RABINDRANATH TAGORE UNIVERSITY, HOJAI, ASSAM, INDIA

Syllabus for Four Year Under Graduate Programme (FYUGP) in Physics of Rabindranath Tagore University

As per NEP-2020 Guidelines

Detailed Syllabus of 1st Semester Major Courses

Course Title: Mechanics and Properties of matter
Course Code: PHY MAJ 1.1
Nature of course: Major/Core
Total credits: 4
Total marks = 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to impart knowledge of Newtonian mechanics and its applications, explore the properties of matter, and develop a foundational understanding of the special theory of relativity.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Newtonian Mechanics	1.1: Frames of Reference, Inertial Frames, Galilean Transformations, Galilean Invariance; Dynamics of aSystem of Particles, Centre of Mass, centre of mass of a half-ring, half-disc and hemisphere. Principle of Conservation of Linear Momentum. Momentum of variable mass: motion of rocket.	5	5	5
	1.2: The Work-Energy Theorem, Conservative and Non- conservative Forces, Conservation of Mechanical Energy, Work done by non-conservative forces, Force as gradient of potential energy, Energy Diagram.	4	4	4
	1.3: Principle of Conservation of Angular Momentum, Rotation about a fixed axis, Moment of Inertia, Calculation of Moment of Inertia for rectangular, cylindrical and spherical bodies, Kinetic Energy of Rotation, Motion involving both translation and rotation.	6	6	6
Unit 2: Properties of Matter	2.1: Relation between Elastic constants, Twisting torque on a Cylinder or Wire.	3	3	3
	2.2: Kinematics of Moving Fluids, Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.	3	3	3
Unit 3: Oscillations	Simple Harmonic Motion (SHM) and Oscillations, Differential Equation of SHM and its solution, Kinetic Energy, Potential Energy, Total energy and their time- average values, Damped oscillation, Forced oscillations,Resonance, Power Dissipation and Quality Factor.	6	6	6
Unit 4: Non-Inertial Systems	Non-inertial Frames and Fictitious Forces, Uniformly Rotating Frame, Laws of Physics in rotating coordinate systems, Centrifugal Force,	6	6	6

	Coriolis Force and its applications, Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.			
Unit 5: Special Theory ofRelativity	Michelson-Morley Experiment and its outcome, Postulates of Special Theory of Relativity, Lorentz Transformations, Simultaneity and order of events, Lorentz contraction, Time dilation. Twin paradox. Relativistic Transformation of Velocity, Frequency and Wave- number, Relativistic addition of Velocities, Variation ofMass with Velocity, Mass-energy Equivalence. Relativistic Kinematics, Transformation of Energy and Momentum, Relativistic Doppler effect.	12	12	12
Total		**45**	**45**	**45**

Lab Practical (Minimum four experiments are to be performed):
1. To determine the Young's modulus of a given material by Searle's apparatus.
2. To determine the Modulus of rigidity of a given wire by static method.
3. To determine the value of 'g' using Bar Pendulum.
4. To determine the value of 'g' using Kater's Pendulum.
5. To determine the Moment of inertia of cylinder about two different axes of symmetry by torsional oscillation method.
6. To determine the height of a building using Sextant device.
7. To measure the length of an object using vernier caliper, screw gauge and spherometer.

Course Outcomes: At the completion of this course, a student will be able to
CO1: Understand the basic concepts of mechanics by parallel studies of linear dynamics and dynamics.
CO2: Understand the basic conservation laws by studying them in various mechanicalsystems including collisions, oscillations, gravitational systems etc.
CO3: Analyze simple harmonic oscillators in detail.
CO4: Understand the concept of frame of reference, importance of relative transformations and invariance of laws of Physics.
CO5: Realize the consequences of a non-inertial frame in our real physical world.
CO6: Know about the peculiar phenomena of special relativity which are not seen in Newtonian relativity.

Suggested Readings:

1. Kleppner, D., & Kolenkow, R. J. (1973). *An Introduction to Mechanics*. McGraw-Hill.
2. Kittel, C., Knight, W., et al. (2007). *Mechanics* (Berkeley Physics, Vol. 1). Tata McGraw-Hill.
3. Resnick, R., Halliday, D., & Walker, J. (2008). *Physics* (8th ed.). Wiley.
4. Fowles, G. R., & Cassiday, G. L. (2005). *Analytical Mechanics*. Cengage Learning.
5. Feynman, R. P., Leighton, R. B., & Sands, M. (2008). *The Feynman Lectures on Physics, Vol. I*. Pearson Education.
6. Resnick, R. (2005). *Introduction to Special Relativity*. John Wiley and Sons.
7. Reese, R. L. (2003). *University Physics*. Thomson Brooks/Cole.
8. Mathur, D. S. (2000). *Mechanics*. S. Chand and Company Limited.

9. Sears, F. W., Zemansky, M. W., & Young, H. D. (1986). *University Physics* (13th ed.). Addison Wesley.
10. Jewett, J. W., & Serway, R. A. (2010). *Physics for Scientists and Engineers with Modern Physics*. Cengage Learning.

Detailed Syllabus of 1st semester Minor Courses

(Minor-I)

Course Title: Mechanics
Course Code: PHY MIN 1.1
Nature of course: Minor
Total credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to impart knowledge of Newtonian mechanics and the properties of matter, along with the fundamental concepts of the special theory of relativity.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Newtonian Mechanics	1.1: Frames of Reference, Inertial Frames, Galilean Transformations, Galilean Invariance; Dynamics of a System of Particles, Centre of Mass, Principle of Conservation of Linear Momentum. Momentum of variable mass: motion of rocket	5	5	5
	1.2: The Work-Energy Theorem, Conservative and Non-conservative Forces, Conservation of Mechanical Energy, Work done by non-conservative forces, Force as gradient of potential energy, Energy Diagram.	6	6	6
	1.3: Principle of Conservation of Angular Momentum, Rotation about a fixed axis, Moment of Inertia, Calculation of Moment of Inertia for rectangular, cylindrical and spherical bodies, Kinetic Energy of Rotation, Motion involving both translation and rotation.	8	8	8
Unit 2: Properties of Matter	2.1: Relation between Elastic constants, Twisting torque on a Cylinder or Wire.	4	4	4
	2.2: Kinematics of Moving Fluids, Poiseuille's Equationfor Flow of a Liquid through a Capillary Tube	4	4	4
Unit 3: Oscillations	Simple Harmonic Motion (SHM) and Oscillations, Differential Equation of SHM and its solution, Kinetic	8	8	8
	Energy, Potential Energy, Total energy and their time-average values, Damped oscillation, Forced			

	oscillations, Resonance, Power Dissipation and Quality Factor.			
Unit 4: Special Theory of Relativity	Michelson-Morley Experiment and its outcome, Postulates of Special Theory of Relativity, Lorentz Transformations, Simultaneity and order of events, Lorentz contraction, Time dilation. Relativistic addition of Velocities, Variation of Mass with Velocity, Mass-energy Equivalence.	10	10	10
Total		**45**	**45**	**45**

Lab Practical (Minimum four experiments are to be performed)
1. To determine the Young's modulus of a given material by Searle's apparatus.
2. To determine the Modulus of rigidity of a given wire by static method.
3. To determine the value of 'g' using Bar Pendulum.
4. To determine the value of 'g' using Kater's Pendulum.
5. To determine the Moment of inertia of cylinder about two different axes of symmetry by torsional oscillation method.
6. To determine the height of a building using Sextant device.
7. To measure the length of an object using vernier caliper, screw gauge and spherometer

Course Outcomes: At the completion of this course, a student will be able to
CO1: Understand the basic concepts and ideas in mechanics- e.g. motion, force and torque, mass and moment of inertia, linear and angular momentum, kinetic energyand potential energy etc. by parallel studies of linear dynamics and rotational dynamics.
CO2: Understand the basic conservation laws by studying them in various mechanical systems including collisions, oscillations, gravitational systems etc.
CO3: Analyze simple harmonic oscillator in detail.
CO4: Understand the concept of frame of reference, importance of relative transformations and invariance of laws of Physics.
CO5: Realize the consequences of a non-inertial frame in our real physical world.

Suggested Readings:

1. Kleppner, D., & Kolenkow, R. J. (1973). *An Introduction to Mechanics*. McGraw-Hill.
2. Kittel, C., Knight, W., et al. (2007). *Mechanics* (Berkeley Physics, Vol. 1). Tata McGraw-Hill.
3. Resnick, R., Halliday, D., & Walker, J. (2008). *Physics* (8th ed.). Wiley.
4. Fowles, G. R., & Cassiday, G. L. (2005). *Analytical Mechanics*. Cengage Learning.
5. Feynman, R. P., Leighton, R. B., & Sands, M. (2008). *The Feynman Lectures on Physics, Vol. I.* Pearson Education.
6. Mathur, D. S. (2000). *Mechanics*. S. Chand and Company Limited.
7. Resnick, R. (2005). *Introduction to Special Relativity*. John Wiley and Sons.
8. Reese, R. L. (2003). *University Physics*. Thomson Brooks/Cole.

Detailed Syllabus of 1st Sem Generic Elective Courses (GEC)

Option 1

Course Title: Evolution of Science

Course Code: PHY GEC1.1

Nature of course: Generic Elective Course

Total credits: 3

Total marks: 75

Distribution of Marks: End Sem: Th=45

In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to provide students with an understanding of the historical development of scientific knowledge and key contributors, examine the interdisciplinary nature and impact of science across fields, explore the ethical and social implications of scientific advancements, and foster appreciation for the scientific method through critical thinking, experimentation, and observation.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Origins and Foundations of Science	Invention of wheel and beginning of science, Science for progress. Science in ancient world Medieval science Renaissance and industrial revolution: Rise of westernscience Contributions of Aristotle, Galileo Galilei, Robert Hooke, Darwin, Kepler etc. Contributions of Sir Isaac Newton: Laws of motion, Universal law of Gravitation.	14	14	14
Unit 2: The Dawn of Modern Science	Nineteenth century and beginning of modern science: Developments of electricity and magnetism, Maxwell's contributions, Contributions of Thomas A. Addison.	13	13	13
Unit 3: Twentieth Century and Contemporary Scientific Advancements	Einstein and Special Theory of Relativity: The paradigm shift. Quantum Theory, Quantum generation, The Second creation: development of concept of field quantisation,ups and downs. Nuclear era: space science and technology.Electronic age and birth of computers. Laser and optical evolution. Contemporary science and India's contribution.	18	18	18
Total		**45**	**45**	**45**

Course outcomes: At the completion of this course, a student will be able to

CO1: Attain a comprehensive comprehension of the development of science from antiquity to the present era.

CO2: Comprehend the noteworthy scientific breakthroughs, inventions, and contributions that have paved the way for modern science.

CO3: Assess the influence of science on human civilization and how scientific progress has positively impacted societal progress.

Suggested Readings:

1. Shapin, S. (1996). *The Scientific Revolution*. University of Chicago Press.
2. Cajori, F. (1899). *A History of Physics in Its Elementary Branches, Including the Evolution of Physical Laboratories*. Macmillan.
3. Kisak, P. F. (2015). *A Brief History of Physics*. CreateSpace Independent Publishing Platform.

Option 2

Course Title: Introduction to Communication Technology

Course Code: PHY GEC 1.1

Nature of Course: Generic Elective Course

Total Credits: 3

Total marks: 75

Distribution of Marks: End Sem: Th=45

In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to introduce students to the technologies used in modern communication systems, familiarize them with antennas, and discuss the basic principles of cellular and satellite communication.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Fundamentals of Communication Systems	What is a communication system, Block diagram of a communication system, Need of modulation, basic idea of Amplitude Modulation its advantage, disadvantages and application, Frequency modulation, advantages, disadvantages and its application, electromagnetic Spectrum	15	15	15
Unit 2: Digital Communication	Digital communication, Block diagram of Pulse codemodulation and its applications, What is digital modulation, advantages and disadvantages of digital modulation.	5	5	5
Unit 3: Antennas and Radiation Systems	What is an antenna, Dipole antenna, Yagi antenna, different parameters used in antenna	5	5	5
Unit 4: Microwave and Cellular Communication	Introduction to microwave, Microwave communication system, advantages and disadvantages. Cellular communication, basic idea of spectrum and technologies used in cellular communication, generations of cellular communications. Introduction to satellite communication, antenna look angles, satellite communication block diagrams and frequency ranges used, Basic principle of GPS. Historical development of optical communication, general system, advantages, disadvantages, and applications of optical fiber communication, optical	20	20	20

	fiber waveguides, cylindrical fiber, single mode fiber, cutoff wavelength. Optical Fiber materials			
Total		**45**	**45**	**45**

Course outcomes: At the completion of this course, a student will be able to
CO1: Understand the basics of communication systems and modulation techniques.
CO2: Explain digital communication methods and their applications.
CO3: Describe antenna types and key parameters.
CO4: Demonstrate knowledge of microwave, cellular, satellite, and optical fiber communication systems

Suggested Readings:

1. Tomasi, W. (2003). *Electronic Communications System: Fundamentals Through Advanced*. Pearson Education.
2. Kennedy, G., & Davis, B. (1992). *Electronic Communication Systems*. McGraw-Hill Education.
3. Frenzel, L. E. (2015). *Principles of Electronic Communication Systems*. McGraw-Hill Education.
4. Keiser, G. (2010). *Optical Fiber Communications*. McGraw-Hill Education.

Detailed Syllabus of 1st Sem Skill Enhancement Courses (SEC)

Course Title: Solar Energy
Course code: PHY SEC 1
Nature of course: Skill Enhancement Course
Total credits: 3 (Theory- 2, Practical- 1)
Total Marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course Objective: To impart fundamental knowledge and practical skills on solar energy technologies, including solar thermal and photovoltaic systems, their components, applications, and performance evaluation

Course Outlines

Units	Content	L	M	Hours
Unit 1: Solar Energy Definition	Solar energy definition, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	9	15	9
Unit 2: Solar Radiation	Sun as a source of energy, Solar radiation, Solar radiation at the Earth's surface, Measurement of Solar radiation-Pyroheliometer, Pyranometer, Sunshine recorder, Prediction of available solar	7	10	7

	radiation, Solar energy-Importance, Storage of solar energy, Solar pond.			
Unit 3: Solar Thermal Systems	Principle of conversion of solar radiation into heat, Collectors used for solar thermal conversion: Flat plate collectors and Concentrating collectors, Solar Thermal Power Plant, Solar cookers, Solar hot water systems, Solar dryers, Solar Distillation, Solar greenhouses.	8	13	8
Unit 4: Solar Photovoltaic Systems	Conversion of Solar energy into Electricity - Photovoltaic Effect, Solar photovoltaic cell and its working principle, Different types of Solar cells, Series and parallel connections, Photovoltaic applications: Battery chargers, domestic lighting, street lighting and water pumping.	6	12	6
Total		**30**	**50**	**30**

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Activities /Demonstration/Practical /Project (Marks = 25)
(Any four of the following are to be performed)
1. Plot sun chart and locate the sun at your location for a given time of the day.
2. Analyse shadow effect on incident solar radiation and find out contributors.
3. Connect solar panels in series & parallel and measure voltage and current.
4. Measure intensity of solar radiation using Pyranometer and radiometers.
5. Construct a solar lantern using Solar PV panel (15W)
6. Assemble solar cooker
7. Desigining and constructing photovoltaic system for a domestic house requiring 5kVA power
8. Assignments/Model Exam.

Course Outcomes: After successful completion of the course, students will be able to
CO1: Explain the basic concepts, importance, and applications of solar energy and different methods of solar energy storage.
CO2: Analyze solar radiation characteristics, measurement techniques, and predict solar energy availability for various locations.
CO3: Demonstrate understanding of solar thermal systems, including collectors, solar cookers, heaters, and solar power generation systems.
CO4: Illustrate the working principles and configurations of solar photovoltaic systems and evaluate their practical applications.
CO5: Develop hands-on skills through activities and projects related to solar energy system design, assembly, and performance analysis.

Suggested Readings:

1. Rai, G. D. (1995). *Solar Energy Utilization*. Khanna Publishers.
2. Tiwari, G. N. (2002). *Solar Energy: Fundamentals, Design, Modeling & Applications*. Narosa Publishing House.

3. Sukhatme, S. P. (2009). *Solar Energy: Principles of Thermal Energy Collection & Storage*. McGraw-Hill Education.
4. Solanki, C. S. (2015). *Solar Photovoltaics: Fundamentals, Technologies and Applications*. PHI Learning Pvt. Ltd.
5. Reddy, P. Jayarama. (2010). *Science and Technology of Photovoltaics* (2nd ed.). BS Publications.
6. Agarwal, M. P. (1983). *Solar Energy*. S. Chand & Co.
7. Sukhatme, S. P. (2009). *Solar Energy: Principles of Thermal Collection and Storage* (3rd ed.). Tata McGraw-Hill.
8. Rai, G. D. (2005). *Non-Conventional Energy Sources* (4th ed.). Khanna Publishers.

Detailed Syllabus of 2nd Semester Major Courses

Course title: Waves and Optics
Course code: PHY MAJ 2.1
Nature of the course: Major/Core
Total credits: 4 (Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to develop theoretical knowledge of waves, oscillations, and the superposition principle, acquaint learners with fascinating light phenomena, and build a strong foundation in the functioning of various optical instruments.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Superpositionof Harmonic Oscillations	1.1: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.	3	3	3
	1.2: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.	3	3	3
Unit 2: WaveMotion	2.1: Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation of a Wave, Pressure of a Longitudinal Wave, Energy Transport. Water waves: Ripple and gravity waves.	5	5	5
	2.2: Velocity of Transverse Vibrations of Stretched Strings, Velocity of Longitudinal Waves in a Fluid in a Pipe, Newton's Formula for Velocity of Sound, Laplace's Correction.	4	4	4
Unit 3: Harmonic Waves	Standing (Stationary) Waves in a String: Fixed and Free Ends, Analytical Treatment, Phase and Group Velocities, Changes with respect to Position and Time, Energy of Vibrating String, Transfer of Energy, Normal Modes of Stretched Strings, Plucked and Struck Strings, Melde's Experiment, Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes, Superposition of N Harmonic Waves.	5	5	5
Unit 4: Waveoptics	Electromagnetic nature of light, definition and properties of wave front, Huygens principle, Temporal and Spatial coherence.	2	2	2

Unit 5: Interference	5.1: Division of amplitude and wavefront, Young's double slit experiment, Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: Measurement of wavelength and refractive index.	5	5	5
	5.2: Michelson Interferometer- (i) Idea of form of fringes (theory not required), (ii) Determination of Wavelength, (iii) Wavelength Difference, (iv) Refractive Index and (v) Visibility of Fringes. Fabry-Perot interferometer.	4	4	4
Unit 6: Diffraction	6.1: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula (Qualitative discussion only)	2	2	2
	6.2: Fraunhofer Diffraction: Single slit, Circular aperture. Resolving Power of a telescope, Double slit, Multiple slits. Diffraction grating, Resolving power of grating.	4	4	4
	6.3: Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.	5	5	5
Unit 7: Holography	Principle of Holography, Recording and Reconstruction Method, Theory of Holography as Interference between two Plane Waves, Point Source Holograms.	3	3	3
Total		**45**	**45**	**45**

Lab Practical (Minimum four experiments are to be performed)

1. To determine the Frequency of an electrically maintained tuning fork by Melde's experiment and to verify Z2 – T law.
2. To study of Lissajous Figure of two different waves using CRO and find out the unknown frequency of an electric signal.
3. To familiarize with Schuster's focusing, and determine angle of prism.
4. To determine the dispersive power and Cauchy constants of 6the material of a prism using mercury source.
5. To determine the Refractive index of the material of a prism using sodium light.
6. To determine the wavelength of sodium light using Newton's ring.
7. To determine wavelength of light using Fresnel Biprism.

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

CO1: Understand and analyze the principle of superposition in harmonic oscillations and visualize their results using Lissajous figures.

CO2: Describe and derive the properties of various types of waves, including longitudinal,

transverse, and water waves, and understand the mathematical form of the wave equation.
CO3: Explain the formation and characteristics of stationary waves in strings and pipes, and evaluate energy transfer and normal modes in vibrating systems.
CO4: Understand the electromagnetic nature of light, wavefronts, coherence, and apply Huygens' principle to explain wave propagation.
CO5: Analyze interference patterns resulting from division of wavefront and amplitude, and apply principles to measure physical parameters using devices like the Michelson and Fabry-Perot interferometers.
CO6: Examine diffraction phenomena using Fresnel and Fraunhofer theories, and determine resolving power of optical instruments including telescopes and diffraction gratings.
CO7: Understand the basic principles and applications of holography, including recording and reconstruction techniques and the theory behind point-source holograms.

Suggested Readings:

1. Crawford, F. S. (1968). *Waves: Berkeley Physics Course, Vol. 3*. McGraw-Hill.
2. Jenkins, F. A., & White, H. E. (1976). *Fundamentals of Optics* (4th ed.). McGraw-Hill.
3. Born, M., & Wolf, E. (1999). *Principles of Optics* (7th ed.). Cambridge University Press.
4. Ghatak, A. (2005). *Optics*. Tata McGraw-Hill.
5. Gupta, A. B., & Islam, N. (2006). *Modern Optics*. Books & Allied.
6. Pain, H. J. (1999). *The Physics of Vibrations and Waves* (5th ed.). John Wiley & Sons.
7. Bajaj, N. K. (1988). *The Physics of Waves and Oscillations*. Tata McGraw-Hill.
8. Kumar, A., Gulati, H. R., & Khanna, D. R. (2011). *Fundamentals of Optics*. R. Chand & Co.

Detail syllabus of 2nd Sem Minor Courses
(Minor-I)

Course title: Waves and Optics
Course code: PHY MIN 2.1
Nature of the course: Minor
Total credits: 4 (Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: This course will enable students to analyze phenomena arising from the interaction of light with light and matter, train them in the use of various optical instruments, and help them understand natural phenomena through laboratory experiments.

Course Outlines

Units	Content	L	M	Hours

Unit 1: Superposition of Harmonic Oscillations	1.1: Linearity and Superposition Principle, Superposition of two collinear oscillations having (i)equal frequencies and (ii) different frequencies (Beats), Superposition of N collinear Harmonic Oscillations with (i) equal phase differences and (2) equal frequency differences.	5	5	5
	1.2: Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures with equal and unequal frequencyand their use.	5	5	5
Unit 2: Wave Motion	2.1: Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation of a Wave, Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave.	4	4	4
	2.2: Velocity of Transverse Vibrations of Stretched strings. Velocity of longitudinal waves in a fluid in pipe. Newton's formula for velocity of sound, Laplace's correction.	3	3	3
Unit 3: Superposition of Harmonic Waves	Standing (Stationary) Waves in a String: Fixed and Free Ends, Analytical Treatment, Phase and Group Velocities, Changes with respect to Position and Time, Energy of Vibrating String, Transfer of Energy, Normal Modes of Stretched Strings, Plucked and Struck Strings, Melde's Experiment, Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes, Superposition of N Harmonic Waves.	7	7	7
Unit 4: Wave optics	Electromagnetic nature of light, definition and properties of wave front, Huygens principle, Temporal and Spatial coherence	3	3	3
Unit 5: Interference	5.1: Division of amplitude and wavefront, Young's double slit experiment, Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: Measurement of wavelength and refractive index	10	10	10
	5.2: Michelson Interferometer- (i) Idea of form of fringes (No theory required), (ii) Determination of Wavelength, (iii) Wavelength Difference, (iv) Refractive Index and (v) Visibility of Fringes. Fabry- Perot interferometer.	8	8	8
Total		**45**	**45**	**45**

Lab Practical (2.1): (Minimum four experiments are to be performed)
1. To determine the Frequency of an electrically maintained tuning fork by Melde's 3experiment and to verify Z2 – T law.

2. To determine the focal length of a convex mirror with the help of convex lens.
3. To determine the refractive index of a liquid by using plane mirror and convex lens.
4. To determine the focal length of two lenses and their combination by displacement method.
5. To determine the Refractive index of the material of a prism using sodium light.
7. To determine the wavelength of sodium light using Newton's ring.
8. To familiarize with Schuster's focusing; determination of angle of prism.

Course outcomes: At the completion of this course, a student will be able to

CO1: Understand and apply the principles of superposition in harmonic oscillations, including the formation and analysis of Lissajous figures.
CO2: Explain the nature and properties of different types of waves and derive key equations governing wave motion, velocity, and energy transport.
CO3: Analyze the behavior of standing waves and harmonic wave superposition in strings and pipes, and interpret experimental results from setups like Melde's experiment.
CO4: Describe the wave nature of light, apply Huygens' principle, and distinguish between temporal and spatial coherence.
CO5: Interpret and evaluate interference phenomena through various experimental setups, including thin film interference, Newton's Rings, and interferometers like Michelson and Fabry-Perot.

Suggested Readings:

1. Crawford, F. S. (2007). *Waves: Berkeley Physics Course, Vol. 3*. Tata McGraw-Hill.
2. Jenkins, F. A., & White, H. E. (1981). *Fundamentals of Optics*. McGraw-Hill.
3. Born, M., & Wolf, E. (1999). *Principles of Optics* (7th ed.). Pergamon Press.
4. Ghatak, A. (2008). *Optics*. Tata McGraw-Hill.
5. Pain, H. J. (2013). *The Physics of Vibrations and Waves*. John Wiley and Sons.
6. Bajaj, N. K. (1998). *The Physics of Waves and Oscillations*. Tata McGraw-Hill.
7. Kumar, A., Gulati, H. R., & Khanna, D. R. (2011). *Fundamentals of Optics*. R. Chand Publications.

Detail Syllabus of 2nd Sem Generic Elective Courses (GEC)

Course Title: Materials Today
Course Code: PHY GEC 2.1
Nature of course: Generic Elective Course
Total credits: 3
Total Marks: 75
Distribution of Marks: End Sem: Th=45
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: This course is intended to introduce students to the various states of matter, distinguish between matter and materials, trace the historical development of materials, explore their classification and properties, and examine advanced materials and their applications.

Course Outlines

Units	Content	L	M	Hours

Unit 1: States of Matter	Overview of the different states ofmatter: Solid, Liquid, Gas, Plasma	7	7	7
Unit 2: History and Evolution of Materials	Materials: Drivers of human civilizationDevelopment of materials: Stone age, Copper age, Bronze age, Iron age Explanation with examples to mark thisdevelopment	10	10	10
Unit 3: Classification of Engineering Materials	Metals & Alloys, Non-Metals, Ceramics, Polymers, Composites etc.with examples and applications Uses, Performance, Composition & Structure; Physical and Chemical properties; Processing & Synthesis ofvarious classes of materials	13	13	13
Unit 4: Trends in Advanced Materials	Breakthroughs in Materials Development Overview of Advanced Materials: Semiconductors, Biomaterials, Smart Materials (Materials of the Future), Nano-structured Materials	15	15	15
Total		**45**	**45**	**45**

Course outcomes: This course will enable the students to
CO1: Define the possible states of matter as well as to distinguish matter from material
CO2: Explain the chronological development that materials have gone through for achieving their present stage
CO3: Compare and classify materials and their properties
CO4: Define advanced materials and their fascinating behavior

Suggested readings:

1. Callister, W. D., Jr., & Rethwisch, D. G. (Year). *Materials Science and Engineering: An Introduction*. John Wiley & Sons, Inc.
2. Hummel, R. E. (Year). *Understanding Materials Science: History, Properties, Applications*. Springer-Verlag, New York.
3. Askeland, D. R., & Fulay, P. P. (Year). *Essentials of Materials Science and Engineering*. Cengage Learning, Canada.

Detailed syllabus of 2nd Semester Skill Enhancement Courses (SEC)

Course Title: Basic Instrumentation Skills
Course Code: PHY SEC 2.1
Nature of course: Skill Enhancement Course
Total credits: 3 (Theory-2, Practical-1)
Total Marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course Objective: This course aims to provide exposure to various aspects of instruments, offer hands-on experience in handling them, and teach effective debugging techniques.

Course Outlines

Units	**Content**	**L**	**M**	**Hours**
Unit 1: Basic of Measurement	Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltageand dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.	6	10	6
Unit 2: Electronic Voltmeter	Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. **AC millivoltmeter:** Type of AC milli voltmeters: Amplifier- rectifier, and rectifier- amplifier. Blockdiagram ac millivoltmeter**,** specifications and theirsignificance.	7	10	7
Unit 3: Cathode Ray Oscilloscope	Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications ofa CRO and their significance.	5	8	5
Unit 4: Signal Generators and Analysis Instruments	Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications.Distortion factor meter, wave analysis.	3	6	3
Unit 5: Impedance Bridges & Q-Meters	Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLCbridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.	3	6	3
Unit 6: Digital Instruments	Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.	3	5	3
Unit 7: Digital Multimeter	Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequencycounter, time- base stability, accuracy and resolution.	3	5	3
Total		**30**	**50**	**30**

Lab practical (Marks = 25)
The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment.
4. Use of Digital multimeter / VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of a receiver circuit.
8. Troubleshooting a circuit
9. Balancing of bridges

Laboratory Exercises:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistanceand high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence onfrequency, using a Q- meter.
4. Measurement of voltage, frequency, time periodand phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times usinga CRO.
7. Measurement of distortion of a RF signalgenerator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge / universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuringinstrument (voltmeter, ammeter)

Course outcomes: After completing this course the students will be able to

CO1: Understand fundamental measurement concepts including accuracy, precision, sensitivity, and errors.

CO2: Explain the working principles and specifications of multimeters and electronic voltmeters.

CO3: Describe the construction and operation of Cathode Ray Oscilloscopes (CRO) and interpret their specifications.

CO4: Analyze the functioning and applications of signal generators and wave analysis instruments.

CO5: Understand the principles of impedance bridges, Q-meters, and digital LCR bridges.

CO6: Compare analog and digital instruments, and explain the working of digital meters and digital voltmeters.

CO7: Demonstrate knowledge of digital multimeters and frequency/time measurement using universal counters.

Suggested Readings:

1. Theraja, B. L. (Year). *A Textbook in Electrical Technology*. S. Chand and Co.
2. Say, M. G. (Year). *Performance and Design of AC Machines*. ELBS Edition.
3. Venugopal, K. (2011). *Digital Circuits and Systems*. Tata McGraw Hill.
4. Vingron, S. P. (2012). *Logic Circuit Design*. Springer.
5. Ghoshal, S. (2012). *Digital Electronics*. Cengage Learning.
6. Salivahanan, S., & Kumar, N. S. (2012). *Electronic Devices and Circuits* (3rd ed.). Tata McGraw Hill.

7. Tietze, U., & Schenk, C. (2008). *Electronic Circuits: Handbook of Design and Applications*. Springer.
8. Floyd, T. L. (2008). *Electronic Devices* (7th ed.). Pearson India.

Detailed Syllabus of 3rd Semester Major Courses

Course Title: Mathematical Physics I
Course Code: PHY MAJ 3.1
Nature of course: Major/Core
Total Credits: 4 (Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: This course will develop the requisite mathematical skills of a student to understand the fundamental topics in vector algebra, applications of vectors in different fields, differential equation & its applications, different coordinate systems and idea of probability etc.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Vector algebra	Recapitulation of vector algebra. Scalar products, Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Cartesean components of a vector, Scalar and vector fields. Directional derivatives and normal derivatives. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Ordinary integrals of vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line integral, surface integral and volume integral of vector fields. Flux of a vector field. Gauss' divergence theorem, Green's theorem, Stokes theorem and their applications (proofs not necessary).	20	32	25
Unit 2: Differential Equations	First Order Differential Equations, Integrating Factor. Second order Differential equations. Homogeneous and Inhomogeneous Equations with constant coefficients. Wronskian and general solution. Calculus of functions of more than one variable: Partial derivatives, Exact differentials, Inexact differentials. Constrained maximization using Lagrange Multipliers.	10	20	17
Unit 3: Orthogonal Curvilinear Coordinates	Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.	5	12	8
Unit 4: Dirac Delta function	Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function	5	8	5
Unit 5: Introduction to Probability	Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance.	5	8	5
Total		**45**	**45**	**45**

Computer Lab Practical: (Marks: 25)
The aim of this Lab is to teach computer programming, numerical analysis and to emphasize its role in solving problems in Physics.

- Highlights the use of computational methods to solve physical problems
- The course will consist of lectures (both theory and practical) in the Lab
- Evaluation done not on the programming but on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved
- Students can use any one operating system Linux or Microsoft Windows.

Introduction and Overview Computer architecture and organization, memoryandInput/output devices.
Basics of scientific computing Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.
Review of C & C++/Python/ Matlab/ Mathematica Programming fundamentals Introduction to Programming, constants, variables and data types, operators and Expressions I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (if statement. if-else Statement. Nested if Structure. else-if Statement. Ternary Operator. goto Statement. switch Statement. Unconditional and Conditional Looping. while Loop. do-while Loop. for Loop. break and continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects.
Programs Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation Area of circle, area of square, volume of sphere, value of pi (π)
Introduction to Numerical computation softwares Introduction to

Scilab/Mathematica/Matlab/Python, Advantages and disadvantages, Scilab / Mathematica / Matlab/ Python environment, Command window, Figure window, Edit window, Variables and arrays, initializing variables in Scilab / Mathematica / Matlab/ Python, Multidimensional arrays, Subarray, Special values, displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab / Mathematica / Matlab/Python functions, Introduction to plotting, 2D and 3D plotting. **Curve fitting, least square fit, Goodness of fit, standard deviation** Ohms law to calculate R, Hooke's law to calculate spring constant.

Course outcomes: This course will enable the students to
CO1: Apply vector algebra and vector calculus concepts to physical problems, including computation of gradients, divergence, curl, and use of vector integral theorems.
CO2: Solve first and second order differential equations, including homogeneous and inhomogeneous cases, and apply techniques like integrating factors and Wronskian.
CO3: Understand and use orthogonal curvilinear coordinate systems to derive differential operators in Cartesian, spherical, and cylindrical coordinates.
CO4: Comprehend the definition, properties, and applications of the Dirac delta function in physics and engineering contexts.
CO5: Analyze basic probability distributions (binomial, Gaussian, Poisson), their properties, and apply statistical measures like mean and variance.
CO6: Develop computational problem-solving skills using programming languages (C/C++, Python, Matlab, Mathematica, Scilab) for numerical analysis relevant to physics.
CO7: Implement basic programming constructs (loops, conditional statements, arrays,

functions, structures) to solve scientific computing problems.

CO8: Utilize numerical computation software for mathematical modeling, data visualization, curve fitting, and simulation of physical laws (e.g., Ohm's and Hooke's laws).

Recommended readings:

1. Arfken, G. B., Weber, H. F., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier.
2. Riley, K. F., Hobson, M. P., & Bence, S. J. (Year). *Mathematical Methods for Physics and Engineering*. Cambridge University Press.
3. Coddington, E. A. (2009). *An Introduction to Ordinary Differential Equations*. PHI Learning.
4. Simmons, G. F. (2007). *Differential Equations*. McGraw Hill.
5. Rajput, D. S. (Year). *Mathematical Physics*.
6. Kreyszig, E. (2008). *Advanced Engineering Mathematics*. Wiley India.
7. Riley, K. F., & Hobson, M. P. (2011). *Essential Mathematical Methods*. Cambridge University Press.

Course Title: Thermal Physics I
Course Code: PHY MAJ 3.2
Nature of course: Major/Core
Total Credits: 4 (Theory-3, Practical-1)
Total marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: To provide students with a comprehensive understanding of the fundamental laws of thermodynamics and kinetic theory of gases, enabling them to analyze thermal systems, gas behaviors, and energy transformations both qualitatively and quantitatively.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Fundamentals of Thermodynamics	Review of basic concepts: Systems, variables, equilibrium. Zeroth Law of Thermodynamics and concept of temperature. First Law of Thermodynamics: Heat, work, and internal energy, Applications: Relation between C_p and Cv. Work done in isothermal and adiabatic processes. Compressibility and expansion coefficient. Second Law of Thermodynamics: Kelvin-Planck and Clausius statements. Carnot cycle, Carnot engine and efficiency. Thermodynamic temperature scale and equivalence with perfect gas scale	9	9	9
Unit 2: Entropy and the Second & Third Laws	Concept of entropy and Clausius theorem, Clausius inequality and the Second Law in terms of entropy, Entropy of a perfect gas, Entropy changes in reversible and irreversible processes	9	9	9

	(with examples), Entropy of the universe; Principle of increase of entropy, Temperature–Entropy (T-S) diagrams for Carnot cycle, Third Law of Thermodynamics and unattainability of absolute zero			
Unit 3: Thermodynamic Potentials and Phase Transitions	Thermodynamic potentials: Internal energy, Enthalpy, Helmholtz and Gibbs free energies, Properties and applications of potentials, Maxwell's thermodynamic relations: derivations and applications, TdS equations, Clausius-Clapeyron equation, Joule-Kelvin coefficient (ideal and Van der Waals gases), Cp - Cv relation, energy equations, adiabatic temperature changes, Phase transitions: First and second order (with examples), Clausius-Clapeyron and Ehrenfest equations, Magnetic work and adiabatic demagnetization, Surface tension variation with temperature	9	9	9
Unit 4: Kinetic Theory of Gases I	Maxwell-Boltzmann distribution of velocities and experimental verification, Mean, RMS, and most probable speeds, Doppler broadening and Stern's experiment, Degrees of freedom; Law of equipartition of energy (qualitative), Specific heats of gases, Molecular collisions: Mean free path and collision probability, Transport phenomena: Viscosity, Thermal conductivity, Diffusion. Brownian motion and its significance	9	9	9
Unit 5: Real Gases and Joule-Thomson Effect	Deviations from ideal gas behavior, Van der Waals equation of state and critical constants, Andrews' experiments on CO_2 and continuity of gas-liquid phase, Law of corresponding states, Boyle temperature, P-V diagrams, Virial equation of state, Joule's experiment and free adiabatic expansion, Joule-Thomson porous plug experiment, Joule-Thomson effect in real and Van der Waals gases, Inversion temperature and cooling	9	9	9
Total		**45**	**45**	**45**

General Lab Practical: (25 Marks) <u>(A minimum of five experiments to be performed in classes)</u>

One experiment is to be performed in Examination.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal conductivity of Cu by Angstrom's Method.

4. To determine the Coefficient of Thermal conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its two Junctions.
7. To determine Stefan's Constant by electric bulb method.

Course Outcomes:

CO1: Understand and apply the Zeroth, First, and Second Laws of Thermodynamics to analyze heat, work, and internal energy changes in various thermodynamic processes, including Carnot cycles and temperature scales.

CO2: Explain the concept of entropy and its implications in reversible and irreversible processes, and evaluate the significance of the Second and Third Laws of Thermodynamics in real-world thermodynamic systems.

CO3: Analyze thermodynamic potentials and derive Maxwell's relations to evaluate phase transitions, energy equations, and the thermodynamic behavior of systems under different constraints.

CO4: Describe the kinetic theory of gases by applying the Maxwell-Boltzmann distribution and relate microscopic molecular behavior to macroscopic transport properties such as viscosity, diffusion, and thermal conductivity.

CO5: Evaluate the behavior of real gases using the Van der Waals equation, interpret phase transitions and Joule-Thomson effects, and differentiate between ideal and non-ideal gas behavior through experimental and theoretical approaches.

Suggested Readings:

1. Zemansky, M. W., & Dittman, R. (1981). *Heat and Thermodynamics*. McGraw-Hill.
2. Saha, M., & Srivastava, B. N. (1958). *A Treatise on Heat*. Indian Press.
3. Garg, S., Bansal, R., & Ghosh, (1993). *Thermal Physics* (2nd ed.). Tata McGraw-Hill.
4. Helrich, C. S. (2009). *Modern Thermodynamics with Statistical Mechanics*. Springer.
5. Flint, B. L., & Worsnop, H. T. (1971). *Advanced Practical Physics for Students*. Asia Publishing House.
6. Nelson, M., & Ogborn, J. M. (1985). *Advanced Level Physics Practicals* (4th ed., reprinted). Heinemann Educational Publishers.
7. Prakash, I., & Ramkrishna. (2011). *A Textbook of Practical Physics* (11th ed.). Kitab Mahal.
8. Panigrahi, S., & Mallik, B. (2015). *Engineering Practical Physics*. Cengage Learning India Pvt. Ltd.
9. Squires, G. L. (2015). *Practical Physics* (4th ed.). Cambridge University Press.
10. Khandelwal, D. P. (1985). *A Laboratory Manual of Physics for Undergraduate Classes*. Vani Publications.

Detailed syllabus of 3rd Semester Generic Elective Courses (GEC)

Course Title: Atmosphere of the Earth
Course code: GECPHY 3.1
Nature of the Course: Generic Elective Course
Total Credits: 3
Total marks: 75
Distribution of Marks: End Sem: Th=45
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course Objectives: The aim of the course is to provide a comprehensive understanding of Earth's atmosphere, atmospheric processes, climate dynamics, and the comparative atmospheres of other planets in the solar system.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Introduction	1.1: Evolution of the earth's atmosphere. Layers of the atmosphere: Troposphere, Stratosphere, Mesosphere, Thermosphere, Ionosphere: D, E and F layers. Hydrostatic Balance.	7	7	7
	1.2: Composition of the atmosphere: Atmospheric gases, aerosols, clouds.	5	5	5
	1.3: atmospheric thermodynamics: First law of thermodynamics for atmosphere and its application, Clausius-Clapeyron equation.	5	5	5
Unit 2: Atmospheric processes	2.1: Ggreenhouse effect- natural, enhanced, Antarctic ozone hole, global warming.	7	7	7
	2.2: Climate of the earth, climate change, adaptation and mitigation.	7	7	7
Unit 3: Atmosphere of the other solar system planets	3.1: Terrestrial planets: Physical properties and chemical composition, difference between Terrestrial and Jovian planets.	7	7	7
	3.2: Jovian planets: physical properties and chemical composition. Difference between gas and ice giants, rings in Jovian planets.	7	7	7
Total		**45**	**45**	**45**

Course Outcomes: This course will enable the students to
CO1: Understand the different layers of atmosphere and the related physical phenomena.
CO2: Understand chemical composition of the atmosphere of the earth and other planets.
CO3: Understand the phenomenon of climate change and other processes.

Suggested Readings:

1. Stull, R. B. (2000). *Meteorology for Scientists and Engineers* (2nd ed.). Brooks/Cole Thomson Learning.
2. Seinfeld, J. H., & Pandis, S. N. (2016). *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change* (3rd ed.). John Wiley & Sons.
3. Jacobson, M. Z. (2005). *Fundamentals of Atmospheric Modeling* (2nd ed.). Cambridge

University Press.

Detailed Syllabus of 3rd Semester Minor Courses

(Minor -I)

Course Title: Thermal Physics
Nature of Course: Minor
Course Code: PHY MIN 3.1
Total credits: 4 (Theory-3, practical-1)
Total marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objective: The aim of the course is to To equip students with a critical understanding of thermodynamic principles, enabling them to analyze statistical interpretations of thermodynamic laws and comprehend key thermodynamic properties and potentials.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Basic Laws and First Law of Thermodynamics	Thermodynamic Equilibrium, Zeroth Law of Thermodynamics and Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy and First Law for various processes, Applications of First Law: Relation between CPC_PCP and CVC_VCV Work done in isothermal and adiabatic processes	9	9	9
Unit 2: Second Law of Thermodynamics and Entropy	Reversible and Irreversible processes, Heat Engines, Carnot's Cycle and Efficiency, Refrigerators and Coefficient of Performance, Second Law: Kelvin-Planck and Clausius Statements, their equivalence, Carnot's Theorem, Thermodynamic Scale of Temperature, Concept of Entropy, Clausius Theorem and Inequality, Entropy in reversible and irreversible processes, Entropy of a perfect gas and entropy of the universe.	9	9	9
Unit 3: Thermodynamic Potentials and Phase Transitions	Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Definitions, Properties and Significance, Magnetic Work and Adiabatic Demagnetization. First and Second Order Phase Transitions (with examples), Temperature–Entropy diagram for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.	9	9	9
Unit 4: Maxwell's Relations and Applications	Derivation of Maxwell's Relations, Applications: Clausius-Clapeyron Equation, Calculation of $C_P - C_V$, TdS Equations, Joule-Kelvin Coefficient for Ideal and Van der Waals gases, Energy Equations	9	9	9

Unit 5: Kinetic Theory of Gases and Real Gases	Maxwell-Boltzmann Distribution and Experimental Verification, Doppler Broadening, Stern's Experiment, Mean, RMS and Most Probable Speeds, Degrees of Freedom and Law of Equipartition (qualitative), Behaviour of Real Gases, Virial Equation, Andrew's Experiment on CO_2, Van der Waals Equation, Critical Constants, P-V Diagrams, Continuity of States, Joule's and Joule-Thomson Experiments, Joule-Thomson Effect for Real and Van der Waals Gases.	9	9	9
Total		**45**	**45**	**45**

General Lab Practical: (Marks: 25)
Note: Minimum five experiments are to be performed in classes. One experiment is to be performed in the Examination

1. Use a multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC current, (d) Capacitance
2. To determine an unknown Low Resistance using a Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To determine self-inductance of a coil by Anderson's bridge.
5. To study the characteristics of a series RC Circuit.
6. To determine the Surface Tension of water by capillary rise method.
7. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
8. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
9. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
10. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).

Course outcomes: After completing this course the students will be able to
CO1: Understand and apply the zeroth and first laws of thermodynamics to different thermodynamic systems and processes.
CO2: Evaluate the implications of the second and third laws of thermodynamics, including entropy changes in reversible and irreversible processes.
CO3: Analyze thermodynamic potentials and their applications in physical and magnetic systems, including phase transitions.
CO4: Derive and utilize Maxwell's relations and related equations to study energy changes and properties of thermodynamic systems.
CO5: Interpret kinetic theory and real gas behavior, including molecular velocity distributions and deviations from ideal gas laws.

Suggested Readings:

1. Worsnop, B. L., & Flint, H. T. (1923). *Advanced Practical Physics for Students*. Asia Publishing House.
2. Nelson, M., & Ogborn, J. M. (1985). *Advanced Level Physics Practicals* (4th ed.). Heinemann Educational Publishers.
3. Prakash, I., & Ramakrishna. (2011). *A Textbook of Practical Physics* (11th ed.). Kitab Mahal.
4. Panigrahi, S., & Mallick, B. (2015). *Engineering Practical Physics*. Cengage Learning India Pvt. Ltd.
5. Squires, G. L. (2001). *Practical Physics* (4th ed.). Cambridge University Press.

Detailed Syllabus of 3rd Semester Skill Enhancement Course (SEC)

Option 1

Course Title: Renewable Energy and Energy Harvesting
Course Code: PHY SEC 3.1
Nature of Course: Skill Enhancement
Credits: 3 (Theory-2, Practical-1)
Total marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course objectives: The aim of this course is not just to impart theoretical knowledge to the students about the various energy sources in nature, but to provide them with exposure and hands-on learning wherever possible.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Renewable Energy Sources – Fundamentals and Applications	**Fossil Fuels and Nuclear Energy**: Limitations and the need for renewable alternatives **Non-conventional and Renewable Energy Sources**: Overview: Offshore Wind Energy, Tidal Energy, Wave Energy, Ocean Thermal Energy Conversion, Solar Energy, Biomass, Biochemical Conversion, Biogas Generation, Geothermal Energy, Hydroelectricity **Solar Energy Systems**: Solar ponds (convective and non-convective), storage and applications, Solar water heaters, flat plate collectors, solar cookers, solar distillation, greenhouses, Solar cells, PV systems and characteristics, PV equivalent models, sun tracking systems, Absorption air-conditioning.	10	18	10
Unit 2: Wind, Ocean, and Hydro Energy Systems	**Wind Energy**: Fundamentals, Wind turbines, Electrical machines used in wind turbines, Power electronic interfaces and grid integration **Ocean Energy**: Ocean energy potential compared to wind and solar, Wave characteristics and wave energy devices, Tidal characteristics, tidal energy technologies, Ocean Thermal Energy Conversion (OTEC), Osmotic Power, Ocean Biomass **Hydropower**: Resources and technologies, Environmental impact of hydro energy.	10	15	10
Unit 3: Emerging Energy Harvesting Technologies and Sustainability	**Geothermal Energy**: Geothermal resources and technologies **Piezoelectric Energy Harvesting**: Physics of piezoelectric effect, materials, modeling, generators, Applications: wearable, human-powered systems **Electromagnetic Energy Harvesting**: Linear generators, mathematical models, applications **Carbon Capture Technologies** **Energy Storage & Devices**: Cells, batteries, power consumption trends **Environmental Issues and Energy Sustainability**: Role of renewable energy in addressing environmental	10	17	10

	concerns, Sustainable development goals and energy.			
Total		**30**	**50**	**30**

1- Credits practical: Demonstration and Experiment/Project
1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials.
3. Conversion of thermal energy into voltage using thermoelectric modules.
4. Project Preparation

Course outcomes: After completion of this course the students will be able to
CO1: Understand the limitations of conventional energy sources and explain the working principles, technologies, and applications of major renewable energy systems including solar, wind, hydro, ocean, and geothermal energy.
CO2: Analyze the design, operation, and integration of energy harvesting technologies such as photovoltaic systems, piezoelectric and electromagnetic harvesters, and evaluate their potential in modern energy systems.
CO3: Assess the environmental impact of different energy sources and demonstrate an understanding of sustainable energy practices and emerging technologies for clean energy transition.

Suggested Readings:

1. Worsnop, B. L., & Flint, H. T. (1923). *Advanced Practical Physics for Students*. Asia Publishing House.
2. Nelson, M., & Ogborn, J. M. (1985). *Advanced Level Physics Practicals* (4th ed., reprinted). Heinemann Educational Publishers.
3. Prakash, I., & Ramkrishna. (2011). *A Textbook of Practical Physics* (11th ed.). Kitab Mahal.
4. Panigrahi, S., & Mallik, B. (2015). *Engineering Practical Physics*. Cengage Learning India Pvt. Ltd.
5. Squires, G. L. (2015). *Practical Physics* (4th ed.). Cambridge University Press.

Option 2

Course Title: Computational Physics Skills
Course Code: PHY SEC 3.1
Nature of Course: Skill Enhancement
Credits: 3 (Theory-2, Practical-1)
Total Marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course objectives: The objective of this course is to equip students with the skills to use computer programming and numerical analysis as practical tools for solving physics problems through computational methods and hands-on problem-solving training.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Fundamentals of	**Importance of Computers in Physics**: Role in problem-solving and simulation. **Problem-Solving Paradigm**: Steps from problem	10	18	10

Computational Physics and Programming Basics	definition to solution. **Introduction to Linux as a Working Environment**: Editors and basic usage. **Algorithms and Flowcharts**: Definitions, properties, and development of algorithms Flowcharts: concepts, symbols, guidelines, types **Examples**: Cartesian to Spherical Coordinates, Roots of a Quadratic Equation, Matrix operations, Sin(x) as a series, Lissajous figures and projectile motion **Introduction to FORTRAN**: History and significance in scientific computing, Basic syntax: character set, constants, variables, keywords, Arithmetic, relational, logical, and assignment operators, Simple I/O statements and examples from physics.			
Unit 2: Programming Structures and Applications in Physics	**Control Structures and Logic**: Sequential, selection, and repetition logic, Branching statements: IF types, SELECT CASE, Looping statements: DO, WHILE, Nested loops, Jumping statements: GOTO (all types) **Arrays and Subscripted Variables**: Types, DIMENSION statements, input/output operations **Functions and Subroutines**: Statement functions, subprograms, subroutines, Statements: RETURN, CALL, COMMON, EQUIVALENCE **File Operations**: OPEN, READ, WRITE for disk I/O **Applications**: Solving real physics problems using structured programming	10	17	10
Unit 3: Scientific Documentation and Visualization Tools	**Scientific Word Processing with LaTeX**: Basics: document class, structure, environments, compilation, Equations and formulae, figures, tables, symbols, Advanced features: bibliography, citations, indexing, glossaries **Visualization with Gnuplot**: Role of data visualization in physics, Basic commands: plotting data, exporting graphs, Curve fitting: straight line, polynomial, user-defined functions, Application: using Gnuplot for plotting physical data and simulations	6	15	6
Total		**30**	**50**	**30**

1- Credit Practical
Programming:
1. Exercises on syntax on usage of FORTRAN, usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write source codes in FORTRAN.
2. To print out all natural even/ odd numbers between given limits.
3. To find maximum, minimum and range of a given set of numbers.
4. Calculating Euler number using exp(x) series evaluated at x=1

Hands on Exercises:
1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.

3. To find the product of two matrices.
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation. 10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

Course Outcomes: The completion of the course will enable the students to
CO1: Understand and apply algorithmic approaches, flowcharts, and programming constructs to solve fundamental problems in physics using FORTRAN.
CO2: Develop structured scientific programs incorporating control statements, functions, subroutines, arrays, and file handling to model and simulate physical systems.
CO3: Use LaTeX for scientific documentation and Gnuplot for visualization of computational results, enhancing the ability to present scientific data effectively.

Suggested Readings:

1. Sastry, S. S. (2012). *Introduction to Numerical Analysis* (5th ed.). PHI Learning Pvt. Ltd.
2. Rajaraman, V. (n.d.). *Computer Programming in Fortran 77*. PHI.
3. Lamport, L. (1994). *LaTeX–A Document Preparation System* (2nd ed.). Addison-Wesley.
4. Janert, P. K. (2010). *Gnuplot in Action: Understanding Data with Graphs*. Manning.
5. Lipschutz, S., & Poe, A. (1986). *Schaum's Outline of Theory and Problems of Programming with Fortran*. McGraw-Hill Book Co.
6. Verma, R. C., et al. (1999). *Computational Physics: An Introduction*. New Age International Publishers.
7. Ascher, U. M., & Greif, C. (2012). *A First Course in Numerical Methods*. PHI Learning.
8. Atkinson, K. E. (2007). *Elementary Numerical Analysis* (3rd ed.). Wiley India Edition.

Detailed Syllabus of 4th Semester Major Courses

Course Title: Electricity and Magnetism
Course Code: PHY MAJ 4.1
Nature of Course: Major/Core
Credits: 4
Total marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objectives: The objective of this course is to enable students to understand the behavior of electric and magnetic fields in matter, including dielectric and magnetic properties, electromagnetic induction, Kirchhoff's laws, and network theorems in electrical circuits.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Electric field and Potential	Electric field: Electric field lines, Electric flux, Gauss' law and its applications to charge distribution with spherical, cylindrical and planer symmetry. Conservative nature of Electrostatic field. Electrostatic potential. Laplace's equation, Poisson's equation. The Uniqueness theorem. Potential and Electric field of a dipole. Force and torque on dipole. Electrostatic energy of a system of charges. Electrostatic energy of charged sphere. Conductors in an electrostatic field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to (i) Plane infinite sheet and (ii) Sphere	20	20	20
Unit 2: Dielectric properties of matter	Electric field in matter. Polarization, Polarization charges. Electrical Susceptibility and Dielectric constant. Capacitors (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. relation between electric field **E**, polarization vector **P** and displacement vector **D**.	8	8	8
Unit 3: Magnetic field and Ballistic galvenometer	Magnetic force on a point charge. Definition and properties of a magnetic field B. curl and divergence. vector potential. Magnetic force on (i) a current carrying wire (ii) between current elements. Torque on a current loop in a uniform magnetic field. Biot-Savert law and its applications to (i) straight wire and (ii) circular loop. Current loop as magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application to (i) Solenoid and (ii) Torus. Torque on a current loop. Ballistic galvanometer: current and charge sensitivity. Electromagnetic damping. Logarithmic damping. CDR.	14	14	14
Unit 4: Magnetic	Magnetization vector (**M**). Magnetic Intensity (**H**). Magnetic Susceptibility and permeability. Magnetic	4	4	4

properties of matter	flux density (**B**). Relation among **B**, **H** and **M**. Ferromagnetism. B-H curve and hysteresis.			
Unit 5: Electromagnetic induction.	Faraday's law. Lenz's law. Self-inductance and Mutual inductance. Reciprocity theorem. Energy stored in a magnetic field. Introduction to Maxwell's equations. Charge conservation and displacement current.	6	6	6
Unit 6: Electrical circuits and Network Theorems	AC circuits: Kirchhoff's laws for ac circuits. Complex reactance and impedance. Series LCR circuit: Resonance, Power dissipation, Quality factor and Band width. Parallel LCR circuit. Ideal constant voltage and constant current sources. Netwok theorems: Thevenin theorem, Norton theorem, Superposition theorem, reciprocity theorem. Maximum power transfer theorem. Application to dc circuits.	8	8	8
Total		**60**	**60**	**60**

Course Outcomes: At the completion this course the students will able to
CO1: Apply Gauss's law and potential theory to solve electrostatics problems.
CO2: Explain dielectric behavior and analyze capacitors with dielectrics.
CO3: Use Biot–Savart and Ampère's laws to calculate magnetic fields.
CO4: Describe magnetic material properties and interpret B-H curves.
CO5: Understand electromagnetic induction and Maxwell's equations.
CO6: Solve AC/DC circuits using network theorems and resonance concepts.

Suggested Readings:

1. Electricity, Magnetism and electromagnetic Theory, S Mahajan and Choudhury, 2012, Tata Mc Graw hill.
2. Electricity and Magnetism, Edward M Purcell, 1986, Tata Mc Graw hill Education.
3. Introduction to Electrodynamics, D J Griffiths, 3rd Edition, 1998, Benjamin Cummings.
4. Feynman lectures Vol 2. R P Feynman, M Sands, 2008, Pearson Education.
5. Elements of Electromagnetics, M N O Sadiku, 2010, Oxford University Press.
6. Electricity and Magnetism, J H Fewkes & J Yarwood, Vol 1, 1991, Oxford University Press.

Course Title: Elements of Modern Physics
Course Code: PHY MAJ 4.2
Nature of Course: Core/Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objectives: The objective of the course is to introduce students to the foundational principles of quantum mechanics and nuclear physics, exploring wave-particle duality, nuclear structure and decay, detection techniques, nuclear energy processes, and the fundamentals of laser physics.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Quantum Theory	Quantum theory of light; photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. group and phase velocities and relation between them. Two-slit experiment with electrons. Probability. wave amplitude and wave functions.	12	12	12
Unit 2: Uncertainty and Wave-Particle Duality	Position measurement: gamma ray microscope thought experiment; wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from wave packets, impossibility of a particle following a trajectory; estimating minimum energy of a confined particle using uncertainty principle; energy-time uncertainty principle- application to virtual particles and range of an interaction.	7	7	7
Unit 3: Structure of the Atomic Nucleus	Size and structure of atomic nucleus and its relation with atomic weight; impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Atomic Mass Unit. Mass defect and binding energy Nuclear forces, Nature of nuclear forces, N–Z graph, liquid drop model: semi-empirical mass formula and binding energy, nuclear shell model (qualitative discussions) and magic numbers.	8	8	8
Unit 4: Radioactivity	Stability curve and stability of nuclei, Law of radioactive decay, disintegration constant, half-life and mean life. Activity unit. Law of successive disintegration, Secular equilibrium, Transient equilibrium. Alpha decay, Range of alpha particles, Range energy relation, Fine structure of alpha energy spectrum. Beta decay energy released, continuous beta spectrum and Pauli's prediction of neutrino. Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.	10	10	10

Unit 5: Detection of nuclear radiation	Method of energy loss by charged particles and gamma photons. Photoelectric, Compton and Pair-production processes Gas filled detectors – principle and construction of a gas filled detector, Ionization, proportional, GM and spark region.	5	5	5
Unit 6: Nuclear Reactions	Nuclear Reactions, Energy consideration in Nuclear Reaction, Q-value of nuclear reaction, Mass deficit in nuclear reaction, Einstein's mass-energy equivalence principle and generation of nuclear energy. Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235. Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).	8	8	8
Unit 7: Lasers	Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Characteristics of LASER. Three-Level and Four-Level Lasers. Basic lasing. Ruby Laser and He-Ne Laser.	10	10	10
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of the course students will be able to
CO1: Explain the quantum theory of light, photoelectric effect, and matter waves using key experiments and wave-packet concepts.
CO2: Apply Heisenberg's uncertainty principle to physical scenarios and understand its implications on particle behavior and measurement.
CO3: Describe the structure of the atomic nucleus, calculate binding energies, and interpret nuclear models qualitatively.
CO4: Analyze radioactive decay processes and characterize alpha, beta, and gamma emissions and their properties.
CO5: Identify nuclear radiation detection techniques and explain the working principles of gas-filled detectors.
CO6: Evaluate nuclear reactions in terms of Q-values and energy generation through fission and fusion processes.
CO7: Understand the principles of laser operation, including population inversion, stimulated emission, and construction of common lasers.

Suggested Readings:

1. Krane, K. S. (1983). *Introduction to Modern Physics*. Wiley.
2. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). McGraw-Hill.
3. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
4. Bransden, B. H., & Joachain, C. J. (2000). *Quantum Mechanics* (2nd ed.). Pearson.
5. Silfvast, W. T. (2004). *Laser Fundamentals* (2nd ed.). Cambridge University Press.

Course Title: General Lab & Computer Lab Practical
Course Code: PHY MAJ 4.3
Nature of Course: Core
Credits: 4
Distribution of Marks: 80 (End Sem) + **20** (In sem)
Unit 1: General Lab Practical (Marks: 40)

Unit 1: Minimum seven experiments are to be performed in classes from Unit 1 (Two experiments are to be performed in examinations for Unit 1).

1. Use a Multimeter for measuring
(a)Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength **B** and its variation in a solenoid (determine dB/dx).
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self-inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.
12. Measurement of Planck's constant using black body radiation and photo-detector.
13. To draw the characteristic curve of a photo cell and find the maximum velocity of emitted electron.
14. To determine work function of material of filament of directly heated vacuum diode.
15. To determine the Planck's constant using LEDs of at least 4 different colours.

Unit 2: Computer Lab Practical (Marks: 40)

Aim:

The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem.

Solution of Linear system of equations Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalisation of matrices, Inverse of a matrix, Eigen vectors, eigenvalues problems. Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses).

Generation of Special functions Generation of Special functions using User defined functions in Scilab / Mathematica / Matlab. Generating and plotting Legendre Polynomials Generating and plotting Hermite function.

First order ODE Solution of first order Differential equation Euler, modified Euler and Runge-Kutta second order methods. First order differential equation (a) Current in RC, LC circuits with DC source (b) Classical equations of motion.

Second order ODE Second order differential equation. Fixed difference method. Second order Differential Equation (a) Harmonic oscillator (no friction) (b) Damped Harmonic oscillator (c) Over damped (d) Critical damped.

Partial Differential Equation (PDE) Solution of Partial Differential Equation: (a) Wave equation (b) Heat equation.

Solution of Algebraic and Transcendental equations by Newton Raphson methods Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$, $I=I_0 (\sin\alpha/\alpha)^2$ in optics

Interpolation by Newton Gregory Forward and Backward difference formula Evaluation of trigonometric functions e.g. $\sin\theta$, $\cos\theta$, $\tan\theta$ etc.

Numerical Integration (Trapezoidal and Simpson rules), Monte Carlo method Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop

Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modifted Euler and Runge-Kutta (RK) second and fourth order methods First order differential equation

(a) Radioactive decay (b) Newton's law of cooling.

Detailed Syllabus of 4th Semester Minor Courses

(Minor-I)

Course Title: Electricity and Magnetism
Course Code: PHY- MIN 4.1
Nature of Course: Minor
Credits: 4 (Theory-3, practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The objective of this course is to provide a comprehensive understanding of vector calculus and its application to electrostatics, magnetism, electromagnetic induction, and Maxwell's equations, enabling students to analyze and solve fundamental problems in classical electromagnetism and electromagnetic wave propagation.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Vector Analysis	Vector algebra, Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).	8	8	8
Unit 2: Electrostatics	Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem – Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.	10	10	10
Unit 3: Magnetism	Magnetostatics: Biot-Savart's law, and its applications to – (i) straight conductor, (ii) circular coil and (iii) solenoid carrying current. Divergence and curl of a magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia, para, and ferro-magnetic materials.	8	8	8
Unit 4: Electromagnetic Induction	Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.	7	7	7

Unit 5: Maxwell's Equations and EM Wave	Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.	12	12	12
Total		**45**	**45**	**45**

General Lab Practical (Marks: 25) (Minimum six experiments are to be performed in classes) (Two experiments are to be performed in examinations)
1. Use a Multimeter for measuring (a)Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength **B** and its variation in a solenoid (determine dB/dx).
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self-inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.

Course Outcomes: Upon completion of this course, students are expected to
CO1: Understand and apply vector algebra, differential operators, and vector theorems to physical problems.
CO2: Analyze electrostatic fields and potentials for various charge distributions and dielectric media.
CO3: Explain magnetostatics concepts including Biot-Savart law, Ampere's law, and magnetic properties of materials.
CO4: Describe electromagnetic induction phenomena including self and mutual inductance and energy stored in magnetic fields.
CO5: Comprehend Maxwell's equations, electromagnetic wave propagation, and associated energy and polarization concepts.

Suggested Readings:

1. Griffiths, D. J. (2013). *Introduction to Electrodynamics* (4th ed.). Pearson.
2. Sadiku, M. N. O. (2014). *Elements of Electromagnetics* (6th ed.). Oxford University Press.
3. Hayt, W. H., & Buck, J. A. (2012). *Engineering Electromagnetics* (8th ed.). McGraw-Hill.
4. Balanis, C. A. (2012). *Advanced Engineering Electromagnetics* (2nd ed.). Wiley.
5. Jackson, J. D. (1999). *Classical Electrodynamics* (3rd ed.). Wiley.

Detailed Syllabus of 5th Semester Major Courses

Course Title: Mathematical Physics II
Course Code: PHY MAJ 5.1
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objective: The objectives of this course are to offer the students the knowledge to solve differential equations using power series solution method, solve differential equation using separation of variables method, special integrals, different properties of matrix, Fourier series etc.

Course Outlines

Units	Content	L	M	Hours
Unit 1: IKS-1	Definition and scope of Indian knowledge systems in the context of physics. • Key texts and scholars in Indian physics. • Study of the philosophical and metaphysical foundations of Indian physics. • Concepts like Prakriti (nature), Purusha (consciousness), and their relevance to physics. • Detailed exploration of classical Indian physics principles. • Theory of five elements (Panchabhuta) and the concept of ether (Akasha). • Concepts like sound (Nada), light (Prakasha), and heat (Tejas) in Indian physics.	10	8	10
Unit 1: Frobenius Method and Special Functions	Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials.	10	10	10
Unit 2: Partial Differential Equations	Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.	10	10	10

Unit 3: Matrices	Matrix algebra using index notation, Properties of matrices, Special matrix with their properties: Transpose matrix, complex conjugate matrix, Hermitian matrix, Anti-Hermitian matrix, special square matrix, unit matrix, diagonal matrix, co-factor matrix, adjoint of a matrix, self-adjoint matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix. Determinant, Rank, Eigen value, Eigen vector and diagonalization of matrix.	10	10	10
Unit 4: Fourier Series	Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.	5		5
Total		**45**	**45**	**45**

Computer Lab
Practical (Marks: 25)

Course objectives: The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem.

Introduction to Numerical computation softwares: Introduction to Scilab/Mathematica/Matlab/Python, Advantages and disadvantages, Scilab / Mathematica / Matlab/ Python environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab / Mathematica / Matlab/ Python, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab / Mathematica / Matlab/Python functions, Introduction to plotting, 2D and 3D plotting.

Curve fitting, least square fit, Goodness of fit, standard deviation Ohms law to calculate R, Hooke's law to calculate spring constant.

Solution of Linear system of equations Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalisation of matrices, Inverse of a matrix, Eigen vectors, eigenvalues problems. Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses).

Generation of Special functions Generation of Special functions using User defined functions in Scilab / Mathematica / Matlab. Generating and plotting Legendre Polynomials Generating and plotting Hermite function.

First order ODE Solution of first order Differential equation Euler, modified Euler and Runge-Kutta second order methods. First order differential equation (a) Current in RC, LC circuits with DC source (b) Classical equations of motion.

Second order ODE Second order differential equation. Fixed difference method. Second order Differential Equation (a) Harmonic oscillator (no friction) (b) Damped Harmonic oscillator (c) Over damped (d) Critical damped.

Partial Differential Equation (PDE) Solution of Partial Differential Equation: (a) Wave equation (b) Heat equation.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand key concepts of Indian Knowledge Systems and their relevance to physics.
CO2: Solve second-order differential equations using Frobenius method and apply special functions like Legendre, Hermite, and Laguerre.
CO3: Use separation of variables to solve Laplace, wave, and diffusion equations in various symmetries.
CO4: Apply matrix algebra and analyze properties of special matrices, eigenvalues, and eigenvectors.
CO5: Expand periodic functions using Fourier series and compute Fourier coefficients.

Suggested Readings:

1. Arfken, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier.
2. Coddington, E. A. (2009). *An Introduction to Ordinary Differential Equations*. PHI Learning.
3. Simmons, G. F. (2007). *Learning Differential Equations*. McGraw-Hill.
4. Nearing, J. (2010). *Mathematical Tools for Physics*. Dover Publications.
5. McQuarrie, D. A. (2003). *Mathematical Methods for Scientists and Engineers*. Viva Books.
6. Zill, D. G., & Wright, W. S. (2012). *Advanced Engineering Mathematics* (5th ed.). Jones and Bartlett Learning.
7. Goswami, B. K. (n.d.). *Mathematical Physics* (1st ed.). Cengage Learning.
8. Pal, S., & Bhunia, S. C. (2015). *Engineering Mathematics*. Oxford University Press.
9. Kreyszig, E. (2008). *Advanced Engineering Mathematics*. Wiley India.
10. Riley, K. F., & Hobson, M. P. (2011). *Essential Mathematical Methods*. Cambridge University Press.

Course Title: Electromagnetic Theory
Course Code: PHY MAJ 5.2
Nature of Course: Major
Credits: 4
Total Marks: 100

Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objective: The objectives of this course are to offer the students the knowledge of Maxwell's equations, propagation of EM waves in different media, production and detection of different types of polarized EM waves, general information as waveguides and fiber optics.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Maxwell's equations	Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector.	7	7	7
Unit 2: EM Wave Propagation in unbounded Media	Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.	9	9	9
Unit 3: EM Wave Propagation in bounded Media	Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence).	9	9	9
Unit 4: Polarization of Electromagnetic Waves	Uniaxial and Biaxial Crystals. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Mathematical treatment for the production of different type of polarized light. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Optical Rotation: Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.	10	10	10
Unit 5: Wave Guides	Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.	5	5	5
Unit 6: Optical Fibres	Definitions of various optical fibers. Numerical Aperture. Step and Graded Indices. Concept of Single and Multiple Mode fibers and their uses.	5	5	5
Total		**45**	**45**	**45**

General Lab Practical (Marks: 25) Minimum five experiments are to be performed in classes.(One experiment is to be performed in examination.)
1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To study the reflection, refraction of microwaves.
6. To study Polarization and double slit interference in microwaves.
7. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
8. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
9. To verify the Stefan's law of radiation and to determine Stefan's constant.
10. To determine the Boltzmann constant using V−I characteristics of PN junction diode.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Apply Maxwell's equations and displacement current to derive wave equations.
CO2: Analyze EM wave propagation in dielectric, conducting, and plasma media.
CO3: Explain reflection, refraction, and polarization using boundary conditions and Fresnel's laws.
CO4: Understand production, detection, and analysis of polarized light.
CO5: Describe wave propagation in optical waveguides and fibers, and compute numerical aperture and mode types.

Suggested Readings:

1. Griffiths, D. J. (1998). *Introduction to Electrodynamics* (3rd ed.). Benjamin Cummings.
2. Sadiku, M. N. O. (2001). *Elements of Electromagnetics*. Oxford University Press.
3. Chow, T. L. (2006). *Introduction to Electromagnetic Theory*. Jones & Bartlett Learning.
4. Miah, M. A. W. (1982). *Fundamentals of Electromagnetics*. Tata McGraw-Hill.
5. Kshetrimayun, R. S. (2012). *Electromagnetic Field Theory*. Cengage Learning.
6. Hayt, W. H. (2012). *Engineering Electromagnetics* (8th ed.). McGraw-Hill.
7. Lehner, G. (2010). *Electromagnetic Field Theory for Engineers & Physicists*. Springer.

Course Title: Solid State Physics
Course Code: PHY MAJ 5.3
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: On successful completion of the course students will understand to explain the crystal lattices and its features; elementary lattice dynamics and its influence on the properties of materials; describe the main features of the physics of electrons in solids; the dielectric ferroelectric and magnetic properties of solids and the basic concept in superconductivity.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Crystal Structure	Amorphous and Crystalline Materials. Lattice Translation Vectors. Symmetry operations, Lattice with a Basis - Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.	8	8	8
Unit 2: Elementary Lattice Dynamics	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law.	8	8	8
Unit 3: Magnetic Properties of Matter	Dia, Para, Ferri, and Ferromagnetic materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Quantum Mechanical Treatment of Para-magnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.	6	6	6
Unit 4: Dielectric Properties of Materials	Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena.	6	6	6
Unit 5: Ferroelectric Properties of Materials	Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electro strictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.	4	4	4
Unit 6: Free Electron Theory of Metals	Electrical and thermal conductivity of metals, Wiedemann-Franz law. Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (4-probe method) & Hall coefficient.	9	9	9
Unit 7: Superconductivity	Experimental Results. Critical temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (Qualitative Discussion Only).	4	4	4
Total		**45**	**45**	**45**

Lab Practical: Marks:25
(A minimum of five experiments to be done)
1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency.
5. To study the *PE* Hysteresis loop of a Ferroelectric Crystal.
6. To draw the B – H curve of Fe using Solenoid & determine energy loss from Hysteresis.
7. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 _C) and to determine its band gap.
8. To determine the Hall coefficient of a semiconductor sample.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Explain the main features of crystal lattices and the concept of phonons.
CO2: Understand elementary lattice dynamics and its effects on material properties.
CO3: Describe the basic physics of electrons in solids.
CO4: Explain dielectric, ferroelectric, and magnetic properties of solids.
CO5: Understand the fundamental concepts of superconductivity.

Suggested Readings:

1. Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley India Pvt. Ltd.
2. Srivastava, J. P. (2015). *Elements of Solid-State Physics* (4th ed.). Prentice-Hall of India.
3. Azaroff, L. V. (2004). *Introduction to Solids*. Tata McGraw-Hill.
4. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Cengage Learning.
5. Ibach, H., & Lüth, H. (2009). *Solid-State Physics*. Springer.
6. John, R. (2014). *Solid State Physics*. McGraw-Hill.
7. Omar, M. A. (1999). *Elementary Solid-State Physics* (1st ed.). Pearson India.
8. Wahab, M. A. (2011). *Solid State Physics*. Narosa Publishing House.

Course Title: Analog Electronics
Course Code: PHY MAJ 5.4
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam =15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: The objective of the course is to offer the students the knowledge of physics of semiconductor p-n junction, rectifier diodes, zener diode, photodiode, bipolar junction transistors, transistor biasing and stabilization circuits, the concept of feedback in amplifiers and the oscillator circuits.

Course Outlines

Units	Content	L	M	Hours

Unit 1: Two-terminal semiconductor Devices	P and N type semiconductors. Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Principle and structure of LEDs, Photodiode.	8	8	8
Unit 2: Bipolar Junction Transistors	n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.	7	7	7
Unit 3: Amplifiers	Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Two stage RC- coupled amplifier and its frequency response. Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise	13	13	13
Unit 4: Sinusoidal Oscillators	Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.	6	6	6
Unit 5: Operational Amplifiers & Applications	Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. 74 (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.Conversion: Resistive network (Weighted and Ladder). Accuracy and Resolution. A/D Conversion (successive approximation).	11	11	11
Total		**45**	**45**	**45**

General Lab Practical: Marks:25

(A minimum of six experiments to be done).

1. To study V - I characteristics of PN junction diode, and Light emitting diode.
2. To study the V -I characteristics of a Zener diode and its use as voltage regulator.

3. To study the characteristics of a Bipolar Junction Transistor in CE/CB configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
7. To design a Wien bridge oscillator for given frequency using an op-amp.
8. To design a phase shift oscillator of given specifications using BJT.
9. To design a digital to analog converter (DAC) of given specifications.
10. To study the analog to digital convertor (ADC) IC.
11. To design inverting amplifier using Op-amp (741/351) and study its frequency response.
12. To design non-inverting amplifier using Op-amp (741/351) & study its frequency response.
13. To study the zero-crossing detector and comparator.
14. To add two dc voltages using Op-amp in inverting and non-inverting mode.
15. To investigate the use of an op-amp as an Integrator.
16. To investigate the use of an op-amp as a Differentiator.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the physics of semiconductor p-n junctions and their characteristics.
CO2: Analyze the working and applications of devices like rectifier diodes, Zener diodes, and photodiodes.
CO3: Explain the operation of bipolar junction transistors and design biasing and stabilization circuits.
CO4: Understand the concept of feedback in amplifiers and study different types of oscillator circuits.
CO5: Learn the basics of operational amplifiers and their various practical applications.

Suggested Readings:

1. Millman, J., & Halkias, C. C. (1991). *Integrated Electronics*. Tata McGraw-Hill.
2. Ryder, J. D. (2004). *Electronics: Fundamentals and Applications*. Prentice Hall.
3. Streetman, B. G., & Banerjee, S. K. (2009). *Solid State Electronic Devices* (6th ed.). PHI Learning.
4. Salivahanan, S., & Kumar, N. S. (2012). *Electronic Devices & Circuits* (3rd ed.). Tata McGraw-Hill.
5. Gayakwad, R. A. (2000). *OP-Amps and Linear Integrated Circuit* (4th ed.). Prentice Hall.
6. Sedra, A. S., Smith, K. C., & Chandorkar, A. N. (2014). *Microelectronic Circuits* (6th ed.). Oxford University Press.
7. Tietze, U., & Schenk, C. (2008). *Electronic Circuits: Handbook of Design & Applications*. Springer.
8. Sze, S. M. (2002). *Semiconductor Devices: Physics and Technology* (2nd ed.). Wiley
9. Rashid, M. H. (n.d.). *Microelectronic Circuits* (2nd ed.). Cengage Learning.
10. Floyd, T. L. (2008). *Electronic Devices* (7th ed.). Pearson India.

<u>Detailed syllabus of 5th Semester Minor Courses</u>
(Minor-1)

Course Title: Nuclear Physics and Electronics -I
Course Code: PHY MIN 5.1
Nature of Course: Minor
Credits: 4
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course is to offer the students the knowledge of general properties of nucleus, radioactivity, particle accelerator and detector etc.

Course Outlines

Units	Content	L	M	Hours
Unit 1: General Properties of Nuclei	Constituents of a nucleus. Mass, volume, density, radius, charge of a nucleus. Atomic mass unit (amu). Mass-defect, binding energy, packing fraction, average binding energy, binding energy curve and its significance. Nuclear reactions, fission and fusion reactions. Q value of a nuclear reaction. Endothermic and exothermic reactions.	12	10	12
Unit 2: Radioactivity	Types of radioactive decay. Soddy–Fazan's displacement law. Radioactive decay law. Half-life and mean life of a radioelement. Radioactive dating. Unit of radioactivity. Activity of radioactive sources. Radioisotopes, their production and uses. Alpha (α) decay. Range of an α particle. Geiger Nuttall law, (b) -decay: energy kinematics for -decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.	15	12	15
Unit 3: Accelerators and detectors	Need of particle accelerators. Linear accelerator – construction and working principle. Nuclear detectors. Ionization chamber- construction and working principle.	7	8	7
Unit 4: Semi-conductors	P and N type semiconductors, P-N junction diodes, unbiased and biased P-N junctions, depletion layer, barrier potential, diode characteristics, photo-diode, Zenter diode and their uses, LED and their uses	7	8	7
Unit 5: Rectifiers	Rectifier: half wave and full wave rectifier. Efficiency of rectification, ripple factor, shunt capacitor filter.	6	6	6
Unit 6: Transistors	Transistors. Different configurations and characteristics of transistors. Alpha and beta of a transistor and their relations. Transistor as amplifier. DC load line and Q-point of a transistor, Biasing and stability factors of a circuit. h parameter and its equivalent circuit. Classification of amplifiers: Class A, B and C.	13	12	13

Total	60	60	60

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand nuclear properties, binding energy concepts, and nuclear reactions including fission, fusion, and Q-value.
CO2: Explain types of radioactive decay, laws of radioactivity, and applications of radioisotopes.
CO3: Describe α, β, and γ decay mechanisms along with related laws and concepts like neutrino hypothesis and internal conversion.
CO4: Understand the working of particle accelerators and nuclear detectors such as ionization chambers.
CO5: Analyze semiconductor devices, rectifiers, and transistors, including their configurations, biasing, amplifier classes, and applications.

Suggested readings:

1. Millman, J., & Halkias, C. C. (1991). *Integrated Electronics*. Tata McGraw-Hill.
2. Beiser, A. (2002). *Concepts of Modern Physics*. Tata McGraw-Hill.
3. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
4. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory*. Pearson Education.
5. Enge, H. A. (1986). *Introduction to Nuclear Physics*. Addison-Wesley.
6. Theraja, B. L. (2006). *Basic Electronics*. S. Chand & Company.
7. Neamen, D. A. (2012). *Semiconductor Physics and Devices*. McGraw-Hill Education.

Detailed Syllabus of 6th Semester Major Courses

Course Title: Quantum Mechanics I
Course Code: PHY MAJ 6.1
Nature of Course: Major
Credits: 4
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: On successful completion of the course students will able to understand the modern development of physics, starting from Planck's law, its development of the idea of probability interpretation and the formulation of Schrodinger equation, wave functions etc.

Course Outlines

Units	Content	L	M	Hours
Unit 1: IKS-2	Ancient Indian contributions to Physics. Study of scientific treatises such as Aryabhatya, Brahmagupta and Acharya Kanad Vedic cosmology and its connection to modern cosmological theories. Exploration of the Indian concept of time, measurement, and cosmology. Study of ancient Indian astronomical knowledge, including the Siddhantas and planetary calculations.	12	12	12
Unit 1: Introductory Quantum Mechanics	Development of quantum mechanics in light of black body radiation. Failure of classical idea. Plank's quantum hypothesis. Photoelectric effect and Compton effect. Matter wave: Wave particle duality, De Broglie wave associated with moving particles – (i) non relativistic case and (ii) relativistic case. G.P. Thomson's electron diffraction experiment. Complimentary principle of Neils Bohr. Gamma ray microscope experiment, application of uncertainty principle.	14	14	14
Unit 2: Schrödinger Equation	Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrödinger equation for non- relativistic particles; expectation value, momentum and energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; probability and probability current densities in one dimension. Schrodinger wave equation- (i) time dependent and (ii) time independent. Corresponding principle.	14	14	14
Unit 3: Wave function	Wave function and its probabilistic interpretation as probability amplitude. Continuity equation, probability density and probability current density. Normalized wave function, properties of well-behaved wave functions in quantum mechanics.	8	8	8

Unit 4: One-dimensional Box	Introduction to operator formalism, Dynamical variable as operator (position, momentum and Hamiltonian). One dimensional infinitely rigid box- energy eigen values and eigen functions, Expectation values, Ehrenfest's theorem. Normalization; quantum dot as example; quantum mechanical scattering and tunneling in one dimension-across a step potential and rectangular potential barrier.	12	12	12
Total		**60**	**60**	**60**

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

CO1: Understand ancient Indian contributions to physics, including key scientific texts and Vedic cosmology's links to modern theories.
CO2: Explain the development of quantum mechanics from classical failures, including Planck's hypothesis, photoelectric and Compton effects, and wave-particle duality.
CO3: Analyze key quantum experiments and principles, such as electron diffraction, Bohr's complementarity, uncertainty principle, and two-slit interference.
CO4: Apply Schrödinger's wave equation (time-dependent and independent) and interpret the wave function and related quantum concepts.
CO5: Use operator formalism to solve quantum problems like the infinite potential well, and understand quantum tunneling and scattering phenomena.

Suggested Readings:

1. Sakurai, J. J. (1994). *Modern Quantum Mechanics*. Addison-Wesley.
2. Schiff, L. I. (1968). *Quantum Mechanics*. McGraw-Hill.
3. Bransden, B. H., & Joachain, C. J. (2000). *Quantum Mechanics* (2nd ed.). Pearson Education.
4. Powell, J. L., & Craseman, B. (1993). *Quantum Mechanics*. Narosa Publishing House.
5. Shankar, R. (1994). *Quantum Mechanics*. Kluwer Academic.
6. Griffiths, D. J. (2004). *Quantum Mechanics* (2nd ed.). Pearson Education.
7. Mathews, P. M., & Venkatesan, K. (1976). *Quantum Mechanics*. McGraw-Hill.
8. Liboff, R. L. (2002). *Quantum Mechanics* (3rd ed.). Pearson Education.
9.

Course Title: Statistical Mechanics
Course Code: PHY MAJ 6.2
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objectives of this course are to offer the students the knowledge of the techniques of Statistical Mechanics to apply in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, Chemistry and in many other directions.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Classical Statistics	Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.	18	18	18
Unit 2: Classical Theory of Radiation	Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.	10	10	10
Unit 3: Quantum Theory of Radiation	Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.	6	6	6
Unit 4: Bose-Einstein Statistics	Bose-Einstein (B-E) distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	13	13	13
Unit 5: Fermi-Dirac Statistics	Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	13	13	13
Total		**60**	**60**	**60**

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

CO1: Understand the concepts of macrostate, microstate, ensembles, entropy, and thermodynamic probability in statistical mechanics.

CO2: Explain the laws of thermal radiation, blackbody radiation, and derive key radiation laws including Planck's law and its consequences.

CO3: Analyze the Maxwell-Boltzmann distribution, partition function, and thermodynamic functions for ideal gases and two-level systems.

CO4: Describe Bose-Einstein and Fermi-Dirac distribution laws, their thermodynamic functions, and applications like Bose-Einstein condensation and electron gas in metals.

CO5: Apply quantum statistical mechanics to astrophysical phenomena such as white dwarf stars and understand related concepts like Fermi energy and Chandrasekhar limit.

Suggested Readings:
1. Pathria, R. K. (1996). *Statistical Mechanics* (2nd ed.). Oxford University Press.
2. Reif, F. (2008). *Statistical Physics*. Tata McGraw-Hill.
3. Lokanathan, S., & Gambhir, R. S. (1991). *Statistical and Thermal Physics*. Prentice Hall.
4. Sears, F. W., & Salinger, G. L. (1986). *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*. Narosa.
5. Helrich, C. S. (2009). *Modern Thermodynamics with Statistical Mechanics*. Springer.
6. Swendsen, R. H. (2012). *An Introduction to Statistical Mechanics & Thermodynamics*. Oxford University Press.

Course Title: Digital Electronics
Course Code: PHY MAJ 6.3
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The aim of this course is to provide students with a fundamental understanding of digital electronics concepts, including number systems, logic gates, Boolean algebra, combinational and sequential circuits, and the architecture and components of basic computer systems.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Digital circuits	Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. Boolean algebra AND, OR, NOT gates, NAND and NOR Gates as Universal Gates, XOR gate;	8	8	8
Unit 2: Boolean algebra	De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.	7	7	7
Unit 3: Arithmetic and Data Processing Circuits	Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders with examples.	8	8	8
Unit 4: Sequential Circuits	SR, D and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.	10	10	10
Unit 5: Timers: IC 555	Block diagram and applications: Astable multivibrator and Monostable multivibrator	9	9	9

Unit 6: Shift registers	Basic idea of Shift registers (serial and parallel form) Counters: Ring Counter. Asynchronous and Synchronous Counter.	10	10	10
Unit 7: Basic Computer Organization	Vonn Newmann and Havard architecture, Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory types, speed and organization. Basic features of 8085 as examples of CPU. Components: Buses, Registers, ALU.	8	8	8
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the difference between analog and digital circuits and convert between various number systems.
CO2: Apply Boolean algebra and De Morgan's theorems to simplify logic circuits and design using universal gates.
CO3: Design and analyze combinational circuits such as adders, subtractors, multiplexers, and decoders.
CO4: Understand and implement sequential circuits including flip-flops, counters, and shift registers.
CO5: Describe basic computer architecture concepts, including Von Neumann and Harvard architectures, memory types, and components of a CPU like the 8085.

Suggested Readings:

1. Malvino, A. P., Leach, D. P., & Saha. (2011). *Digital Principles and Applications* (7th ed.). Tata McGraw-Hill.
2. Kumar, A. (2009). *Fundamentals of Digital Circuits* (2nd ed.). PHI Learning Pvt. Ltd.
3. Venugopal. (2011). *Digital Circuits and Systems*. Tata McGraw-Hill.
4. Kharate, G. K. (2010). *Digital Electronics*. Oxford University Press.
5. Tocci, R. J., & Widmer, N. S. (2001). *Digital Systems: Principles & Applications*. PHI Learning.
6. Vingron, S. P. (2012). *Logic Circuit Design*. Springer.
7. Ghoshal, S. (2012). *Digital Electronics*. Cengage Learning.
8. Mandal, S. K. (2010). *Digital Electronics* (1st ed.). McGraw-Hill.
9. Chattopadhyay, D., & Rakshit, P. C. (2023). *Electronics Fundamentals and Applications* (17th ed.). New Age International Publishers.

Course Title: Laboratory Practical
Course Code: PHY MAJ 6.4
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: 50 (Gr A) + **50** (Gr B)

Course Objective: The aim of this course is to develop practical skills in designing and analyzing digital electronic circuits and applying computational techniques for solving mathematical problems related to differential equations, special functions, and signal processing.

Group A: Digital electronics Lab Practical (Marks: 50)

(Minimum of five experiments are to be performed in classes)
(One experiment is to be performed in the examination)

[1] To design a switch (NOT gate) using (i) a PNP transistor and (ii) an NPN transistor.
[2] To verify and design AND, OR, NOT, and XOR gates using NAND gates.
[3] To design a combinational logic system for a specified Truth Table.
[4] To convert a Boolean expression into a logic circuit and design it using logic gate ICs.
[5] To design a Half Adder and Full Adder
[6] To design a 4-bit binary Adder.
[7] To design Half Subtractor and Full Subtractor
[8] To design Adder-Subtractor using Full Adder IC.
[9] To design an astable multivibrator of given specifications using 555 Timer.
[10] To build a D flip-flop circuit using NAND gates.
[11] To build a JK flip-flop circuit using NAND gates.
[12] To build JK Master-slave flip-flop using flip-flop ICs.
[13] To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
[14] To build SR flip-flop circuit using NAND gates

Group B: Computer lab Practical (Marks: 40)

(Minimum of five experiments are to be performed in classes)
(One experiment is to be performed in the examination)

1. Solve differential equations

$$\frac{dy}{dx} = e^x \text{ with } y = 0 \text{ for } x = 0$$
$$\frac{dy}{dx} + e^{-x}y = x^2$$
$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$$
$$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$$

2. Dirac delta function

Evaluate the integral I

$I = \frac{1}{\sqrt{2\pi\sigma^2}} \int \exp\left[-\frac{(x-2)^2}{2\sigma^2}\right](x+3)dx$ for $\sigma = 1.0, 0.1, 0.01$ and show the $I \to 5$

3. Fourier Series

Make a program to evaluate

$$\sum_{n=1}^{\infty} 0.2)^{\mathrm{n}}$$

Evaluate the Fourier coefficients of a given periodic function (square wave)
4. Frobenius method and Special Functions

Evaluate

$$\int_{-1}^{1} P_n(x)\mathrm{P_m}(x)\mathrm{dx} = \delta_{n,m}$$

Plot $P_n(x), j_\vartheta(x)$ and show the recursion relation.
5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two)
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions e.g. $\sin\theta$, , given Bessel'sfunctionat N points find its value at an intermediate point.
8. Integrate

$$\frac{1}{(x^2 + 2)}$$

Numerically in a given interval.
9. Compute the nth roots of unity for $\mathrm{n} = 2, 3$ and 4.
10. Find the two square roots of $5 + 12j$.
11. Integral transform

Evaluate FFT of e^{-x^2}
12. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform

Course Outcomes: After successful completion of this course, students will be able to
CO1: Design and implement fundamental digital logic circuits using transistors and logic gate ICs, including combinational and sequential circuits.
CO2: Construct and analyze flip-flops, shift registers, and timer-based circuits to understand timing and memory elements in digital electronics.
CO3: Apply programming skills to solve differential equations, compute Fourier series, and evaluate special functions using computational tools.
CO4: Perform numerical methods including error analysis, least square fitting, and numerical integration to analyze experimental data.
CO5: Utilize integral transforms like FFT and Laplace transforms to solve engineering problems such as signal analysis and circuit laws computationally.

Detailed Syllabus of 6th Semester Minor Courses

(Minor-I)

Course Title: Atomic Physics, Solid state Physics
Course Code: PHY MIN 6.1
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The objective of the course is to offer the students to acquire the knowledge of positive rays, Bohr's theory of hydrogen atom, vector atom model, X-rays etc. of atomic physics; and the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials, explain the dielectric ferroelectric and magnetic properties of solid.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Positive rays	Positive rays: analysis of positive rays. Properties of positive rays. Production of positive rays. Aston and Bainbridge mass spectrographs.	6	6	6
Unit 2: Bohr's theory	Bohr's theory of hydrogen atom. Energy level diagram. Ritz combination principle. Excitation potential, critical potential and ionization potential. Fine structures of the spectral lines. Sommerfield's extension of the Bohr's theory (qualitative only).	10	10	10
Unit 3: Vector atom model	Vector atom model. Bohr magneton, spinning electron. Quantum numbers. Pauli's exclusion principle, source of radiation in external fields – normal Zeeman effect.	8	8	8
Unit 4: X-rays and matter wave	Origin and production of X-rays. Continuous and characteristic X-rays. Moseley's law, diffraction of X-rays by crystals, Bragg's law, Compton effect. Frank and Hertz experiment, matter wave, Davisson and Germar experiment.	10	10	10
Unit 5: Crystal Structure	Amorphous and Crystalline Materials. Lattice Translation Vectors. Symmetry operations, Lattice with a Basis - Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law.	10	10	10
Unit 6: Elementary Lattice Dynamics	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.	8	8	8

Unit 7: Magnetic Properties of Matter	Dia, Para, Ferri, and Ferromagnetic Materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Hysteresis and B-H Curve.	8	8	8
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the fundamental concepts of positive rays, Bohr's hydrogen atom theory, and the vector atom model.
CO2: Explain the nature and properties of X-rays and their applications.
CO3: Describe the structure and characteristics of crystal lattices and phonons in solids.
CO4: Analyze elementary lattice dynamics and their impact on material properties.
CO5: Explain the dielectric, ferroelectric, and magnetic properties of solids and the behavior of electrons in solids.

Suggested Readings:

1. White, H. E. (1934). *Introduction to Atomic Spectra*. Tata McGraw-Hill.
2. Kumar, R. (1990). *Atomic and Molecular Spectra*.
3. Beiser, A. (1987). *Concepts of Modern Physics*. McGraw-Hill.
4. Rajam, J. B. (2007). *Atomic Physics*. S. Chand & Co.
5. Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley India Pvt. Ltd.
6. Ghatak, A. K., & Kothari, L. S. (1970). *Lattice Dynamics*. Tata McGraw-Hill.
7. Dekker, A. J. (1966). *Solid State Physics*. Macmillan.
8. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Saunders College.
9. Pillai, S. O. (2005). *Solid State Physics*. New Age International Publishers.

Detailed Syllabus of 7th Semester Major Courses

Course Title: Advanced Mathematical Physics
Course Code: PHY MAJ 7.1
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of the course is to offer the students the knowledge to solve complex integrals using residue theorem, apply Fourier and Laplace transforms in solving differential equations, understand properties of Tensors, Transformation of coordinates, contra variant and co-variant tensors, indices rules for combining tensors.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Fourier Transforms	Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian functions Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem (Statement only). Properties of Fourier transforms (translation, change of scale, complex conjugation).	15	15	15
Unit 2: Laplace Transforms	Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem (Statement only). Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator.	15	15	15
Unit 3: Linear Vector Spaces	Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear	20	20	20

	Transformations by Matrices.			
Unit 4: General Tensors	Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.	10	10	10
Total		**60**	**60**	**60**

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

CO1: Understand the theory of complex functions, including analyticity, Cauchy-Riemann conditions, and classification of singularities such as poles and branch points.

CO2: Apply complex integration techniques, including Cauchy's integral formula, Laurent and Taylor expansions, and use the residue theorem for evaluating complex integrals.

CO3: Master Fourier transform methods, including the Fourier integral theorem, transform properties, and applications to functions and derivatives, along with the representation of the Dirac delta function.

CO4: Learn Laplace transform techniques and properties, and apply them to solve differential equations, including unit step and delta functions and the damped harmonic oscillator problem.

CO5: Gain foundational knowledge of tensor analysis, including coordinate transformations, tensor operations, and physical tensor quantities, using Einstein summation convention and related tensor properties.

Suggested Readings:

1. Arfken, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier.
2. Coddington, E. A. (2009). *An Introduction to Ordinary Differential Equations*. PHI.
3. Simmons, G. F. (2007). *Learning Differential Equations*. McGraw-Hill.
4. Nearing, J. (2010). *Mathematical Tools for Physics*. Dover Publications.
5. McQuarrie, D. A. (2003). *Mathematical Methods for Scientists and Engineers*. Viva Books.
6. Zill, D. G., & Wright, W. S. (2012). *Advanced Engineering Mathematics* (5th ed.). Jones and Bartlett Learning.
7. Goswami, D. N. (n.d.). *Mathematical Physics* (1st ed.). Cengage Learning.
8. Pal, S., & Bhunia, S. C. (2015). *Engineering Mathematics*. Oxford University Press.
9. Kreyszig, E. (2008). *Advanced Engineering Mathematics*. Wiley India.
10. Riley, K. F., & Hobson, M. P. (2011). *Essential Mathematical Methods*. Cambridge University Press.

Course Title: Advanced Quantum Mechanics
Course Code: PHY MAJ 7.2
Nature of Course: Major/Core
Credits: 4

Distribution of Marks: End Sem: Th=60

In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The aim of the course is to the knowledge to the students so that can be able to understand the principles in quantum mechanics, such as the Schrödinger equation, the wave function, the uncertainty principle, stationary and non-stationary states, time evolution of solutions, as well as the relation between quantum mechanics and linear algebra. Moreover, the students may be able to solve the Schrödinger equation for hydrogen atom. Students acquire the idea of understanding of angular momentum and spin, as well as the rules for quantization and addition of these, spin-orbit coupling and Zeeman Effect.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Time Dependent Schrödinger Equation	Time dependent Schrödinger equation and dynamical evolution of a quantum state, properties of wave function. Interpretation of wave function. Probability and probability current densities in three dimensions. Conditions for physical acceptability of wave functions. Normalization. Linearity and Superposition Principles. Eigenvalues and eigenfunctions. Position, momentum and energy operators; commutator of position and momentum operators. Expectation values of position and momentum. wave function of a free particle.	10	10	10
Unit 2: Time Independent Schrödinger Equation	Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wave function as a linear combination of energy eigenfunctions; General solution of the time dependent Schrödinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave function; Position-momentum uncertainty principle.	12	12	12
Unit 3: Bound States	Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.	12	12	12
Unit 4: Hydrogen-like Atoms	Time independent Schrödinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wave functions from Frobenius method; shapes of the probability densities for ground & first excited states.	12	12	10

Unit 5: Atoms in Electric & Magnetic Fields	Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Zeeman Effect: Normal and Anomalous Zeeman Effect. Paschen-Back Effect and Stark Effect (Qualitative Discussion only).	14	14	12
Total		**60**	**60**	**60**

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

CO1: Understand and apply the time-dependent Schrödinger equation and interpret the physical meaning of the wave function.
CO2: Analyze operators, eigenvalues, eigenfunctions, and use superposition principles to solve quantum systems including free particles and wave packets.
CO3: Solve quantum mechanical problems with boundary conditions, including the one-dimensional potential well and harmonic oscillator using appropriate mathematical methods.
CO4: Apply the time-independent Schrödinger equation in spherical coordinates to understand angular momentum, quantum numbers, and radial wave functions.
CO5: Explain electron spin, magnetic moments, and related phenomena such as the Stern-Gerlach experiment and Zeeman effects qualitatively.

Suggested Readings:

1. Mathews, P. M., & Venkatesan, K. (2010). *A Textbook of Quantum Mechanics* (2nd ed.). McGraw-Hill.
2. Eisberg, R., & Resnick, R. (2002). *Quantum Mechanics* (2nd ed.). Wiley.
3. Schiff, L. I. (2010). *Quantum Mechanics* (3rd ed.). Tata McGraw-Hill.
4. Aruldhas, G. (2002). *Quantum Mechanics* (2nd ed.). PHI Learning of India.
5. Reed, B. C. (2008). *Quantum Mechanics*. Jones and Bartlett Learning.
6. Bohm, A. (1993). *Quantum Mechanics: Foundations & Applications* (3rd ed.). Springer.
7. Miller, D. A. B. (2008). *Quantum Mechanics for Scientists & Engineers*. Cambridge University Press.

Course Title: Nuclear Physics & Plasma Physics
Course Code: PHY MAJ 7.3
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam =15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The objective of the course is to offer the students the knowledge of different nuclear models, semi empirical mass formula & its applications, energy loss of charge particles, gamma ray interaction, Compton scattering etc., various detectors, accelerators. Another objective is to offer the knowledge of plasma, its importance and applications.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Nuclear Models	Liquid drop model approach, Semi-empirical mass formula and significance of its various terms, its applications. Condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.	10	10	10
Unit 2: Interaction of Radiation with matter	Energy loss due to ionization (Bethe- Bloch formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.	6	6	6
Unit 3: Detector & Particle Accelerators	Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.	10	10	10
Unit 4: Idea of plasma	Definition of plasma, concept of temperature, Debye shielding, plasma frequency, plasma parameters, collective behavior of plasma, plasma criteria, plasma sheath, controlled thermonuclear reaction, space and astrophysical plasma, solid state plasma, Classification of Plasma, Gas Lasers, Applications of Plasma.	9	9	9
Unit 5: Particle motion	Single particle motion, particles in electro-magnetic fields, uniform E and B fields, gravitational field, non-uniform B field, non-uniform E fields diffusion across magnetic field, time varying E and B fields, Adiabatic invariants, Magnetic mirror	5	5	5
Unit 6: Plasma as fluids:	Introduction, relation of plasma physics to ordinary electromagnetics, Fluid equation of motion, Fluid drifts perpendicular and parallel to B, Plasma approximation.	5	5	5
Total		**45**	**45**	**45**

Course Outcomes: After completion of the course the students will be able to
CO1: Understand nuclear models and nuclear stability.
CO2: Explain radiation interaction with matter.
CO3: Describe radiation detectors and particle accelerators.
CO4: Define plasma properties and applications.

CO5: Analyze charged particle motion in fields.
CO6: Apply fluid dynamics to plasma behavior.

Suggested Readings:

1. Krane, K. S. (2008). *Introductory Nuclear Physics*. Wiley India Pvt. Ltd.
2. Cohen, B. L. (1998). *Concepts of Nuclear Physics*. Tata McGraw-Hill.
3. Dunlap, R. A. (2004). *Introduction to the Physics of Nuclei & Particles*. Thomson Asia.
4. Perkins, D. H. (2000). *Introduction to High Energy Physics* (4th ed.). Cambridge University Press.
5. Griffith, D. (1987). *Introduction to Elementary Particles*. John Wiley & Sons.
6. Halzen, F., & Martin, A. D. (1984). *Quarks and Leptons: An Introductory Course in Modern Particle Physics*. Wiley India.
7. Heyde, K. (2004). *Basic Ideas and Concepts in Nuclear Physics – An Introductory Approach*. IOP Publishing.
8. Knoll, G. F. (2000). *Radiation Detection and Measurement* (3rd ed.). John Wiley & Sons.
9. Chen, F. F. (2016). *Introduction to Plasma Physics and Controlled Fusion* (3rd ed.). Springer.
10. Bittencourt, R. A. (2004). *Fundamentals of Plasma Physics* (3rd ed.). Springer.
11. Hutchinson, I. H. (2002). *Principles of Plasma Diagnostics* (2nd ed.). Cambridge University Press.

Course Title: Atomic and Molecular Physics
Course Code: PHY MAJ 7.4
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam =15, Activity (assignment, Quiz, seminar etc) =15

Course Objective

To provide students with a comprehensive understanding of atomic and molecular spectra, their interaction with external fields, and various spectroscopic techniques for probing structural and dynamical properties of atoms and molecules.

Outlines

Units	**Topics**	**L**	**M**	**Hours**
Unit I: Atomic Spectra	Quantum states of electron in atoms – hydrogen atom spectrum – electron spin – Stern Gerlach Experiment – spin-orbit interaction – Lande interval rule – two electron systems – LS-JJ coupling schemes – fine structure – spectroscopic terms and selection rules – hyperfine structure – exchange symmetry of wave function – Pauli's exclusion principle – periodic table – alkali type spectra – equivalent electrons.	10	10	10

Unit II: Atoms in External Fields and Resonance Spectroscopy	Zeeman and Paschen Back Effect of one and two electron systems – selection rules – Stark effect – inner shell vacancy – X-ray – Auger transitions – Compton Effect – NMR – basic principles – classical and quantum mechanical description – spin-spin and spin-lattice relaxation times – magnetic dipole coupling – chemical shift – Knight shift – ESR – basic principles – nuclear interaction and hyperfine structure – g-factor – zero field splitting.	10	10	10
Unit III: Microwave Spectroscopy and IR Spectroscopy	Rotational spectra of diatomic molecules – rigid rotator – effect of isotropic substitution – non-rigid rotator – rotation spectra of polyatomic molecules – linear, symmetric top and asymmetric top molecules – experimental techniques – diatomic vibrating rotator – linear, symmetric top molecule – analysis by infrared techniques – characteristic and group frequencies.	10	10	10
Unit IV: Raman Spectroscopy	Raman effect – quantum theory of Raman effect – rotational Raman spectra – vibrational Raman apectra – Raman spectra of polyatomic molecules – Raman spectrometer – hyper- Raman effect – experimental techniques.	7	7	7
Unit V: Electronic Spectroscopy	Electronic spectra of diatomic molecules – Frank-Condon principle – dissociation energy and dissociation products – rotational fine structure of electronic vibration transitions – Fortrat Diagram – predissociation.	8	8	8
Total		**45**	**45**	**45**

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

CO1: Explain the origin of atomic spectra, electron spin phenomena, fine and hyperfine structures, and their significance in atomic models.

CO2: Analyze the effects of external fields on atoms, including Zeeman, Paschen-Back, and Stark effects, and interpret resonance spectroscopic techniques like NMR and ESR.

CO3: Interpret microwave and infrared spectra of diatomic and polyatomic molecules, and deduce molecular structure and vibrational modes.

CO4: Apply the principles of Raman spectroscopy to study rotational and vibrational spectra of molecules, and evaluate experimental techniques for Raman effect.

CO5: Understand and assess electronic spectra of molecules using concepts like Franck–Condon principle, dissociation energy, Fortrat diagrams, and predissociation mechanisms.

Suggested Readings:

1. Chanda, M. (2003). *Atomic Structure and Chemical Bond*. Tata McGraw-Hill, New Delhi.
2. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). Tata McGraw-Hill, New

Delhi.
3. Aruldhas, G. (2002). *Molecular Structure and Spectroscopy*. Prentice Hall of India, New Delhi.
4. Aruldhas, G. (2002). *Molecular Structure and Spectroscopy*. Prentice Hall of India, New Delhi.
5. Barrow, G. M. (1986). *Introduction to Molecular Spectroscopy*. McGraw-Hill Ltd., Singapore.

Detailed Syllabus of 7th Semester Minor Courses
(Minor-I)

Course Title: Atomic Physics
Course Code: PHY MIN 7.1
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of the course is to provide a conceptual understanding of atomic structure and spectra, highlighting key experiments and applications relevant to various scientific and technological fields.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Foundations of Atomic Structure	Discovery of electron, proton, neutron, Rutherford's alpha particle experiment and nuclear model, Bohr's atomic model: postulates, hydrogen spectrum, energy levels, Limitations of Bohr's model, Basic idea of quantization in atoms.	11	10	10
Unit 2: Quantum View of Atoms	Introduction to quantum numbers: n, l, m, s (without Schrödinger equation), Electronic configuration of elements (up to Z = 30), Pauli Exclusion Principle and Hund's Rule (qualitative), Shapes and significance of s, p, d orbitals (conceptual only).	11	10	10
Unit 3: Atomic Spectra and Excitation	Emission and absorption spectra: line vs continuous spectra, Explanation of spectral lines using Bohr model, Hydrogen spectral series: Lyman, Balmer, Paschen (qualitative idea), Introduction to X-rays: production and characteristics, Applications in astronomy, material science, and medicine.	14	14	14
Unit 4: Electron Spin and Magnetic Effects	Concept of electron spin and magnetic moment, Stern-Gerlach experiment, Introduction to Zeeman effect (normal only), Role of magnetic fields in atomic transitions, Magnetic resonance and its applications (e.g., MRI – qualitative only).	12	12	12

Unit 5: Modern Applications of Atomic Physics	Lasers: basic principle of stimulated emission, population inversion, Types and applications of lasers (medical, industrial, communication), Atomic clocks and GPS, Atomic absorption and emission spectroscopy in material analysis, Role of atomic physics in modern technology (overview).	12	12	12
Total		**60**	**60**	**60**

Course Outcomes: On successful completion of this course students will be able to
CO1: Understand the historical development and basic models of atomic structure.
CO2: Describe quantum numbers and explain the arrangement of electrons in atoms.
CO3: Interpret atomic spectra and relate them to energy levels in atoms.
CO4: Explain electron spin and its role in magnetic and spectroscopic phenomena.
CO5: Identify the relevance of atomic physics in modern applications such as lasers, spectroscopy, and atomic clocks.

Suggested Readings:

1. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). McGraw-Hill.
2. Mani, H. S., & Mehta, G. K. (2000). *Introduction to Modern Physics*. Affiliated East-West Press.
3. Ghoshal, S. N. (2010). *Atomic and Nuclear Physics*. S. Chand & Company.
4. Verma, R. M. (2011). *Atomic and Molecular Physics*. Ane Books Pvt. Ltd.
5. Brij Lal & N. Subrahmanyam. (2010). *Atomic and Molecular Physics*. S. Chand & Company.
6. Young, H. D., & Freedman, R. A. (2012). *University Physics with Modern Physics* (13th ed.). Pearson.
7. Singh, R. (2009). *Physics for Degree Students – B.Sc. Second Year*. S. Chand.

Detailed Syllabus of 7th Semester Discipline Specific Elective Courses (DSE)

(any one is to be chosen from DSE 7.1 and DSE 7.2)

(DSE course is in lieu of Research Project)

Course Title: Advanced Mathematical physics
Course Code: PHY-DSE 7.1
Nature of Course: DSE
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course is to offer the students to acquire the knowledge to solve problems in Physics related to Linear Vector space, Cartesian Tensor, General tensors and non-linear dynamics.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Fourier Transforms	Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian functions Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem (Statement only). Properties of Fourier transforms (translation, change of scale, complex conjugation).	15	15	15
Unit 2: Laplace Transforms	Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem (Statement only). Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator.	15	15	15
Unit 3: Linear Vector Spaces	Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.	20	20	20
Unit 4: General Tensors	Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.	10	10	10
Total		**60**	**60**	**60**

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

CO1: Develop a foundational understanding of abstract systems, including binary operations, groups, fields, and vector spaces, with emphasis on linear independence, basis, and transformations.

CO2: To build proficiency in linear transformations and tensor algebra, enabling students to represent and manipulate physical and geometric quantities using coordinate-independent formulations.

CO3: To explore the role of tensors in physical systems, including stress, strain, moment of inertia, and transformations in Minkowski space, while reinforcing vector calculus using Cartesian tensors.

CO4: To introduce the fundamentals of nonlinear dynamical systems, focusing on one-dimensional flows, fixed-point analysis, and bifurcation theory, with applications to real-world physical problems.

Suggested Readings:

1. Kamal, R. (2008). *Embedded Systems: Architecture, Programming & Design*. Tata McGraw Hill.
2. Mazidi, M. A., Mazidi, J. G., & McKinlay, R. D. (2007). *The 8051 Microcontroller and Embedded Systems Using Assembly and C* (2nd ed.). Pearson Education India.
3. Valvano, J. W. (2000). *Embedded Microcomputer Systems: Real-Time Interfacing*. Brooks/Cole.
4. Susnea, I., & Mitescu, M. (2005). *Microcontrollers in Practice*. Springer.
5. Barrett, S. F. (2008). *Embedded Systems: Design & Applications*. Pearson Education India.
6. Valvano, J. W. (2011). *Embedded Microcomputer Systems: Real-Time Interfacing*. Cengage Learning.
7. Rao, B. K. (2011). *Embedded System*. PHI Learning Pvt. Ltd.

Course Title: Physics of Devices and Instruments

Course Code: PHY-DSE7.2

Nature of Course: DSE

Credits: 4

Total Marks: 100

Distribution of Marks: End Sem: Th=60

In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The objective of this course is that the students can gain knowledge on advanced electronics devices such as UJT, JFET, MOSFET, CMOS etc., detailed process of IC fabrication, Digital Data serial and parallel Communication Standards along with the understanding of communication systems.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Devices	Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconduc-tor Junction. Metal oxide semiconductor (MOS)device. Ideal MOS and Flat Band voltage. SiO_2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.	12	15	12
Unit 2: Power supply & Filters	Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, short circuit protection. Active and Passive filters: Low Pass, High Pass, Band Pass and band Reject Filters.	10	10	10

Unit3: Multivibrators	Astable, Monostable and Bistable Multivibrators using transistors	7	5	7
Unit 4: Phase Locked Loop (PLL)	Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter–Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046)	7	5	7
Unit 5: Processing of Devices	Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography.	6	10	6
Unit 6: Digital Data Commu-nication Standards	Serial Communications: RS232, Handshaking, Implementation of RS232 on PC. Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART). Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines.	6	5	6
Unit 7: Communi-cation System	Block diagram of electronic communication system, Need for modulation. Analysis of Amplitude Modulated wave. Modulation Index. Sideband frequencies in AM wave. Power content in different parts of the modulated wave. CE Amplitude Modulator. Square law modulation, SSB transmission. Demodulation of AM wave using Diode Detector.	12	10	12
Total		**60**	**60**	**60**

Course Outcomes: Upon completion of this course, students will be able to
CO1: Describe the characteristics and working of UJT, JFET, MOSFETs, and Tunnel diodes.
CO2: Analyze power supply circuits and design passive and active filters.
CO3: Design and explain transistor-based multivibrators and PLL circuits.
CO4: Explain IC fabrication steps including oxidation, lithography, and metallization.
CO5: Understand digital communication standards (RS232, USB, GPIB) and AM modulation technique.

Suggested Readings:

1. Millman, J., & Halkias, C. C. (1991). *Integrated Electronics: Analog and Digital Circuits and Systems*. Tata McGraw-Hill.
2. Sedra, A. S., Smith, K. C., & Chandorkar, A. N. (2014). *Microelectronic Circuits* (6th Ed.). Oxford University Press.
3. Streetman, B. G., & Banerjee, S. K. (2009). *Solid State Electronic Devices* (6th Ed.). PHI Learning.
4. Gayakwad, R. A. (2000). *Op-Amps and Linear Integrated Circuits* (4th Ed.). Prentice Hall.
5. Sze, S. M. (2002). *Semiconductor Devices: Physics and Technology* (2nd Ed.). Wiley India.
6. Tomasi, W. (2004). *Electronic Communications Systems: Fundamentals through*

Advanced (5th Ed.). Pearson Education.
7. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory*. Pearson Education.

Detailed Syllabus of 8th Semester Major Courses

Course Title: Research Ethics and Methodology
Course Code: PHY MAJ 7.4
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th = 60
In Sem: Sessional Exam = 20, Activity (assignment, Quiz, seminar etc) =20

Course Objectives: The objective of this course is to equip students with foundational knowledge and practical skills in research methodology and ethics, enabling them to design, conduct, and report scientific research responsibly and effectively.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Fundamentals of Research	Introduction to research: Meaning, purpose, and types of research, Scientific method and its applications, Interdisciplinary and multidisciplinary research, Hypothesis: Definition, formulation, and types, Research problem identification and formulation, Objectives and significance of research.	12	12	12
Unit 2: Literature Survey and Review Writing	Importance of literature review, Sources of scientific information: journals, databases (Scopus, Web of Science, arXiv, etc.), How to read a scientific paper, Use of reference management tools (e.g., Mendeley, Zotero), Writing a review report	12	12	12
Unit 3: Research Ethics and Integrity	Definition and importance of research ethics, Plagiarism: definition, types, consequences; use of plagiarism detection software, Authorship and publication ethics, Data fabrication and falsification, Institutional Ethics Committees and ethical clearances, Intellectual Property Rights (IPR) and patents (basic introduction)	12	12	12
Unit 4: Experimental Methods and Data Handling in Physics	Designing experiments and recording observations, Statistical analysis: mean, standard deviation, error analysis, curve fitting, Graphical representation of data using software tools (Excel, Python, Origin, etc.), Uncertainty and propagation of errors	12	12	12

Unit 5: Scientific Writing and Communication	Structure and components of research reports, and scientific papers, technical writing skills and style (LaTeX), writing project proposals and abstracts, Preparing presentations and posters for seminars/conferences, Communication skills for interviews and research discussions.	12	12	12
Total		**60**	**60**	**60**

Course outcomes: By the end of the course, students will be able to

CO1: Understand the fundamental principles and types of scientific research in physics.

CO2: Recognize and address ethical issues such as plagiarism and data integrity.

CO3: Conduct effective literature reviews using scientific databases and referencing tools.

CO4: Apply suitable experimental methods and statistical techniques for data analysis.

CO5: Develop strong scientific writing and communication skills for preparing research proposals, reports, and presentations.

Suggested Readings:

1. Kothari, C. R., & Garg, G. (2019). *Research Methodology: Methods and Techniques*. New Age International.
2. Kumar, P. (2014). *Research Methodology: A Step-by-Step Guide for Beginners*. SAGE Publications.
3. Steneck, N. H. (2007). *ORI Introduction to the Responsible Conduct of Research*. U.S. Department of Health and Human Services.
4. Day, R. A., & Gastel, B. (2006). *How to Write and Publish a Scientific Paper* (7th ed.). Cambridge University Press.
5. Selected research articles and ethical guidelines from UGC, DST, CSIR, and INSA (various years).

Course Title: Condensed Matter Physics II
Course Code: PHY MAJ 8.1
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The objective of the course is to equip a student with basic concepts of Condensed Matter Physics so that the knowledge can be applied for further development of the subject, enable a student to work in both theoretical and experimental aspects of Condensed Matter Physics and help the students in thorough learning of the concepts associated with the course through numerical problems.

Course Outlines

Units	Content	L	M	Hours
Unit 1:	Introductory concepts, Origin of Defects, Point	10	10	10

Defects and Imperfections in Crystals	Defect, Line Defect, Volume Defect, Activation Energy for Defect Formation, Schottky, Frenkel defects, Color centers, Dislocations, Diffusion, Fick's law.			
Unit 2: XRD, Electron & Neutron Diffraction	Crystal Structure Determination, Interaction of X-Rays with matter, absorption of X-Rays, Elastic scattering from a perfect lattice, X-Ray diffraction, Laue, Powder and Rotating Crystal method, Scattering Factor, Structure Factor, Electron Diffraction, Neutron Diffraction.	12	12	12
Unit 3: Electron Energy Band, Theory and Related Ideas	Electrons in a periodic potential, Kronig Penny model. E-k diagram, Brillouin Zone, Effective Mass, Conductor, Semiconductor and insulator. Semiconductors: Conductivity, Mobility, Hall Effect. Hall coefficient, Measurement of conductivity, Four probe method.	10	10	10
Unit 4: Magnetic Properties of Materials	Review of origin of magnetic moments, paramagnetism due to free ions (Quantum Theory) and conduction electrons (Pauli paramagnetism), Molecular field theory of Ferromagnetism, Domains, Hysteresis loop, Anti ferromagnetism, Ferrimagnetism, Magnetic Anisotropy.	10	10	10
Unit 5: Ferroelectric Properties of Materials	Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.	6	8	6
Unit 6: Supercondu-civity	Introductory concepts, Critical Temperature. Critical magnetic field., Meissner Effect, Type-I & Type-II superconductors, London equations, Penetration Depth, Thermodynamics of superconducting transition, Isotope effect, introduction to BCS theory, Cooper pair, Basic idea on High temperature superconductivity	12	10	12
Total		**60**	**60**	**60**

Course Outcomes: Upon completion of this course, students will be able to
CO1: Identify and explain different types of crystal defects and their effects on material properties.
CO2: Apply diffraction techniques to determine crystal structures.
CO3: Analyze electronic properties in solids using band theory and related models.
CO4: Understand magnetic behavior in materials and related phenomena.
CO5: Explain ferroelectric and superconducting properties and their underlying mechanisms.

Suggested Readings:

1. Kittel, C. (2005). *Introduction to Solid State Physics* (8th ed.). John Wiley & Sons.
2. Dekker, A. J. (1986). *Solid State Physics*. Macmillan India Ltd.
3. Omar, M. A. (2001). *Elementary Solid-State Physics: Principles and Applications*.

Pearson Education.
4. Verma, A. R., & Srivastava, O. N. (1991). *Crystallography Applied to Solid State Physics*. New Age International.
5. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Brooks/Cole.

Course Title: Electronics
Course Code: PHY-MAJ 8.2
Nature of Course: MAJ
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course is to equip students with fundamental and applied knowledge of analog and digital electronics—including semiconductor devices, microprocessors, and microcontrollers—enabling them to design small electronic systems through application-oriented learning.

Course Outcomes

Units	Content	L	M	Hours
Unit 1: Transistor Fundamentals	BJT amplifier, Emitter follower, impedance matching application, ac models: T and π, analysis, IC circuit current mirror, open collector, pull up resistor. Bootstrapped and Darlington amplifier Field effect transistors: JFET, MESFET and MOSFET, structure, working, derivation of the equations of IV characteristics under different conditions, JFET as amplifiers and switch MOSFET, E- MOSFET, Digital switching, active load, introduction to CMOS and FINFET technology. Silicon Controlled Rectifier, Liquid Crystal Display, OLED, Solid State battery.	20	20	20
Unit 2: Integrated Circuits: Operational Amplifier	Differential amplifier: circuit configuration, dual input, balanced output differential amplifier, DC-AC analysis, inverting and non-inverting inputs, Review of applications of Operational amplifiers Applications of linear digital ICs Comparator, A/D, D/A, PLL, VCO, interfacing Circuit Instrumentation amplifier, Schmitt Trigger Circuits Active filters (Filter approximation,) Filtering and noise reduction.	15	15	15

Unit 3: Memory element, Microprocessor and Microcontroller	RAM and ROM as memory element. Introduction to microprocessor: Architecture of digital computer system, Von Neumann and Harvard architecture, different microprocessors, architecture, pin diagram, different bus, programming model using intel 8085, register set, memory organization, instruction set, simple programming: addition, subtraction, multiplication etc. Introduction to 8051 microcontroller and embedded systems, instruction set, addressing mode, programming, time delay generation, look up table implementation etc.	15	15	15
Unit 4: Digital transmission	Sampling theorem, quantization, Dynamic range, Companding, Pulse code modulation (PCM), Delta modulation, granular noise, slope overloading, adaptive delta modulation, differential PCM,	10	10	10
Total		**60**	**60**	**60**

Course outcomes: After completion of the course the students will be able to

CO1: Understand and apply the working of BJT, FET, MOSFET, CMOS, and FINFET in amplifiers and digital circuits.
CO2: Design and analyze op-amp-based circuits and use linear ICs in instrumentation and filtering.
CO3: Explain microprocessor and microcontroller architecture and write simple programs using 8085 and 8051.
CO4: Understand digital transmission techniques like PCM, delta modulation, and apply sampling and quantization concepts.

Suggested Readings:

1. Malvino, A. P., & Bates, D. J. (2007). *Electronic Principles* (7th ed.). Tata McGraw-Hill.
2. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory* (10th ed.). Pearson India.
3. Gaekwad, R. A. (2000). *Op Amps and Linear Integrated Circuits* (4th ed.). Prentice Hall of India.
4. Jain, R. P. (2010). *Modern Digital Electronics* (4th ed.). Tata McGraw-Hill.
5. Millman, J., & Halkias, C. (1991). *Integrated Electronics: Analog and Digital Circuit Systems*. McGraw-Hill.
6. Leach, D. P., & Malvino, A. P. (2006). *Digital Principles and Applications* (7th ed.). Tata McGraw-Hill.
7. Neamen, D. A. (2012). *Semiconductor Physics and Devices* (4th ed.). Tata McGraw-Hill.
8. Horowitz, P., & Hill, W. (2015). *The Art of Electronics* (3rd ed.). Cambridge University Press.
9. Gaonkar, R. S. (2002). *Microprocessor Architecture, Programming & Applications with the 8085* (5th ed.). Prentice Hall.

10. Mazidi, M. A., Mazidi, J. G., & McKinlay, R. D. (2007). *The 8051 Microcontroller and Embedded Systems* (2nd ed.). Pearson Education.

Course Title: Classical Mechanics
Course Code: PHY MAJ 8.3
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The aim of this course is to offer the students the knowledge to overview of Newton's Laws of Motion, the knowledge of understanding of the Lagrangian and Hamiltonian of a system. Finally, after completion of the course, students will be able to solve the seen or unseen problems/numericals in classical mechanics.

Units	Content	L	M	Hours
Unit 1: Review of Newtonian mechanics	Mechanics of a system of particles, Constraints of motion and their classification, Generalised co-ordinates, D' Alembert's principle, Lagrange's equations of motion and its simple applications: (i) Atwood machine, (ii) Simple pendulum, (iii) Compound pendulum, (iv) Keplarian motion and (v) Linear harmonic oscillator. Hamilton's principle, Calculus of variation, shortest distabce between two points. Lagranges equations from Hamiltion's principle. Cyclic coordinates.	10	10	10
Unit 2: Motion in central potential	Maps, winding numbers and orbital stability, Hidden symmetry in the Kepler problem, Small Oscillations, Solution of one-dimensional harmonic oscillator problem, Forced oscillations in one dimension, Damped harmonic motion in one dimensiongeneral solution of the problem, Displacement as a function of time, Systems with many degrees of freedom, Eigen value equation and normal co-ordinates.	12	15	12
Unit 3: Lagrangian dynamics	Lagrangian dynamics and transformations in configuration space, geometry of motion in configuration space, canonical moment and covariance of Lagrange's equation in configuration space. Hamiltonian dynamics and transformations in phase space, Generating functions, Poisson brackets, Integrable canonical flows, Hamilton-Jacobi equation, Action-angle variables.	13	12	13

Unit 4: Linear transfor-mations	Linear transformations, rotations and rotating frames, similarity transformations, linear transformations and eigen value problem, dynamics in rotating reference frames. Rigid Body Dynamics, Definition of Rigid body, Eulerian Angles, Euler's theorem, Angular momentum and kinetic energy, Moment of inertia tensor, Euler's equation of motion, Symmetrical top.	15	13	15
Unit 5: Noncano-nical flows	Flows on spheres, local vs complete integrability, globally integrable noncanonical flows, attractors, Damped driven Euler-Lagrange dynamics, Liapunov exponents, geometry and integrability. Damped driven Newtonian systems, period doubling, fractal and multifractal orbits in phase space, strange attractors, the two-frequency problem.	10	10	10
Total		**60**	**60**	**60**

Course outcomes: Upon completion of this course, students will be able to
CO1: Apply Newtonian, Lagrangian, and Hamiltonian mechanics to particle systems with constraints.
CO2: Analyze central force motion and small oscillations using appropriate mathematical tools.
CO3: Use advanced Lagrangian and Hamiltonian formalisms including Poisson brackets and action-angle variables.
CO4: Solve problems in rigid body dynamics using linear transformations and Euler's equations.
CO5: Understand and analyze non-canonical flows, chaos, and stability in dynamical systems.

Suggested Readings:

1. Goldstein, H., Poole, C., & Safko, J. (2002). *Classical Mechanics* (3rd ed.). Pearson Education.
2. Landau, L. D., & Lifshitz, E. M. (1976). *Mechanics* (3rd ed., Vol. 1 of Course of Theoretical Physics). Butterworth-Heinemann.
3. Arnold, V. I. (1989). *Mathematical Methods of Classical Mechanics* (2nd ed.). Springer.
4. Thornton, S. T., & Marion, J. B. (2003). *Classical Dynamics of Particles and Systems* (5th ed.). Cengage Learning.
5. Fowles, G. R., & Cassiday, G. L. (2004). *Analytical Mechanics* (7th ed.). Thomson Brooks/Cole.

Course Title: Dissertation (collection of Data, Analysis, Report preparation)/DSE Course
Course Code: PHY MAJ 8.4
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: 60 (End Sem) + **40** (In sem)

Course Objective: To make the students understand how to use the basic knowledge of electronics, thermodynamics, optics, matter etc. in practical environment and proceed to do research on the subject.

Course Outcomes:
CO1: Collect data and revise an experimental procedure iteratively and reflectively.
CO2: Gain the ability to use the theoretical knowledge of physics to evaluate the process and outcome of an experiment quantitatively and qualitatively.
CO3: Extend the scope of investigation whether or not result come out as expected and communicate the process and outcome of an experiment.

Detailed Syllabus of 8th Semester Minor Courses
(Minor-I)

Course Title: Electronics, Nuclear Physics & Electronics -II
Course Code: PHY MIN 8.1
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objectives: The objective of this course, is to offer the students the understanding of the different transistors with different configurations, transistor biasing etc. Moreover, they will have to gain knowledge about binding energy, nuclear models and their applications in different branches of Physics. The course will develop problem-based skills and the acquire knowledge can be applied in the areas of nuclear, medical, archeology, geology and other interdisciplinary fields of Physics and Chemistry.

Course Outlines

Unit:	Content	L	M	Hours
Unit 1: Nuclear Properties, Models	Binding energy, average binding energy and its variation with mass number, angular momentum, magnetic moment, electric moments, nuclear excites. Semi empirical mass formula. Liquid drop model of nucleus, Shell model of nucleus, concept of nuclear force	15	15	15
Unit 2: Neutron, Positron	Neutron, Discovery of neutron by Chadwick. Properties of neutron: mass of neutron, charge of neutron. Discovery of positron.	6	6	6
Unit 3: Detectors and Acceler-Ators	Gas detectors: Ionization chamber and GM Counter. Construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (idea only). Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.	13	13	13

Unit 4: Feedback in amplifiers & Sinusoidal Oscillators	Concept of feedback, different types of feedback, Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, Hartley, Colpitts oscillators and determination of Frequency oscillations.	11	10	11
Unit 6: Number system logic gates	Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates.	10	11	10
Unit 7: Logic circuit	De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra.	5	5	5
Total		**60**	**60**	**60**

Course Outcomes: After completion of this course the students
CO1: Understand nuclear properties, models, and nuclear forces.
CO2: Explain the discovery and properties of neutron and positron.
CO3: Describe working principles of detectors and particle accelerators.
CO4: Analyze feedback in amplifiers and design sinusoidal oscillators.
CO5: Differentiate analog and digital systems; convert between number systems.
CO6: Simplify logic circuits using Boolean algebra and universal gates.
CO7: Apply concepts to solve problems in nuclear physics and electronics.

Suggested Readings:

1. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
2. Krane, K. S. (1987). *Introductory Nuclear Physics*. Wiley.
3. Knoll, G. F. (2010). *Radiation Detection and Measurement* (4th ed.). Wiley.
4. Lee, S. Y. (2012). *Accelerator Physics* (3rd ed.). World Scientific.
5. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory* (10th ed.). Pearson Education.
6. Schilling, D. L., & Belove, C. (1989). *Electronic Circuits: Discrete and Integrated*. McGraw Hill.
7. Mano, M. M. (2004). *Digital Logic and Computer Design*. Pearson Education.

Detailed Syllabus of 8th Semester Discipline Specific Elective Courses (DSE)

(any one is to be chosen from DSE 8.1 and DSE 8.2)

(DSE course is in lieu of Dissertation)

Course Title: Astronomy and Astrophysics

Course Code: PHY-DSE 8.1

Nature of Course: DSE
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: This course introduces the origin and evolution of the Universe, covering basic astronomical measurements, observational tools, and planetary system formation. Students will learn about the Sun, solar system, stars, interstellar matter, and the Milky Way, along with galaxy formation, dark matter, and large-scale cosmic structures.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Stellar properties	Radiant flux and Luminosity, Magnitude scale. Measurement of astronomical quantities: Stellar distances(parallax), Radii, Mass and Effective Temperature. Equilibrium of stars, Gravity and thermodynamics, virial theorem. Stellar spectral classification – Hertzsprung-Russell (HR) diagram. Introductory idea of stellar evolution: white dwarf, neutron stars and black holes.	12	12	12
Unit 2: Solar System	The Sun; properties of photosphere, chromosphere and corona. Solar system's objects: Theory of formation of the solar system (introductory idea only); physical properties of the planets- their distances, atmospheres, asteroid belt, meteorites and the comets – Kuiper belt and the Oort cloud; Introduction to Extra-Solar Planets.	12	12	12
Unit 3: Positional Astronomy	Celestial sphere, spherical geometry and celestial coordinates. Concept of time: universal time, solar time, mean solar time, local sidereal time and Julian day. Introduction to constellations (hands on practice in evening sky with small telescopes or laser pointer), ecliptic and diurnal motion of stars. Solar system's objects : rotation, revolution and coordinates in the sky.	10	10	10
Unit 4: Astrono-mical Techni-ques	Introduction to telescopes – telescope size and light gathering power, resolving power, f-number. Different types of optical telescopes (reflecting and refracting). Space telescopes. Concept of virtual observatory, on-line tools in astronomy: SDSS, SkyView, SIMBAD, Aladin, AAVSO database etc.	10	10	10
Unit 5: Galaxies & Cosmology	The Milky Way, properties of the galactic centre. Classification of galaxies, Hubble's tuning fork diagram, normal (spiral, elliptical and lenticular) and active galaxies. Black holes in galaxies. Distance ladder in cosmology, Cepheid variables. Cosmic expansion of the universe and Hubble(- Lemaitre) law. Clusters of galaxies and dark matter - virial theorem. Concept of the Hot Big Bang, Oscillating Universe.	16	16	16
Total		**60**	**60**	**60**

Course Outcomes: Upon completion of this course, students will be able to
CO1: Understand stellar properties, spectral classification, and basic stellar evolution.
CO2: Describe the Sun, planets, and other solar system objects, including extrasolar planets.
CO3: Apply celestial coordinate systems and time concepts; identify constellations and motions.
CO4: Explain telescope types, their functions, and use online astronomy tools.
CO5: Classify galaxies, understand cosmology basics, cosmic expansion, and dark matter.

Suggested Readings:

1. Carroll, B. W., & Ostlie, D. A. (2007). *An Introduction to Modern Astrophysics* (2nd ed.). Pearson Education.
2. Choudhuri, A. R. (2010). *Astrophysics for Physicists*. Cambridge University Press.
3. Ryden, B., & Peterson, B. M. (2010). *Foundations of Astrophysics*. Pearson Education.
4. Morison, I. (2008). *Introduction to Astronomy and Cosmology*. Wiley.
5. Shu, F. H. (1982). *The Physical Universe: An Introduction to Astronomy*. University Science Books.

Course Title: Physics of Earth
Course Code: PHY-DSE 8.2
Nature of Course: DSE
Credits: 4
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course is to develop critical and quantitative thinking on scientific issues related to Cosmology and Earth Sciences, enabling students to understand Earth's processes, apply knowledge to the study of the Universe, explore careers in related fields, and engage with contemporary environmental challenges.

Course Outlines

Units	Content	L	M	Hours
Unit 1: The Earth & Universe	Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. Energy and particle fluxes incident on the Earth, The Cosmic Microwave Background.	12	12	12
Unit 2: Structure	The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field,	10	10	10

	geothermal energy. How do we learn about Earth's interior? The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems. The Atmosphere: variation of temperature, density and composition with altitude, clouds. The Cryosphere: Polar caps and ice sheets. Mountain glaciers. The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.			
Unit 3: Dynamical Processes	Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types of products and distribution. The Hydrosphere: Ocean circulations. Oceanic current system and effect of Coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis. The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones. Climate: Earth's temperature and greenhouse effect, Paleoclimate and recent climate changes, The Indian monsoon system. Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorus cycle. The role of cycles in maintaining a steady state.	18	18	18
Unit 4: Evolution	Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of the Indian subcontinent. (i) Timeline of major geological and biological events. (ii) Origin of life on Earth. (iii) Role of the biosphere in shaping the environment. (iv) Future of evolution of the Earth and solar system: Death of the Earth.	14	14	14
Unit 5:	Disturbing the Earth – Contemporary dilemmas Human population growth, Atmosphere: Greenhouse gas emissions, climate change, air pollution; Hydrosphere: Fresh water depletion, Geosphere: Chemical effluents, nuclear waste. Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecology.	6	6	6
Total		**60**	**60**	**60**

Course Outcomes: After completion of the course the students will able to
CO1: Understand the origin and structure of the universe, solar system, and Earth's basic physical properties.
CO2: Describe Earth's internal structure, atmosphere, hydrosphere, cryosphere, and biosphere along with their characteristics.
CO3: Explain key geophysical processes including plate tectonics, earthquakes, volcanism, oceanic and atmospheric circulation.
CO4: Analyze geological time scales, evolution of Earth's stratigraphy, and the role of the biosphere in Earth's history.
CO5: Evaluate contemporary environmental challenges affecting Earth's systems such as climate change, pollution, and biodiversity loss.

Suggested Readings:

1. Melosh, H. J. (2011). *Planetary Surface Processes*. Cambridge University Press.
2. Harte, J. (1988). *Consider a Spherical Cow: A Course in Environmental Problem Solving*. University Science Books.
3. Holmes, A. (1993). *Holme's Principles of Physical Geology* (4th ed., revised by D.L. Holmes). Chapman & Hall.
4. Emiliani, C. (1992). *Planet Earth: Cosmology, Geology and the Evolution of Life and Environment*. Cambridge University Press.