. https://swayam.gov.in/nd1_noc19_ph08/preview
3. https://ocw.mit.edu/courses/physics/8-07-electromagnetism-ii-fall-2012/lecture-notes/
4. https://www.feynmanlectures.caltech.edu/II_toc.html
5. http://galileo.phys.virginia.edu/classes/109N/more_stuff/Maxwell_Eq.html