Parvatibai Chowgule College of Arts and Science

(Autonomous)

Accredited by NAAC with Grade 'A+'

Best Affiliated College-Goa University Silver Jubilee Year Award

DEPARTMENT OF PHYSICS

COURSE STRUCTURE AND SYLLABUS FOR

UNDERGRADUATE DEGREE

PROGRAMME IN PHYSICS

(2025-2026)

DEPARTMENT OF PHYSICS

Course Structure for the Academic Year 2025-2026

SEMESTER	MAJOR CORE	MINOR/ VOCATIONAL	MULTI-DISCIPLINARY COURSE (MDC)	VALUE ADDED COURSE (VAC)	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 **Or** **UG-PHY-MDC4:** Introduction to Astronomy	**UG-PHY-VAC2:** Environmental Physics	**UG-PHY-SEC1:** Introduction to Mathematical Physics-I **Or** **UG-PHY-SEC4:** Python programming fundamentals and mathematical techniques
II	**UG-PHY-103:** Electricity and Magnetism	**UG-PHY-104:** Electricity, Magnetism and Electronics	**UG-PHY-MDC2:** General Physics: Light and atoms	**UG-PHY-VAC1** Eminent Indian physicists and their contribution	**UG-PHY-SEC2:** Introduction to Mathematical Physics-II **Or** **UG-PHY-SEC5:** Matrices and Differential Equations
III	**UG-PHY-201:** Electromagnetic Theory-I	**UG-PHY-211:** Wave Optics and Elementary Modern Physics	**UG-PHY- MDC3:** General Physics: Nucleus, Relativity and Beyond **Or** **UG-PHY-MDC5:** Stars, Galaxies and Cosmology		**UG-PHY-SEC3:** Introduction to Error Analysis **Or** **UG-PHY-SEC6:** Numerical Techniques
	UG-PHY-202: Optics				
	UG-PHY-204: Oscillation, Waves and Sound				
IV	**UG-PHY-203:** Modern Physics	**UG-PHY-VOC1:** Computational Physics			
	UG-PHY-206: Quantum Mechanics				
	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** Tools and Techniques for Computational Material Science			
	UG-PHY-302 Solid State Physics	**UG-PHY- VOC3** Solid State Devices			
	UG-PHY-303 Thermodynamics and Statistical Mechanics				
VI	**UG-PHY-305** Atomic and Molecular Physics	**UG-PHY-VOC4** Instrumentation			
	UG-PHY-306 Mechanics II				
	UG-PHY-307 Nuclear and Elementary Particle Physics				
	UG-PHY-308 Introduction to Special Theory of Relativity				
	UG-PHY-PRJ: Project				
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-407: Quantum Mechanics II				
	UG-PHY-408: Laboratory (General Physics)				
	UG-PHY-409: Advanced Solid-State Physics				

SEMESTER I

Course Title : **Mechanics I (CORE: THEORY)**

Course Code : **UG-PHY-101**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisite : **Nil**

Course Objectives: This course provides an introduction to topics in mechanics, which are essential for advanced work in physics. An objective of this course is to train students to think about some of the physical phenomenon in mathematical terms.

Course Learning Outcomes: At the end of this course students will be able to:
CLO1: Describe the classical view of space and time in mechanics and demonstrate a thorough understanding of Newton's First, Second, and Third Laws, with the ability to apply these laws to solve problems involving forces, mass, and acceleration.
CLO2: Apply momentum and energy theorems for one and two-dimensional motion.
CLO3: Solve problems in 1-D motion for time-dependent forces, damping forces, conservative forces, including the formulation of equations of motion for systems influenced by these forces.
CLO4: Utilise vector algebra for the analysis of forces and motion in two dimensions, including the differentiation and integration of vectors. Analyze the concepts of centers of gravity for extended bodies and apply gravitational field equations to calculate gravitational fields and potentials.
CLO5: Analyze the motion of harmonic oscillators and projectiles in two dimensions.
CLO6: Develop experimental and analytical skills and to develop proficiency in using fundamental laboratory instruments. Demonstrate an understanding of kinematics and dynamics by performing experiments on motion, forces, and Newton's laws.

Module I:

Elements of Newtonian Mechanics, Motion of Particle in one dimension [15 hrs]

1. **Elements of Newtonian Mechanics**
   Mechanics an exact science, Brief description of classical view of Space and Time. Kinematics, the description of motion. Dynamics, the concept of Mass and Force. Newton's First and Second Laws; Inertial frames. Equations of motion. Interpretation of Newton's third Law as Conservation of Momentum. Units and dimensions, Some elementary problems in Mechanics (Applications of Newton's Laws) - Atwood Machine, Forces acting on a brick sliding down an inclined plane.

2. **Motion of Particle in one dimension**
   Momentum and Energy theorems, Discussion of the general problem of one-dimensional motion, Applied force dependent on time, Damping force dependent on the velocity. Conservative force depending on position. Potential Energy, Falling bodies.

Module II: **Motion of a particle in two dimensions** **[15 hrs]**

Vector algebra, Applications to set of forces acting on a particle, differentiation and integration of vectors, kinematics in a plane, momentum and energy theorems, plane and vector angular momentum theorems, The harmonic oscillator in two dimensions, projectiles, potential energy.

Module III: **Motion of system of particles, Gravitation** **[15 hrs]**

1. **Motion of system of particles**
   Conservation of linear momentum, conservation of angular momentum, conservation of energy.
2. **Gravitation**
   Centres of gravity for extended bodies, Gravitational field and gravitational potential, Gravitational field equations.

Course Title **: Mechanics I (CORE: PRACTICAL)**

Course Code **: UG-PHY-101**

Credits **: 1**

Marks **: 25**

Duration **: 30 hrs.**

List of Experiments:

1. Dimensions of different solid body **[02 hrs]**
2. Moment of Inertia of a flywheel **[04 hrs]**
3. Atwood Machine **[04 hrs]**
4. Conservation of linear momentum using Air Track **[04 hrs]**
5. Simulate the effect of different forces on an object and verify Newton's laws. Simulations /Python / Mathematica for numerical modelling **[03 hrs]**
6. Freely falling body and motion of falling body including air drag. (using Euler’s method) **[03 hrs]**
7. Spring Mass System: Determining the Spring Constant **[04 hrs]**
8. Simple Pendulum **[04 hrs]**
9. Determining “g” using time of flight method using Python **[02 hrs]**

REFERENCES:

Mandatory Reading:

1. Symon Keith, 2016, *Mechanics*, Pearson Education.
2. Taylor J. R., 2005, *Classical Mechanics*, University Science Books, USA.
3. Kleppner, Kolenkow, 2013, *Introduction to Mechanics*, Cambridge University Press, UK.
4. David Morin, 2008, *Introduction To Classical Mechanics With Problems And Solutions*, Cambridge University Press, UK.
5. Atam Arya, 1997, *Introduction to Newtonian Mechanics*, Addison-Wesley.

Supplementary Reading:

1. Kittle, Knight, 2011, *Mechanics*, Berkeley Physics Course, Vol. 1, McGraw Hill Education.
2. Mathur D. S, 2005, *Mechanics*, S. Chand & Co., New Delhi.
3. Takwale R. G., and Puranik P. S., 1997, *Introduction to Classical Mechanics*, Tata Mc-Graw Hill, New Delhi.
4. Javier E. Hasbun, 2010, *Classical Mechanics*, Jones and Bartlett India Pvt. Ltd.
5. Symon K. R., 1971, *Mechanics*, Addison Wesley, New York
6. Brij Lal and N. Subramanyam, 2005, *Mechanics and Electrodynamics*, S. Chand and Company Ltd., New Delhi.

Web References:

1. https://nptel.ac.in/courses/122106027/
2. https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/
3. https://www.khanacademy.org/science/ap-physics-1/
4. https://www.feynmanlectures.caltech.edu/I_13.html
5. http://hep.physics.wayne.edu/~harr/courses/5200/f07/lecture06.htm

Course Title : **Mechanics, Sound and Properties of Matter (CORE: THEORY)**

Course Code : **UG-PHY-102**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Course Objectives: This course provides an introduction to topics in mechanics, sound and properties of matter. 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: After successful completion of this course students will be able to:
CLO1: Apply Newton's Laws, conservation principles, and gravitational concepts to solve problems in mechanics, analyze motion under various forces, and model one-dimensional motion and gravitational fields.
CLO2: Summarize the principles of sound, including wave velocity in gases and solids, intensity levels, and the Doppler Effect, and apply concepts like the production and detection of ultrasonic waves to real-world applications.
CLO3: Explain and apply concepts of elasticity, surface tension, and viscosity to solve problems involving bending, torsion, capillarity, and fluid flow.
CLO4: Demonstrate and apply experimental techniques to measure the moment of inertia, spring constant, Young's modulus, surface tension, and viscosity, and analyze data to determine the physical properties of materials and fluids through hands-on experiments.

Module I: **[20 hrs]**

1. **Elements of Newtonian Mechanics**
   Newton's Laws of motion, equation of motion. Elementary problems in mechanics: Atwood machine and motion along a rough inclined plane and free fall.
2. **Motion of a particle in one dimension**
   Momentum and energy conservation theorems. Discussion of the general problem of one dimensional motion. Applied force depending on time. Motion under damping force depending on velocity. Conservative force depending on position. Brief review of simple harmonic motion and potential energy curve. Body falling under gravity in a resistive medium proportional to velocity.
3. **Gravitation Field and potentials:**
   Newton's Law of Gravitation. Gravitation field and Gravitation potential energy, Gravitational potential and field due to a thin spherical shell.

Module II: **[10 hrs]**

1. **Sound**

   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. Doppler Effect. Source and listener in relative motion (Normal incidence only). Production and detection of Ultrasonic waves and its applications.

Module III: **[15 hrs]**

1. **Elasticity**

   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 center. A vibrating cantilever. Torsion in a string-couple per unit twist, Torsional Pendulum.
2. **Surface Tension**

   Brief review of molecular theory of surface tension. Relation between surface tension and surface energy. Angle of contact. Capillarity-rise of liquid in a capillary tube.
3. **Viscosity**

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

Course Title	**: Mechanics, Sound and Properties of Matter (CORE: PRACTICAL)**
Course Code	**: UG-PHY-102**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hrs.**

List of Experiments:

1. Dimensions of different solid body **[02 hrs]**
2. Moment of Inertia of a flywheel **[04 hrs]**
3. Spring Mass System: Determining the Spring Constant **[04 hrs]**
4. Young's Modulus by Vibration **[04 hrs]**
5. Young's Modulus by Bending **[04 hrs]**
6. Surface Tension by rise of a liquid in a capillary tube **[04 hrs]**
7. Coefficient of Viscosity by Poiseuille's Method **[04 hrs]**
8. Velocity of sound by Helmholtz resonator **[04 hrs]**

REFERENCES:

Mandatory Reading:

1. K. R. Symon, *Mechanics (*Addison Wesley, 1971)
2. Brij Lal and N. Subrahmanyam, *Mechanics and Electrodynamics*, (S. Chand and Company LTD , 2005)
3. D. R. Khanna and R. S. Bedi ,*A Textbook of Sound* (Atma Ram and Sons, 1992)
4. N. Subrahmanyam and Brijlal,*Waves and Oscillation* (Vikas Publishing House 1994)
5. D. S. Mathur, *Elements of Properties of Matter* (S.Chand& Co. 2005

Supplementary Reading:

1. John Taylor, *Classical Mechanics* (University Science Books, 2004)
2. Atam Arya, *Introduction to Newtonian Mechanics,* (Addison-Wesley, 1997)
3. Kittle and Knight, *Mechanics (Berkeley Physics Course, Vol. 1)*, (McGraw Hill Education, 2011)
4. R. G. Takawale and P. S. Puranik*, Introduction to Classical Mechanics*, (Tata McGraw-Hill, 1997)
5. R. Murugeshan and Er. KiruthigaSivaprasath, *Properties of Matter and Acoustics* (S. Chand & Co., 2011)

Web References:

1. https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/
2. https://ocw.mit.edu/courses/8-01l-physics-i-classical-mechanics-fall-2005/
3. https://archive.nptel.ac.in/courses/112/104/112104212/
4. https://archive.nptel.ac.in/courses/105/104/105104160/
5. https://ocw.mit.edu/courses/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/pages/fluid-mechanics/

Course Title : **General Physics: Fluids and Heat (MDC: THEORY)**

Course Code : **UG-PHY-MDC1**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Course Objectives: The objective of this course is to build up an understanding of the fundamental laws and principles that govern the physical world. The course will help the students to understand the principles of fluid dynamics and the concepts of temperature, heat engines and laws of thermodynamics.

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

CLO1: Demonstrate the importance of measurement and mathematics in physics
CLO2: Explain the fundamental concepts of pressure, exploring the behavior of gases and liquids.
CLO3: Illustrate Pascal's principle, Archimedes' principle and Bernoulli's principle along with its applications.
CLO4: Explain the concept of temperature and its measurement, including the different temperature scales.
CLO5: Appraise the basic concepts of thermodynamics, including the laws of thermodynamics, thermodynamic systems, thermodynamic properties and heat engines.
CLO6: Apply theoretical concepts to perform experiments related to behaviour of fluids, heat transfer and thermometry.

Module I: **[10 hrs]**

Physics, the Fundamental Science

Scope of Physics. Role of measurement and mathematics in Physics. Physics and Everyday Phenomenon.

The Behavior of Fluids

Pressure and Pascal’s Principle. Atmospheric pressure and the behavior of gases. Archimedes principle. Fluids in motion. Bernoulli’s principle.

Module II: **[20 hrs]**

Temperature of Heat

Temperature and its measurement, Heat and specific capacity, Joule’s experiment and the First Law of thermodynamics. Gas behavior and the First Law. The Flow of heat.

Heat Engines and Second Law of Thermodynamics

Heat engines. The second Law of Thermodynamics. Refrigerators, Heat Pumps and Entropy. Thermal Power plants and Energy Resources. Perpetual motion and Energy Frauds.

Course Title : **General Physics: Fluids and Heat (MDC: PRACTICAL)**

Course Code : **UG-PHY-MDC1**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of Experiments:

1. Thermal conductivity of copper. **[04 hrs]**
2. Jaeger's Method: Determination of Surface Tension **[04 hrs]**
3. Viscosity of a liquid by Poiseuilles method **[04 hrs]**
4. Capillarity: determination of Surface tension **[04 hrs]**
5. Specific heat of Graphite **[04 hrs]**
6. Thermal conductivity by Lee's method. **[04 hrs]**
7. Silicon Diode as a thermometer **[03 hrs]**
8. Pt-100 as a temperature sensor. **[03 hrs]**

REFERENCES:

Mandatory Reading:

1. Griffiths Thomas and Brosing Juliet, 2009, *The Physics of Everyday Phenomenon: A conceptual introduction to Physics*, 6th Edition. McGraw-Hill Companies.
2. Young, Freedman, 2020, *University Physics with Modern Physics*, 15th Edition, Pearson..
3. Serway, Jewett, 2018, *Physics for Scientists and Engineers*, 10th Edition, Cengage Learning.
4. Brij Lal, Subramanyam N., Hemne P.S. 2007, *Heat Thermodynamics and Statistical Physics*, S. Chand & Company Ltd., New Delhi
5. Saha M.N., Shrivastava B.N. 1965, *Treatise on Heat*, 5th Ed., The Indian Press, Allahabad and Calcutta.

Supplementary Reading:

1. Halliday, Resnick, Walker, 2008, *Fundamentals of Physics* Extended, 8th Edition, Wiley India Pvt Ltd.
2. H.C. Verma, 2021, *Concept of Physics* by H.C Verma, 1st Edition, Bharati Bhawan (Publishers & Distributors).
3. Hugh Young, Roger Freedman, 2019, *University Physics with Modern Physics*, 15th Edition, Pearson.
4. Yunus Cengel, 2007, *Introduction to Thermodynamics and Heat Transfer*, 2nd Edition, McGraw-Hill Education.
5. Feynman, R. 2012, *Feynman Lectures on Physics: Mechanics, Radiation and Heat (Volume - 1)*, Pearson Education, India.

Web References:

1. https://iubtgedu.org/files/Engineering%20Thermodynamics%20and%20Fluid%20Mechanics%202.pdf
2. https://www3.nd.edu/~powers/ame.20231/notes.pdf
3. https://www.physics.ox.ac.uk/system/files/file_attachments/all_thermo_notes.pdf
4. https://www.tfd.chalmers.se/~nian/courses/fluidmech/notes/MTF053_All.pdf
5. https://en.wikipedia.org/wiki/Bernoulli%27s_principle

Course Title : **Introduction to Astronomy (MDC: THEORY)**

Course Code : **UG-PHY-MDC4**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Pre-requisite : **Nil**

Preference: This course can be taken by students who are interested in understanding the fundamentals of astronomy, the science behind celestial phenomena, the nature of light, the structure and evolution of our solar system, and the fascinating motions of the night sky.

Course Objectives: This is an introductory course with the goal of giving students insights into the field of astronomy.

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

CLO1: Explain the universe from the solar system to galaxies using the scientific method, integrating ancient astronomy and celestial motions.

CLO2: Explain the nature of light and its fundamental properties.

CLO3: Elaborate on the rich diversity of Solar System, including planets, moons, asteroids, and other celestial bodies, while exploring their origins.

CLO4: Analyze and interpret celestial phenomena using astronomical tools and observations, applying coordinate systems and motion principles to understand planetary and stellar dynamics.

Module I: Introduction to Astronomy, Constellations, and Eclipses [15 hrs]

1. **Astronomy and the Universe**
   Astronomy and the Scientific Method, The Solar System, Stars and Stellar Evolution, Galaxies and Cosmology, Angles and Angular Measure, Astronomical Distances
2. **Knowing the Night Sky**
   Ancient Astronomy, Constellations, Motions of the Sky, The Celestial Sphere, The Celestial Coordinates, The Seasons, Time and Timekeeping
3. **Eclipses and Motion of the Moon**
   Phases of the Moon, The Moon's Rotation, Eclipses and the Line of Nodes, Lunar Eclipses, Solar Eclipses

Module II: From Light Theory to Solar System [15 hrs]

1. **The Nature of Light**
   The Speed of Light, The Wave Nature of Light, Blackbody Radiation, Wien's Law and the Stefan-Boltzmann Law, Kirchhoff's Laws, Atomic Structure, Spectral Lines, The Doppler Effect.

2. **Our Solar System**
   Terrestrial and Jovian Planets, Satellites of the Planets, The Evidence of Spectroscopy, Chemical Composition of Planets, Asteroids, Trans-Neptunian Objects and Comets
3. **The Origin of our Solar System**
   Models of Solar System Diversity, Abundances of the Elements, The Age of the Solar System, The Origin of the Solar System

Course Title : **Introduction to Astronomy (MDC: PRACTICAL)**

Course Code : **UG-PHY-MDC4**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of Experiments:

1. Location of celestial objects using astronomical coordinates from different locations and examination of the position of the Sun in the sky in Stellarium **[04 hrs]**
2. Location of the Sun at noon and measurement of the lengths of solar and sidereal days in Stellarium **[04 hrs]**
3. Measurement of the synodic and sidereal period of the Moon using celestial coordinates in Stellarium **[04 hrs]**
4. Location of astronomical objects and constellations in the night sky in Stellarium / Sky observation to locate astronomical objects and constellations using the telescope and comparing the observation with Stellarium **[04 hrs]**
5. Identification of the retrograde motion of Mars with respect to the background stars in Stellarium **[02 hrs]**
6. Determination of orbital inclination of the planet Mars in Stellarium **[04 hrs]**
7. Measurement of planetary distances in Stellarium **[04 hrs]**
8. Measurement of distance to Moon in Stellarium **[04 hrs]**

REFERENCES:
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. 2003. *Astronomy A Physical Perspective*. Second ed. New York: Cambridge University Press.
4. Palen, S. E. 2002. *Schaum's Outline Series, Astronomy*. United States of America: McGraw Hill.

Supplementary Reading:

1. Sule, A. 2013. *A Problem Book in Astronomy and Astrophysics.* [Online]
2. Roy A.E., Clarke D. 1989. *Astronomy structure of the Universe*, Adam Hilger Pub.
3. Glasstone S. 1965. *Source book on the Space Sciences*, Van Nostrand Reinhold Inc., U.S
4. Narlikar J.V. 1976. *Structure of the Universe*, Oxford Paperbacks.

Web References:

1. https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/
2. IGNOU. Self-Learning Material (SLM) on Astronomy. [Online]. Available at: https://egyankosh.ac.in/handle/123456789/1/browse?type=subject&order=ASC&rpp=20&value=Astronomy
3. https://archive.nptel.ac.in/courses/115/105/115105046/
4. https://archive.nptel.ac.in/courses/121/104/121104006/
5. https://ocw.mit.edu/courses/12-409-hands-on-astronomy-observing-stars-and-planets-spring-2002/

Course Title : **Environmental Physics (VAC: THEORY)**

Course Code : **UG-PHY-VAC2**

Credits : **02**

Marks : **50**

Duration : **30 hrs.**

Prerequisites : **Nil**

Course Objectives: This course aims to equip students with the comprehensive understanding of the physical principles of underlying environmental processes.

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

CLO1: Describe the physical nature of the environment and the many biological responses that environments evoke.

CLO2: Apply the laws of thermodynamics, to analyze earth's atmospheric systems in relation to weather or climate.

Module I: **[10 hrs]**

1. **Introduction to Environmental Physics**
   Environmental science, The environment, environmental physicist, water and the hydrosphere, air and the atmosphere, Earth, Life, The Anthro sphere and Technology, The Biosphere, Ecology, Energy and cycles of Energy, Light and electromagnetic radiation, energy flow and photosynthesis in living systems, energy utilization, matter and cycles of matter, Endogenic and exogenic cycles, carbon cycle, the Nitrogen cycle, the Oxygen cycle, the phosphorus cycle, sulfur cycle, Human impact and pollution, some definitions pertaining to pollution, pollution of various spheres of the environment, Technology: The problems it poses and solutions it offers.

Module II: **[20 hrs]**

1. **Essentials of Environmental Physics**
   Structure of the atmosphere, major gases, important trace gases, Aerosols, principal layers, Exosphere, Thermosphere, Mesosphere, Stratosphere, Troposphere, other layers, laws of thermodynamics, first law of thermodynamics, second law of thermodynamics, third law of thermodynamics, thermodynamics of the atmosphere, overview, applications, tropical cyclone and Carnot cycle, water vapour and global climate change, composition of air , greenhouse effect, basic mechanism, greenhouse gases, energy transfers, conduction, convection. Radiation, evaporation, transport of matter, energy and momentum in nature, conservation of mass and energy, applicability of the strict mass energy equivalence formula, stratification of atmosphere, atmospheric stability, lapse rates, stability of the atmosphere, the stability of the atmosphere, inversions, the neutral atmosphere, the unstable atmosphere, conditional instability, convective or potential instability, hydrostatic equilibrium.

REFERENCES:

Mandatory reading:

1. Wani S., 2011, *Basic Environmental physics*, Pragati Prakashan
2. Kaushik A., Kaushik C.P., 2018, *Perspectives in Environmental Studies*, New Age International Publishers.
3. Rao C.S., 2006, *Environmental Pollution Control Engineering*, New Age International Publishers.
4. Singh J.S., Singh S.P., Gupta S.R., 2017, *Ecology, Environment and Resource Conservation*, Anamaya Publishers.
5. Boeker E. and Van Grondelle R. (2011). *Environmental Physics: Sustainable Energy and Climate Change*, Wiley.

Supplementary reading:

1. Mason N. and Hughes P. (2001). *Introduction to environmental physics: planet, earth, life and climate,* CRC press.
2. Monteith J. L. and Unsworth M. (2013). *Principles of environmental physics plants, animals and the atmosphere*, Academic press.
3. Jackson A.R.W. and Jackson J.M. (2000). *Environmental Science: The Natural Environment and Human Impact*, Pearson Education.
4. Smith K. (2005). *Environmental Hazards: Assessing Risk and Reducing Disaster*, Routledge.
5. Guyot G. (1998). *Physics of the Environment and Climate*, John Wiley & Sons.

Web references:

1. https://coeng.uobaghdad.edu.iq/wp-content/uploads/sites/3/2021/09/Environmental.-Physics.pdf
2. https://denning.atmos.colostate.edu/readings/Monteith.and.Unsworth.4thEd.pdf
3. https://climatehomes.unibe.ch/~stocker/cep22intro.pdf
4. https://djelatnici.unizd.hr/~mdzela/nastava/EnvironmentalPhysics.pdf
5. https://www.bgu.ac.il/~georg/envphys.pdf

Course Title : **Introduction to Mathematical Physics-I (SEC: THEORY)**

Course Code : **UG-PHY-SEC1**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Pre-requisite : **Nil**

Course Objectives : To develop basic competence in certain areas of mathematics required for understanding several important topics in physics.

Course Learning Outcomes:

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

CLO1: Apply various tests to examine the convergence and divergence of different kinds of series and learn how to expand a function in power series.

CLO2: Understand the basics of complex numbers.

CLO3: Solve problems using the basics of partial differentiation and its application in physics.

CLO4: Solve ordinary first and second order differential equations important in the physical sciences.

CLO5: Apply mathematical and computational techniques to solve several problems in physics and enhance problem solving skills.

Module I: **[15 hrs]**

1. **Infinite Series and Power Series**
   Geometric Series and other infinite series. Convergent and Divergent Series. Testing series for convergence. Power series. Expanding functions in power series. Techniques for obtaining power series expansion.

2. **Complex Numbers**
   Real and imaginary Parts of a complex number. Complex plane. Complex algebra. Euler's formula. Powers and roots of complex numbers. Exponential and trigonometric functions.

Module II: **[15 hrs]**

1. **Partial Differentiation**
   Definition of the partial derivative. Total differentials. Exact and inexact differentials. Theorems of partial differentiation. Chain rule. Thermodynamic relations. Differentiation of Integrals.

2. **Ordinary Differential Equation**
   Introduction. Linear differential equation of the first order. Homogenous and inhomogeneous linear differential equation of the second order.

Course Title **: Introduction to Mathematical Physics-I (SEC: PRACTICAL)**

Course Code **: UG-PHY-SEC1**

Credits **: 1**

Marks **: 25**

Duration **: 30 hrs.**

List of Experiments:

1. Introduction to a programming language and programs on basic concepts of Python **[04 hrs]**
2. Programs that involve the management of program flow using conditional statements such as "if" and "elif". **[04 hrs]**
3. Programs that require looping and iteration using control structures such as "for" and "while" loops. **[04 hrs]**
4. Programs that utilize standard libraries like Numpy and Sympy. **[04 hrs]**
5. Exploring series expansions using a programming language and its applications in physics. **[04 hrs]**
6. Exploring complex numbers in Physics analysis using a programming language. **[04 hrs]**
7. Using programming to solve Partial Differentiation. **[02 hrs]**
8. Applying programming techniques to solve ordinary differential equations. **[04 hrs]**

REFERENCES:

Mandatory Reading:

1. Riley K. F., Hobson M. P., Bence S . J. 1998. *Mathematical Methods for Physics and Engineering*, Cambridge University Press, UK
2. Mary L. Boas, *Mathematical Methods in Physical Sciences* 3rd Edition, John Wiley and Sons, USA
3. Charlie Harper, *Introduction to Mathematical Physics*, Prentice Hall of India, New Delhi.
4. G. F. Simmons. 2019. *Differential Equations with Historical Notes*, Tata McGraw Hill.
5. H. K Dass ,R. Verma. 2019. *Mathematical Physics*, 8th Edition, S. Chand Publishing.

Supplementary Reading:

1. B. D. Gupta, 2004. *Mathematical Physics,* Vikas Publishing House, New Delhi
2. C. Hill, Learning. 2020, *Scientific Programming with Python*, 2nd Edition, Cambridge University Press.
3. Abhijit Gupta. 2021. *Scientific Computing in Python*, 3rd Edition, Techno world, Kolkata.
4. Steven Holzner. 2008. *Differential Equations for Dummies*, For Dummies, UK
5. A. Scopatz, K. D. Huff. 2015. *Effective Computation in Physics*, O'Reilly Media

Web References:

1. https://physicscatalyst.com/elec/electric-potential-energy.php
2. https://physicscatalyst.com/elec/electric-potential.php
3. https://physicscatalyst.com/elec/relation-between-electric-field-and-potential.php
4. https://physicscatalyst.com/elec/equipotential-surfaces.php
5. https://physicscatalyst.com/elec/electric-potential-dipole.php
6. https://physicscatalyst.com/elec/potential-energy-of-dipole.php
7. https://ocw.mit.edu/courses/physics/8-02t-electricity-and-magnetism-spring-2005/lecture-notes/

Course Title : **Python programming fundamentals and mathematical techniques. (SEC: THEORY)**

Course Code : **UG-PHY-SEC4**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Pre-requisite : **Nil**

Course Objectives : Introduce learners to the fundamentals of scientific Python programming with a focus on developing skills for problem-solving in scientific contexts.

Course Learning Outcomes: At the end of this course students will be able to:
CLO1: Demonstrate an understanding of basic Python elements, gain proficiency in implementing control structures and understand functions.
CLO2: Acquire skills in utilizing packages such as Numpy and Sympy.
CLO3: Apply various tests used to examine the convergence and divergence of different kinds of series and learn how to expand a function in power series.
CLO4: Solve problems using the basics of partial differentiation and its application in physics.

Module I: **[15 hrs]**

1. **Basic Elements of Python**
   Variables. Mathematical & Logical operations. Python interpreter. Built-in functions. Input and Output. Commenting. Import modules.
2. **Loops, conditions, functions**
   Loops: for loop. while loop.
   Conditions: Logical if. If-else, if-else-if
   Functions: Define ordinary functions. Function with arbitrary number of arguments. Function with keyword arguments. Local and global parameters in function. Function inside another functions.
3. **Numpy and Sympy:**
   Numpy: Characteristics of arrays. Vectorized operations. Iterator on arrays. Axes of higher dimensional arrays. Various data types. Method of creation of arrays. Indexing of arrays. Slicing of arrays. Swap elements. Numpy methods on arrays. Check elements. Insert and delete elements. Append, Concatenate arrays. Split arrays. Stack arrays. Statistics over array, Product difference. Trace of array. Transpose flip rotate, Products of special kinds. Matrix like operations.
   Sympy: Symbols, Expressions, Calculations. Matrix. Calculus.

Module II: **[15 hrs]**

1. **Infinite Series and Power Series**
   Geometric Series and other infinite series. Convergent and Divergent Series. Testing series for convergence. Power series. Expanding functions in power series. Techniques for obtaining power series expansion.

2. **Partial Differentiation**
   Definition of the partial derivative. Total differentials. Exact and inexact differentials. Theorems of partial differentiation. Chain rule. Thermodynamic relations. Differentiation of Integrals.

Course Title : **Python programming fundamentals and mathematical techniques. (SEC: PRACTICAL)**

Course Code : **UG-PHY-SEC4**

Credits : **1**

Marks : **25**

Duration : **30 hours**

List of experiments:

1. Programs on basic concepts of Python. **[04 hrs]**
2. Programs that involve the management of program flow using conditional statements such as "if" and "elif". **[04 hrs]**
3. Programs that require looping and iteration using control structures such as "for" and "while" loops. **[04 hrs]**
4. Programs that employ built-in functions as well as functions that are created by the user. **[04 hrs]**
5. Programs that utilize like Numpy Library. **[04 hrs]**
6. Programs that utilize like Sympy Library. **[04 hrs]**
7. Exploring series expansions using a programming language and its applications in physics. **[04 hrs]**
8. Using programming to solve Partial Differentiation. **[02 hrs]**

REFERENCES:

Mandatory Reading:

1. Abhijit Gupta, 2021, *Scientific Computing in Python*, 3rd Edition, Techno world, Kolkata.
2. Mary L. Boas, *Mathematical Methods in Physical Sciences* 3rd Edition, John Wiley and Sons, USA
3. Riley K. F., Hobson M. P., Bence S . J., 1998, *Mathematical Methods for Physics and Engineering*, Cambridge University Press, UK
4. Steven Holzner. 2008. *Differential Equations for Dummies*, For Dummies, UK
5. John Shovic, Alan Simpson. 2020. *Python All-in-One for Dummies*, Wiley India.

Supplementary Reading:

1. B. D. Gupta, 2004. *Mathematical Physics,* Vikas Publishing House, New Delhi
2. C. Hill, Learning. 2020, *Scientific Programming with Python*, 2nd Edition, Cambridge University Press.
3. Charlie Harper, *Introduction to Mathematical Physics*, Prentice Hall of India, New Delhi.
4. H. K Dass ,R. Verma. 2019. *Mathematical Physics*, 8th Edition, S. Chand Publishing.
5. A. Scopatz, K. D. Huff. 2015. *Effective Computation in Physics*, O'Reilly Media

Web References:

1. https://www.w3schools.com/python/
2. https://www.tutorialspoint.com/python/index.htm
3. https://www.geeksforgeeks.org/python-programming-language/
4. https://ocw.mit.edu/resources/res-18-007-calculus-revisited-multivariable-calculus-fall-2011/
5. https://www.math.upenn.edu/~deturck/m104/notes/week6.pdf
6. http://tutorial.math.lamar.edu/Classes/CalcIII/CalcIII.aspx

SEMESTER II

Course Title : **Electricity and Magnetism (CORE: THEORY)**

Course Code : **UG-PHY-103**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Course Objectives : The objective of this course is to introduce fundamentals of electricity and magnetism to the students, which is an essential preparation for more advanced courses like Electromagnetic theory.

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

CLO1: Understand Gauss law, Coulomb's law for the electric field, and apply these laws to system of point charges as well as line, surface, and volume distributions of charges.

CLO2: Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.

CLO3: Demonstrate a working understanding of capacitors and dielectrics.

CLO4: Apply Biot–Savart's law and Ampere's circuital law, and understand the phenomena of electromagnetic induction.

CLO5: Apply Kirchhoff's rules to analyse working of DC circuits and AC circuits consisting of parallel and series combinations of voltage source, resistor, capacitor, and inductor.

CLO6: Construct and verify the working of DC circuits, and AC circuits with help of various measuring instruments.

Module I: **[15 hrs]**

1. **Electrostatics**

   Coulomb's law: Statement, Vector form of Coulomb's law for like and unlike charges, Variation of force with distance (F.vs.r graph), Concept of electric field and Electric Field Lines: Electric field, Electric field due to (i) a Point Charge, (ii) an Electric Dipole, (iii) a Line of Charge and (iv) a Charged Disk, Concept of electric flux: Gauss' Law of electrostatics (Conceptual explanation), Applications of Gauss law: Coulomb's Law from Gauss' Law, Electric Field due to (i) an isolated uniformly charged sphere, (ii) an uniform distribution of charge throughout the sphere and (iii) an uniformly charged hollow cylinder, Electric Field near (i) a charged infinite cylindrical conductor or a cable and (ii) a plane of sheet charge, Concept of Electric Potential: Electric Potential Energy, Equipotential Surfaces, Calculating the Potential from the Field Potential due to (i) a Point Charge, (ii) a Group of Point Charges and (iii) an Electric Dipole Calculating the Field from the Potential.

2. **Capacitors and Dielectrics**
Capacitance: Calculation of capacitance of (i) a Parallel-Plate Capacitor, (ii) a Cylindrical Capacitor and (iii) a Spherical Capacitor; Energy stored in an electric field, Capacitor with a Dielectric, Dielectrics: An Atomic View, Dielectrics and Gauss' Law, Relation between three electric vectors (E, D and P)(Without derivation, qualitative discussion only)

Module II: **[15 hrs]**

1. **Magnetostatics**

Concept of magnetic field: Definition and properties of magnetic field Biot–Savart's law and its applications: (i) a long straight wire and (ii) a current carrying circular loop (for a point on the axis only) Ampere's circuital law and its applications: (i) Field of solenoid and (ii) Field of toroidal solenoid Magnetic Field lines and Magnetic flux; Gauss' law for magnetism.

2. **Self and Mutual Inductance**

Self-induction; Calculation of self-inductance of (i) a long solenoid, (ii) long parallel wires and (iii) a coaxial cable, Mutual inductance, Coefficient of coupling; Calculation of mutual inductance between two coaxial solenoids, Mutual inductance of two coils in series, Energy stored in a magnetic field and Energy density of a magnetic field.

Module III: **[15 hrs]**

1. **Transient Circuits**

Transient currents, Growth and Decay of current in an inductive (L-R) circuit, Physical meaning of time constant, Charging and Discharging of a capacitor through resistor in C-R circuit, Physical meaning of time constant, Charging and Discharging of a capacitor through resistor and inductor in L-C-R circuit: Over damped, Critically damped and Under damped conditions of L-C-R circuit.

2. **Alternating Current Circuits**

Inductive and Capacitive reactance, Variation of inductive reactance and capacitance reactance with frequency Introduction to vector or phasor diagrams method and its application to A.C. circuits(Series L-R, Series C-R, Series L-C-R and Parallel L-C-R) Introduction to j-operator method and its application to A.C. circuits (Series L-C-R and Parallel L-C-R) Physical significance of Series resonance, Parallel resonance, Quality factor and Bandwidth, Graphical representation of resonance A.C. bridges: Maxwell's inductive bridge, Maxwell's L/C bridge, de Sauty's capacitance bridge, Wien's frequency bridge.

Course Title : **Electricity and Magnetism (CORE: PRACTICAL)**

Course Code : **UG-PHY-103**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of Experiments:

1. Susceptibility measurement of a parallel plate capacitor in a dielectric medium **[03 hrs]**
2. Step Response of RC circuit with DC emf. **[04 hrs]**
3. Study of LR circuit to DC using Excel worksheet **[04 hrs]**
4. Response of LR circuit to A.C. - phasor diagrams **[04 hrs]**
5. Response of CR circuit to A.C. - phasor diagrams **[04 hrs]**
6. LCR- Series resonance –Resonant frequency, Q value and Bandwidth **[03 hrs]**
7. LCR- Parallel resonance –Resonant frequency, Q value and Bandwidth **[03 hrs]**
8. de Sauty's bridge - comparison of capacitance **[02 hrs]**
9. Maxwell's Inductive bridge - determination of mutual inductance **[03 hrs]**

REFERENCES:

Mandatory Reading:

1. Halliday David, Resnik Robert and Walker Jearl, 2003, *Fundamentals of Physics*, John Wiley & Sons, Inc., 6th Edition.
2. Vasudeva D. N., 1999, *Fundamentals of Magnetism and Electricity*, S. Chand & Company Ltd., 12th Revised Edition.
3. Young Hugh D., Freedman Roger A. and Ford A. Lewis, 2012, Sears and Zemansky's *University Physics with Modern Physics*, Addison-Wesley Publishers, 13th Edition(PDF).
4. Fewkes J. H. and Yarwood John,1991, *Electricity, Magnetism and Atomic Physics*, Volume I, Oxford University Press Ltd., 10th Impression.

Supplementary Reading:

1. Purcell Edward M., *Electricity and Magnetism-Berkeley Physics Course*,Volume 2, McGraw-Hill Book Company (PDF)
2. Brij Lal and Subramaniam, 1966, *Electricity and Magnetism*, Ratan Prakashan, New Delhi.
3. Thereja B.L., 1990, *Text Book of Electrical Technology*, S. Chand and Co Ltd. New Delhi.

Web References:

1. https://physicscatalyst.com/elec/electric-potential-energy.php
2. https://physicscatalyst.com/elec/electric-potential.php
3. https://physicscatalyst.com/elec/relation-between-electric-field-and-potential.php
4. https://physicscatalyst.com/elec/equipotential-surfaces.php
5. https://physicscatalyst.com/elec/electric-potential-dipole.php

6. https://physicscatalyst.com/elec/potential-energy-of-dipole.php
7. https://ocw.mit.edu/courses/physics/8-02t-electricity-and-magnetism-spring-2005/lecture-notes/

Course Title : **Electricity, Magnetism and Electronics (CORE: THEORY)**

Course Code : **UG-PHY-104**

Credits : **3**

Marks : **75**

Duration : **30 hrs.**

Course Objectives: The objective of this course is to introduce fundamentals of electricity, magnetism and basic electronics to the students, which are essential allied learning components for most of the subjects of Physical Sciences.

Course Learning Outcomes: At the end of this course, students will be able to:
CLO1: Comprehend basic concepts like: Coulomb's law and Gauss law of electrostatics.
CLO2: Understand the laws of magnetostatics, and the phenomena of electromagnetic induction.
CLO3: Apply Kirchhoff's rules to analyse working of DC circuits and AC circuits consisting of parallel and series combinations of voltage source, resistor, capacitor, and inductor.

CLO4: Understand the working and application of various electronic circuits like rectifiers and voltage regulator.

CLO5: Understand the working of transistor in CB and CE modes, and CE Amplifier.

CLO6: Correlate the theoretical basis of various concepts of electricity, magnetism and electronics while performing experiments.

Module I: **[15 hrs]**

1. **Laws of Electrostatics**
   Coulomb's law: Statement, Vector form of Coulomb's law for like and unlike charges, Variation force with distance (F v/s r graph), Concept of electric field and Electric Field Lines, Concept of electric flux: Gauss's theorem in electrostatics (conceptual explanation), Coulomb's Law from Gauss' Law, Concept of Electric Potential: Electric Potential Energy, Equipotential Surfaces, Calculating the Potential from the Field, Calculating the Field from the Potential.
2. **Laws of Magnetostatics**
   Concept of magnetic field, Definition and properties of magnetic field, Biot – Savart's law and its applications: (i) Long straight conductor and (ii) Current carrying circular loop (for a point on the axis only) Ampere's circuital law and its application: Field of solenoid. Magnetic Field lines and Magnetic flux, Gauss's law for magnetism.

Module II: **[15 hrs]**

1. **Self and Mutual Inductance**
   Self-induction; Calculation of self-inductance of (i) a long solenoid, (ii) long parallel wires and (iii) a coaxial cable. Mutual inductance, Coefficient of coupling; Mutual inductance of coils in series. Energy stored in the magnetic field

2. **Transient Circuits and Alternating Current Circuits**
   Transient currents: Growth and Decay of current in an inductive (L-R) circuit, Physical meaning of time constant, Charging and Discharging of a capacitor through resistor in C-R circuit, Physical meaning of time constant. Inductive and Capacitive reactance, Variation of inductive reactance, capacitance reactance with frequency. Introduction to vector or phasor diagrams method and its application to A.C. circuits (Series L-R and Series C-R); Physical significance of Quality factor A.C. bridges: Maxwell's Inductive bridge and de Sauty's Capacitance bridge

Module III. **[15 hrs]**

1. **Rectifiers and Regulators**
   Volt-ampere characteristics of Junction diode, Working of Half Wave and Full Wave Rectifiers without and with capacitive filters, Percentage regulation, Ripple factor and Rectification efficiency (only qualitative explanation with respect to HWR and FWR). Zener diode characteristics and its use as a simple voltage regulator. Thermistor characteristics and its use in A.C. voltage regulation.

2. **Transistors**
   Basic configurations of transistors, Transistor's leads identification, Biasing of Transistor and working of Transistor as a switch Transistor characteristic in CE and CB mode, Current gains and their interrelation, Leakage currents in transistor Basic Amplifier Characteristics: Current gain, Voltage gain, Power gain, Input resistance, Output resistance, Classes of amplifier operations, DC load Line, Frequency response and Amplifier bandwidth of CE Amplifier.

Course Title	**: Electricity, Magnetism and Electronics (CORE: PRACTICAL)**
Course Code	**: UG-PHY-104**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hrs.**

List of Experiments:

3. Step Response of RC circuit: Charging and discharging of a capacitor **[04 hrs]**
4. Response of LR and CR circuits to A.C. using phasor diagrams **[04 hrs+04 hrs]**
5. de Sauty's capacitance bridge **[02 hrs]**
6. Mutual inductance of two coils in series using Maxwell's inductive bridge **[03 hrs]**
7. Half wave and Full wave rectifier using Junction Diode, Load regulation characteristics. **[03 hrs+03 hrs]**
8. Zener Diode Regulation **[03 hrs]**
9. C.E. Amplifier: DC Load Line and Linear Response **[04 hrs]**

REFERENCES:

Mandatory Reading:

1. Halliday David, Resnik Robert and Walker Jearl, *Fundamentals of Physics*, John Wiley & Sons, Inc., 6th Edition (2003)
2. Fewkes J. H. and Yarwood John, *Electricity, Magnetism and Atomic Physics,* Volume I, Oxford University Press Ltd., 10th Impression (1991)
3. Mottershed Allen, *An Introduction to Electronics Devices and Circuits*, Prentice-Hall of India Private Ltd., Eastern Economy Edition (2008)
4. Mehta V. K. and Mehta Rohit, *Principles of Electronics*, S. Chand & Company, Multicolour Revised Edition (2008)

Supplementary Reading:

1. Malvino A. P., *Electronic Principles*, Tata McGraw Hill Education Private Ltd., 5th Edition (1996)
2. Vasudeva D. N., *Fundamentals of Magnetism and Electricity*, S. Chand & Company Ltd., 12th Revised Edition (1999)
3. Young Hugh D., Freedman Roger A. and Ford A. Lewis, Sears and Zemansky's *University Physics with Modern Physics*, Addison-Wesley Publishers, 13th Edition (PDF) (2012)
4. Bhargava N. N., Kulshreshtha D. C. and Gupta S. C., *Basic Electronics and Linear Circuits*, Tata McGraw Hill Education Private Ltd., 54th Reprint (2010)

Web References:

1. https://physicscatalyst.com/elec/electric-potential-energy.php
2. https://physicscatalyst.com/elec/electric-potential.php
3. https://ocw.mit.edu/courses/physics/8-02t-electricity-and-magnetism-spring-2005/lecture-notes/
4. https://www.elprocus.com/different-types-rectifiers-working/
5. https://www.pitt.edu/~qiw4/Academic/ME2082/Transistor%20Basics.pdf
6. https://nptel.ac.in/courses/115/102/115102014/

Course Title : **General Physics: Light and atoms (MDC: THEORY)**

Course Code : **UG-PHY-MDC 2**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Course Objectives : The objective of the course is to familiarize students with wave nature of light, geometrical optics and the structure of the atom.

Course Learning Outcomes: At the end of this course, students will be able to:
CLO1: Outline and analyze the principles of wave motion, electromagnetic waves, interference, polarization, and image formation, and explain their properties and applications in optics.
CLO2: Recall the principles of atomic and subatomic particles, atomic spectra, radioactivity, and matter waves, including the historical development of atomic theory and key scientific contributions.
CLO3: Demonstrate and apply experimental techniques to investigate wave phenomena, the photoelectric effect, electron properties, and X-ray emission, and analyze data to determine key physical constants such as the e/m ratio and wavelength/energy relationships.

Module I: **[20 hrs]**

Wave motion

Wave pulses and periodic waves. Waves on a rope. Interference and standing waves. Sound waves. The Physics of music.

Light waves

Electromagnetic waves. Wavelength and color. Interference of light waves. Diffraction gratings. Polarized light.

Light and Image formation

Reflection and image formation. Refraction of light. Lenses and image formation. Focusing light with curved mirrors. Eyeglasses. Microscopes and telescope.

Module II: **[10 hrs]**

The Structure of the Atom

The existence of atoms. Cathode rays, electrons and X-rays. Radioactivity and discovery of the nucleus. Atomic spectra and Bohr model of the atom. Particle waves and Quantum Mechanics.

Course Title **: General Physics: Light and atoms (MDC: PRACTICAL)**

Course Code **: UG-PHY-MDC 2**

Credits **: 1**

Marks **: 25**

Duration **: 30 hrs.**

List of Experiments:

1. Newton's Rings **[04 hrs]**
2. Wedge Shaped Air Film **[04 hrs]**
3. Single Slit Diffraction using LASER **[04 hrs]**
4. Double Slit Diffraction **[04 hrs]**
5. Photoelectric effect **[04 hrs]**
6. Determination of e/m of electrons using Thomson's method **[04 hrs]**
7. Frank Hertz Experiment **[04 hrs]**
8. X-ray Emission (characteristic lines of copper target)- Calculation of wavelength and Energy **[02 hrs]**

REFERENCES:

Mandatory Reading:

1. Griffiths Thomas and Brosing Juliet, 2009, *The Physics of Everyday Phenomenon: A conceptual introduction to Physics*, 6th Edition. McGraw-Hill Companies.
2. Halliday, Resnick , Walker, 2008, *Fundamentals of Physics Extended*, 8th Edition, Wiley India Pvt Ltd.
3. Fowles, G. R., 1975. *Introduction to Modern Optics*. United States of America: Holt, Rinehart and Winston Inc

Supplementary Reading:

1. H.C. Verma , 2021, *Concept of Physics*, 1st Edition, Bharati Bhawan (Publishers & Distributors).
2. Hugh Young, Roger Freedman, 2019, *University Physics with Modern Physics*, 15th Edition, Pearson.
3. Eugene Hecht , A. R. Ganesan , 2019. *Optics*, 5th Edition, Pearson Education.

Web References:

1. https://ocw.mit.edu/courses/8-03sc-physics-iii-vibrations-and-waves-fall-2016/pages/part-i-mechanical-vibrations-and-waves/lecture-11/
2. https://archive.nptel.ac.in/courses/115/106/115106119/
3. https://onlinecourses.nptel.ac.in/noc24_ph44/preview
4. https://onlinecourses.nptel.ac.in/noc19_ph18/preview

Course Title : **Eminent Indian physicists and their contribution (VAC: THEORY)**

Course Code : **UG-PHY-VAC1**

Credits : **2**

Marks : **50**

Duration : **30**

Pre-requisites : **Nil**

Course Objectives: To create awareness of Indian contribution to the subject of Physics.

Course Learning Outcomes: At the end of this course, students will be able to:
CLO1: Articulate the life paths and achievements of distinguished Indian physicists.

CLO2: Describe significant contributions made by the Indian physicists across various principles and concepts within the realm of science.

CLO3: Explain the profound impact that prominent Indian physicists have had on the advancement of various scientific branches

Module I: **[15 hrs]**

1. **Jagdish Chandra Bose**
   Early Life and Background. Scientific journey. Contribution of Jagadish Chandra Bose to science.
2. **Chandrashekhar Venkata Raman**
   Early Life and Background. Molecular Diffraction of Light, Raman Effect and Its Significance, Tenure at the Indian Institute of Science, Raman's impact on experimental and theoretical physics.
3. **Satyendra Nath Bose**
   Early Life and Background. Bose and his Statistical Methods, Collaboration with Einstein and Bose Einstein Condensation, Impact on Quantum Mechanics, Legacy in Physics.
4. **Meghnad Saha**
   Early Life and Background. Career Achievements. Contribution to Astrophysics. Role in Indian Science and National Development

Module II: **[15 hrs]**

1. **Subrahmanyam Chandrashekar**
   Early Life and Background. Scientific journey. Contribution in understanding of stars, black holes and stellar evolution.
2. **Homi Jehangir Bhabha**
   Early Life and Background. Pioneering Research in Cosmic Rays, Initiating Atomic Energy Research in India, Multifaceted Contributions to National Science: Delving into diverse contributions across various scientific domains.

3. **Vikram Sarabhai**
   Early Life and Background. Leadership at the Physical Research Laboratory (PRL), Visionary Role in Indian Space Program, Contributions to the Indian Space Research Organization (ISRO), Involvement in the Atomic Energy Commission, Shaping India's Scientific Landscape.

REFERENCES:

Mandatory Reading:

1. Das S. (2023). *Jagadish Chandra Bose: The Reluctant Physicist*. Niyogi Books Private Limited, India
2. Venkataraman G. (1995). *Raman and his Effect*, Universities Press. India
3. Parameswaran U. (2010). *C. V. Raman: A Biography*, Affiliated East-West Press.
4. Venkataraman G. (1992). *Chandrasekhar and His Limit*, Universities Press
5. Venkataraman G. (2018). *Bose and His Statistics*, Universities Press, India
6. Wali K. (2009). *Satyendra Nath Bose-His Life and Times: Selected Works*, World Scientific Publishing Co Pte Ltd
7. Venkataraman G. (1994). *Bhabha and his magnificent obsessions*, Universities Press
8. Bharati V. (2017). *Vikram Sarabhai - The Legend Unveiled,* Universities Press
9. Shah A. (2016). *Vikram Sarabhai: A Life,* Penguin Books Limited, India
10. Naik P. (2017). *Meghnad Saha: His Life in Science and Politics*, Spinger Biographies.

Supplementary Reading:

1. Wali K. (1992). *Chandra: A Biography*, University of Chicago Press, India
2. Salwi D. (2015). S. N. Bose: The Immortal Scientist, Rupa Publications India.
3. Nath B. (2022). *Homi J Bhabha: A Renaissance Man among Scientists*. Niyogi Books Pvt.
4. C. N. R. Rao and Indumati Rao (2021). *Founders of Modern Science in India*, Indian
5. Geddes P. (2022). *The Life and Work of Sir Jagadish C. Bose*, Pharos Books.

Web References:

1. https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/
2. IGNOU. Self-Learning Material (SLM) on Astronomy. [Online]. Available at: https://egyankosh.ac.in/handle/123456789/1/browse?type=subject&order=ASC&rpp=20&value=Astronomy
3. https://archive.nptel.ac.in/courses/115/105/115105046/
4. https://archive.nptel.ac.in/courses/121/104/121104006/https://ocw.mit.edu/courses/12-409-hands-on-astronomy-observing-stars-and-planets-spring-2002/

Course Title : **Introduction to Mathematical Physics-II (SEC: THEORY)**

Course Code : **UG-PHY-SEC2**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Pre-requisite : **Nil**

Course Objectives: The brief objective of this course is to provide a foundation in mathematical concepts and techniques that are essential for further study in physics.

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

CLO1: Solve problems involving vector algebra and its applications in physics.
CLO2: Understand spherical and cylindrical coordinate systems.
CLO3: Evaluate matrix operations and properties of matrices.
CLO3: Explain and apply the concepts of Normal, Binomial, and Poisson distributions to analyze probabilities and statistical data.
CLO4: Develop skills in using programming languages and Excel for mathematical analysis, statistical distributions, and data visualization in physics.

Module I **[15 hrs]**

1. **Vector Algebra**
   Scalars and vectors. Basis vectors and components. Multiplication of Vectors. Equation of lines and planes. Using vectors to find distances.
2. **Coordinate Systems**
   Plane polar coordinates. Cylindrical and Spherical polar coordinates.
3. **Matrices**
   Matrix Analysis and Notation, Matrix Operations, Properties of matrices. Transpose matrix. Complex Conjugate Matrix, Hermitian Matrix, Unit matrix, Diagonal matrix, Adjoint and self-adjoint matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix. Solution of a system of linear equations. The eigenvalue problem.

Module II: **[15 hrs]**

1. **The Normal Distribution**
   Histograms and Distributions, Limiting distributions. The normal distribution. The standard deviation as 68% confidence limit. Justification of the mean as the best estimate. Justification of addition in quadrature. Standard deviation of the mean. Acceptability of the measured answer.
2. **The Binomial Distribution**
   Distributions. Probability in dice throwing. Definition of binomial distribution. Properties of binomial distribution. The Gauss distribution for random errors. Application: testing of hypothesis

3. **The Poisson Distribution**
   Definition of Poisson distribution. Properties of Poisson distribution. Applications. Subtracting a background.

Course Title : **Introduction to Mathematical Physics-II (SEC: PRACTICAL)**

Course Code : **UG-PHY-SEC2**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of experiments:

1. Exploring vector algebra using a programming language and its applications in physics. **[04 hrs]**
2. Investigating Matrix Operations in Physics using a Programming Language -I. **[04 hrs]**
3. Statistical analysis with normal distribution using a programming language/Excel. **[04 hrs]**
4. Exploring the binomial distribution through programming/Excel. **[04 hrs]**
5. Exploring the Poisson distribution through programming/Excel. **[04 hrs]**
6. Investigating Matrix Operations in Physics using a Programming Language -II **[04 hrs]**
7. Exploring Matrix Diagonalization: Eigenvalues and Eigenvectors using a programming language. **[04 hrs]**
8. Plotting of various algebraic and trigonometric functions using Excel. **[02 hrs]**

REFERENCES:

Mandatory Reading:

1. Mary L. Boas, *Mathematical Methods in Physical Sciences* 3rd Edition, John Wiley and Sons, USA
2. Charlie Harper, *Introduction to Mathematical Physics*, Prentice Hall of India, New Delhi
3. Taylor J, 1997, *An Introduction to Error analysis*, University Science Books.
4. H. K Dass ,R. Verma. 2019. *Mathematical Physics*, 8th Edition, S. Chand Publishing.
5. Abhijit Gupta. 2021. *Scientific Computing in Python*, 3rd Edition, Techno world, Kolkata.

Supplementary Reading:

1. B. D. Gupta, 2004. *Mathematical Physics,* Vikas Publishing House, New Delhi
2. Riley K. F., Hobson M. P., Bence S. J., 1998, *Mathematical Methods for Physics and Engineering*, Cambridge University Press, UK
3. C. Hill, Learning. 2020, *Scientific Programming with Python*, 2nd Edition, Cambridge University Press.
4. A. Scopatz, K. D. Huff. 2015. *Effective Computation in Physics*, O'Reilly Media
5. George Arfken, Hans Weber, Frank Harris. 2012. *Mathematical Methods for Physicists*, 7th Edition, Elsevier

Web References:

1. http://home.iitk.ac.in/~peeyush/102A/Lecture-notes.pdf
2. http://www.jimahoffman.com/MathB30/Matrices/Matrix1.pdf
3. http://web.pas.rochester.edu/~physlabs/manuals/L2C-StatisticsForWeb-AB5-short.pdf
4. https://library2.lincoln.ac.nz/documents/Normal-Binomial-Poisson.pdf
5. https://www.tutorialspoint.com/python/index.htm

Course Title : **Matrices and Differential Equations (SEC: THEORY)**

Course Code : **UG-PHY-SEC5**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Pre-requisite : **Nil**

Course Objectives: To gain proficiency in matrix analysis and solve ordinary differential equation of first and higher order and apply these acquired skills across diverse fields and applications.

Course Learning Outcomes: Upon completion of the course, the student will be able to

CLO1: Demonstrate proficiency in matrix analysis
CLO2: Obtain precise solutions for first-order differential equations
CLO3: Apply various techniques for obtaining solutions of second order differential equations.
CLO4: Utilize computational techniques to solve several problems in matrices and differential equations.

Module I: **[15 hrs]**

1. **Matrices**

   Matrix Analysis and Notation, Matrix Operations, Properties of matrices. Transpose matrix. Complex Conjugate Matrix, Hermitian Matrix, Unit matrix, Diagonal matrix, Adjoint and self-adjoint matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix. Solution of a system of linear equations. The eigenvalue problem.
2. **Differential equation**

   Introduction. Some simple situations where we come across ODE. First order ODE. Variable separable, Homogeneous, Non- Homogeneous, Exact differential equations, integrating factor, linear differential equations, Bernoulli equations.

Module II: **[15 hrs]**

1. **Second order Differential equation**

   Second-order differential equations, Homogeneous and non-homogeneous differential equations, complementary function, particular integral, General solution, complex solutions. Some methods of solving second-order differential equations (undetermined coefficients, variation of parameters, using one solution to find another). Finding particular integral by operator method. Linear differential equations of higher order.

Course Title **: Matrices and Differential Equations (SEC: PRACTICAL)**

Course Code **: UG-PHY-SEC5**

Credits **: 1**

Marks **: 25**

Duration **: 30 hrs.**

List of experiments:

1. Investigating Matrix Operations in Physics using a Programming Language -I **[04 hrs]**
2. Investigating Matrix Operations in Physics using a Programming Language -II. **[04 hrs]**
3. Exploring Matrix Diagonalization: Eigenvalues and Eigenvectors in Python. **[04 hrs]**
4. Exploring complex numbers using Python. **[04 hrs]**
5. Applying programming techniques to solve ordinary differential equations. **[04 hrs]**
6. Applying programming techniques to solve first order ordinary differential equations. **[04 hrs]**
7. Applying programming techniques to solve first order ordinary differential equations-II **[02 hrs]**
8. Applying programming techniques to solve second order differential equations. **[04 hrs]**

REFERENCES:

Mandatory reading:

1. Charlie Harper, *Introduction to Mathematical Physics*, Prentice Hall of India, New Delhi
2. Simmons G.F., *Differential Equations with Historical Notes*, Tata McGraw Hill
3. Mary L. Boas, *Mathematical Methods in Physical Sciences* 3rd Edition, John Wiley and Sons, USA
4. Boyce W.E. & DiPrima R.C., *Elementary Differential Equations and Boundary Valued Problems*, John Wiley Pvt Ltd.

Supplementary reading:

1. Abhijit Gupta, 2021, Scientific Computing in Python, 3rd Edition, Techno world, Kolkata.
2. Braun C, *Differential Equations and Their Applications: An Introduction to Applied Mathematics* (Texts in Applied Mathematics), springer.
3. Coddington E., *Theory of Ordinary Differential Equations*, Tata McGraw Hill
4. Rainville E.D., *Elementary Differential Equations*, Pearson.

Web references:

1. https://ocw.mit.edu/resources/res-18-007-calculus-revisited-multivariable-calculus-fall-2011/
2. https://nptel.ac.in/courses/111108081/
3. https://math.libretexts.org/Bookshelves/Applied_Mathematics/Applied_Finite_Mathematics_(Sekhon_and_Bloom)/02%3A_Matrices/2.01%3A_Introduction_to_Matrices

4. https://math.libretexts.org/Courses/Monroe_Community_College/MTH_211_Calculus_II/Chapter_8%3A_Introduction_to_Differential_Equations/8.1%3A_Basics_of_Differential_Equations
5. https://ocw.mit.edu/courses/res-18-009-learn-differential-equations-up-close-with-gilbert-strang-and-cleve-moler-fall-2015/

SEMESTER III

Course Title : **Electromagnetic Theory – I (CORE: THEORY)**

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

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisite : Electricity and Magnetism and Introduction to Mathematical Physics-II

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: Analyze electric fields and potentials for various charge distributions using Coulomb's Law and Gauss's Law.

CLO3: Apply suitable techniques to solve various electrostatic problems.

CLO4: Interpret the behavior of electric fields in dielectric materials and apply boundary conditions for electric field vectors

CLO5: Explain the microscopic theory of dielectrics, including polarization, susceptibility, and the Clausius-Mossotti relation.

CLO6: Apply theoretical principles to perform experiments related to electrostatics and dielectric properties of materials in various configurations.

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

1. **Vector Analysis**

   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 hrs]

1. **Electrostatics**

   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**

   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 hrs]

1. **Electrostatic Field in Matter**

   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**

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

Course Title : Electromagnetic Theory – I (CORE: PRACTICAL)

Course Code : UG-PHY-201

Credits : 1

Marks : 25

Duration: : 30 hrs.

List of Experiments:

1. Measurement of dielectric constant and susceptibility of liquid using parallel metal plates. **[04 hrs]**
2. Measurement of dielectric constant and susceptibility of liquid using coaxial metal tubes. **[04 hrs]**

3. Measurement and Study of variation of dielectric constant of $BaTiO_3$ ferroelectric and determination of its Curie temperature. **[04 hrs]**
4. E and D measurement for a parallel plate capacitor and calculation of dielectric constant. **[04 hrs]**
5. Law of Capacitance using Dielectric Constant Measurement Kit. **[03 hrs]**
6. Absolute capacity by ballistic galvanometer. **[04 hrs]**
7. C_1/C_2 by De-Sauty's method using ballistic galvanometer. **[04 hrs]**
8. Dipole Moment and Polarizability of Benzene. **[03 hrs]**

REFERENCES:

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
4. Boas, M. L., 2006, *Mathematical methods in the physical sciences,* 3rd Ed., Wiley.
5. Jackson, J. D., 1998, *Classical electrodynamics*, 3rd ed., Wiley

Supplementary Reading:

1. Mukherji U., 2008, *Electromagnetic Field Theory and Wave Propagation*, Narosa Publishing House.
2. Mahajan A. S., Rangawala A. A., 2017, *Electricity and Magnetism*, Tata McGraw-Hill Publishing Company Ltd.
3. Chattopadhay D., Rakshit P. C., 2011, *Electricity and Magnetism*, 9th Ed., New Central Book Agency.
4. Laud B. B., *Electromagnetics*, 1987, Wiley Eastern Ltd., New Delhi
5. Puri S. P., 1997, *Classical Electrodynamics,* Tata McGraw Hill, New Delhi.

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_10.html
5. https://www.iiserkol.ac.in/~ph324/ExptManuals/DielectricConstant.pdf

Course Title **: Optics (CORE: THEORY)**

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

Credits **: 3**

Marks **: 75 `**

Duration **: 45 hrs.**

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, 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: Derive Brewster's law, Malus's law, and apply Huygen's theory of double refraction to differentiate between Positive and Negative Uniaxial crystals.

CLO5: Understand working and uses of Nicol Prism, Retardation plates and Polarimeters.

CLO6: Correlate the theoretical basis of various concepts of Geometrical Optics and Wave Optics while performing experiments with help of various optical instruments.

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

1. **Fundamentals of Reflection and Refraction**
   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**
   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**

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

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

1. **Introduction to Interference and Interference in Thin Films**

   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**

   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**

   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**

   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 hrs]**

1. **Production and Analysis of Polarized lights**

   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**

   Optical activity, Specific rotation, Simple Polarimeter, Laurent's Half-Shade Polarimeter.

Course Title : **Optics (CORE: PRACTICAL)**

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

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of Experiments:

1. Cardinal points of Two lenses **[04 hrs]**
2. Prism Spectrometer: Refractive index **[04 hrs]**
3. Dispersive power of prism **[03 hrs]**
4. Newton's Rings **[03 hrs]**
5. Wedge shaped air film **[03 hrs]**
6. Single Slit Diffraction using LASER Source **[03 hrs]**
7. Resolving Power of Telescope **[04 hrs]**
8. Malus's Law using LASER source. **[03 hrs]**
9. Brewster's Law using LASER source. **[03 hrs]**

REFERENCE BOOKS:

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*, 8^{th} 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.

Web References:

1. https://ocw.mit.edu/courses/mechanical-engineering/2-71-optics-spring-2009/video-lectures/

Course Title **: Oscillations, Waves and Sound [CORE: THEORY]**

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

Credits **: 3**

Marks **: 75**

Duration **: 45 hrs.**

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: Explain the principles of undamped free oscillations, including different types of equilibria, formulate equations of motion and analyze superposition effects in simple harmonic motions.

CLO2: Analyze the nature of damped and driven oscillations, apply the concept of resonance and quality factor, and evaluate coupled oscillations and their energy.

CLO3: Explain the dependence of velocity of sound waves on various factors like temperature, pressure, density, humidity, apply concepts like the production and detection of ultrasonic waves to real-world applications and solve problems for different cases of Doppler effect.

CLO4: Demonstrate experimental techniques, apply principles to determine physical constants such as acceleration due to gravity and sound velocity, and analyze the effects of damping on oscillatory systems.

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

1. **Undamped free oscillation**

   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 hrs]**

1. **Damped Oscillations**

   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**
   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**
   Coupled oscillations. Normal Coordinates. Energy of coupled oscillations.

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

1. **Waves and Sound**
   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**
   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.

Course Title **: Oscillations, Waves and Sound [CORE: PRACTICAL]**

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

Credits **: 1**

Marks **: 25**

Duration **: 30 hrs.**

List of Experiments:

1. To determine the equivalent length of the Kater's pendulum and the acceleration due to gravity using a resonance pendulum **[04 hrs]**
2. To determine the damping constant using Damped harmonic oscillator **[04 hrs]**
3. To determine the velocity of Sound using Helmholtz resonator **[04 hrs]**
4. To determine the value of acceleration due to gravity using a bar pendulum **[04 hrs]**
5. To determine the frequency of AC mains using Sonometer **[02 hrs]**
6. Bifilar suspension: Dependence of the time period on the geometry of non-parallel bifilar suspension **[04 hrs]**
7. Log Decrement **[04 hrs]**
8. Velocity of Sound using CRO **[04 hrs]**

REFERENCES:

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.
4. Freedman, Y. a., n.d. *University Physics*. 15th edition ed. s.l.:Sears and Zemansky

Web References:

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 : **Wave Optics and Elementary Modern Physics (CORE: THEORY)**

Course Code : **UG-PHY-211**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Course Objectives:
The course will focus on the two major theories, the wave optics and the quantum mechanics. Course will help the students to learn basic concepts of Physical Optics and Modern Physics.

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

CLO1: Apply division by wave front and division by amplitude techniques to study interference patterns, derive conditions for Fraunhofer class diffraction, and solve numerical problems based on basic concepts of interference and diffraction.
CLO2: Understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
CLO3: Understand and apply uncertainty principle to solve numerical problems related to subatomic physics.
CLO4: Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques.
CLO5: Solve the Schrödinger equation for particle using 1-dimensional infinite Square Well, 3-dimensional rigid box and interpret the solutions.
CLO6: Correlate the theoretical basis of various concepts of Wave Optics and Modern Physics by performing experiments.

Module I: **[15 hrs]**

1. **Introduction to Interference and Interference in Thin Films**
   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 lights in thin films: Plane Parallel Film, Wedge-shaped Film, Newton's Rings.

2. **Introduction to Diffraction and Fraunhofer Class Diffraction**

   Difference between Interference and Diffraction, Diffraction at a single slit, Diffraction at double slit, Determination of wavelength of a spectral line using Plane Transmission Grating. Resolving Power, Rayleigh's criterion, Resolving power of telescope.

Module II: **[15 hrs]**

1. **Particle Properties of waves:**

   Concepts of Black Body Radiation. The Photoelectric effect. Compton effect, Experimental verification of the Photoelectric effect.

2. **Wave Properties of Particles:**

   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: **[15 hrs]**

Schrodinger's Wave Equation and its applications:

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. Free particle. Particle in a one-dimensional infinite square well potential. Particle in a three-dimensional rigid box, Degree of degeneracy.

Free particle. Particle in a one-dimensional infinite square well potential. Particle in a three-dimensional rigid box. Degree of degeneracy

Course Title	**: Wave Optics and Elementary Modern Physics (CORE: PRACTICAL)**
Course Code	**: UG-PHY-211**
Marks	**: 25**
Credits	**: 1**
Duration	**: 30 hrs.**

List of Experiments:

1. Measurement of diameter of Lycopodium powder **[03 hrs]**
2. Fraunhoffer diffraction over single slit **[03 hrs]**
3. Fraunhoffer diffraction over double slit **[04 hrs]**
4. Newton's rings **[03 hrs]**
5. Wedge shaped air film **[03 hrs]**
6. Frank Hertz Experiment **[04 hrs]**
7. Photoelectric effect. **[04 hrs]**
8. Numerically solving the Time Independent Schrödinger equation for the case of Infinite potential well. **[06 hrs]**

REFERENCES:

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.
5. Subramanyam N., Lal Brij, Avadhanulu M. N., 2006, *A Text book of Optics*, First multicolour Edition, S. Chand & Company Ltd., 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
6. Education, India.
7. Mathur B. K., *Principles of Optics*, New Global Printing Press, Kanpur.
8. Ghatak A., 1977, *Optics*, Tata McGraw-Hill Publishing Company Ltd., New Delhi

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1. https://openstax.org/books/college-physics-2e/pages/27-1-the-wave-aspect-of-light-interference
2. https://openstax.org/books/college-physics-2e/pages/27-5-single-slit-diffraction
3. https://openstax.org/books/college-physics-2e/pages/29-5-the-particle-wave-duality
4. https://openstax.org/books/college-physics-2e/pages/29-6-the-wave-nature-of-matter
5. https://stanford.edu/QMGreensite
6. https://engineering.purdue.edu/QMAII20161206

Course Title : **General Physics: Nucleus, Relativity and Beyond (MDC: THEORY)**

Course Code : **UG-PHY-MDC 3**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

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 the structure of the nucleus and radioactive decay, identify types of nuclear reactions, and explain the basic concepts underlying nuclear reactors and weapons.

CLO2: Acquire an understanding of the key concepts of special theory of relativity, describe relative motion, comprehend fundamental concepts of the general theory of relativity and gain basic knowledge of quarks, cosmology, semiconductors, and superconductors.

CLO3: Perform experiments to apply theoretical concepts, analyze results, and demonstrate an understanding of various physical phenomena in semiconductor devices and electronics.

Module I: **[10 hrs]**

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 hrs]**

1. **Relativity**

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

2. **Beyond everyday phenomena**

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

Course Title : **General Physics: Nucleus, Relativity and Beyond (MDC: PRACTICAL)**

Course Code : **UG-PHY-MDC 3**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of Experiments:

1. Energy band of a semiconductor using a diode **[04 hrs]**
2. Zener diode characteristics **[04 hrs]**
3. Simulation of Doppler effect **[03 hrs]**
4. Verify truth tables of logic gates **[04 hrs]**
5. V-I characteristics of a P-N junction diode **[04 hrs]**
6. Radioactive dice experiment **[03 hrs]**
7. To identify unknown radiation source using Geiger Muller counter (Virtual Lab) **[04 hrs]**
8. Determine half-life of Ba-137 m (Virtual Lab) **[04 hrs]**

REFERENCES:

Mandatory Reading:

1. Griffiths Thomas and Brosing Juliet, 2009, *The Physics of Everyday Phenomenon*: A conceptual introduction to Physics, 6th Edition. McGraw-Hill Companies.
2. Halliday, Resnick , Walker, 2008, *Fundamentals of Physics,* Extended, 8th Edition, Wiley India Pvt Ltd
3. Freedman, Y. a., n.d. *University Physics*. 15th edition ed. s.l.:Sears and Zemansky
4. Pugh, T. W. a. O., 2013. *Particle Physics A Graphic Guide*. London: Icon Books Ltd.
5. Weinberg, S., n.d. *The First Three Minutes A modern view of the origin of the universe.* s.l.:Fontana Paperbacks

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*, 6th Edition , prentice- Hall of India Pvt ltd , New Delhi

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1. https://astronuclphysics.info/Fyzika-NuklMed.htm
2. https://openstax.org/books/university-physics-volume-3/pages/9-8-superconductivity
3. https://archive.nptel.ac.in/courses/112/103/112103243/
4. https://archive.nptel.ac.in/courses/115/102/115102017/
5. https://ocw.mit.edu/courses/22-101-applied-nuclear-physics-fall-2006/pages/lecture-notes/

Course Title : **Stars, Galaxies and Cosmology (MDC: THEORY)**

Course Code : **UG-PHY-MDC5**

Credits : **2**

Marks : **50**

Duration : **30 hrs.**

Pre-requisite : **Nil**

This course can be taken up by students who are interested in exploring the fundamental properties of stars, the structure of galaxies, the origins of the universe and the cutting-edge concepts in astronomy and cosmology.

Course Objectives: This is an introductory course with emphasis on the universe outside our own solar system. The aim is to convey the excitement of studying the cosmos.

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

CLO1: Summarize stellar parameters and interpret Hertzsprung-Russell (HR) diagrams effectively.

CLO2: Analyze galaxy classification, redshift-distance relation, and the expanding universe, including its curvature, age, and dark energy.

CLO3: Examine the unification of the fundamental forces of nature and the process of virtual pair production and annihilation of matter and anti-matter.

CLO4: Analyze stellar properties, motions, and distances using spectral data, celestial observations, and astrophysical techniques.

Module I: Stellar Properties and Galactic Structure **[20 hrs]**

1. **The Nature of the Stars**

   Stellar Distances and Parallax, Apparent Brightness and Luminosity, The Magnitude Scale, Star Colors and Temperatures, Spectral Classes, Review of Doppler Effect, The Sizes of Stars, The Hertzsprung-Russell Diagram, Spectroscopic Parallax.

2. **Galaxies**

   Island Universe, The Distances to Galaxies, Classifying Galaxies, The Distance Ladder, The Hubble Law, Clusters and Superclusters, Dark Matter in the Universe, The Evolution of Galaxies

Module II: Cosmic Origins and the Expanding Universe **[10 hrs]**

1. **Cosmology**
   The Dark Night Sky, The Expanding Universe, The Big Bang, The Cosmic Microwave Background, The Universe before Recombination, The Shape of the Universe, Dark Energy and the Accelerating Universe.
2. **Exploring Early Universe**
   Cosmic Inflation, The Fundamental Forces and Symmetry Breaking, Matter, Antimatter and the Uncertainty Principle, Matter-Antimatter Annihilation

Course Title	**: Stars, Galaxies and Cosmology (MDC: PRACTICAL)**
Course Code	**: UG-PHY-MDC5**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hrs.**

List of experiments:

1. Identification of the prominent spectral lines in the spectrum of our sun **[04 hrs]**
2. Correlation of absorption lines of different stars against a standard reference list of atomic spectral lines **[04 hrs]**
3. Location of prominent stars, nebulae and galaxies in the night sky in Stellarium/ Sky observation to locate prominent stars, nebulae and galaxies using the telescope and comparing the observations with Stellarium. **[06 hrs]**
4. Measurement of the Proper Motion of Barnard's Star in Stellarium **[04 hrs]**
5. Identification of a Circumpolar Star in Stellarium **[04 hrs]**
6. Determination of the distance and age of cluster using Colour Magnitude Diagram. **[04 hrs]**
7. Identification of elements based on the emission lines and determination of the radial velocity of an astronomical object by observing the Doppler shift. **[04 hrs]**

REFERENCES:

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. 2003. *Astronomy A Physical Perspective*. Second ed. New York: Cambridge University Press.
4. Roy A.E., Clarke D. 1989. *Astronomy structure of the Universe*, Adam Hilger Pub.
5. Palen, S. E. 2002. *Schaum's Outline Series, Astronomy*. United States of America: McGraw Hill.

Supplementary Reading:

1. Glasstone S. 1965. *Source book on the Space Sciences*, Van Nostrand Reinhold Inc., U.S
2. Narlikar J.V. 1976. *Structure of the Universe*, Oxford Paperbacks.
3. Sule, A. 2013. *A Problem Book in Astronomy and Astrophysics.* [Online]
4. Hawking, S. 1988. The Universe in a Nutshell. London: The Bantam Press.

Web References:

1. https://javalab.org/en/category/astronomy_en/star_en/
2. IGNOU. Self-Learning Material (SLM) on Astronomy. [Online]. Available at: https://egyankosh.ac.in/handle/123456789/1/browse?type=subject&order=ASC&rpp=20&value=Astronomy
3. https://archive.nptel.ac.in/courses/115/105/115105046/
4. https://ocw.mit.edu/courses/8-942-cosmology-fall-2001/
5. https://onlinecourses.swayam2.ac.in/arp19_ap73/preview

Course Title : **Introduction to Error Analysis (SEC: THEORY)**

Course Code : **UG-PHY-SEC3**

Marks : **50**

Credits : **2**

Duration : **30 hrs.**

Pre-requisite : **Nil**

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:

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

CLO2: Apply the methods of propagation of errors and statistical analysis to estimate uncertainties in experimental and statistical data.

CLO3: Explain and apply the concepts of Normal, Binomial, and Poisson distributions to analyze probabilities and statistical data.

CLO4: Plot graphs and estimate the best fit lines through the data points.

CLO5: Apply error analysis, statistical methods, and data fitting techniques to experimental data using programming and computational tools.

Module I: **[15 hrs]**

1. **Preliminary description**
   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**
   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.
3. **Statistical analysis of random uncertainties**
   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.

Module II: **[15 hrs]**

- **The Normal Distribution**
  Histograms and Distributions, Limiting Distributions, The Normal Distribution, The Standard Deviation as 68% Confidence Limit. Justification of the Mean as Best Estimate.
- **Binomial distribution**
  Distributions. Probabilities in Dice Throwing. Definition of the Binomial Distribution. Properties of the Binomial Distribution.

- **The Poisson Distribution**
  Definition of the Poisson Distribution. Properties of the Poisson Distribution. Applications.
- **Least-Squares fitting**
  Data that should fit a straight line. Calculation of slope and intercept. Uncertainty in the slope and intercept. Least-squares fit to other curves.

Course Title	**: Introduction to Error Analysis (SEC: PRACTICAL)**
Course Code	**: UG-PHY-SEC3**
Marks	**: 25**
Credits	**: 1**
Duration	**: 30 hrs.**

List of experiments:

1. Application of propagation of errors to experimental data-I. **[04 hrs]**
2. Exploring Propagation of uncertainties using programming./ Application of propagation of errors to experimental data-II **[04 hrs]**
3. Application of Statistical analysis of random uncertainties to experimental data-I. **[04 hrs]**
4. Application of Statistical analysis of random uncertainties to experimental data-II./ Programming-based exploration of Statistical analysis for random uncertainties. **[04 hrs]**
5. Application of Least-Squares fitting to experimental data-I. **[04 hrs]**
6. Programming-based exploration of least-squares fitting./ Application of Least-Squares fitting to experimental data-II. **[04 hrs]**
7. Programming-based exploration of Normal and Binomial. **[04 hrs]**
8. Programming-based exploration of Poisson distribution. **[02 hrs]**

REFERENCES:

Mandatory reading:

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

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

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

4. Mary L. Boas, *Mathematical Methods in Physical Sciences* 3rd Edition, John Wiley and Sons, USA

5. N. J. Berendsen. 2011. A Students Guide to Data and Error Analysis, Cambridge University Press.

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. Abhijit Gupta, 2021, Scientific Computing in Python, 3rd Edition, Techno world, Kolkata.
4. Naseem Ahmed. 2010. *Fundamental Numerical Analysis and Error Estimation*, Anamaya Publishers.
5. Jack Merrin. 2017. *Introduction to Error Analysis*, Kindle Publishing

Web References:

1. https://www.physics.columbia.edu/sites/default/files/content/Lab%20Resources/Error_Analysis_Guide.pdf
2. https://faraday.physics.utoronto.ca/PVB/Harrison/ErrorAnalysis/
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

Course Title **: Numerical Techniques (SEC: THEORY)**

Course Code **:UG-PHY-SEC6**

Credits **: 2**

Marks **: 50**

Duration **: 30 hrs.**

Course Objectives:
The aim of this course is to make the student acquainted with several computational techniques for solving a broad range of problems.

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

CLO1: Analyze errors arising in numerical computation of solutions to mathematical and applied problems. Solve algebraic equations numerically. Apply mathematical procedure for finding the best-fitting curve for a given set of points.

CLO2: Apply numerical techniques for differentiation and integration.

CLO3 Apply numerical techniques for solving ordinary differential equations

CLO4: Develop practical computational skills/techniques to solve various problems.

Module I: **[15 hrs]**

1. **Errors in Numerical Calculations**
   Preliminaries of Computing (Basic concepts)
   Errors and their computations, absolute, relative and percentage errors. A general error formula. Error in series approximation.
2. **Solution of Algebraic Equations**
   Bisection method, iteration method, Newton-Raphson method, secant method.
3. **Least square curve fitting**
   Fitting a straight line, Multiple linear least squares (function of two variables)

Module II: **[15 hrs]**

1. **Numerical differentiation and integration**
   Forward differences. Numerical differentiation. Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule.
2. **Numerical solution of ordinary differential equations**
   Solution by Taylor series, Euler's Method, Runge-Kutta methods, Finite difference method

Course Title **: Numerical Techniques (SEC: PRACTICAL)**

Course Code **: UG-PHY-SEC6**

Credits **: 1**

Marks **: 25**

Duration **: 30 hours**

List of Experiments:

1. Introduction to a programming language. **[04 hrs]**
2. Applying programming techniques/Excel to solve Linear equations using Bisection method. **[03 hrs]**
3. Applying programming techniques/Excel to solve Linear equations Newton-Raphson method. **[03 hrs]**
4. Applying programming techniques/Excel to solve differential Equation using Euler's Method. **[04 hrs]**
5. Applying programming techniques/Excel to solve differential equation using Finite difference method. **[04 hrs]**
6. Applying programming techniques/Excel to solve integrals using Trapezoidal rule. **[04 hrs]**
7. Applying programming techniques/Excel to solve integrals using Simpson's 1/3 rule. **[04 hrs]**
8. Applying programming techniques/Excel for Least Square Curve Fitting. **[04 hrs]**

REFERENCES:

Mandatory Reading:

1. S. S. Sastry, 2025, *Introductory Methods of Numerical Analysis*, PHI Learning Private Limited, Delhi
2. Ian Hutchinson,2015, *A Student's Guide to Numerical Methods,* Cambridge University Press, UK
3. Jaan Kiusalaas, 2005, *Numerical Methods in Engineering with Python*, Cambridge University Press, UK
4. E. Balaguruswamy, 2017, *Numerical Methods*, Mc Graw Hill Education
5. Steven Chapra, Raymond Canale 2021, *Numerical Methods for Engineers*, Mc Graw Hill

Supplementary Reading:

1. Verma P. K. and Ahluwalia and Sharma K. C. 1999, *Computational Physics*, New Age International Publishers, India.
2. Rajaraman V. 1999, *Computer Oriented Numerical Methods*, Prentice-Hall of India, New Delhi.
3. H. R. Schwarz, 1989, Numerical Analysis: A Comprehensive Introduction, John Wiley & Sons, Inc.

4. Rajesh Kumar Gupta, 2019, Numerical Methods : Fundamentals And Applications, Cambridge University Press.
5. Richard Hamming,1987, Numerical Methods for Scientists and Engineers Dover Publications Inc.

Web References:

1. https://nptel.ac.in/courses/115/106/115106118/
2. http://digimat.in/nptel/courses/video/111106101/L18.html
3. https://web.stanford.edu/class/me200c/tutorial_77/
4. http://nm.mathforcollege.com/mcd/gen/05inp/mcd_gen_inp_bck_defintion.pdf
5. https://www.coursera.org/learn/numerical-methods-engineers

SEMESTER IV

Course Title : **Modern Physics (CORE: THEORY)**

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

Marks : **75**

Credits : **3**

Duration : **45 hrs.**

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: Inspect the properties of electrons, atoms, and the nucleus by determining e/m for cathode rays, analyzing Rutherford's and Bohr's model of the atom and apply this knowledge to particle properties of waves like the photoelectric and compton effects.

CLO2: Examine and interpret experiments that reveal the wavelike properties of particle and apply uncertainty principle to solve numerical problems related to subatomic physics

CLO3: Illustrate the working of mass spectrographs, particle accelerators and explain the operating principle of the LASER and the optical fiber.

CLO4: Perform experiments to apply theoretical concepts, analyze experimental data, and demonstrate proficiency in using various scientific instruments and techniques.

Module I: **[15 hrs]**

1. **Electrons, Nucleus and Atoms:**
   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:**
   Atomic Spectra. Frank-Hertz experiment. The Bohr Atom: Quantization of energy. Bohr-Sommerfield model. Nuclear motion and reduced mass. Bohr's Correspondence Principle.
3. **Particle Properties of waves:**
   Concepts of Black body radiation. The Photoelectric effect. Compton Effect. Experimental verification of the Photoelectric effect.

Module II: **[15 hrs]**

1. **De Broglie's Postulate - Wavelike properties of Particles:**
    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:**
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 hrs]**

1. **Measurement of Mass and accelerators**
Measurement of Mass: Thomson's positive ray analysis, Dempster's Mass spectrometer, Bainbridge Mass spectrograph. Linear accelerator and Cyclotron.
2. **LASERs:**
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.

Course Title **: Modern Physics (CORE: PRACTICAL)**
Course Code **: UG-PHY-203**
Marks **: 25**
Credits **: 1**
Duration **: 30 hrs.**
List of Experiments:

1. Determination of e/m of electrons using Thomson's method **[04 hrs]**
2. Measurement of k using transistor **[04 hrs]**
3. Measurement of diameter of Lycopodium powder **[04 hrs]**
4. To determine wavelength of Laser source by diffraction of double slit **[04 hrs]**
5. Frank Hertz Experiment **[04 hrs]**
6. Photoelectric effect **[04 hrs]**

7. IV Characteristics of LASER **[02 hrs]**
8. Optical fibre: Numerical aperture/ Bending loss in optical fibre **[04 hrs]**

REFERENCES:

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.
4. R Murugeshan, K. S., 2016. *Modern Physics*. Eighteenth Edition ed. New Delhi: S Chand and Company Limited.
5. Krane, K. S., 2020. *Modern Physics*. Fourth Edition ed. Singapore: John Wiley & Sons, Inc.
6. Beiser, A., 1973. *Concepts of Modern Physics*. International Student Second Edition ed. Japan: McGraw Hill Inc.

Web References:

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://phet.colorado.edu/en/simulations/category/physics

Course Title : **Quantum Mechanics (CORE: THEORY)**

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

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

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: Describe 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.

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

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 **[20hrs]**

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 hrs]**

1. **Angular momentum and Spin**
   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**

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

Course Title : Quantum Mechanics (CORE: PRACTICAL)

Course Code : UG-PHY-206

Credits : 1

Marks : 25

Duration : 30 hrs.

List of experiments:

1. Introduction to Numerov method and numerically solving the Time Independent Schrödinger equation for the case of Infinite potential well. **[04 hrs]**
2. Numerically solving the Time Independent Schrödinger equation for the case of finite potential well. **[04 hrs]**
3. Numerically solving the Time Independent Schrödinger equation for the case of Infinite potential well with a cosine bump. **[04 hrs]**
4. Numerically solving the Time Independent Schrödinger equation for the case of Step potential. **[04 hrs]**
5. Numerically solving the Time Independent Schrödinger equation for the case of Sloping potential well. **[04 hrs]**
6. IV Characteristics of Tunnel Diode. **[04 hrs]**
7. Mini project: Numerical Solution of the Time-Independent Schrödinger Equation for the Double Potential Well: Application to Ammonia Molecule Oscillation. **[06 hrs]**

REFERENCES:

Mandatory Reading:

1. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles,* 2^{nd} 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.
4. Verma, H. 2012, *Quantum Physics*, TBS, Calicut.
5. Wichmann, E. 2010, *Quantum Physics: Berkeley Physics Course Vol 4*, Tata McGraw-Hill Book Company, 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. Sengupta, K. and Pal, P. B. Qua 2023, *Introduction to Quantum Mechanics*, Cambridge University Press.

Web References:

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 (CORE: THEORY)**

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

Credits **: 3**

Marks **: 75**

Duration **: 45 hrs.**

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: Explain different types of temperature scales and describe the relationship between various temperature scales.

CLO2: Analyze the effects of changes in temperature, pressure and volume on physical systems at macroscopic scale by evaluating collective motion of their particles.

CLO3: Apply the laws of thermodynamics to represent the relationship between heat and mechanical work.

CLO4: Apply the laws of thermodynamics to explain the working principles of engines, refrigerators, and air conditioners.

CLO5: Analyze the concept of entropy and calculate the change in entropy when the matter is heated/cooled or when the matter undergoes change in phase.

CLO6: Apply experimental techniques to measure temperature, thermal conductivity, validating theoretical principles in heat and thermodynamics.

Module I: **[15 hrs]**

1. **Principle of Thermometry**
   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**
   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 hrs]**

1. **Laws of Thermodynamics**

   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 hrs]**

1. **Applications of First and Second Law of Thermodynamics**

   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** 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.

Course Title **: Heat and Thermodynamics (CORE: PRACTICAL)**

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

Credits **: 1**

Marks **: 25**

Duration **: 30 hrs.**

List of Experiments:

1. Emf of a thermocouple **[02 hrs]**
2. Calibration of Si diode as a thermometer. **[02 hrs]**
3. Constant volume air thermometer. **[04 hrs]**
4. Constant pressure air thermometer. **[04 hrs]**
5. Thermal conductivity of a bad conductor. **[04 hrs]**
6. Thermal conductivity of copper. **[04 hrs]**
7. Temperature coefficient of resistance of copper. **[04 hrs]**
8. Temperature coefficient of resistance of Platinum thermometer using PT-100. **[02 hrs]**
9. Callender-Griffith Bridge/Latent heat of ice **[04 hrs]**

REFERENCES:

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.
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4. Garg S. C., Bansal R. M., Ghosh C. K., 2013, *Thermal Physics,* Tata McGraw Hill.
5. Schroeder D. V., 2000, *An Introduction to Thermal Physics*, Addison-Wesley, San Francisco.

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
3. Sharma J. K., 2007, *Heat and Thermodynamics*, Krishna Prakashan Media Pvt. Ltd.
4. Arora C. P., 2010, *Heat and Thermodynamics*, Tata McGraw-Hill.
5. Jain M.K., Iyengar S.R.K., 2002, *Advanced Engineering Thermodynamics*, Narosa Publishing House.

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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

Course Title **: Electronics-I (CORE: THEORY)**

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

Credits **: 3**

Marks **: 75**

Duration **: 45 hrs.**

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: Develop basic knowledge of resistor circuits, including current and voltage sources and apply various techniques for solving complex circuit problems.

CLO2: Acquire knowledge of semiconductor materials, diode characteristics, and its applications.

CLO3: Use knowledge of transistor structure and biasing techniques in the operation of BJT in various modes, with emphasis on BJT amplifier analysis and performance

CLO4: Learn the principles of positive and negative feedback, their effects on circuit performance, and the operation of oscillators such as phase shift, Wein bridge, Hartley, and Colpitt's oscillators.

CLO5: Develop knowledge of ideal operational amplifiers, differential amplifier, CMRR, and practical op-amp circuits including inverting and non-inverting amplifiers, integrators, and differentiators.

CLO6: Analyze and evaluate the performance of rectifiers, CE amplifiers, operational amplifiers (Op-Amps), and oscillators through practical experiments

Module I: **[15 hrs]**

1. **Basic concepts and resistor circuits**

   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**

   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: **[20hrs]**

Bipolar Junction Transistors (BJTs)

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.

Sinusoidal oscillators

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 hrs]**

Operation Amplifier (Op-amps)

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.

Course Title **: Electronics-I (CORE: PRACTICALS)**

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

Credits **: 1**

Marks **: 25**

Duration **: 30 hours**

List of Experiments:

1. Half wave rectifier using Junction Diode **[03 hrs]**
2. Full wave rectifier using Junction Diode **[03 hrs]**
3. Bridge rectifier with capacitor filter- Ripple factor using CRO. **[04 hrs]**
4. C.E. Amplifier: Input and Output Impedance **[04 hrs]**
5. C.E. Amplifier: Frequency response, Calculation of Gain Bandwidth product **[04 hrs]**
6. OP-Amp: Input and Output impedance measurement **[03 hrs]**
7. OP-Amp: Inverting and Non-inverting amplifier **[03 hrs]**
8. Colpitt's Oscillator **[03 hrs]**
9. Wein's Bridge Oscillator **[03 hrs]**

REFERENCES:

Mandatory Reading:

1. Eggleston D. L., 2011, *Basic Electronics for Scientists and Engineers*, 1stedition Cambridge University Press.
2. Mehta V. K., Rohit Mehta, 2023, *Principles of Electronics*, S. Chand and Co. Ltd. New Delhi
3. Bhargava N. N., Kulshrestha D. C., Gupta S. C., 2017, *Basic Electronics and Linear Circuits*, 2nd Edition, Tata McGraw Hill, New Delhi
4. Bhagyashree, Guruprasad K. N.,Pradeep Kumar Y, 2021,*Basic Electronics*,Notion Press

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. Gayakwad R. A., 2015, *Op-Amps and Linear Integrated Circuits*, 4th Edition, Pearson Education, Delhi
5. D. Chattopadhyay, P.C. Rakshit, 2022, *Electronics: Fundamentals and Applications*, New age International Publishers.

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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 (CORE: THEORY)**

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

Credits **: 3**

Marks **: 75**

Duration **: 45 hrs.**

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: Acquire knowledge of the dynamics of rigid bodies and apply it to solve basic physical problems.
CLO2: Evaluate the acoustic requirements of an auditorium, and demonstrate an understanding and application of musical intervals, harmony, melody, the diatonic scale, and the tempered scale.
CLO3: Apply the basic principles of elasticity, including moduli of elasticity and Poisson's ratio to analyze the behavior of beams under various loading conditions, specifically focusing on bending moments, flexural rigidity, and the depression of cantilevers.
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.
CLO6: Develop experimental skills to determine fundamental physical properties related to elasticity, fluid dynamics.

Module I:

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

   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 solid cone.

Module II: **[15 hrs]**

1. **Elasticity:**

   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:**

   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 hrs]**

1. **Viscosity**

   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**

   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)

Course Title	**: Properties of Matter and Acoustics (CORE: PRACTICAL)**
Course Code	**: UG-PHY-209**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hours**

List of Experiments:

1. Cantilever: Determination of Young's modulus by vertical vibrations of a cantilever.**[4hrs]**
2. Torsional Pendulum: Determination of Rigidity Modulus of the material of a wire. **[04 hrs]**
3. Viscosity of a liquid by Poiseuilles method **[04 hrs]**
4. Bending of beams: determination of Young's modulus **[04 hrs]**
5. Capillarity: determination of Surface tension **[04 hrs]**
6. Flat Spiral Spring: determination of elastic constants by vertical and torsional oscillations of a loaded spring **[04 hrs]**
7. Young's Modulus of Brass by Flexural Vibrations of Bar (virtual lab/ python code)**[03 hrs]**
8. Rigidity Modulus of Brass (virtual lab/ python code) **[03 hrs]**

REFERENCES:

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
4. H.C. Verma, 1992, *Concepts of Physics (Vol. 1)*, Bharati Bhawan Publishers & Distributors
5. Resnick, Halliday, Krane, *Physics (Vol. 1 & 2),* Wiley International

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
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2. https://archive.nptel.ac.in/courses/105/105/105105177/
3. https://archive.nptel.ac.in/courses/105/108/105108070/
4. https://ocw.mit.edu/courses/18-357-interfacial-phenomena-fall-2010/pages/lecture-notes/
5. https://archive.nptel.ac.in/courses/112/104/112104212/

Course Title : **Introduction to Astronomy and Astrophysics (CORE: THEORY)**
Course Code : **UG-PHY-210**
Credits : **3**
Marks : **75**
Duration : **45 hrs.**
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: Identify celestial objects in the night sky using astronomical coordinate systems, outline the significance of Kepler's laws and examine various stellar parameters.
CLO2: Apply fundamental concepts of optics to analyze design features of optical and radio telescopes, determine fascinating details of the constituents of the solar system and the physics of tides, summarize the lives of stars, discuss phases of stellar evolution and classify stellar spectra.
CLO3: Model the structure of our own galaxy and outline emergence of the early universe from the Big Bang.
CLO4: Utilize astronomical tools to observe and locate celestial objects, measure various astronomical periods, identify spectral lines and stellar features, and analyze celestial data to determine distances, motions, and ages of astronomical entities.

Module I: Fundamentals of Astronomy **[15 hrs]**

1. **The Celestial Sphere and Mechanics:**

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**

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 hrs]**

1. **Astronomical Instruments:**

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:**

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:**

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 hrs]**

1. **Star formation**

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**

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

3. **The Early Universe**

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

Course Title	**: Introduction to Astronomy and Astrophysics (CORE: PRACTICAL)**
Course Code	**: UG-PHY-210**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hrs.**

List of Experiments:

1. Location of astronomical objects and constellations in the night sky in Stellarium/ Sky observation to locate astronomical objects and constellations using the telescope and comparing the observation with Stellarium. **[04 hrs]**
2. Location of celestial objects using astronomical coordinates from different locations and examination of the position of the Sun in the sky in Stellarium **[02 hrs]**
3. Location of the Sun at noon and measurement of the lengths of solar and sidereal days in Stellarium **[04 hrs]**
4. Measurement of the synodic and sidereal period of the Moon using celestial coordinates in Stellarium / Measurement of distance to Moon in Stellarium **[04 hrs]**

5. Identification of the prominent spectral lines in the spectrum of our sun and correlation of absorption lines of different stars against a standard reference list of atomic spectral lines **[04 hrs]**
6. Measurement of the Proper Motion of Barnard's Star in Stellarium/ Identification of a Circumpolar Star in Stellarium **[04 hrs]**
7. Determination of the distance and age of cluster using Colour Magnitude Diagram **[04 hrs]**
8. Location of prominent stars, nebulae and galaxies in the night sky in Stellarium/ Sky observation to locate prominent stars, nebulae and galaxies using the telescope and comparing the observations with Stellarium **[04 hrs]**

REFERENCES:

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.
4. Carroll, B. W. & Ostlie, D. A., n.d. *An Introduction to Modern Astrophysics*. Second ed. San Francisco: Addison Wesley.

Supplementary Reading:

1. Bhatia V. B., 2001, *Textbook of Astronomy and Astrophysics* with Elements of Cosmology, Narosa Publishers, New Delhi.
2. Narlikar J.V., 1976, *Structure of the Universe*, Oxford Paperbacks.
3. Sule, A., 2013. *A Problem Book in Astronomy and Astrophysics.* [Online]
4. Palen, S. E., 2002. *Schaum's Outline Series, Astronomy*. United States of America: McGraw Hill.

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2. https://ocw.mit.edu/courses/physics/8-901-astrophysics-i-spring-2006/
3. https://ocw.mit.edu/courses/physics/8-902-astrophysics-ii-fall-2004/
4. IGNOU. Self-Learning Material (SLM) on Astronomy. [Online]. Available at: https://egyankosh.ac.in/handle/123456789/1/browse?type=subject&order=ASC&rpp=20&value=Astronomy
5. https://archive.nptel.ac.in/courses/115/105/115105046/

Course Title **: Computational Physics (VOC: THEORY)**

Course Code **: UG-PHY-VOC1**

Credits **: 3**

Marks **: 75**

Duration **: 45 hrs.**

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 the basics of algorithms, their properties, and how to develop the algorithm using flowcharts and standard symbols. Develop skills in Fortran programming, including writing basic programs, working with numerical constants and variables.
CLO2: Develop skills in Fortran programming and use of arithmetic expressions, input-output statements, conditional statements, loops, logical expressions, functions, subroutines, and arrays.
CLO3: Identify computational errors, including truncation and round-off errors, caused by finite bit representation in computer systems.
CLO4: Develop the ability to create algorithms and FORTRAN programs to solve numerical problems, including root finding with the bisection and Newton-Raphson methods, least square curve fitting, numerical integration, and solving differential equations using Euler's method.

Module I: Concepts of programming with simple FORTRAN programs: [10 hrs]

Definition and Properties of algorithms, Algorithm development, Flow charts- symbols and simple flowcharts.

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

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

Module II: FORTRAN Programming [15 hrs]

1. 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.
2. Input-Output Statements:
   List-directed input statements, List-directed output statements.
3. Conditional Statements:
   Relational Operators, The block IF construct, Example programs Using IF structure.
4. Implementing Loops in Program:
   The block DO loop, count control DO loop, Rules to be followed in writing DO loops.
5. 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.

6. Functions and subroutines:
   Introduction, function subprogram, syntax rules for function subprograms, Generic functions, Subroutines, Internal Procedures.
7. 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 hrs]

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.

Course Title : Computational Physics (CORE: PRACTICALS)

Course Code : UG-PHY-VOC1

Credits : 1

Marks : 25

Duration : 30 hours

List of experiments:

1. Sum of digits of an integer **[02 hrs]**
2. To find factorial of a number **[02 hrs]**
3. Checking and printing of prime numbers **[02 hrs]**
4. Matrix operations – addition, subtraction, multiplication **[04 hrs]**
5. Root of equation-Bisection method, Newton Raphson method **[04 hrs]**
6. Numerical integration- Trapezoidal, Simpson's 1/3rd rule **[04 hrs]**

7. Least square curve fitting- data for ohm's law **[04 hrs]**
8. Electric field due to a point charge **[04 hrs]**
9. Charging and Discharging of Capacitor in RC circuit/Growth and Decay of current in RL Circuit. **[04 hrs]**

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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.
3. T.M.R. Ellis, I.R. Philips, Thomas M. Lahey, 1994, *Fortran 90 Programming*, Addison-Wesley Longman Limited, USA
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Supplementary Reading:

1. Verma P. K. and Ahluwalia and Sharma K. C. 1999, *Computational Physics*, New Age International Publishers, India.
2. Ian Chivers, Jane Sleightholme, 2018, Introduction to Programming with Fortran, Springer, New York
3. John Metcalf, Michael L. Reid, and Malcolm Cohen, 1993, Fortran 90/95 Explained, Oxford University Press, UK
4. Brian Hahn, 1997, Fortran 90 for Scientists and Engineers, Taylor & Francis
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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

SEMESTER V

Course Title : **Electromagnetic Theory – II (CORE: THEORY)**

Course Code : **UG-PHY-301**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisite : **Electromagnetic Theory – I**

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: Explain the microscopic theory of magnetism and describe the origins of diamagnetism, paramagnetism, and ferromagnetism.
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.
CLO6: Perform experimental measurements of magnetic properties, analyze B-H curves, and determine key electromagnetic parameters such as magnetic susceptibility, mutual inductance, and core losses in magnetic materials and circuits.

Module I: Magnetostatics **[15 hrs]**

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.

Module II: Magnetic Fields in Matter and Microscopic Theory of Magnetism **[15 hrs]**

1. **Magnetic Fields in Matter**

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**

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

Module III: Maxwell's Equations and Propagation of Electromagnetic Waves [15 hrs]

1. **Maxwell's Equations**

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

2. **Propagation of Electromagnetic Waves**

   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.

Course Title	**: Electromagnetic Theory – II (CORE: PRACTICAL)**
Course Code	**: UG-PHY-301**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hrs.**

List of Experiments:

1. Study of Hysteresis by magnetometer. **[04 hrs]**
2. Determination of B, H and plotting the B-H curve in a soft ferrite. **[04 hrs]**
3. Measurement of core losses and copper losses in a transformer. **[03 hrs]**
4. Measurement of mutual inductance using ballistic galvanometer. **[04 hrs]**
5. Calibration of lock-in-amplifier and determination of mutual inductance. **[04 hrs]**
6. Determination of magnetic susceptibility of $FeCl_3$ by Quincke's method. **[04 hrs]**
7. Determination of 'M/C' using ballistic galvanometer **[04 hrs]**
8. Study and application of Biot-Savart's law **[03 hrs]**

REFERENCES:

Mandatory Reading:

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.
3. Laud B. B., *Electromagnetics*, 1987, Wiley Eastern Ltd., New Delhi
4. Puri S. P., 1997, *Classical Electrodynamics,* Tata McGraw Hill, New Delhi.
5. Jackson, J. D., 1998, *Classical electrodynamics*, 3rd ed., Wiley

Supplementary Reading:

1. Mukherji U., 2008, *Electromagnetic Field Theory and Wave Propagation*, Narosa Publishing House.
2. Mahajan A. S., Rangawala A. A., 2017, *Electricity and Magnetism*, Tata McGraw-Hill Publishing Company Ltd.
3. Chattopadhay D., Rakshit P. C., 2011, *Electricity and Magnetism*, 9th Ed., New Central Book Agency.
4. Zangwill, A., 2012, *Modern electrodynamics*, Cambridge University Press.
5. Sadiku, M. N. O., 2014, *Elements of electromagnetics,* 6th ed., Oxford University Press.

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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

Course Title : **Solid State Physics (CORE: THEORY)**

Course Code : **UG-PHY-302**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisites : **Quantum Mechanics**

Course Objective: This course deals with crystalline solids and is intended to provide students with basic physical concepts and mathematical tools used to describe solids. The course broadly deals with the topics related to structural aspects and the various physical properties of crystalline solids.

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

CLO1: Identify bonding types in crystalline solids and correlate the nature of bonding of solid to some of the physical properties associated with it.

CLO2: Identify different crystal systems and determine structural parameters like unit cell of crystal lattices, translation vectors, atomic packing, crystal planes and directions with help of Miller Indices. Determine the crystal structure using various methods of diffraction of X-ray by crystals.

CLO3: Explain and apply classical theory of electrical conduction and quantum mechanical principles to understand the electrical and thermal properties of metals.

CLO4: Derive Kronig-Penney Model using Bloch's theorem and interpret energy band structures in solids and related concepts.

CLO5: Distinguish materials with respect to their magnetic properties.

CLO6: Perform experiments to measure the lattice constant from X-ray diffraction, Fermi Energy, Energy bandgap, Energy loss using hysteresis loop and magnetic susceptibility, thus by correlating theoretical concepts with experimental findings.

Module I: Bonding in Solids and Crystal Structures **[20 hrs]**

1. **Bonding in Solids**
   Introduction, Bonding in Solids, Cohesive energy, Ionic bonding, Calculation of Cohesive energy of ionic solids, Covalent bonding, Metallic bonding, Hydrogen bonding, Van der Waals (Molecular) bonding.
2. **Crystal Structure**
   Introduction, Space Lattice, Unit cell, Lattice Parameter of unit cell, Bravais lattices, Crystal Symmetry, Stacking sequences in metallic crystal structure, SC, BCC, FCC and

HCP structures, Crystal structures- NaCl, diamond, CsCl, ZnS, Directions in crystals, Planes in crystals- Miller indices, Distances of Separation between Successive (*hkl*) Planes.

3. **Diffraction of X-rays by Crystals**

   Introduction, Bragg's law, Bragg's X-ray Spectrometer, Powder Crystal method (Debye Scherrer method), Rotating Crystal method.

Module II: Properties of Solids **[15 hrs]**

1. **Electrical Properties:**
   The Classical Free Electron Theory: Free Electron Gas Model, Relaxation Time, Collision Time and Mean Free Path, Success and Drawbacks of Classical theory.
   The Quantum Theory of Free Electrons: Revision of particle in a rectangular three-dimensional box, Electrical conductivity.
   Fermi distribution function, Density of energy states: Carrier concentration, Fermi energy and Mean energy of electron at absolute zero
   Electrical conductivity from Quantum mechanical consideration, Sources of electrical resistance in metals
2. **Thermal Conductivity and Thermionic Emission:**
   Thermal Conductivity in metals, Joule's Law, Thermionic emission, Failure of Sommerfeld's free electron model
3. **Magnetic Properties:**
   Introduction, Classification of magnetic materials, The quantum numbers, Origin of magnetic moment, Ferromagnetism, Ferromagnetic domains, Hysteresis, Hard and soft materials.

Module III: Band Theory of Solids **[10 hrs]**

Bloch's Theorem, Kronig-Penney model, Construction of Brillouin Zones in one-dimension and in two-dimension, Extended and reduced Zone Scheme, Number of possible wave functions in a band, Motion of electrons in one- dimensional periodic potential: Crystal momentum, Velocity and Effective mass of electron, Distinction between Conductors, Intrinsic Semiconductors and Insulators.

Course Title : **Solid State Physics (CORE: PRACTICAL)**

Course Code : **UG-PHY-302**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of Experiments:

1. Energy band gap of a semiconductor using a diode **[04 hrs]**
2. Energy band gap of a thermistor **[04 hrs]**
3. Determination of Fermi energy of Copper **[04 hrs]**
4. Measurement of Hysteresis loss using CRO **[06 hrs]**
5. Calculation of lattice constant of Copper by using X-ray diffraction pattern **[04 hrs]**
6. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap **[04 hrs]**
8. Determination of magnetic susceptibility using Gouy's method **[04 hrs]**

REFERENCES:

Mandatory Reading:

1. Pillai S. O., 2018, *Solid State Physics,* 8th Multi Colour Edition, New Age International Publisher.
2. Palanisamy P. K., 2004, *Solid State Physics*, Scitech Publications (India) Pvt. Ltd.

Supplementary Reading:

1. Kittel C., 2004*, Introduction to Solid State Physics*, 8th Edition, John Wiley and Sons.
2. Dekker A. J., 1998, *Solid State Physics*, Macmillan India Ltd. Publisher.
3. Puri R. K. and Babbar V. K., 2010, *Solid State Physics*, S. Chand.

Web References:

1. https://www.classcentral.com/course/swayam-introduction-to-solid-state-physics-13045
2. https://www.classcentral.com/course/swayam-solid-state-physics-14298
3. https://bmsce.ac.in/Applied_physics_consolidated_notes
4. https://onlinecourses.nptel.ac.in/noc22_ph37/preview
5. https://www.damtp.cam.ac.uk/user/tong/solidstate.html
6. https://bdu.ac.in/physics

Course Title : **Thermodynamics and Statistical Mechanics (CORE: THEORY)**

Course Code : **UG-PHY-303**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisite : **Heat and Thermodynamics**

Course Objectives: This course will introduce kinetic theory, classical thermodynamics, and statistical methods to analyse physical systems.

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

CLO1: Explain the basics of kinetic theory of gases.

CLO2: Comprehend concepts of thermodynamic potentials and their physical interpretation.

CLO3: Analyze and interpret Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics, applying them to classical gases, black body radiation, and electron behavior in metals.

CLO4: Describe lattice vibration theories and the concept of Fermi energy to analyse the specific heat of solids.

CLO5: Apply experimental and computational techniques to study thermal, electrical, and statistical properties of materials.

Module I: Kinetic theory of Gases and Thermodynamic Potentials. [15 hrs]

1. **Kinetic theory of Gases:**
   Basic assumptions, Equation of State of an Ideal Gas, Collisions with a moving wall, the principle of equipartition of energy, classical theory of specific heat capacity, specific heat capacity of a solid.
2. **Thermodynamic Potentials**
   Internal Energy. Helmholtz's Free Energy, Enthalpy, Gibb's Free Energy, Maxwell's Relations Applications of Maxwell's Thermodynamic Relations.

Module II: Statistical Thermodynamics and Quantum Statistics [20 hrs]

1. **Statistical Thermodynamics**
   Phase space, Probability of distribution, The most probable distribution, Maxwell Boltzmann Statistics. Molecular speeds: mean, most probable and r. m. s. speeds. Experimental verification of Maxwell Boltzmann statistics.

2. **Quantum Statistics**
   Bose Einstein statistics, Blackbody Radiation, Rayleigh Jeans formula, Plank radiation formula, Fermi Dirac statistics.

Module III: Lattice Vibrations and Specific Heats of Solids **[10 hrs]**

Thermal Vibrations: Frequencies. Thermal Vibrations: Amplitudes. Normal Modes of a Lattice. Phonons. Specific Heats of Solids. The Einstein's theory. The Debye Theory. Fermi energy, Electron energy distribution.

Course Title **: Thermodynamics and Statistical Mechanics (CORE: PRACTICAL)**

Course Code **: UG-PHY-303**

Credits **: 1**

Marks **: 25**

Duration **: 30 hrs.**

List of experiments:

1. Specific heat of Graphite. **[04 hrs]**
2. Comparative Analysis of Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac Distributions Using Computational Simulation. **[04 hrs]**
3. Study the temperature dependence of resistivity. **[04 hrs]**
4. OPAMP as a bridge amplifier and its application in temperature measurement. **[04 hrs]**
5. Determination of Boltzmann constant. **[02 hrs]**
6. Study of Stefan's Law. **[04 hrs]**
7. Determination of Stefan's constant. **[04 hrs]**
8. Thermal conductivity of poor conductor by LEE's method/Thermal conductivity of material (Online simulation) **[04 hrs]**

REFERENCES:

Mandatory Reading:

1. Beiser A. 1995. *Perspectives of modern physics*, 5th edition, McGraw hill.
2. Sears F. and Salinger G. 1998. *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, 3rd Edition, Narosa Publishing House Pvt. Ltd.
3. Kachhava C. M. 2003. *Solid State Physics Solid State Devices and electronics*, New Age International (P) Limited.
4. Singh D., Mishra G. Yadav R. 2016. *Thermal Physics: Kinetic Theory and Thermodynamics*, Narosa Publishing House Pvt. Ltd.
5. Daniel Schroeder. 2021. *An Introduction to Thermal Physics*, OUP Oxford.

Supplementary Reading:

1. Garg S., Bansal R.and Ghosh C. 1993. *Thermal Physics*, Tata McGraw Hill.
2. Zemansky M. and Ditman R. 1997. Heat *and Thermodynamics*, McGraw Hill.
3. Reif F., 1965, *Fundamentals of Statistical and Thermal Physics*, Mc Graw Hill
4. Brijlal, Subrahmanyam N. 2008. *Heat thermodynamics and Statistical Physics*, S Chand Company Ltd.
5. Laud B. 2003. *Introduction to Statistical Mechanics*, New Age International.
6. Saha M. and Shrivastava B. 1965. *Treatise on heat*, The Indian Press.
7. Huang k. 2021. *Statistical Mechanics*. Wiley India Pvt Ltd

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1. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/
2. https://nptel.ac.in/courses/113106039/
3. https://edurev.in/t/188012/Einstein-Debye-Theory-of-Specific-Heat
4. https://aptv.org/Education/khan/topic.php?topic=thermodynamics
5. https://itp.uni-frankfurt.de/~gros/Vorlesungen/TD/5_Thermodynamic_potentials.pdf

Course Title	**: Solid State Devices (VOC: THEORY)**
Course Code	**: UG-PHY- VOC3**
Credits	**: 3**
Marks	**: 75**
Duration	**: 45 hours**
Pre-requisites	**: Nil**

Course Objectives: To provide a clear explanation of the operation of most commonly used solid state devices.

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

CLO1: Comprehend the p-n junction theory and analyse the effect of heat and light on the performance of the semiconductor devices.

CLO2: Classify different types of special diodes, their characteristics and use of these devices in various electronics applications.

CLO3: Use different types of optoelectronic and industrial devices and their uses in various electronics applications.

CLO4: Design, construct and working of the circuits based on breakdown devices.

CLO5: Contrast the advantages and disadvantages of FETs, including the construction and operation of JFETs and MOSFETs, their characteristic curves, parameters, temperature effects, and applications in various circuits.

CLO6: Develop experimental skills in analyzing device characteristics.

Module I: Basic Semiconductor and pn-Junction Theory and Special Diodes [15 hrs]

1. **Basic Semiconductor and pn-Junction Theory**
   The Atom, Electron Orbit and Energy Levels, Energy Bands, Conduction in Solids, Conventional Current and Electron Flow, Bonding Forces between Atoms, Classification of Solids, Intrinsic Semiconductor, Conduction of Electrons and Holes, *p*-Type and *n*-Type Semiconductors, Effect of Heat and Light, Drift Current and Diffusion Current, The *pn*-Junction, Reverse-biased Junction, Forward-biased Junction, Temperature Effect, Mobility and Conductivity, Hall Effect and Hall Coefficient.
2. **Special Diodes:**
   Zener Diode, Use of Zener Diode as voltage regulator and as Peak Clipper, Meter Protection, Tunneling Effect, Tunnel Diode, Tunnel Diode as Oscillator, Varactor, PIN Diode, Schottky Diode, Step Recovery Diode.

Module II: Optoelectronic Devices and Industrial Devices [20 hrs]

1. **Optoelectronic Devices:**
   Light Units, Photomultiplier tube, Photoconductive Cell, Photovoltaic Cell, Photodiode, Solar Cell, Phototransistor, PhotoFET, Spectral response of Human eye, Light Emitting Diode(LED), Liquid Crystal Display(LCD), Optoelectronic Couplers, Laser Diode, Light Dependent Resistor (LDR).

2. **Industrial Devices:**
   Silicon Controlled Rectifier(SCR), SCR Characteristic and Parameters, Simple applications of SCR: HWR, Battery-charging regulator and Temperature Controller, Silicon Controlled Switch (SCS), Gate Turn Off switch (GTO), Light Activated SCR (LASCR), Shockley Diode, The TRIAC and DIAC, Typical Diac-Triac Phase control circuit, The Unijunction Transistor(UJT), UJT Characteristics, UJT Parameter and Specification, UJT Relaxation Oscillator, UJT Control of SCR, Programmable Unijunction Transistor.

Module III: Field Effect Transistors **[10 hrs]**

Advantage and Disadvantage of The FET, Basic Construction of JFET, Characteristics curves of The JFET, Principle of operation of The JFET, Effect of V_{DS} on Channel Conductivity, Channel Ohmic Region and Pinch-Off Region, Characteristic Parameters of The FET, Effect of Temperature on FET Parameters, The MOSFET, The Depletion MOSFET, The Enhancement MOSFET, The difference between JFETs and MOSFETs, Dual Gate MOSFET, FET used in Phase-Shift Oscillator Circuit, Applications of FET in its Channel Ohmic Region, FET as a VVR in Voltage controlled Attenuator and in an Automatic Gain Controlled Circuit, Field-Effect Diode and its use as CRD, Power MOSFETs.

Course Title	**: Solid State Devices (VOC: PRACTICAL)**
Course Code	**: UG-PHY- VOC3**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hrs.**

List of Experiments:

1. Study of VI characteristics and determination of energy gap of LEDs. **[03 hrs]**
2. Study of Zener Diode Characteristics and Voltage regulation. **[03 hrs]**
3. Study of LDR Characteristics **[03 hrs]**
4. Study of Phototransistor **[03 hrs]**
5. SCR characteristics and gate-controlled ac half wave rectifier **[04 hrs]**
6. UJT Characteristics and its use in relaxation oscillator **[04 hrs]**
7. FET Characteristics **[04 hrs]**
8. SCR, Diac, Triac Characteristics. **[06 hrs]**

REFERENCES:

Mandatory Reading:

1. Bell D. A.,2000, *Electronics Devices and Circuits*, 3rd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi,
2. Singh K., Singh S. P., 2007, *Solid State Devices and Electronics*,1st Edition, S. Chand & Company Ltd., New Delhi,
3. Theraja B. L., 2005, *Basic Electronics (Solid State)*, 1stMulticolour Edition, S. Chand and Company Ltd., New Delhi,
4. Boylestad R., Nashelsky L., 2000, *Electronic Devices and Circuit Theory*, 6th Edition, Prentice-Hall of India Pvt. Ltd., New Delhi
5. Mottershead A., 2000, *Electronics Devices and Circuits An Introduction*, Prentice-Hall of India Pvt. Ltd., New Delhi

Supplementary Reading:

1. Streetman, 2015, *Solid State Electronic Devices*, Pearson Education India
2. Donald A. Neamen,1992, *Semiconductor Physics and Devices,* McGraw-Hill Education, U.S.
3. R. K. P. Singh,2005, *Fundamentals of Solid State Electronics*, New Age International, India
4. Simon M. Sze, Kwok K. Ng, 2006, *Physics of Semiconductor Devices*, Wiley-Interscience, U.S.
5. R.K. Puri and V.K. Babbar, 2001, *Solid State Physics and Electronics*, S. Chand Publishing, India

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3. https://www.electronicshub.org/types-of-diodes/
4. https://www.electronicshub.org/thyristor-basics/
5. https://onlinecourses.nptel.ac.in/noc25_ee75/preview
6. https://ocw.mit.edu/courses/6-701-introduction-to-nanoelectronics-spring-2010/d4cf00dfef7119a36223c743b2e3b424_MIT6_701S10_part5.pdf

Course Title : **Tools and Techniques for Computational Material Science (VOC: THEORY)**

Course Code : **UG-PHY-VOC2**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisites : **Nil**

Course Objectives: This course will provide hands-on experience with computational tools and techniques for analysing properties of materials.

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

CO1: Understand the Linux environment

CO2: Design crystal structures using crystal visualizers

CO3: Plot and visualize data to explore data sets graphically and create high quality graphs.

CO4: Develop skills in using Quantum Espresso for DFT simulations.

Module I: Introduction to Linux Environment **[10 hrs]**

Installation of Virtual Box.

Navigation: Current working directory. Listing the Contents of a Directory. Changing the Current Working Directory.

Exploring the system: Determining A File's Type With file. Viewing File Contents With less. Manipulating files and directories: Creating, deleting, copying and moving of directories and files. Filters: grep, head/tail, tee, awk, sed, more, less.

Vi Editor: Appending text. Deleting text. Cutting, Copying, and Pasting Text. Saving work.

Simple bash scripting: Introduction and executable permissions, if-then-else, do-while and for loops.

Module II: Crystal Structure Tools and Data Visualization **[15 hrs]**

1. **Crystalline and molecular structure visualization**
   Installing Vesta. Designing crystal structures. Simulate XRD pattern. Visualizing lattice planes and drawing lattice vectors. Creating supercells and structures with impurities and vacancy.
   Visualizing crystal structures using XCrySDen.

2. **Data Visualization**
   Introduction to gnuplot. Simple plots. Plotting data from a file. Abbreviations and defaults. Saving commands and exporting graphs. Plotting functions and data. Math with gnuplot. Multiple data sets per file. Different plot styles. Multiple axis. Plot range. Tic marks.

Module III: Basics of DFT and Quantum Espresso Fundamentals [20 hrs]

1. **Introduction to Density Functional Theory (DFT)**
   Overview of DFT. Schrödinger equation and electron density. From wave function to electron density. Exchange correlational functional. Reciprocal space and k-points. Plane wave basis and Energy cut-off. Pseudopotentials.
2. **Quantum Espresso Fundamentals**
   Installation of Quantum espresso. Introduction to Quantum Espresso input and output files. Total energy and self-consistent field calculations. Plane wave cut-off energy and K-point convergence. Geometric optimization. Magnetic properties. Electronic density of states. Band structure calculations.

Course Title : Tools and Techniques for Computational Material Science (VOC: PRACTICAL)

Course Code : UG-PHY-VOC2

Credits : 1

Marks : 25

Duration : 30 hrs.

List of Experiments:

1. Text manipulation and File editing with Vi editor. **[02 hrs]**
2. Introductory programs for Bash scripting. **[02 hrs]**
3. Designing and visualizing 2D and 3D crystal structures with doping impurities and supercell. **[02 hrs]**
4. Visualizing of Lattice planes and directions using Vesta. **[02 hrs]**
5. Creating plots with Gnuplot. **[02 hrs]**
6. Mini Project 1: Investigating the Electronic and Mechanical Properties of Materials **[10 hrs]**
   - Determine Ground State Energy and SCF Calculation
   - Optimize Kinetic Energy Cut-off and K-Point Grid
   - Geometric Optimization (Relaxation & Variable-Cell Relaxation)
   - Calculate and Plot the Density of States (DOS)
   - Compute and Analyze the Band Structure
   - Report writing and analysis
7. Mini Project 2: Investigating the Mechanical Properties of Materials **[10 hrs]**
   - Determine Ground State Energy and SCF Calculation
   - Optimize Kinetic Energy Cut-off and K-Point Grid

- Geometric Optimization (Relaxation & Variable-Cell Relaxation)
- Evaluate Bulk Modulus via Energy-Volume Fitting

  Or

  Stress-Strain Analysis & Elastic Constants Calculation
- Determine Formation Energy or Binding energy
- Report writing and analysis

REFERENCES:

Mandatory Reading:

1. Shotts W. 2013. *The Linux Command Line* 2nd Edition, No Starch Press, USA
2. Momma, K. & Izumi, F. 2019. *VESTA: A Three-Dimensional Visualization System for Electronic and Structural Analysis*, jp-minerals.org.
3. Kokalj, A. 1999. *J. Mol. Graphics Modelling*, 17, 176–179. Code available from
4. Janert P. 2016. *Gnuplot in Action: Understanding data with graphs* 2nd Edition, Manning Publications, USA
5. Sholl D., Steckel J. 2009. *Density Functional Theory: A Practical Introduction*, John Wiley & Sons, New Jersey.
6. Hung N., Nugraha A., Saito R. 2023. *Quantum ESPRESSO Course for Solid-State Physics*, Jenny Stanford Publishing Pvt. Ltd., Singapore.

Supplementary Reading:

1. Canon J. 2013. Linux for Beginners: An Introduction to the Linux Operating System and Command Line, Kindle publishing.
2. Giustino J. 2014. *Materials Modelling using Density Functional Theory: Properties and Predictions*, OUP Oxford.
3. Tara Prasad. 2021. *Quantum Espresso- Easy way to use it for Research project and PhD*, Kindle publishing.
4. Richard Martin. 2020. *Electronic Structure*. Cambridge University Press.
5. Rajendra Prasad. 2013. Electronic Structure of Material, CRC Press.

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2. https://www.compmatphys.org/
3. https://www.tutorialspoint.com/unix/index.htm
4. https://www.coursera.org/learn/density-functional-theory
5. https://www.quantum-espresso.org/tutorials/

SEMESTER VI

Course Title **: Atomic and Molecular Physics (CORE: THEORY)**

Course Code **: UG-PHY-305**

Credits **: 3**

Marks **: 75**

Duration **: 45 hrs.**

Pre-requisites **: Quantum Mechanics**

Course Objectives: Atomic and molecular physics is the study of dynamics and interactions of the basic building blocks of matter. The objective of this course is to study the behaviour of the electrons that surround the atomic nucleus which will help students to understand the dynamics atoms and molecules.

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

CLO1: Solve the case of the hydrogen atom using the three-dimension time-independent Schrödinger equation, identify atomic effect such as space quantization and interpret the wave functions and probability densities.

CLO2: Explain the orbital, spin and total angular momentum of many electron atoms.

CLO3: Interpret the observed dependence of atomic spectral lines on externally applied magnetic fields.

CLO4: Explain the physics of diatomic molecules, their electronic states, vibrations and rotations and their spectra.

CLO5: Explain classical and quantum theory of Raman effect.

CLO6: Develop computational and experimental skills through problem-solving in quantum mechanics, spectroscopy, and molecular analysis.

Module I: Quantum Mechanics of Hydrogen and Multi-Electron Atoms [15 hrs]

1. **Quantum Theory of the Hydrogen Atom**
   Schrodinger's equation for the H-atom. Separation of variables, Eigen values, Quantum numbers and Magnetic moment. Angular momentum, Electron Probability density.

2. **Many Electron Atoms**
   Electron Spin. Pauli Exclusion Principle and classification of elements in periodic table. Symmetric and Antisymmetric wave functions. Electron configuration. Hund's rule. Total angular momentum. L-S coupling. J-J coupling.

Module II: Magnetic Field Effects, Atomic Spectra, and X-ray Analysis [15 hrs]

1. **Atoms in a Magnetic Field:**
   Effects of magnetic field on an atom. Larmor Precession. The Stern-Gerlach experiment. Spin Orbit Coupling. The Normal Zeeman effect, Lande 'g' factor. Zeeman pattern in a weak field (Anomalous Zeeman effect).

2. **Atomic Spectra:**
   Origin of Spectral lines. Selection rules (derivation from transition probabilities). Alkali metal type spectra. Principal, Sharp, Diffused and Fundamental series, fine structure in alkali spectra.
3. **X-ray Spectra:**
   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.

Module III: Molecular Spectra and Raman Effect **[15 hrs]**

1. **Spectra of Diatomic Molecules:**
   Rotational energy levels. Rotational spectra. Vibrational energy levels. Vibration -Rotation spectra. Fortrat Parabolas and explanation of band structure on its basis. Electronic spectra.
2. **Raman Effect:**
   Quantum theory of Raman effect. Classical theory of Raman effect. Pure rotational Raman spectra. Vibrational Raman spectra. Rotational fine structure. Experimental set up for Raman effect.

Course Title : **Atomic and Molecular Physics (CORE: PRACTICAL)**

Course Code : **UG-PHY-305**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of experiments:

1. To find the wavelengths of Balmer series of visible emission lines and to determine the value of Rydberg constant. **[04 hrs]**
2. Numerically solving the Time Independent Schrödinger equation for the case of Harmonic oscillator. **[04 hrs]**
3. Numerically solving the Radial Schrödinger equation for the case of Hydrogen atom. **[04 hrs]**
4. Mini Project: Numerical analysis of Morse and Other accurate diatomic Potentials for Vibrational Spectra of Molecules **[06 hrs]**
5. Bond length and Bond Force Constant calculations from Vibration-Rotation Spectra. **[04 hrs]**
6. X-ray Emission (characteristic lines of copper target)- Calculation of wavelength and Energy. **[04 hrs]**
7. Resolving Sodium D-lines using grating. **[04 hrs]**

REFERENCES:

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. Mcgervey, J. 1983. *Introduction to Modern Physics*, Academic Press, USA.
4. Rajam, J. 2000. *Atomic Physics*, S. Chand and Company limited, New Delhi.
5. Banwell, C. 1994. *Fundamentals for Molecular Spectroscopy*, 4th Edition, McGraw-Hill Higher Education.

Supplementary Reading:

1. White, H. 1934. *Introduction to Atomic Spectra*, McGraw-Hill Inc., USA.
2. Bransden, B. and Joachain, J. 2003. *Physics of Atom and Molecules*, Pearson Education India.
3. Kumar, R. 2003. *Atomic and Molecular Physics*, Campus Book International.
4. Richtmyer, F., Kennard, E., Cooper, J. 2001. *Introduction to Modern Physics*, 6th ed. Tata McGraw-Hill Book Company, New Delhi.
5. B. H. Bransden, C. J. Joachain. 2003. *Physics of Atoms and Molecules*, Pearson Education India.

Web References:

1. Das, A.K. (2017). Retrieved from https://nptel.ac.in/courses/115/105/115105100/#
2. PhET Interactive Simulations, University of Colorado Boulder, https://phet.colorado.edu/en/simulation/legacy/stern-gerlach
3. Geva, E. (20120). Retrieved form https://demonstrations.wolfram.com/HydrogenAtomRadialFunctions/
4. Morse, P. M. (1929). Diatomic Molecules According to the Wave Mechanics. II. Vibrational Levels. *Physical Review, 34*(57).
5. Singh, R. (2002). C. V. Raman and the Discovery of the Raman Effect. *Physics in Perspective, 4*, 399-420.

Course Title : **Mechanics – II (CORE: THEORY)**

Course Code : **UG-PHY-306**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisites : **Mechanics – I**

Course Objectives: To acquaint students with a higher-level Mechanics which includes advanced concepts through topics like central force problems, mechanics in non-inertial frames, motion of rigid bodies, collision theory and Lagrangian formulation.

Course Learning Outcomes: At the end of this course, students will be able to:
CLO1: Derive and solve the equation of orbit for the motion under inverse square law force and study different types of orbits.
CLO2: Differentiate between elastic and inelastic collisions and calculate cross-sections for particle scattering in central force fields.
CLO3: Relate time derivative of a vector in a fixed frame of reference to that of moving frame of reference and comprehend the occurrence of some pseudo forces such as Coriolis's force, centrifugal force due to relative motion of the particle in the fixed frame and rotating frames of reference.
CLO4: Derive and solve Euler's equations of motion to comprehend the dynamics of rigid bodies.
CLO5: Apply D'Alembert's principle to obtain Lagrange's equation of motion and utilize it to solve various mechanical problems.
CLO6: Apply numerical techniques to solve equation of orbit to model the trajectory of motion under central forces and apply experimental techniques to determine fundamental mechanical properties such as acceleration due to gravity, moment of inertia and analyse rotational motion.

Module I: Motion Under a Central Force and Collisions of Particles **[15 hrs]**

1. **Motion Under a Central Force**
   Center of mass coordinate, equivalent one body problem, general features of motion in a central force field, motion in an inverse square law force field, equation of the orbit, nature of orbits, elliptical orbits: the Kepler problem, hyperbolic orbits, parabolic orbits.
2. **Collisions of Particles**
   Elastic and inelastic cross section, scattering in a central force field, scattering cross section, Rutherford scattering cross-section.

Module II: Moving Coordinate Systems and The Rotation of a Rigid Body **[20 hrs]**

1. **Moving Coordinate Systems**
   Moving origin of coordinates, rotating coordinate system, laws of motion on rotating earth, effect of Corioli's force on freely falling particles, the Foucault pendulum.

2. **The Rotation of a Rigid Body**
   Euler's theorem, angular momentum and kinetic energy, the inertia tensor, Motion of a rigid body in space, Euler's equations of motion for a rigid body, torque free motion, Euler's angles, qualitative discussion of the symmetric top.

Module III: Lagrangian Formulation **[10 hrs]**
Constraints, generalized coordinates, D'Alembert's principle, Lagrange's equations, a general expression for kinetic energy, symmetries and law of conservation, cyclic or ignorable coordinates.

Course Title	**: Mechanics – II (CORE: PRACTICAL)**
Course Code	**: UG-PHY-306**
Credits	**: 1**
Marks	**: 25**
Duration	**: 30 hrs.**

List of Experiments:

1. Determination of 'g' using Kater's Pendulum **[04 hrs]**
2. Measurement of Moment of Inertia of Uniform Rigid Bodies: Bifilar Suspension **[04 hrs]**
3. Principle of conservation of linear momentum using linear air track **[04 hrs]**
4. Value of 'g' by Rod pendulum **[04 hrs]**
5. To Study the different oscillation modes of the coupled pendulum **[04 hrs]**
6. To determine the moment of inertia of Gyroscope disc **[04 hrs]**
7. Equation of Orbit (bounded orbit) simulation experiment **[03 hrs]**
8. Equation of Orbit (unbounded orbit) simulation experiment **[03 hrs]**

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Mandatory Reading:

1. Symon K. R., 1971, *Mechanics*, 3rd Edition, Pearson, India
2. Takwale R. G., and Puranik P. S., 1992, *Introduction to Classical Mechanics*, Tata Mc-Graw Hill, New Delhi
3. Taylor J. R., 2005, *Classical Mechanics*, University Science Books, USA
4. Goldstein H., 1998, *Classical Mechanics,* McMillan, Bombay
5. Rana N. C., Joag P. S., 1991, *Classical Mechanics,* Tata Mcgraw-Hill,

Supplementary Reading:

1. Lindsay R.B., 1961, *Physical Mechanics,* Van Nostrand, New York.
2. Upadhyaya J. C., 1991, *Classical Mechanics,* Himalaya, Publishing House, Mumbai.
3. Gupta S. L., Kumar V., Sharma H. V., 2021, *Classical Mechanics*, Pragati Prakashan.

4. Panat P. V., 2004, *Classical Mechanics*. Alpha Science International Ltd.
5. Hans H. S., Puri S. P., 1997, *Mechanics,* Tata McGraw Hill.

Web References:

1. http://www.dept.aoe.vt.edu/~lutze/AOE4134/4OrbitSolution.pdf
2. http://web.mit.edu/12.004/TheLastHandout/PastHandouts/Chap03.Orbital.Dynamics.pdf
3. http://twister.ou.edu/PM2000/Chapter7.pdf
4. http://www.southampton.ac.uk/~stefano/courses/PHYS2006/chapter4.pdf
5. https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/
6. https://nptel.ac.in/courses/115/105/115105098/

Course Title : **Nuclear and Elementary Particle Physics (CORE: THEORY)**

Course Code : **UG-PHY-307**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Pre-requisites : **Quantum Mechanics**

Course Objectives: The objective of this course is to introduce students to the fundamental principles and concepts governing nuclear and particle physics.

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

CLO1: Understand the properties of nuclei like density, size, binding energy, magnetic moment, quadrupole moment, and nuclear forces.
CLO2: Explain the liquid drop model and shell model to understand nuclear properties.
CLO3: Derive an expression for Q-value and use it to classify the nuclear reactions.
CLO4: Explain the radioactive decays like alpha, beta, and gamma decay.
CLO5: Explain fission as a nuclear process and understand its use to produce nuclear energy in nuclear reactor.
CLO6: Understand the basic aspects of elementary particles and the fundamental interactions.

Module I: **[20 hrs]**

1. **Basic Nuclear Properties**
   Nomenclature, Nuclear Size (Electron scattering and Mirror Nuclei), Nuclear Charge, Nuclear Mass, Nuclear Density, Nuclear Spin, Nuclear Magnetic Moment, Nuclear Electric Quadrupole Moment, Parity, Binding Energy, Nuclear Stability, Packing Fraction
2. **Nuclear forces**
   Main characteristics of Nuclear Forces, Meson theory of nuclear forces, Estimation of the mass of a meson using Heisenberg's Uncertainty Principle, Yukawa potential
3. **Liquid drop model of a nucleus**
   Analogy between liquid drop and a nucleus, Assumptions of Liquid Drop Model, Wiezsacker Semi- Empirical Mass Formula, Equation for Mass Parabola for Isobaric Nuclei, Merit and Demerit of Semi-Empirical Mass Formula, Potential Barrier for Fission, Stability Limit against Spontaneous Fission (Bohr and Wheeler Theory for Fission Process), Energetic of Symmetric Fission
4. **Nuclear Shell Model**
   Experimental basis of Shell Model, Single-Particle Shell Model, Shell Model with Spin-Orbit Coupling, Prediction of ground state spin and parity, Prediction of Magnetic Moment, Prediction of Quadruple moment,

Module II: **[15 hrs]**

1. **Nuclear Reactions** Nuclear Reactions, The Balance of mass and energy in Nuclear Reactions(Q-Value), The Q-Equation.

2. **Radioactive decay**
   Alpha decay: Magnetic Spectrograph-Velocity and Energy of Alpha Particles, Bragg's Experiment-Range of Alpha Particles, Geiger Law, Geiger-Nuttal Law, Disintegration energy of Spontaneous Alpha-decay, The Alpha Spectra and Fine structure: Short Range and Long-Range Alpha Particles, Alpha Decay Paradox-Barrier Penetration (Qualitative treatment)
   Beta Decay: Magnetic Spectrograph-Velocity and Energy of Beta Particles, Origin of Continuous Beta –ray Spectrum and difficulties in understanding it, Pauli's Neutrino Hypothesis. Types of Beta decay, Energies of Beta -decays
   Gamma Decay: Origin of Gamma Decay, Internal Conversion, Nuclear isomerism, The Absorption of Gamma Rays with Matter, Detection of Gamma rays using G. M. Counter
3. **Nuclear Energy**
   Neutron Induced Fission, Asymmetrical Fission-Mass Yield, Energy released in the fission of U-235, Fission Chain Reaction, Principle of a Nuclear Reactor, Neutron cycle in a Thermal Nuclear Reactor (The four-factor formula), Principle of a Breeder Reactor.

Module III: **[10 hrs]**

Elementary Particle Physics

Classification of Elementary Particles, Particles and Antiparticles, Fundamental Interactions, Quantum Numbers, Conservation Laws, Gell-Mann-Nishijima Formula, Concept of Quark Model, Baryons and Mesons as Bound States of Quarks

Course Title : **Nuclear and Elementary Particle Physics (CORE: PRACTICAL)**

Course Code : **UG-PHY-307**

Credits : **1**

Marks : **25**

Duration : **30 hrs.**

List of experiments:

1. Study of the characteristics of a GM tube and determination of its operating voltage, plateau length / slope etc. **[04 hrs]**
2. Determination of Absorption Coefficient using GM counter. **[04 hrs]**
3. Verification of Inverse Square Law using GM counter. **[04 hrs]**
4. Determination of empirical constants of semi-empirical mass formula through data fitting. **[04 hrs]**
5. Analyze the Yukawa potential by numerically solving the Schrödinger equation to obtain the corresponding eigenvalues. **[04 hrs]**
6. Half-Life of Ba-137m **[02 hrs]**
7. Identifying Unknown Radiation **[02 hrs]**
8. Simulation of half-life of radioactive decay using rolling of dice. **[04 hrs]**
9. Gamma Spectroscopy with GeLi Detector: Calibration and Analysis of Radioactive Sources. **[02 hrs]**

REFERENCES:

Mandatory Reading:

1. Jain, V. K., 2015, *Nuclear and Particle Physics*, Ane Books Pvt. Ltd., New Delhi.
2. Patel, S. 2011, *Nuclear Physics: An Introduction*, 2nd Edition. New Age International Limited, New Delhi.
3. Ilangovan, K. 2012, *Nuclear Physics*, MJP Publishers, Chennai.

Supplementary Reading:

1. Krane, K. 1987, *Introductory Nuclear Physics,* 3rd Edition. Wiley, New Jersey.
2. Kaplan, I. 1956, *Nuclear Physics,* 3rd Edition, Addison-Wesley, Boston.
3. Beiser, A. 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.

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2. https://openstax.org/books/college-physics-2e/pages/31-3-substructure-of-the-nucleus
3. https://ocw.mit.edu/courses/22-02-introduction-to-applied-nuclear-physics-spring-2012/d0d046f78c917f107d925f11ac862ae4_MIT22_02S12_lec_ch1.pdf
4. https://www.gigaphysics.com/gmtube_lab.html
5. https://edu.jinr.ru/vlabs/

Course Title **: Introduction to Special Theory of Relativity (CORE: THEORY)**

Course Code **: UG-PHY-308**

Credits **: 4**

Marks **: 100**

Duration **: 45 hrs.**

Pre-requisites **: Topics from Mechanics and Electromagnetic Theory**

Course Objectives: The objective of this course is to introduce students to Special Theory of Relativity.

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

CLO1: Understand the limitations of Newtonian relativity and the implications of the Michelson-Morley experiment, Lorentz-Fitzgerald contraction hypothesis, and the principles underlying Einstein's theory of special relativity.
CLO2: Apply the concepts of relativity of simultaneity and the consequences of Lorentz transformation equations, relativistic addition of velocities, and transformations of velocities with examples, as well as analyze the Doppler effect within the framework of relativity.
CLO3: Comprehend the principles of mechanics and relativity, with a focus on redefining momentum, the concepts of relativistic momentum and mass, the equivalence of mass and energy, and the transformation properties of momentum, energy, mass, and force in relativity.
CLO4: Illustrate the interdependence of electric and magnetic fields, including the transformations for electric (E) and magnetic (B) fields, the field of a uniformly moving point charge, and the forces and fields associated with current-carrying wires and moving charges, while evaluating the invariance of Maxwell's equations.
CLO5: Illustrate the concepts of simultaneity, length contraction and time dilation and the twin paradox using Minkowski space-time diagrams.

Module I: **[20 hrs]**

1. **Experimental Background:**
   Galilean Transformation, Newtonian relativity, Electromagnetism and Newtonian relativity, Michelson Morley experiment, Lorentz-Fitzgerald contraction hypothesis, Ether Drag hypothesis, attempts to modify electrodynamics, postulates of the theory of special Relativity. Einstein and origin of relativity theory.
2. **Relativistic Kinematics**
   Relativity of simultaneity, Derivation of Lorentz transformation equations, some consequences of Lorentz transformation equations, Relativistic addition of velocities, relativistic transformation of velocities and Doppler effect in Relativity.

Module II: Relativistic Mechanics **[10 hrs]**

Mechanics and Relativity, Redefining momentum, Relativistic momentum, Relativistic mass, Equivalence of mass and energy. The transformation properties of Momentum, Energy, Mass and Force.

Module III: **[15 hrs]**

1. **Relativity and Electromagnetism**
   Interdependence of electric and magnetic fields, Transformation for E and B, Field of a uniformly moving point charge, Forces and fields near a current carrying wire, Forces between moving charges, The invariance of Maxwell's equations, Limitations of special relativity.
2. **The Geometric Representation of Space –Time and Twin Paradox**
   Space-Time Diagrams, Simultaneity, Contraction and Dilation, The time Order and Space Separation of events, The route dependence of proper time, space time diagram of the twin paradox, The experimental test.

Module IV: Tutorials **[15 hrs]**

1. Michelson Interferometer
2. Tutorial on Relativistic Kinematics 1
3. Tutorial on Relativistic Kinematics 2
4. Tutorial on Relativistic Kinematics 3
5. Tutorial on Relativistic Mechanics 1
6. Tutorial on Relativistic Mechanics 2
7. Tutorial on Relativistic Mechanics 3
8. Tutorial on Relativity and Electromagnetism 1
9. Tutorial on Relativity and Electromagnetism 2
10. Tutorial on Relativity and Electromagnetism 3

REFERENCES:

Mandatory Reading:

1. Resnick R., 1965, *Introduction to Special Relativity*, John Wiley, New Jersey, USA
2. James H. Resnick, 1968, *Introduction to Special Relativity*, John Wiley & Sons, New Jersey, USA
3. Albert Einstein, 1920, *Relativity: The Special and General Theory*, H. Holt and Company, USA
4. French A. P., 1968, *Special Relativity*, Chapman & Hall, London, UK.
5. Tatsu Takeuchi*, An Illustrated Guide to Relativity*, Cambridge University Press, UK

Supplementary Reading:

1. Ghatak A., 2009, *Special Theory of Relativity,* Sheth Publishers Pvt., Ltd., Mumbai
2. Beiser A. 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.

3. Feynman R. 2012, *Feynman Lectures on Physics: Quantum Mechanics (Volume - 1)*, Pearson Education, India.
4. Russell B., 2020, *ABC of Relativity*, L.G. Publishers, UK
5. Susskind Leonard, Friedman Art, 2018, *Special Relativity and Classical Field Theory*, Penguin Books Limited, USA

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2. http://edu.itp.phys.ethz.ch/hs10/ppp1/PPP1_2.pdf
3. https://cosmolearning.org/video-lectures/relativistic-kinematics/
4. https://arxiv.org/ftp/arxiv/papers/0910/0910.5847.pdf
5. https://arxiv.org/pdf/physics/0509161.pdf
6. https://nptel.ac.in/courses/115/101/115101011/
7. https://www.ibiblio.org/ebooks/Einstein/Einstein_Relativity.pdf
8. http://www.physics.iisc.ernet.in/~vasant/publications/popular/apr_05.pdf
9. http://physics.mq.edu.au/~jcresser/Phys378/LectureNotes/VectorsTensorsSR.pdf

Course Title : **Instrumentation (VOC: THEORY)**

Course Code : **UG-PHY-VOC4**

Credits : **3**

Marks : **75**

Duration : **45 hrs.**

Course Objectives: The objective of this course is to understand basic concepts related to the various types of measuring instruments and measuring techniques.

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

CLO1: Design, construct, and analyse regulated power supplies using various IC regulators, including LM7800 and LM79XX series, and adjustable regulators like LM317.

CLO2: Demonstrate the working principles and applications of different signal generators.

CLO3: Comprehend the design and operation of measuring instruments, including ammeters, voltmeters, ohmmeters, and mustimeters.

CLO4: Comprehend the principles, characteristics, and performance of various measuring instruments, including digital multimeters, frequency meters, and Q meters.

CLO5: Analyse the usage of various types of transducers in instrumentation applications.

CLO6: Demonstrate the working principles and practical applications of measuring instruments by constructing and analysing circuits using regulated power supplies, signal generators, and transducers.

Module I: Regulated Power Supplies and Signal Generator **[15 hrs]**

1. **Regulated Power Supplies**
   Supply characteristics, Shunt regulators, Series regulators, Monolithic linear regulators: Basic types of IC regulators, LM7800 series, LM79XX series, Regulated dual supplies, Adjustable regulators, LM-317 as a voltage regulator.
2. **Signal Generator:**
   Standard Signal Generator, AF Sine and Square Wave Generator, Function Generator.

Module II: Measuring Devices **[15 hrs]**

DC Ammeter, Multirange Ammeter, Universal Shunt, Requirements of a Shunt, Extending of Ammeter Ranges. Basic Meter as a DC Voltmeter, DC Voltmeter, Multirange Voltmeter, Extending Voltmeter Ranges, Loading, Transistor Voltmeter (TVM), FET DC Voltmeter. AC Voltmeter using Rectifiers, Multirange AC Voltmeter, AC current measurements using AC Voltmeter and a series Resistor. Ohmmeter: Series type and Shunt type, Multimeter. Digital voltmeter: Ramp Technique, Digital Multimeters and Frequency meter (with help of Block Diagrams), Q meter.

Module III: Introduction to Transducers and its applications **[15 hrs]**

Introduction, Electrical Transducer, Selecting a Transducer, Strain Gauges, Resistance Wire Gauge, Types of Strain Gauges (Wire), Foil Strain Gauge, Semiconductor Strain Gauge, Inductive Transducer, Differential Output Transducers, Linear Variable

Differential Transducers (LVDT), Capacitive Transducer, Piezo-Electric Transducer, Semiconductor Diode Temperature Sensor, Temperature Transducers: Resistance Temperature Detectors, Thermistors, Thermocouples.

Course Title **: Instrumentation (VOC: PRACTICAL)**

Course Code **: UG-PHY-VOC4**

Marks **: 25**

Credits **: 1**

Duration **: 30 hrs.**

List of Experiments:

1. Study of IC LM 317 voltage regulator. **[04 hrs]**
2. Construction and design of analog two ranges Voltmeter. **[02 hrs]**
3. Construction and design of analog two ranges Ohmmeter. **[02 hrs]**
4. Crystal Oscillator: Determination of velocity of ultrasonic waves in a liquid medium. **[02 hrs]**
5. Construction and Calibration of a Thermocouple **[04 hrs]**
6. Thermistor as a temperature sensor. **[02 hrs]**
7. Application of Pt 100 as a temperature sensor. **[02 hrs]**
8. Study of strain Gauges **[02 hrs]**
9. Mini Projects: **[10 hrs]**
   a. Design and construction of regulated power supply using LM78XX series (XX = +05, +06, +08, + 10, + 12, + 15).
   b. Design and construction of regulated power supply using LM79XX series (XX = -05, -06, -08, - 10, - 12, - 15)
   c. Design and construction of regulated dual power supply using LM78XX and LM79XX series.

REFERENCES:

Mandatory Reading:

1. Malvino A. and Bates D.J., 2007, *Electronic Principles*, 7th edition, Tata McGraw Hill
2. Kalsi H S, 2010, *Electronics Instrumentation*, 3rd Edition, Tata McGraw Hill Education Pvt. Ltd. New Delhi
3. Mottershead Allen, 2000, *Electronics Devices and Circuits: An Introduction*, Prentice-Hall of India Pvt. Ltd., New Delhi
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5. Doebelin E. O., 2017, *Measurement Systems: Application and Design*, McGraw-Hill.

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1. Boylestad R., and Nashelsky L., 2000, *Electronic Devices and Circuit Theory*, 6th Edition Prentice-Hall of India Pvt. Ltd., New Delhi
2. Helfrick A. D., Cooper W. D., 1994, *Modern Electronic instrumentation as Measurement Techniques*, 2nd Edition Prentice-Hall of India Pvt. Ltd., New Delhi
3. Rangan C. S., Sharma G. R., Mani V. S., 2016, *Instrumentation Devices and Systems*, Tata McGraw-Hill
4. Murthy D. V. S., 2003, *Transducers and Instrumentation*, Prentice Hall of India.
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3. https://electronics-diy.com/Function_Generator_XR2206.php
4. https://www.electronics-tutorials.ws/io/io_1.html
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