SNDT Women's University, Mumbai

Undergraduate Degree / UG Programme (Syllabus as Per NEP) - Faculty of Science & Technology

Bachelor of Science
Physics

B.Sc. In Physics

As Per NEP – 2020

Semester – V & VI

Syllabus
(W.E.F. Academic Year 2025-26)

Terminologies

Vertical	Full-Form/Definition	Remarks	Related To Major And Minor Courses
Major (Core)	Subject Comprising Mandatory and Elective Courses, Major Specific IKS, Vocational Skill Courses, Internship/ Apprenticeship, Field Projects, Research Projects Connected to Major	Minimum 50% Of Total Credits Corresponding to Three/Four - Year UG Degree- Mandatory Courses	Related To The Major
Minor Course	Course From Same Or Different Faculty	Minimum 18-20 Credits to Be Completed in The First Three Years of UG Programme	Related To the Minor
OEC	Open Elective Courses/ Generic Courses	10-12 Credits to Be Offered in I And/Or II Year. Faculty-Wise Baskets of OEC To Be Prepared	OEC Is to Be Chosen Compulsorily from Faculty Other Than That of the Major
VSC	Vocational Skill Courses, Including Hands On Training Corresponding To The Major And/Or Minor Subject	8-10 Credits, To Be Offered in First Three Years, Wherever Applicable Vocational Courses Will Include Skills Based on Advanced Laboratory Practical's of Major	Related To the Major or Minor
SEC	Skill Enhancement Courses	06 Credits, To Be Offered in I And II Year, To Be Selected from The Basket of Skill Courses Approved by University	Related To the Major or Minor Any Relevant Skill
AEC	Ability Enhancement Courses	08 Credits, To Be Offered in I And II Year, English: 04 Credits to Be Earned in Sem - I, Modern Indian Language Of 04 Credits to Be Offered in II Year	NA
VEC	Value Education Courses	Understanding India, Environmental Science/Education, Digital	NA

		and Technological Solutions, Health & Wellness, Yoga Education, Sports, And Fitness	
IKS	Indian Knowledge System	Generic IKS Course: Basic Knowledge Of The IKS To Be Offered At First Year Level	Major-Specific IKS Courses: Advanced Information About the Major, Part of the Major Credit to Be Offered at Second- Or Third-Year Level
OJT	On-Job Training (Internship / Apprenticeship)	Corresponding To the Major Subject	Related To The Major
FP	Field Projects	Corresponding To the Major Subject	Related To the Major
CC	Co-Curricular Courses	Health And Wellness, Yoga Education Sports, And Fitness, Cultural Activities, NSS/NCC And Fine/ Applied/Visual/ Performing Arts	NA
CE	Community Engagement and Service		Related To Major
RP	Research Project	Corresponding To the Major Subject	Related To Major

Programme Template

Degree		B.Sc.
Programme		Physics
Preamble		The B.Sc. Physics program, structured under the National Education Policy (NEP) 2020, is designed to provide students with a comprehensive understanding of fundamental and advanced concepts in physics. This program emphasizes a blend of theoretical knowledge and practical skills, ensuring that graduates are well-prepared for both academic pursuits and professional careers. By fostering critical thinking, analytical skills, and a strong Foundation in scientific principles, the program aims to cultivate a deep appreciation for the physical sciences and their applications in various technological and interdisciplinary fields. Aligned with the NEP 2020's vision for holistic and multidisciplinary education, the B.Sc. Physics program offers flexibility through multiple entry and exit options, integration of vocational education, and opportunities for research and innovation. The curriculum is designed to be inclusive and equitable, catering to diverse learning needs and promoting the use of regional languages alongside English to enhance comprehension. Graduates of this program will find diverse employment opportunities in fields such as research and development, education, healthcare, engineering, data science, and information technology. Emphasizing ethical scientific practices and social responsibility, the program seeks to produce graduates who are not only proficient in physics but also capable of contributing to societal and global challenges through scientific Inquiry and innovation.
Programme Specific Outcomes(PSOs)		After completing this programme, Learners will be able to
	1	Synthesize core principles across physics disciplines to develop profound understanding, laying the foundation for specialization.
	2	Apply theoretical and experimental knowledge of physics in diverse contexts, fostering adaptability and innovative problem-solving skills.
	3	Evaluate complex physics problems critically, Employing creative thinking to generate effective solutions.
	4	Communicate findings and ideas clearly and logically, demonstrating proficiency in conveying complex physics concepts.

	5	Demonstrate analytical prowess in data analysis and hypothesis formulation, facilitating proficient research conduct across physics domains.
	6	Lead and collaborate effectively in interdisciplinary teams, exhibiting adaptability and readiness for leadership roles while fostering a culture of continuous learning.
	7	Construct a framework for promoting multicultural competence and ethical values, fostering sustainability and responsible citizenship in the global physics community.
Eligibility Criteria for Programme		10+2 certificate preferably with Physics as one of the major subjects
Intake		120

Structure with Course Titles

B.Sc. In Physics

Semester – V

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester – V					
50132211	Solid State Physics (Th+Pr) (2+2)	Major (Core)	4	100	50	50
50132212	Mathematical Physics (Th+Pr) (2+2)	Major (Core)	4	100	50	50
51032211	India's Contribution to Physics (Th)	IKS (Major Specific)	2	50	0	50
50232211	Astronomy and Astrophysics-I (Th+Pr) (2+2)	Major (Elective) **(Any One)**	4	100	50	50
50232212	Mathematical Physics					
50332211	Electronic Instrumentation (Th+Pr) (2+2)	Minor Stream	**4**	100	50	50
50632201	Solar PV System: Installation, Repairing and Maintenance (Th)	VSC-4	2	50	50	0
51332201	Field Project (Pr)	FP	2	50	50	0
			22	**550**	**300**	**250**

Semester – VI

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester - VI					
60132211	Classical Mechanics	Major (Core)	4	100	50	50
60132212	Nuclear Physics	Major (Core)	4	100	50	50
60232211	Atomic & Molecular Physics	Major (Elective) **(Any One)**	4	100	50	50
60232212	Special Theory of Relativity					
60332211	Applied Optics	Minor Stream	2	50	0	50
60332212	C++ Programming	Minor Stream	**4**	100	50	50
61232221	On Job Training	OJT	4	100	50	50
			22	**550**	**250**	**300**

Exit with Degree (3-year)

Course Syllabus

Semester – V

.5.1 Major (Core)

Course Titles	**Solid State Physics (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	1. CO1: Explain the fundamentals of the classical free electron theory of metals, including concepts such as relaxation time, collision time, and mean free path, and critically analyze its limitations.
	2. CO2: Apply the principles of quantum free electron theory and Fermi–Dirac statistics to describe electronic distribution in solids, and evaluate concepts like density of states and Fermi energy.
	3. CO3: Understand the phenomenon of superconductivity, including its basic mechanism, Meissner effect, penetration depth, and distinguish between Type I and Type II superconductors with reference to BCS theory.
	4. CO4: Analyze the band theory of solids, including the Kronig–Penney model, Brillouin zones, and the formation of energy bands, and explain the motion of electrons in periodic potentials.
	5. CO5: Differentiate between metals, insulators, and intrinsic semiconductors based on band theory and evaluate the role of electronic structure in determining electrical properties of materials.
Module 1(Credit 1) Electrical Properties of Matter	
Learning Outcomes	After learning the module, learners will be able to
	1. LO1: Describe the classical free electron theory of metals and explain concepts such as relaxation time, collision time, and mean free path.
	2. LO2: Identify and explain the limitations (drawbacks) of the classical free electron theory in explaining electrical properties of metals.
	3. LO3: Explain the fundamentals of the quantum theory of free electrons and its significance in improving the classical model.
	4. LO4: Apply Fermi–Dirac statistics to analyze electronic distribution in solids and interpret the concept of Fermi energy.
	5. LO5: Explain and analyze the density of energy states in solids and its role in determining electrical properties of materials.
Content Outline	• Electrical properties of metals : Classical free electron theory of metals, Drawbacks of classical theory, Relaxation time, Collision

	time and mean free path • Quantum theory of free electrons, Fermi Dirac statistics and electronic distribution in solids, Density of energy states and Fermi energy
Module 2 (Credit 1) Superconductivity and Band Theory of Solids	
Learning Outcomes	1. LO1: Explain the fundamental concepts of superconductivity, including its mechanism and key characteristics.
	2. LO2: Describe the effects of magnetic fields on superconductors, including the Meissner effect, penetration depth, and distinguish between Type I and Type II superconductors.
	3. LO3: Understand and explain the BCS theory as a microscopic theory of superconductivity.
	4. LO4: Analyze the band theory of solids, including the Kronig–Penney model, Brillouin zones, and the formation of energy bands in periodic potentials.
	5. LO5: Differentiate between metals, insulators, and intrinsic semiconductors based on band structure and explain electron motion in a one-dimensional periodic potential.
Content Outline	• Superconductivity: A survey, Mechanism of Superconductors, Effects of magnetic field, The Meissner effect, the penetration depth, Type I and Type II Superconductors. BCS theory. • Band theory of solids, The Kronig- Penney model (Omit eq. 6.184 to 6.188), Brillouin zones, Number of wave functions in a band, Motion of electrons in a one-dimensional periodic potential, Distinction between metals, insulators and intrinsic semiconductors.
Module 3 & 4 (Credit 2) - Practical's Course	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO1: Demonstrate the ability to perform experiments to determine the acceleration due to gravity (g) using Kater's pendulum and bar pendulum, and analyze experimental data accurately.
	2. LO2: Apply experimental techniques to determine optical properties, such as locating cardinal points using a goniometer.
	3. LO3: Evaluate mechanical properties of materials by determining modulus of rigidity (η) and Young's modulus (Y) using a flat spiral spring.
	4. LO4: Determine fluid properties such as surface tension (using Quinke's method) and analyze the underlying physical principles.
	5. LO5: Use modern instruments like an ultrasonic interferometer to measure velocity of liquid and adiabatic compressibility, and

	interpret the results scientifically.
Content Outline	• To determine of acceleration due to gravity 'g' by Kater's Pendulum • To determine cardinal points by using Goniometer • To determine modulus of rigidity (η) and young's modulus (Y) by flat Spiral Spring • To determine surface tension of mercury using Quinke's Method • To determine acceleration due to gravity 'g' by bar pendulum • To determine velocity of liquid and adiabatic compressibility using Ultrasonic Interferometer.
Learning Outcomes	1. LO1: Demonstrate the ability to design and analyze circuits using operational amplifiers (IC 741) and timers (IC 555) for applications such as Schmitt trigger, astable multivibrator, and ramp generator.
	2. LO2: Analyze and interpret the characteristics of semiconductor devices such as FET, UJT, and SCR through experimental observations.
	3. LO3: Construct and evaluate electronic circuits like relaxation oscillators and rectifiers, and understand their working principles.
	4. LO4: Investigate the behavior of photosensitive devices such as photodiodes and phototransistors, and relate their characteristics to practical applications.
	5. LO5: Develop practical skills in circuit assembly, measurement, and data analysis, using electronic instruments and components to draw valid conclusions
Content Outline	• To study the Schmitt trigger using IC 741 OpAmp • To study the IC-555 timer as a Astable Multivibrator • To study the IC-555 timer as ramp generator • To study FET characteristics • To study UJT as relaxation oscillator • To study SCR characteristics • To study SCR Half wave rectifier. • To study Photodiode/Phototransistor characteristics

Main References:

1. Mechanics by Keith R. Symon (KRS)
2. Classical Mechanics by A Modern Perspective by V. D Barger & M. S Olsson (BO)
3. Classical Mechanics by Herbert Goldstein (G)

Additional References:

4. An Introduction to Mechanics by Daniel Kleppner& Robert Kolenkow

5. Chaotic Dynamics – An Introduction by Baker and Gollup

Semester – V

.5.2 Major (Core)

Course Titles	**Mathematical Physics (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO1: Apply fundamental matrix operations Students will be able to perform addition, multiplication, and classification of matrices, including special types such as diagonal, unit, triangular, and symmetric matrices.
	2. CO2: Analyze and solve matrix-related problems Students will be able to compute transpose, inverse (by adjoint method), eigenvalues, and eigenvectors, and apply concepts like Cayley–Hamilton theorem and diagonalization.
	3. CO3: Understand and apply Fourier transforms Students will be able to evaluate complex Fourier, sine, and cosine transforms and use them to analyze mathematical and physical problems.
	4. CO4: Utilize Laplace transform techniques Students will be able to compute Laplace transforms and inverse Laplace transforms, including transforms of derivatives, to solve differential equations.
	5. CO5: Solve advanced problems using transform methods Students will be able to apply convolution theorem and properties of Fourier and Laplace transforms to solve integral equations and engineering/science applications.
Module 1(Credit 1) Matrices	
Learning Outcomes	After learning the module, learners will be able to
	1. Perform matrix operations Students will be able to carry out addition and multiplication of matrices and identify special types such as null, diagonal, scalar, unit, upper triangular, and lower triangular matrices.
	2. Analyze matrix transformations Students will be able to compute the transpose and conjugate of matrices and classify matrices as symmetric, skew-symmetric, Hermitian, and skew-Hermitian.
	3. Determine matrix properties Students will be able to distinguish between singular and non-singular matrices and compute determinants, adjoint, and inverse of a matrix using the adjoint method.
	4. Apply advanced matrix concepts Students will be able to evaluate trace, eigenvalues, and eigenvectors of matrices and understand their significance in solving linear systems.
	5. Use theorems for matrix simplification Students will be able to apply the Cayley–Hamilton theorem and perform diagonalization

	of matrices to simplify matrix computations and solve related problems.
Content Outline	• Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper Triangular and Lower-Triangular Matrices • Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. • Adjoint of a Matrix. Inverse of a Matrix by Adjoint Method. Orthogonal and Unitary Matrices. Trace of a Matrix. Eigenvalues and Eigenvectors. Cayley- Hamilton Theorem. Diagonalization of Matrices
Module 2 (Credit 1) Fourier and Laplace transforms	
Learning Outcomes	1. Understand Fourier transform concepts Students will be able to explain the introduction and formal development of the complex Fourier transform and interpret its mathematical significance.
	2. Apply different Fourier transforms Students will be able to compute Fourier sine and cosine transforms for given functions and apply them in solving problems.
	3. Evaluate transforms of derivatives Students will be able to determine Fourier transforms of derivatives and use them to simplify differential equations.
	4. Use Laplace transform techniques Students will be able to compute Laplace transforms and Laplace transforms of derivatives to solve initial value problems.
	5. Solve problems using inverse transforms and convolution Students will be able to apply inverse Laplace transforms and the convolution theorem to solve differential and integral equations.
Content Outline	• Fourier transforms: Introduction, Formal development of the complex Fourier transform • Cosine and Sine transforms, The transforms of derivatives • Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem.
Module 3 & 4 (Credit 2) - Practical's Course	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO 1. Understand Experimental Techniques: Students will be able to explain the principles and procedures for measuring physical quantities such as surface tension, elastic constants, and velocity of sound.
	2. LO 2. Perform Optical and Wave Experiments: Students will be able to conduct experiments to determine wavelength (step slit

	method), analyze interference patterns (Edser's 'A' pattern), and calculate Rydberg's constant.
	3. LO 3. Analyze Oscillatory Systems: Students will be able to study damping in oscillations and calculate logarithmic decrement using appropriate experimental setups.
	4. LO 4. Evaluate Electrical and Atomic Parameters: Students will be able to determine fundamental constants such as charge-to-mass ratio (e/m) using Thomson's method and interpret the results.
	5. LO 5. Interpret and Validate Experimental Data: Students will be able to record observations, perform calculations, analyze errors, and validate experimental results with theoretical values.
Content Outline	• Surface tension of soap solution • Elastic constants of a rubber tube • Logarithmic decrement • Determination of Rydberg's constant • Edser's 'A' pattern 8 Determination of wavelength by Step slit • Determination of e/m by Thomson's method • Velocity of sound in air using CRO
Learning Outcomes	1. LO 1. Understand Electrical Measurement Techniques: Students will be able to explain and perform measurements of electrical parameters such as mutual inductance, capacitance, and inductance using bridge circuits (B.G., Maxwell's bridge, parallel bridge).
	2. LO 2.Analyze Magnetic and Semiconductor Properties: Students will be able to study and interpret the hysteresis loop using CRO and determine the band gap energy of a Ge diode.
	3. LO 3. Design and Implement Electronic Circuits: Students will be able to design and construct electronic circuits such as astable multivibrators and Wien bridge oscillators.
	4. LO 4 Evaluate Filter Circuits: Students will be able to design and analyze first-order active low-pass and high-pass filter circuits and study their frequency response.
	5. LO 5. Interpret Experimental Results and Performance: Students will be able to record observations, analyze circuit behavior, calculate relevant parameters, and validate results with theoretical expectations.
	6. LO 1. Understand Electrical Measurement Techniques: Students will be able to explain and perform measurements of electrical parameters such as mutual inductance, capacitance, and inductance using bridge circuits (B.G., Maxwell's bridge, parallel bridge).

Content Outline	• Mutual inductance by BG. • Capacitance by parallel bridge • Hysteresis loop by CRO • L/C by Maxwell's bridge • Band gap energy of Ge diode. • Design and study of transistorized astable multivibrator (BB) • Design and study of Wien bridge oscillator • Design and study of first order active low pass filter circuit (BB) • Design and study of first order active high pass filter circuit (BB)

(Theory) References: -

1. Erwin Kreyszig (Wiley Eastern Limited,1985) Advanced Engineering Mathematics
2. Charlie Harper. (P.H.I.1995) Introduction to Mathematical Physics
3. B S Grewal, Khanna Publishers (2000) Higher Engineering Mathematics
4. H. K. Dass Mathematical Physics

Semester – V

.5.3 Indian Knowledge System (IKS) (Major Specific)

Course Titles	**India's Contribution to Physics**
Course Credits	**2 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. CO 1. Integrate knowledge of ancient and modern Indian physics by connecting philosophical foundations (Nyaya–Vaisheshika) with contemporary scientific developments and research practices.
	2. CO 2. Critically analyze India's contributions to global physics research through the evolution of key institutions like the Tata Institute of Fundamental Research and their role in major scientific advancements.
	3. CO 3. Apply understanding of classical and modern concepts to explain phenomena such as spectroscopy, gravitation, quantum effects, and astrophysical processes in both historical and modern contexts.
	4. CO 4. Evaluate the impact of Indian scientists and missions including C. V. Raman and Indian Space Research Organisation on global scientific progress in areas like space science, nuclear physics, and material science.
	5. CO 5. Develop an interdisciplinary perspective by relating traditional knowledge systems with cutting-edge research in fields such as high-energy physics, nanotechnology, and quantum computing.
Module 1(Credit 1) Ancient Indian Contributions to Physics	
Learning Outcomes	After learning the module, learners will be able to
	1. LO1. Understand foundational concepts of ancient Indian physics by explaining the philosophical principles of the Nyaya and Vaisheshika schools, including atomism (anu), time, and classification of padarthas.
	2. LO2. Analyze classical Indian theories of physical phenomena such as states of matter, gravitation, motion, electricity, sound, and acoustics as described in Vedic and Vaisheshika traditions.
	3. LO3. Interpret ancient Indian contributions to astronomy and calendrical science through the study of texts like the Vedanga Jyotisha, Aryabhatiya, and Panchasiddhantika, including their models and computational methods.
	4. LO4. Evaluate the scientific contributions of modern Indian physicists such as Jagadish Chandra Bose, C. V. Raman, and Meghnad Saha in advancing fields like electromagnetism, spectroscopy, and astrophysics.

	5. LO5. Assess the impact of post-independence Indian physicists including Homi J. Bhabha, Vikram Sarabhai, and Harish-Chandra on nuclear science, space research, and mathematical physics in India.
Content Outline	• **Ancient Indian Contributions to Physics** • Philosophical Foundations: Nyaya and Vaisheshika schools: Concepts of atoms (anu), time. Classification of Predicable (Padartha), States of matter, Theory of gravitation and laws of motion in Vaisheshik Philosophy, Vedic concepts about Electricity, Sound and acoustics, Astronomy and Physics in Vedic Texts: o Astronomical references in the Vedas, Astronomical model and algorithms of the Vedāṅga-jyotiṣa o The Pañca-siddhāntikā of Varāhamihir Meteorology and planetary science, Āryabhaṭīya of Āryabhaṭa, Calendrical computations. • **Modern Indian Physicists and Their Contributions** • 19th and Early 20th Century: J.C. Bose: Contributions to electromagnetism and the demonstration of wireless communication. Studies on the properties of metals and plant physiology from a physical perspective. o C.V. Raman: Raman Effect: Scattering of light and its implications in spectroscopy. Nobel Prize-winning work and its applications. o Meghnad Saha: Saha Ionization Equation: Its importance in astrophysics and stellar atmospheres. Bose-Einstein statistics and its role in quantum mechanics. Collaboration with Albert Einstein. • Post-Independence Era: Homi Bhabha: Development of nuclear physics in India. Contributions to cosmic ray research. Vikram Sarabhai: Contributions to space physics and the establishment of ISRO. Harish-Chandra: Work in mathematical physics and representation theory
Module 2 (Credit1) India in Global Physics Research	
Learning Outcomes	1. LO 1. Describe the development of major Indian research institutions such as the Indian Association for the Cultivation of Science, Tata Institute of Fundamental Research, Saha Institute of Nuclear Physics, and Physical Research Laboratory, and explain their roles in advancing physics research in India.
	2. LO 2. Explain key experiments and discoveries in Indian physics research, including Raman spectroscopy, neutrino studies at the India-based Neutrino Observatory, and contributions to gravitational wave detection through LIGO.
	3. LO 3. Analyze contemporary contributions of India in space and astrophysics, particularly the role of Indian Space Research Organisation and missions like AstroSat in multi-wavelength astronomy.
	4. LO 4. Evaluate advancements in quantum physics and material science in India, including research on Bose–Einstein

	condensates, quantum computing, nanotechnology, and modern material physics.
	5. LO 5. Assess India's participation in global high-energy physics research, including contributions to CERN, the Large Hadron Collider, and studies related to the Higgs boson.
Content Outline	• Module: - 02 India in Global Physics Research :-Development of Research Institutions: Indian Association for the Cultivation of Science (IACS). Tata Institute of Fundamental Research (TIFR). Saha Institute of Nuclear Physics. Physical Research Laboratory (PRL). • Major Experiments and Discoveries: Raman Spectroscopy and its modern applications. Advances in particle physics and neutrino studies at INO (India-based Neutrino Observatory). Contributions to LIGO and gravitational wave detection. • Module-4 Contemporary Indian Contributions • Space and Astrophysics: Contributions of ISRO in space exploration and physics. Astrosat and its role in multi-wavelength astronomy. • Quantum Physics and Material Science: Research in Bose-Einstein condensates and quantum computing. Advances in nanotechnology and material physics by Indian scientists. • High-Energy Physics: Participation in CERN and the Large Hadron Collider. Indian contributions to the study of Higgs boson • Space and Astrophysics: Contributions of ISRO in space exploration and physics. Astrosat and its role in multi-wavelength astronomy. • Quantum Physics and Material Science: o Research in Bose-Einstein condensates and quantum computing • Advances in nanotechnology and material physics by Indian scientists. • High-Energy Physics: Participation in CERN and the Large Hadron Collider. Indian contributions to the study of Higgs boson

References: -

1. R. Balasubramanian, Indian Philosophy and Physics: From Quantum Mechanics to Consciousness.
2. S. Radhakrishnan, Indian Philosophy.
3. Debiprasad Chattopadhyaya, History of Science and Technology in Ancient India
4. Āryabhaṭīya of Āryabhaṭa, K. S. Shukla and K. V. Sarma, Indian National Science Academy, 1976
5. Studies in Indian Mathematics and Astronomy: Selected Articles of Kripa Shankar Shukla, Kolachana et. al. (eds.),

6. Culture and History of Mathematics 12, HBA, 2019
7. Rajinder Singh, J.C. Bose: The First Modern Scientist in India.
8. Venkataraman, Bhabha and His Magnificent Obsessions
9. S. Irfan Habib, J.C. Bose and the Indian Response to Western Science. Ashok Jain, Indian Science and Technology in the 21st Century
10. G. Madhavan Nair, Riding the Waves: A Journey into Space Science and Technology. o K. Kasturirangan, The Indian Space Odyssey.

Semester – V

.5.4 A. Major (Electives)

Course Titles	**Astronomy and Astrophysics-I (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO 1. Integrate knowledge of stellar evolution and galactic structures to explain the formation, life cycle, and end states of stars along with the classification and evolution of galaxies.
	2. CO 2. Analyze astrophysical phenomena and observational events such as eclipses, transits, variable stars, and meteor showers using appropriate scientific principles.
	3. CO 3. Apply classification systems in astronomy including stellar spectral classes and galaxy classification methods like Hubble's tuning fork diagram to interpret observational data.
	4. CO 4. Evaluate fundamental cosmological theories and concepts including dark matter, dark energy, and models of the universe such as the Big Bang and steady state theory.
	5. CO 5. Utilize observational astronomy techniques and measurement systems such as magnitude scales, constellations, and time measurement to study and interpret celestial objects and events.
Module 1(Credit 1) Fundamentals of Astronomy & Instruments	
Learning Outcomes	After learning the module, learners will be able to
	1. LO 1. Identify and describe the fundamental components of the universe, including stars, planets, asteroids, meteors, comets, and galaxies, and explain their basic characteristics.
	2. LO 2. Explain the origin, age, and structure of the Solar System, and interpret key physical parameters such as planetary orbits, distances, mass, density, temperature, and rotation periods.
	3. LO 3. Apply astronomical coordinate systems such as the celestial sphere and celestial hemisphere to locate and describe positions of celestial objects.
	4. LO 4. Understand the working principles of astronomical instruments, including optical telescopes, spectroscopes, CCD cameras, photometers, and filters.
	5. LO 5. Analyze the performance of observational tools by explaining concepts like light-gathering power, magnification, resolution, and basic principles of radio telescopes and interferometry.
Content Outline	• Fundamentals of Astronomy: • Introduction: Components of the Universe; Stars, Planets,

	Asteroids, Meteors, Comets, Galaxies. • Solar System: Age, Origin Basic measurements: Planetary orbits, distances, physical size, mass, density, temperature, rotation period determination, Co-ordinate system, Celestial hemisphere, • Astronomical Instruments: • Optical telescopes, mounts, light gathering power, magnification, Resolution. Spectroscopes, • CCD camera, photometer, filters Radio telescopes, Interferometry (only introduction)
Module 2 (Credit 1) Solar System & galaxies	
Learning Outcomes	1. LO1. Explain the life cycle and internal processes of stars, including nuclear fusion, formation of neutron stars and black holes, and the significance of the Chandrasekhar limit.
	2. LO2. Classify stars based on their spectral characteristics using the O, B, A, F, G, K, M sequence, and interpret their physical properties such as temperature and luminosity.
	3. LO3. Analyze different star systems and observational phenomena, including binaries, Cepheid and RR Lyrae variables, as well as eclipses, transits, occultations, and meteor showers.
	4. LO4. Describe the structure and evolution of galaxies, including their types, formation, and classification through Hubble's tuning fork diagram, along with star clusters.
	5. LO 5. Evaluate key cosmological concepts and observational tools, including evidence for dark matter and dark energy, major universe theories (Big Bang, steady state, oscillating universe), and measurement systems such as apparent and absolute magnitudes and basic constellation mapping.
Content Outline	• Star Systems and basic observations: ○ Stars life cycle, Stellar processes (Nuclear). Neutron stars, black holes, Chandrasekhar limit. Spectral classification of stars, O, B, A, F, G, K, M. Star Systems: Binaries / Cepheids / RR Lyrae, Observation of Sun: Eclipses, Moon, planets, meteor showers, transits, occultations. • **Galaxies, Dark Matter and Dark Energy** ○ Galaxies, types, their formation, Hubble's tuning fork diagram, Open and Globular clusters,Dark Matter / Energy (evidence for both), Cosmology: Theories: BBT, Steady State,Oscillating Universe Theory. ○ Observational Astronomy: Concept of time, Magnitudes: apparent and absolute, introduction to Constellations, Star dial.

PRACTICAL COURSE (2 Credits)	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO 1. Demonstrate understanding of astronomical instruments by studying the construction, working, and mounting of binoculars, refracting, and reflecting telescopes.
	2. LO 2. Apply observational and measurement techniques to determine celestial parameters such as the diameter of the Moon and the solar constant.
	3. LO 3. Analyze different types of spectra (emission, absorption, and continuous) and interpret spectral lines obtained from sources like mercury, sodium, or iodine.
	4. LO 4. Understand modern detection systems in astronomy by explaining the construction and working principles of CCD (Charge-Coupled Device) technology.
	5. LO 5. Observe and interpret celestial events such as solar and lunar eclipses, relating them to the relative positions and motions of the Earth, Moon, and Sun.
Content Outline	• List of experiments:- • Study of Binocular, refracting and reflecting telescopes and their mounts. • To determine the diameter of the Moon. • Measurement of Solar Constant. • Observation of emission, continuous and absorption spectra. (Mercury, sodium or iodine spectra could be obtained.) • Study of Construction and working of CCD. • Study of Solar Eclipse and Lunar Eclipse.
Learning Outcomes	1. LO 1. Determine fundamental atomic constants by performing experiments to evaluate the Rydberg constant and understanding its significance in spectral series.
	2. LO 2. Explain and analyze the Zeeman Effect, demonstrating how spectral lines split under the influence of a magnetic field.
	3. LO 3. Investigate wave nature of light through interference phenomena using Lloyd’s mirror and interpret fringe patterns.
	4. LO 4. Evaluate the resolving power of optical instruments by determining the performance of a diffraction grating and its ability to distinguish closely spaced spectral lines.
	5. LO 5. Measure wavelengths of spectral lines accurately using a constant deviation spectrometer and relate the results to principles of diffraction and dispersion.
Content Outline	• Determination of Rydberg’s constant

	• Zeeman Effect • Llyod's mirror • Determination of Resolving Power of grating • Determination of wavelength by Constant deviation spectrometer

(Theory) Reference books:

1. Astronomy structure of the Universe. A.E. Roy and D. Clarke, Adam Hilger Pub.
2. Source Book of Space Sciences, Samuel Galsstone; D.Van Nostrand Co. Inc
3. Astrophysics - Stars and Galaxies, K.D. Abhyankar, Tata McGraw Hill Pub.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Pub.
5. Structure of the Universe, J.V. Narlikar
6. Astrophysics, Baidyanath Basu.
7. Astrophysical Techniques, third Edition, C. R. Kitchin
8. Fundamentals of Astronomy, Michael Seed
9. Telescopes and techniques, C. R. Kitchin (Springer)

Semester – V

.5.4 B. Major (Electives)

Course Titles	**Mathematical Physics (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	1. CO1: Apply fundamental matrix operations – Students will be able to perform addition, multiplication, and classification of matrices, including special types such as diagonal, unit, triangular, and symmetric matrices.
	2. CO2: Analyze and solve matrix-related problems – Students will be able to compute transpose, inverse (by adjoint method), eigenvalues, and eigenvectors, and apply concepts like Cayley–Hamilton theorem and diagonalization.
	3. CO3: Understand and apply Fourier transforms – Students will be able to evaluate complex Fourier, sine, and cosine transforms and use them to analyze mathematical and physical problems.
	4. CO4: Utilize Laplace transform techniques – Students will be able to compute Laplace transforms and inverse Laplace transforms, including transforms of derivatives, to solve differential equations.
	5. CO5: Solve advanced problems using transform methods – Students will be able to apply convolution theorem and properties of Fourier and Laplace transforms to solve integral equations and engineering/science applications.
	6. CO1: Apply fundamental matrix operations – Students will be able to perform addition, multiplication, and classification of matrices, including special types such as diagonal, unit, triangular, and symmetric matrices.
Module 1(Credit 1) Matrices	
Learning Outcomes	After learning the module, learners will be able to
	1. Perform matrix operations: Students will be able to carry out addition and multiplication of matrices and identify special types such as null, diagonal, scalar, unit, upper triangular, and lower triangular matrices.
	2. Analyze matrix transformations: Students will be able to compute the transpose and conjugate of matrices and classify matrices as symmetric, skew-symmetric, Hermitian, and skew-Hermitian.
	3. Determine matrix properties: Students will be able to distinguish between singular and non-singular matrices and compute determinants, adjoint, and inverse of a matrix using the adjoint method.
	4. Apply advanced matrix concepts: Students will be able to

	evaluate trace, eigenvalues, and eigenvectors of matrices and understand their significance in solving linear systems.
	5. Use theorems for matrix simplification: Students will be able to apply the Cayley–Hamilton theorem and perform diagonalization of matrices to simplify matrix computations and solve related problems.
Content Outline	• Addition and Multiplication of Matrices. • Null Matrices. • Diagonal, Scalar and Unit Matrices. • Upper Triangular and Lower-Triangular Matrices • Transpose of a Matrix. • Symmetric and Skew-Symmetric Matrices. • Conjugate of a Matrix. • Hermitian and Skew-Hermitian Matrices. • Singular and Non-Singular matrices. • Adjoint of a Matrix. • Inverse of a Matrix by Adjoint Method. • Orthogonal and Unitary Matrices. • Trace of a Matrix. • Eigenvalues and Eigenvectors. • Cayley- Hamilton Theorem. • Diagonalization of Matrices
Module 2 (Credit 1) Fourier and Laplace transforms	
Learning Outcomes	1. Understand Fourier transform concepts: Students will be able to explain the introduction and formal development of the complex Fourier transform and interpret its mathematical significance.
	2. Apply different Fourier transforms: Students will be able to compute Fourier sine and cosine transforms for given functions and apply them in solving problems.
	3. Evaluate transforms of derivatives: Students will be able to determine Fourier transforms of derivatives and use them to simplify differential equations.
	4. Use Laplace transform techniques: Students will be able to compute Laplace transforms and Laplace transforms of derivatives to solve initial value problems.
	5. Solve problems using inverse transforms and convolution: Students will be able to apply inverse Laplace transforms and the convolution theorem to solve differential and integral equations.

Content Outline	• Fourier transforms: • Introduction, Formal development of the complex Fourier transform • Cosine and Sine transforms • The transforms of derivatives. • Laplace transforms • Laplace transform of derivatives • Inverse Laplace transform and Convolution theorem.
Module 3 & 4 PRACTICAL COURSE (2 Credits)	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO 1. Understand Experimental Techniques: Students will be able to explain the principles and procedures for measuring physical quantities such as surface tension, elastic constants, and velocity of sound.
	2. LO 2. Perform Optical and Wave Experiments: Students will be able to conduct experiments to determine wavelength (step slit method), analyze interference patterns (Edser's 'A' pattern), and calculate Rydberg's constant.
	3. LO 3. Analyze Oscillatory Systems: Students will be able to study damping in oscillations and calculate logarithmic decrement using appropriate experimental setups.
	4. LO 4. Evaluate Electrical and Atomic Parameters: Students will be able to determine fundamental constants such as charge-to-mass ratio (e/m) using Thomson's method and interpret the results.
	5. LO 5. Interpret and Validate Experimental Data: Students will be able to record observations, perform calculations, analyze errors, and validate experimental results with theoretical values.
Content Outline	• Surface tension of soap solution • Elastic constants of a rubber tube • Logarithmic decrement • Determination of Rydberg's constant • Edser's 'A' pattern • Determination of wavelength by Step slit • Determination of e/m by Thomson's method • Velocity of sound in air using CRO
Learning Outcomes	1. LO 1. Understand Electrical Measurement Techniques: Students will be able to explain and perform measurements of electrical parameters such as mutual inductance, capacitance, and inductance using bridge circuits (B.G., Maxwell's bridge, parallel

	bridge).
	2. LO 2.Analyze Magnetic and Semiconductor Properties: Students will be able to study and interpret the hysteresis loop using CRO and determine the band gap energy of a Ge diode.
	3. LO 3. Design and Implement Electronic Circuits: Students will be able to design and construct electronic circuits such as astable multivibrators and Wien bridge oscillators.
	4. LO 4 Evaluate Filter Circuits: Students will be able to design and analyze first-order active low-pass and high-pass filter circuits and study their frequency response.
	5. LO 5. Interpret Experimental Results and Performance: Students will be able to record observations, analyze circuit behavior, calculate relevant parameters, and validate results with theoretical expectations.
Content Outline	• Mutual inductance by BG. • Capacitance by parallel bridge • Hysteresis loop by CRO • L/C by Maxwell's bridge • Band gap energy of Ge diode. • Design and study of transistorized astable multivibrator (BB) • Design and study of Wien bridge oscillator • Design and study of first order active low pass filter circuit (BB) • Design and study of first order active high pass filter circuit (BB)

(Theory) Reference books:

1. Erwin Kreyszig (Wiley Eastern Limited,1985) Advanced Engineering Mathematics
2. Charlie Harper. (P.H.I.1995) Introduction to Mathematical Physics
3. B S Grewal, Khanna Publishers (2000) Higher Engineering Mathematics
4. H. K. Dass Mathematical Physics

Semester – V

.5.5 Minor Stream

Course Titles	**Electronics Instrumentation**
Course Credits	**2+2**
Course Outcomes	After going through the course, learners will be able to
	1. CO1. Integrate knowledge of transducers and signal conditioning circuits to design and analyze measurement systems for physical parameters like temperature, pressure, displacement, and light.
	2. CO2. Evaluate the performance of different sensing devices such as thermocouples, strain gauges, and Linear Variable Differential Transformer in practical engineering applications.
	3. CO3. Apply concepts of optical and electronic instrumentation using devices like photodiodes and instrumentation amplifiers for accurate data acquisition and processing.
	4. CO4. Analyze and design electronic subsystems including active filters, power supplies, and transducer interfaces for real-world applications in automation and control.
	5. CO5. Assess the application of sensors and electronic systems in diverse fields such as automotive, home appliances, and medical diagnostics, focusing on efficiency, accuracy, and reliability.
Module 1(Credit 1) Instrumentation Amplifier	
Learning Outcomes	After learning the module, learners will be able to
	1. Explain the working principles and applications of instrumentation amplifiers in measurement systems such as temperature indicators, light intensity meters, and analog weighing scales.
	2. Analyze and design active filter circuits, including second-order low-pass and high-pass Butterworth filters, band-pass filters, and band-rejection filters for signal processing applications.
	3. Describe the construction, operation, and specifications of different power supplies, including fixed, variable, dual, constant voltage/constant current supplies, Switched-mode power supply, DC-DC converters, and UPS systems.
	4. Differentiate between linear and switching regulators and evaluate their performance in voltage regulation, current boosting, and power conversion applications.
	5. Design and interpret constant current source and switching regulator circuits such as buck, boost, and buck-boost converters using operational amplifiers and transistor-based

	configurations
Content Outline	• **Instrumentation Amplifier & its applications:** o Basic Instrumentation Amplifier, Instrumentation system, Applications of Instrumentation Amplifier, Temperature indicator, light intensity meter, analog weight scale. • **Active filters:** o Introduction, Active Filters, 2nd order Low Pass Butterworth filter, 2nd order High Pass Butterworth filter, Band pass Filters, wide band pass filter, wide band rejection filter and narrow band rejection filter. • **Power Supplies:** o Principle, block diagram, working, important specifications and operating procedures for- Fixed voltage power supply, variable power supply, dual power supply, CV and CC supply, SMPS, DC to DC converter, UPS. o Linear and switching regulators Fixed output voltage regulator with current booster. o Constant current source (ground load) using OPAmp and pnp transistor. o Basic and Monolithic Switching regulators (buck, boost and buck – boost) (Only basic Configurations.
Module 2 (Credit 1) Transducers and Optical Devices	
Learning Outcomes	1. LO1. Define and classify transducers and explain their role in converting physical quantities into electrical signals for measurement and control systems.
	2. LO2. Explain temperature measurement techniques using devices such as resistance thermometers, thermocouples, and Thermistor, including their working principles and applications.
	3. LO3. Analyze pressure and displacement transducers including strain gauges, Linear Variable Differential Transformer, and capacitive transducers for accurate sensing of physical parameters.
	4. LO4. Describe the working of optical transducers such as photodiodes, phototransistors, and photomultiplier tubes, and their use in light detection and measurement.
	5. LO5. Evaluate practical applications of transducers in various fields including automotive systems, home appliances, and medical diagnostic equipment.
Content Outline	• Introduction to Transducers. • Temperature measurements, Resistance thermometer, thermocouple & thermistor

	• Pressure & Displacement Transducers: Strain Gauges (derivation of gauge factor is not expected), LVDT, Capacitive transducers • Optical Transducers Photo –diode, photo transistor, Photo multiplier tube, • Transducers Applications :Automotive sensors, Home appliance sensors, Medical diagnostic sensors
PRACTICAL COURSE (2 Credits)	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO1. Analyze and construct an instrumentation amplifier using IC 741 op-amps and a resistance bridge, and evaluate its performance in signal amplification.
	2. LO 2. Examine the frequency and phase response of active filters, including second-order low-pass and high-pass Butterworth filter circuits.
	3. LO 3. Investigate the characteristics of an active notch filter by studying its frequency response and phase relationship for signal rejection applications.
	4. LO4. Design and evaluate a constant current source using the LM317 and understand its adjustable current regulation properties.
	5. LO 5. Generate and analyze waveforms using operational amplifiers, including square and triangular waves, and interpret parameters such as frequency and duty cycle.
Content Outline	• To study an Instrumentation Amplifier using three IC- 741 Op-Amps couple with Resistance Bridge. • To study the Second Order active Low Pass filter (frequency response &phase relation). • To study the Active Notch Filter (frequency response & phase relation) • To study the Second Order active High Pass filter (frequency response &phase relation). • To study the Adjustable constant Current Source using LM 317 • Square and Triangular wave generator using OPAMPs with concept of duty cycle
Learning Outcomes	1. LO 1. Analyze the thermal and electrical characteristics of a Thermistor, and evaluate its suitability for temperature sensing applications.
	2. LO 2. Design and implement temperature measurement systems by using thermistors with operational amplifiers and timer circuits for temperature-to-voltage and temperature-to-frequency conversion.

	3. LO3. Evaluate the performance of displacement and force sensors such as Linear Variable Differential Transformer and strain gauge/load cell through characteristic studies.
	4. LO4. Understand optical sensing devices by analyzing the characteristics of photodiodes and phototransistors for light detection applications.
	5. LO 5. Develop and analyze digital and data conversion circuits including seven-segment displays and D/A converters (binary weighted and ladder network) using operational amplifiers.
Content Outline	• Thermistor Characteristics –Thermal and electrical. (H & C) • Thermistor as sensor in temperature to voltage converter using OP • AMP. • Study of LVDT characteristics. • Study of Load Cell / Strain Gauge. • Study of seven segment display. • Characteristics of Photodiodes and phototransistors. • Temperature to frequency Conversion using 555 timer. • OP AMP D/A Converter: Binary weighted resistors. • OP AMP D/A Converter: Ladder network.

(Theory) References: -

1. Basic Electronics and Linear Circuits by N. N. Bhargava, D. C. Kulshreshtha and S. C. Gupta. Technical Teachers Training Institute, Tata McGraw Hill Publishing Company Limited. (BKG)
2. Electronic Instrumentation by H. S. Kalsi, 2nd Edition, Tata McGraw Hill. (K)
3. OPAMPs and Linear Integrated Circuits by Coughlin & F. F. Driscoll (6th Edition), Eastern Economy Education, PHI. (C & D)
4. OPAMPs & Linear Integrated Circuits by R. A. Gayakwad (4th Edition, PHI). (G)
5. D. Patranabis, Sensors and Transducers, 2nd Edition.
6. Albert D. Helfrick & William D. Cooper, Modern Electronic Instrumentation & Measurement Techniques, PHI Edition.
7. H. S. Kalsi, Electronic Instrumentation, 2nd Edition, Tata McGraw Hill.
8. G. L. Tokheim, Digital Electronics (6th Edition), Tata McGraw Hill.

Main References:

1. Basic Electronics and Linear Circuits by N. N. Bhargava, D. C. Kulshreshtha and S. C. Gupta. Technical Teachers Training Institute, Tata McGraw Hill Publishing Company Limited. (BKG)
2. Electronic Instrumentation by H. S. Kalsi, 2nd Edition, Tata McGraw Hill. (K)
3. OPAMPs and Linear Integrated Circuits by Coughlin & F. F. Driscoll (6th Edition), Eastern Economy Education, PHI. (C & D)
4. OPAMPs & Linear Integrated Circuits by R. A. Gayakwad (4th Edition, PHI). (G)
5. Electronic Principles by A. P. Malvino (6th Edition, PHI). (M)
6. Digital Principles & Applications by Malvino & Leach (6th Edition, TMH). (M & L)

Semester – V

.5.5 Vocational Skill Courses (VSC-4)

Course Titles	**Solar PV System: Installation, Repairing and Maintenance**
Course Credits	**2 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. Explain fundamental principles of solar energy systems, including Sun–Earth relationships and the Photovoltaic Effect, and describe the working of solar cells and PV modules.
	2. Analyze solar radiation characteristics and measurement techniques, including solar constant, surface radiation, and the use of instruments like Pyrheliometer and Pyranometer.
	3. Design and evaluate solar PV systems, including on-grid, off-grid, and hybrid configurations, with proper system sizing, component selection, and array alignment.
	4. Assess the performance of PV systems under practical conditions, considering factors such as shading, intensity variation, module combinations, and tracking mechanisms.
	5. Apply practical and analytical skills in solar energy applications, including solar radiation measurement, analysis of electricity consumption (e.g., Maharashtra State Electricity Distribution Company Limited bills), and preparation of technical reports based on PV system experiments and field visits.
Module 1(Credit 1) Solar Energy Basics	
Learning Outcomes	After learning the module, learners will be able to
	1. LO Understand fundamental concepts of solar energy including the relationship between the Sun, Earth, and renewable energy, and explain the Photovoltaic Effect.
	2. LO Explain the working and classification of solar cells, including different types of solar cells and the construction and operation of PV modules and arrays.
	3. LO. Analyze key parameters of photovoltaic systems, such as module efficiency, output characteristics, and the effects of sunshine, shading, and array alignment on system performance.
	4. LO Evaluate solar radiation concepts and their significance, including solar constant, variation of solar radiation at the Earth's surface, and the necessity of radiation measurement.
	5. LO Demonstrate knowledge of solar radiation measurement instruments, such as Pyrheliometer, Pyranometer, Sunshine Recorder, and Lux Meter, and interpret their applications in solar energy systems.
Content Outline	• Unit-1: Introduction

	• The Sun, Earth, and Renewable Energy, Photovoltaic Effect, Working of Solar cell, Types of Solar cell, PV Modules and Arrays, Module Parameters, Sunshine and Shadow, tracking mechanism, Aligning the Array. • Unit-2: Solar Radiations and Measurement • Introduction, Solar Constant, Solar Radiation at the Earth Surface, Need of Solar Radiation Measurement, Instruments For The Measurement of Solar Radiation, Pyrheliometer, Pyranometer, Sunshine Recorder, Sun Meter or Lux Meter
Module 2 (Credit 1) PV System and Activities	
Learning Outcomes	1. LO. Understand and differentiate types of solar PV systems, including on-grid, off-grid, and hybrid systems, and explain their working principles and applications.
	2. LO. Explain the function and integration of key PV system components, such as batteries, charge controllers, inverters, and DC-to-AC conversion in practical solar installations.
	3. LO. Analyze the design aspects of solar PV systems, including system sizing, balancing of system components, and the role of building-integrated photovoltaics (BIPV) in engineering and architecture.
	4. LO. Evaluate the performance of PV modules under varying conditions, including intensity variation, and compare series and parallel configurations through experimental activities.
	5. LO. Apply practical knowledge of solar energy systems, including measurement of solar radiation using instruments like Pyranometer and Sunmeter, interpretation of electricity bills (e.g., Maharashtra State Electricity Distribution Company Limited), and preparation of technical reports based on PV plant visits.
Content Outline	• Unit-3: Basics Solar PV Systems • Basics types of PV Systems On grid and off grid, DC to AC Conversion, Building-integrated Photovoltaics, Engineering and Architecture, Balancing of PV system. System Components, Batteries, Charge Controllers, Inverters, Hybrid Systems, System Sizing, Applications of off grid PV System. • Activity:- • Estimate the value of the Solar Constant. • Study of intensity variation on the performance of PV module. • Study of series and parallel combination of the PV modules. • Measurement of Solar radiation measurement using Sunmeter and Pyranometer.

	• Analysis of MSEB electricity bill. • Energy Farm/PV Plant visit report.

References: -

1. Solar Energy, S.P. Sukhatme (second edition), Tata Mc.Graw Hill Ltd,
2. New Delhi.
3. Solar Energy Utilisation, G. D. RAI (5th edition),
4. Khanna Publishers,Delhi.
5. Electricity from Sunlight, An Introduction to Photovoltaics,
6. Paul A. Lynn, John Wiley & Sons, Ltd.
7. Solar Electricity, 2nd edition, T. Markvart, John Wiley & Sons, Ltd.
8. Solar Photovoltaic Basics, White Sean, Taylor & Francis Ltd.

Course Syllabus

Semester – VI

.6.1 Major (Core)

Course Titles	**Classical Mechanics (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO1: Analyze motion under central forces – Students will be able to study motion under central forces, including inverse-square law forces, and explain orbital motion such as elliptical orbits in the Kepler problem.
	2. CO2: Apply concepts of non-inertial frames – Students will be able to analyze motion in moving and rotating coordinate systems and evaluate effects such as Coriolis and centrifugal forces on the rotating Earth.
	3. CO3: Explain advanced physical phenomena – Students will be able to interpret concepts like Larmor's theorem and the working of the Foucault pendulum in the context of rotating frames.
	4. CO4: Formulate Lagrangian mechanics – Students will be able to apply D'Alembert's principle and generalized coordinates to derive Lagrange's equations for mechanical systems.
	5. CO5: Solve constrained dynamical systems – Students will be able to analyze systems with constraints, identify constants of motion, and use ignorable coordinates to simplify and solve complex mechanical problems.
Module 1(Credit 1) Accelerated Frames	
Learning Outcomes	After learning the module, learners will be able to
	1. Understand motion under central forces: Students will be able to analyze motion under a central force and explain the characteristics of forces inversely proportional to the square of distance.
	2. Analyze orbital motion and Kepler's problem: Students will be able to derive and interpret elliptical orbits and apply the principles of the Kepler problem to planetary motion.
	3. Apply concepts of non-inertial frames: Students will be able to describe motion in moving and rotating coordinate systems and identify inertial and non-inertial frames.
	4. Evaluate effects in rotating systems: Students will be able to explain laws of motion on the rotating Earth, including Coriolis and centrifugal effects, and solve related problems.
	5. Interpret advanced physical phenomena: Students will be able to explain Larmor's theorem (with proof) and analyze the

	working of the Foucault pendulum through qualitative reasoning and problem-solving.
Content Outline	• Motion under a central force • The central force inversely proportional to the square of the distance • Elliptical orbits • The Kepler problem • Moving origin of co-ordinates • Rotating co-ordinate systems • Laws of motion on the rotating earth • Larmor's theorem (with proof) • Foucault pendulum (Qualitative discussion and problems.)
Module 2 (Credit 1) Lagrange's Mechanics	
Learning Outcomes	1. Understand D'Alembert's principle: Students will be able to explain D'Alembert's principle and its role in transforming dynamics problems into equilibrium form.
	2. Apply generalized coordinates: Students will be able to define and use generalized coordinates to describe the motion of mechanical systems.
	3. Derive Lagrange's equations: Students will be able to formulate and derive Lagrange's equations using D'Alembert's principle for various physical systems.
	4. Analyze constrained systems: Students will be able to identify and solve problems involving systems subject to constraints using the Lagrangian approach.
	5. Interpret constants of motion: Students will be able to determine constants of motion and explain the concept of ignorable (cyclic) coordinates in simplifying mechanical problems.
Content Outline	• Lagrange's equations: D'Alembert's principle • Generalized coordinates • Lagrange's equations using D'Alembert's principle • Examples • Systems subject to constraints • Examples of systems subject to constraints • Constants of motion and ignorable coordinates.
Module 3 & 4 PRACTICAL COURSE (2 Credits)	
Learning	After learning the Practical module, learners will be able to

Outcomes	1. LO 1. Understand Transient Response in Circuits: Students will be able to study and analyze the charging and discharging behavior of a capacitor and determine the RC time constant experimentally.
	2. LO 2. Apply Radiation and Detection Techniques: Students will be able to understand the principles of radiation detection and operate basic radiation detection instruments.
	3. LO 3. Analyze Semiconductor Characteristics: Students will be able to plot and interpret the V-I characteristics of a diode and evaluate its electrical behavior.
	4. LO 4. Utilize CRO for Measurement: Students will be able to use a Cathode Ray Oscilloscope (CRO) to measure electrical parameters such as capacitance and analyze waveforms.
	5. LO 5. Design and Study Electronic Circuits: Students will be able to implement and analyze applications such as temperature control using AD590 and study digital circuits like IC 7490 for various counter operations (mod 2, mod 5, mod 7, mod 10).
Content Outline	• Charging and discharging of capacitor and RC time constant • Radiation detection • IV Characteristics of diode • Measuring a value of a capacitor using CRO. • Temperature controller using AD590 • Study of IC 7490 as mod 2, mod 5, mod 7 and mod 10 counter.
Learning Outcomes	1. LO 1. Analyze Semiconductor Device Characteristics: Students will be able to study and plot the characteristics of JFET and interpret its behavior for different operating regions.
	2. LO 2. Design and Implement Digital Circuits: Students will be able to construct and verify half adder and full adder circuits and analyze their truth tables and logical operations.
	3. LO3. Develop Analog Signal Conditioning Circuits: Students will be able to design and analyze an instrumental amplifier using three op-amps for accurate signal amplification.
	4. LO 4. Apply Temperature Sensing and Control Techniques: Students will be able to implement temperature measurement and control systems using sensors such as PT100, thermocouple, and thermistor.
	5. LO 5. Study Electronic Devices and Transducers: Students will be able to analyze circuits like Schmitt trigger for signal shaping and study LVDT for displacement measurement and its practical applications.
Content Outline	• Characteristics of JFET

	• Half adder /Full adder • Instrumental amplifier using three op-amps • Temperature controller using PT 100 / thermocouple /thermistor temperature sensors • Schmitt trigger • Study of LVDT

(Theory) Reference books:

1. KRS : Keith R. Symon Mechanics :. (Addision Wesely) 3rd Ed.
2. G, Herbert Goldstein Classical Mechanics : (Narosa 2nd Ed.)
3. Daniel Kleppner & Robert Kolenkow. An Introduction to Mechanics :, Tata Mc Graw Hill (Indian Ed. 2007)

Semester – VI

.6.2 Major (Core)

Course Titles	**Nuclear Physics (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	1. CO1. Apply principles of nuclear physics to analyze nuclear reactions, decay processes (alpha, beta, gamma), and energy transformations using concepts like the Q-value (nuclear physics).
	2. CO2. Evaluate the behavior and properties of nuclear radiations by explaining mechanisms such as Gamow theory of alpha decay, beta decay with neutrino hypothesis, and gamma decay including internal conversion.
	3. CO3. Analyze and compare nuclear radiation detection techniques using devices like Geiger–Müller counter, scintillation counters, and ionization chambers for practical applications.
	4. CO4. Interpret nuclear structure and stability using theoretical models such as the Liquid drop model and semi-empirical mass formula, including predictions based on mass parabolas.
	5. CO5. Integrate theoretical and experimental concepts of nuclear physics to understand advanced topics such as Mössbauer effect, nuclear isomerism, and limits of nuclear stability including spontaneous fission.
Module 1(Credit 1) Nuclear reactions, Alpha Decay and Beta Decay	
Learning Outcomes	After learning the module, learners will be able to
	1. LO1. Classify different types of nuclear reactions and apply the principles of mass–energy conservation to analyze nuclear processes using the Q-value (nuclear physics) equation.
	2. LO2. Solve numerical problems related to nuclear reactions by evaluating Q-values and interpreting whether reactions are exothermic or endothermic.
	3. LO3. Explain the mechanism of alpha decay including disintegration energy, range, ionization, and stopping power, along with Gamow theory of alpha decay and the Geiger–Nuttall law.
	4. LO4. Analyze the properties and absorption of alpha particles by relating their range and interaction with matter in terms of energy loss processes.
	5. LO5. Describe the theory of beta decay including continuous beta spectrum, Neutrino hypothesis, detection methods, and energy distribution in beta decay.
Content Outline	• Types of Nuclear Reactions, Balance of mass and energy in Nuclear Reaction, the Q-equation and Solution of Q-equation

	• Alpha decay: Range of alpha particles, Disintegration energy, Alpha decay paradox: Barrier penetration (Gamow"s theory of alpha decay and Geiger- Nuttal law), Absorption of alpha particles: Range, Ionization and stopping power • Beta decay: Introduction, Continuous beta ray spectrum- Difficulties encountered in it, Pauli"s neutrino hypothesis, Detection of neutrino, Energetic of beta decay
Module 2 (Credit 1) Gamma Decay and Nuclear Reactors	
Learning Outcomes	1. LO1. Explain the processes involved in gamma decay including internal conversion, nuclear isomerism, and the Mössbauer effect.
	2. LO2.Compare and evaluate nuclear radiation detectors such as ionization chambers, proportional counters, scintillation counters, and Geiger–Müller counter based on their working principles and applications.
	3. LO3. Apply nuclear models to describe atomic nuclei, particularly the Liquid drop model and interpret nuclear properties using these models.
	4. LO4. Analyze nuclear stability using semi-empirical relations, including the Semi-empirical mass formula and mass parabolas for predicting beta decay stability in isobars.
	5. LO5. Evaluate nuclear structure and stability concepts such as mirror nuclei and limits against spontaneous fission in the context of nuclear reactions and decay processes.
Content Outline	• **Gamma decay:** Introduction, internal conversion, nuclear isomerism, Mössbauer effect. • **Nuclear radiation detectors:** Proportional counter, scintillation counter, ionization chamber, proportional counter, and Geiger-Müller (GM) counter. • **Liquid drop model, Weizsäcker's semi-empirical mass formula:** Mass parabolas, prediction of stability against beta decay for members of an isobaric family, stability limits against spontaneous fission, mirror nuclei.
Module 3 & 4 PRACTICAL COURSE (2 Credits)	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO 1. Analyze Magnetic Properties: Students will be able to obtain and interpret the hysteresis loop using a CRO and evaluate magnetic properties such as retentivity and coercivity.
	2. LO 2. Evaluate Dielectric and Elastic Properties: Students will be able to determine the dielectric constant of materials and measure elastic constants of rubber through experimental methods.

	3. LO 3. Understand Optical Communication Principles: Students will be able to study the working of optical fibres and explain light propagation mechanisms such as total internal reflection.
	4. LO4. Investigate Wave Properties of Sound: Students will be able to analyze characteristics of sound waves such as frequency, wavelength, and velocity through experiments.
	5. LO5. Design and Analyze Electronic Circuits: Students will be able to implement and study circuits like window comparator and interpret their behavior in signal processing applications.
Content Outline	• Hysteresis loop by CRO • Determination of dielectric constant • Study of Optical Fibre. • Wave properties of Sound • Elastic constants of rubber • Window Comparator
Learning Outcomes	1. LO 1. Understand Sensor-Based Measurement Systems: Students will be able to study and analyze load cells and strain gauges for force and displacement measurement applications.
	2. LO2. Implement Display and Digital Interface Circuits: Students will be able to construct and analyze circuits using seven-segment displays for numerical data representation.
	3. LO3. Design Temperature Sensing and Conversion Circuits: Students will be able to implement temperature-to-voltage and temperature-to-frequency conversion systems using thermistors, op-amps, and 555 timers.
	4. LO 4. Analyze Signal Processing Circuits: Students will be able to design and study peak detector and sample-and-hold circuits using op-amp 741 for signal acquisition and processing.
	5. LO 5. Evaluate Circuit Performance and Applications: Students will be able to test, analyze, and interpret the performance of analog and digital circuits used in measurement and instrumentation systems
Content Outline	• Study of Load Cell / Strain Gauge. • Study of seven segment display • Thermistor as sensor in temperature to voltage converter using OP AMP • Temperature to frequency Conversion using 555 timer • Peak detector using op-amp 741. • Sample and hold circuit using op-amp 741

(Theory) Reference books:

1. P : S.B. Patel Nuclear Physics: (Wiley Eastern Ltd.).
2. K : Irving Kaplan : Nuclear Physics: (2nd Ed.) (Addison Wesley).
3. G : S. N. Ghoshal : Nuclear Physics : (S. Chand & Co.)
4. Kenneth Krane (2nd Ed.) John Wiley & Sons. Modern Physics
5. N Subrahmanyam, Brij Lal. Atomic & Nuclear Physics (Revised by Jivan Seshan.) S. Chand.
6. AB : Arthur Beiser: Concepts of Modern Physics : (6th Ed.) (TMH).

Semester – VI

.6.3 A. Major (Elective)

Course Titles	**Atomic & Molecular Physics (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO1. Apply quantum mechanical principles to solve the hydrogen atom using the Schrödinger equation and interpret wave functions and quantum numbers.
	2. CO2. Analyze atomic structure and electron configurations using concepts like the Pauli exclusion principle, Hund's rules, and symmetric/antisymmetric wave functions.
	3. CO3. Evaluate angular momentum and coupling schemes by applying vector atom models, spin–orbit interaction, and distinguishing between L–S and J–J coupling.
	4. CO4. Interpret atomic spectra by explaining the origin of spectral lines and applying selection rules for electronic transitions.
	5. CO5. Integrate theoretical and experimental concepts such as electron probability density and the Stern–Gerlach experiment to understand quantum behavior of atoms.
Module 1(Credit 1) Hydrogen Atom	
Learning Outcomes	1. LO1. Solve the Schrödinger equation for the hydrogen atom using separation of variables and interpret the resulting wave functions.
	2. LO2. Explain the origin and significance of quantum numbers (principal, orbital, and magnetic) and their role in determining atomic structure.
	3. LO3. Analyze angular momentum in quantum systems and relate it to orbital motion and quantization in the hydrogen atom.
	4. LO4 Interpret electron probability density distributions by examining the radial part of the wave function and understanding electron localization.
	5. LO5. Describe the concept of electron spin and its experimental verification through the Stern–Gerlach experiment.
Content Outline	• Hydrogen atom: Schrödinger's equation for Hydrogen atom, • Separation of variables, Quantum Numbers: Total quantum number, Orbital quantum number, Magnetic quantum number. Angular momentum, Electron probability density (Radial part). • Electron Spin: The Stern-Gerlach experiment

Module 2 (Credit 1) Spin Orbit Coupling and Atomic Models	
Learning Outcomes	1. LO1. Explain the Pauli exclusion principle and distinguish between symmetric and antisymmetric wave functions in multi-electron systems.
	2. LO2. Analyze spin–orbit coupling and its effect on atomic energy levels, and apply Hund's rules to determine electronic configurations.
	3. LO3. Evaluate total angular momentum in atoms using the vector atom model and distinguish between L–S coupling and J–J coupling schemes.
	4. LO4. Explain the origin of atomic spectral lines in terms of electronic transitions between quantized energy levels.
	5. LO5. Apply quantum mechanical selection rules to predict allowed and forbidden transitions in atomic spectra.
Content Outline	• Pauli's Exclusion Principle Symmetric and Anti-symmetric wave functions. • Spin orbit coupling, Hund's Rule, Total angular momentum, Vector atom model, L-S and J-J coupling. • Origin of spectral lines, Selection rules
Module 3 & 4 PRACTICAL COURSE (2 Credits)	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO 1. Analyze Precision Rectifier Circuits: Students will be able to design and study half-wave precision rectifier circuits using op-amps (OPA177) and evaluate their performance over conventional rectifiers.
	2. LO 2. Implement Wave Shaping Circuits: Students will be able to design and analyze positive and negative clipper and clamper circuits using op-amps for waveform modification.
	3. LO 3. Design Active Filter Circuits: Students will be able to construct second-order active low-pass and high-pass filters and study their frequency response and phase relationships.
	4. LO 4. Evaluate Frequency Selective Circuits: Students will be able to design and analyze active notch filters and interpret their behavior in rejecting specific frequency components.
	5. LO 5. Interpret Signal Behavior and Circuit Performance: Students will be able to observe waveforms using CRO, analyze gain and phase variations, and validate experimental results with theoretical expectations.
Content Outline	• Half wave precision rectifier using precision op-amps (OPA177) • Positive and Negative Clippers using op-amp. • Positive and Negative Clampers using single power supply op-

	amp (124/324). • Second Order active Low Pass filter (frequency response & phase relation) • Second Order active High Pass filter (frequency response & phase relation) • Active Notch Filter (frequency response & phase relation)
Learning Outcomes	1. LO 1. Design Waveform Generator Circuits: Students will be able to design and analyze square and triangular wave generators using op-amps, including the concept of duty cycle.
	2. LO 2. Understand Power Supply Design: Students will be able to construct and study a variable dual power supply using LM317 and LM337 and analyze its voltage regulation.
	3. LO 3. Develop Current Source Circuits: Students will be able to design and implement a constant current source using an op-amp and PNP transistor for low current applications.
	4. LO 4. Implement Audio Signal Amplification: Students will be able to build and analyze a simple microphone amplifier using a transistor and evaluate its performance.
	5. LO 5. Construct and Test Power Amplifiers: Students will be able to design and study audio power amplifiers using IC TBA810 and assess output characteristics and efficiency.
Content Outline	• Square and Triangular wave generator using • OPAMPs with concept of duty cycle • Study of variable dual power supply using LM 317& LM 337 (± 3v to ±15v). • Constant Current source using OPAMP and PNP transistor (o/p current less than 50 mA) • Simple microphone amplifier using a transistor. • Construction of Audio power amplifiers using IC TBA 810.

(Theory) Reference books:

1. B: Arthur Beiser: Perspectives of Modern Physics, McGraw Hill.
2. SA: H. Semat & J. R. Albright: Introduction to Atomic & Nuclear Physics, (5th Ed.)Chapman & Hall.
3. W: H. E. White: Introduction to Atomic Spectra: McGraw Hill

4. PRACTICAL COURSE (2 Credits)

Semester – VI

.6.3 B. Major (Elective)

Course Titles	**Special Theory of Relativity (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO1: Explain the fundamental concepts of special theory of relativity, including inertial frames, Lorentz transformations, simultaneity, and relativistic reference frames.
	2. CO2: Apply Lorentz transformation equations and relativistic velocity transformation formulas to solve problems involving time dilation, length contraction, and relativistic motion. x′=γ(x−vt),t′=γ(t−vxc2)x' = \gamma (x-vt),\quad t' = \gamma \left(t-\frac{vx}{c^2}\right)x′=γ(x−vt),t′=γ(t−c2vx)
	$x' = \gamma(x - vt), t' = \gamma\left(t - \frac{vx}{c^2}\right)$
	1. CO3: Analyze the experimental and theoretical foundations of relativity, including the Michelson–Morley experiment, Doppler effect, aberration, and the failure of ether theories.
	2. CO4: Interpret space-time diagrams and evaluate relativistic phenomena such as simultaneity, twin paradox, and observer-dependent measurements in space-time geometry.
	3. CO5: Demonstrate problem-solving skills in relativistic kinematics by analyzing transformations of velocity, acceleration, space, and time for particles and observers moving at relativistic speeds.
Module 1(Credit 1) Introduction to Special theory of relativity:-	
Learning Outcomes	After learning the module, learners will be able to
	1. Remembering & Understanding: Define and explain inertial and non-inertial frames of reference, Galilean transformations, Newtonian relativity, and the fundamental postulates of the special theory of relativity.
	2. Applying: Apply Lorentz transformation equations to solve problems related to simultaneity, length contraction, and time dilation in relativistic systems. x′=γ(x−vt),t′=γ(t−vxc2)x' = \gamma (x-vt),\quad t' = \gamma \left(t-\frac{vx}{c^2}\right)x′=γ(x−vt),t′=γ(t−c2vx)
	$x' = \gamma(x - vt), t' = \gamma\left(t - \frac{vx}{c^2}\right)$
	3. Analyzing: Analyze the failure of classical concepts of absolute space and ether through the Michelson–Morley experiment, Lorentz–Fitzgerald contraction hypothesis, ether drag hypothesis, and stellar aberration.
	4. Evaluating: Evaluate the limitations of Newtonian relativity and

	compare it with Einstein’s special theory of relativity in explaining electromagnetic phenomena and the role of observers.
	5. Creating / Problem Solving: Solve numerical and conceptual problems involving relativistic kinematics, including time dilation effects observed in meson experiments and relativistic observations of moving bodies. Δt=γ Δt0\Delta t = \gamma \, \Delta t_0Δt=γΔt0
	$\Delta t = \gamma \Delta t_0$
Content Outline	• **Introduction to Special theory of relativity:-** Introduction, Inertial and Non-inertial frames of reference, Galilean transformations, Newtonian relativity, Electromagnetism and Newtonian relativity. Attempts to locate absolute frame: Michelson- Morley experiment (omit derivation part), Attempts to preserve the concept of a preferred ether frame: Lorentz Fitzgerald contraction hypothesis, Ether drag hypothesis (conceptual), Stellar aberration, Attempt to modify electrodynamics. • **Relativistic Kinematics - I:** Postulates of the special theory of relativity, Simultaneity, Derivation of Lorentz transformation equations. Some consequences of the Lorentz transformation equations: length contraction, time dilation and meson experiment. The observer in relativity
Module 2 (Credit 1) Spin Orbit Coupling and Atomic Models	
Learning Outcomes	1. Remembering & Understanding: Define and explain the concepts of relativistic velocity transformation, aberration, Doppler effect, space-time diagrams, simultaneity, and the twin paradox in special relativity.
	2. Applying: Apply relativistic velocity addition and transformation equations to solve problems involving moving reference frames and high-speed particles. u′=u−v1−uvc2u' = \frac{u-v}{1-\frac{uv}{c^2}}u′=1−c2uv u−v
	$u' = \frac{u-v}{1-\frac{uv}{c^2}}$
	3. Analyzing: Analyze the geometrical representation of space-time using space-time diagrams to interpret simultaneity, length contraction, and time dilation between different observers.
	4. Evaluating: Evaluate the physical significance of relativistic Doppler effect, aberration, and the twin paradox in understanding the limitations of classical intuition at relativistic speeds.
	5. Creating / Problem Solving: Solve numerical and conceptual

	problems related to relativistic kinematics, velocity transformations, and space-time relationships to predict observations in relativistic systems. Δx2−c2Δt2\Delta x^2 - c^2\Delta t^2Δx2−c2Δt2
	$\Delta x^2 - c^2\Delta t^2$
Content Outline	• Relativistic Kinematics - II: The relativistic addition of velocities, velocity and acceleration transformation equations, aberration and Doppler effect in relativity, the common sense of special relativity. • The Geometric Representation of Space-Time: Space-time diagrams, simultaneity, length contraction and time dilation, the time order and space separation of events, the twin paradox.
Module 3 & 4 PRACTICAL COURSE (2 Credits)	
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO 1. Analyze Precision Rectifier Circuits: Students will be able to design and study half-wave precision rectifier circuits using op-amps (OPA177) and evaluate their performance over conventional rectifiers.
	2. LO 2. Implement Wave Shaping Circuits: Students will be able to design and analyze positive and negative clipper and clamper circuits using op-amps for waveform modification.
	3. LO 3. Design Active Filter Circuits: Students will be able to construct second-order active low-pass and high-pass filters and study their frequency response and phase relationships.
	4. LO 4. Evaluate Frequency Selective Circuits: Students will be able to design and analyze active notch filters and interpret their behavior in rejecting specific frequency components.
	5. LO 5. Interpret Signal Behavior and Circuit Performance: Students will be able to observe waveforms using CRO, analyze gain and phase variations, and validate experimental results with theoretical expectations.
Content Outline	• Half wave precision rectifier using precision op-amps (OPA177) • Positive and Negative Clippers using op-amp. • Positive and Negative Clampers using single power supply op-amp (124/324). • Second Order active Low Pass filter (frequency response & phase relation) • Second Order active High Pass filter (frequency response & phase relation) • Active Notch Filter (frequency response & phase relation
Learning	1. LO 1. Design Waveform Generator Circuits: Students will be able to design and analyze square and triangular wave generators

Outcomes		using op-amps, including the concept of duty cycle.
	2.	LO 2. Understand Power Supply Design: Students will be able to construct and study a variable dual power supply using LM317 and LM337 and analyze its voltage regulation.
	3.	LO 3. Develop Current Source Circuits: Students will be able to design and implement a constant current source using an op-amp and PNP transistor for low current applications.
	4.	LO 4. Implement Audio Signal Amplification: Students will be able to build and analyze a simple microphone amplifier using a transistor and evaluate its performance.
	5.	LO 5. Construct and Test Power Amplifiers: Students will be able to design and study audio power amplifiers using IC TBA810 and assess output characteristics and efficiency.
Content Outline	•	Square and Triangular wave generator using
	•	OPAMPs with concept of duty cycle
	•	Study of variable dual power supply using LM 317& LM 337 (± 3v to ±15v).
	•	Constant Current source using OPAMP and PNP transistor (o/p current less than 50 mA)
	•	Simple microphone amplifier using a transistor.
	•	Construction of Audio power amplifiers using IC TBA 810.

(Theory) Reference books:

1. Introduction to Special Relativity: Robert Resnick (Wiley Student Edition).
2. Special theory of Relativity: A. P. French.
3. Very Special Relativity – An illustrated guide: by Sander Bais - Amsterdam University Press.
4. Chapter 1: Concepts of Modern Physics by Arthur Beiser.
5. Chapter 2: Modern Physics by Kenneth Krane.

Semester – VI

.6.4 Major (Core)

Course Titles	**Applied Optics (Th)**
Course Credits	**2 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. CO1: Explain the principles of polarization, optical activity, holography, and fibre optics along with their fundamental physical concepts and working mechanisms.
	2. CO2: Apply the concepts of Malus law, phase retardation, numerical aperture, acceptance angle, and pulse dispersion to solve theoretical and numerical problems in optics.
	3. CO3: Analyze the behavior of polarized light, holographic recording and reconstruction processes, and light propagation in single-mode and multimode optical fibres.
	4. CO4: Evaluate the characteristics, advantages, and limitations of holography and fibre optic communication systems in scientific, industrial, and telecommunication applications.
	5. CO5: Demonstrate problem-solving skills by interpreting and designing basic optical and fibre optic systems using the principles of modern optics and photonics.
Module 1(Credit 1) Polarization and Holography	
Learning Outcomes	After learning the module, learners will be able to
	1. Remembering & Understanding: Define and explain the concepts of polarization, Malus law, double refraction, optical activity, and the basic principles of holography.
	2. Applying: Apply the working principles of quarter-wave plates, half-wave plates, and polarimeters to analyze polarized light and optical rotation phenomena.
	3. Analyzing: Analyze the role of coherence, phase retardation, and interference in the recording and reconstruction processes of holography.
	4. Evaluating: Compare the characteristics and applications of different polarization devices and evaluate the advantages and limitations of holography in scientific and technological fields.
	5. Creating / Problem Solving: Solve numerical and conceptual problems related to Malus law, phase retardation plates, optical activity, and holographic systems to interpret optical phenomena quantitatively.
Content Outline	• Introduction and Revision of Polarization. • Malus law

	• Double refraction • Phase retarded plate • Quarter wave plate and half wave plate • Optical activity and Polarimeter • Introduction and Theory of Holography. • Importance of coherence and Principle of holography. • Characteristics, recording and reconstruction of Holography • Applications of Holography. • Problems.
Module 2 (Credit 1) Fibre Optics	
Learning Outcomes	1. Remembering & Understanding: Define and explain the basic principles, structure, and working of optical fibres, including numerical aperture, acceptance angle, and pulse dispersion.
	2. Applying: Apply the concepts of numerical aperture, acceptance angle, and pulse dispersion to solve problems related to light propagation in optical fibres.
	3. Analyzing: Analyze the differences between single-mode and multimode fibres with respect to modes of propagation, attenuation, and communication efficiency.
	4. Evaluating: Evaluate the performance, advantages, and limitations of fibre optic communication systems in modern telecommunication applications.
	5. Creating / Problem Solving: Design and interpret simple fibre optic communication systems and solve numerical and conceptual problems related to attenuation, dispersion, and fibre optic applications.
Content Outline	• Introduction to Fibre Optics. • The Optical Fibre: Principle and Structure. • Fibre Optics: Numerical aperture and Acceptance angle • Pulse dispersion and Calculation of pulse dispersion. • Types of Optical Fibres: Concept of Mode • Multimode and Single mode fibre. • Attenuation in optical fibers • single mode and multimode fibers. • Fibre Optic communication system: Fiber optical telecommunication system. • Advantages of Fibre Optics. • Applications of Fibre Optics.

	• Problems.

(Theory) Reference books:

1. Ghatak Ajoy, Optics 3rd Edition, The McGraw Hill companies.
2. N. Subrahmanyam, A textbook of Optics, S. Chand publications.
3. Optical Fiber and Fiber Optic communication System, S.K Sarkar S. Chand.
4. Practical Optics, Naftaly Menn, Academic press (2004)
5. M. Born and E. Wolf, Principles of Optics, Cambridge University Press
6. F. A. Jenkins, H.E White, Fundamental of Optics, McGraw companies

Semester – VI

.6.5 Minor Stream

Course Titles	**C++ Programming (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO1: Apply fundamental Object-Oriented Programming concepts using C++ to design and develop simple programs.
	2. CO2: Analyze and implement C++ programs using appropriate tokens, data types, variables, and expressions with proper type compatibility and conversions.
	3. CO3: Utilize various operators, including memory management and operator overloading, to perform efficient computations and problem-solving.
	4. CO4: Design structured programs using control statements and modular programming concepts through functions and parameter passing techniques.
	5. CO5: Develop efficient and reusable C++ programs using advanced function features such as inline functions, default arguments, function overloading, and standard library functions.
Module 1(Credit 1) Basics of Object-Oriented Programming	
Learning Outcomes	After learning the module, learners will be able to
	1. LO1. Understand OOP Concepts: Students will be able to explain fundamental concepts of Object-Oriented Programming such as classes, objects, encapsulation, inheritance, and polymorphism, along with their benefits and applications.
	2. LO2. Explain Structure and Basics of C++ Programs: Students will be able to describe the structure of a C++ program, write simple programs, and demonstrate the process of creating, compiling, and linking source files.
	3. LO3. Apply Object-Oriented Approach in C++: Students will be able to develop basic C++ programs using classes and objects to solve simple real-world problems.
	4. LO4. Identify and Use C++ Tokens and Data Types: Students will be able to classify and use different tokens in C++ including keywords, identifiers, constants, and various data types (basic, user-defined, and derived).
	5. LO5. Analyze Expressions and Type Compatibility: Students will be able to construct and evaluate expressions in C++, understand type compatibility, and effectively use symbolic constants in program development.
Content Outline	• Basics of Object-Oriented Programming & Beginning with C++:

	◦ Basic concepts of Object-Oriented Programming ◦ Benefits of OOP ◦ Object Oriented Languages ◦ Applications of OOP. ◦ What is C++? ◦ Applications of C++ ◦ A simple C++ program ◦ More C++ Statements ◦ Example with Class ◦ Structure of C++ Program ◦ Creating the Source File ◦ Compiling and Linking • Tokens and Expressions in C++: ◦ Introduction ◦ Tokens ◦ Keywords ◦ Identifiers and Constants ◦ Basic Data Types ◦ User-Defined Data Types ◦ Derived Data Types ◦ Symbolic Constants ◦ Type Compatibility.
Module 2 (Credit 1) Variables, Control Structures and Functions	
Learning Outcomes	1. LO1. Understand Variable Handling and Initialization: Students will be able to declare variables, perform dynamic initialization, and use reference variables effectively in C++ programs.
	2. LO2. Apply Operators and Expressions: Students will be able to use various C++ operators (arithmetic, relational, memory management, etc.), analyze expressions, and apply type casting, implicit conversions, and operator precedence rules.
	3. LO3. Implement Advanced Operator Concepts: Students will be able to demonstrate the use of scope resolution, member dereferencing, manipulators, and implement operator overloading for customized operations.
	4. LO4. Design Programs Using Control Structures and Functions: Students will be able to construct programs using decision-making and looping control structures along with modular programming using functions.

	5. LO5. Utilize Advanced Function Features: Students will be able to apply function concepts such as function prototyping, call by reference, return by reference, inline functions, default and constant arguments, function overloading, and use of standard math library functions.
Content Outline	• Declaration of Variables, Dynamic Initialization of Variables, Reference Variables, Operators in C++, Scope Resolution Operator, Member Dereferencing Operators, Memory Management Operators, Manipulators, Type Cast Operator, Expressions and Their Types, Special Assignment Expressions, Implicit Conversions, Operator Overloading, Operator Precedence • Control Structures and Functions: Control Structures, Functions: The Main Function, Function Prototyping, Call by Reference, Return by Reference, Inline Functions, Default Arguments, Constant Arguments, Function Overloading, Math Library Functions.
Module 3 & 4 PRACTICAL COURSE (2 Credits)	
Course Outcomes	CO1: Develop C++ programs to perform input and output operations and execute basic arithmetic computations using user-provided data.
	1. CO2: Apply decision-making constructs such as if-else, nested if, switch, and if-else ladder to solve logical and condition-based problems.
	2. CO3: Design and implement programs using looping constructs (for, while, do-while) to handle repetitive tasks efficiently.
	3. CO4: Construct modular programs using functions, including function declaration, definition, calling, and the use of function prototypes.
	4. CO5: Integrate control structures and functions to develop structured, efficient, and reusable programs for real-world problem-solving.
Learning Outcomes	After learning the Practical module, learners will be able to
	1. LO1. Perform Input and Output Operations in Lab: Students will be able to write and execute C++ programs in the lab to accept user input using cin and display results using cout.
	2. LO2. Develop Arithmetic Programs: Students will be able to create, compile, and run programs that take two numbers as input and perform basic arithmetic operations with correct output.
	3. LO3. Implement Conditional Programs: Students will be able to write and test programs using if-else and nested if statements to solve decision-making problems (e.g., finding largest number).

	4. LO4. Execute Loop-Based Programs: Students will be able to implement and debug programs using for, while, and do-while loops for repetitive computations (e.g., sum of series, factorial).
	5. LO5. Debug and Validate Program Output: Students will be able to identify logical and syntax errors, debug programs, and verify outputs for correctness through multiple test cases.
Content Outline	• Program based on Input, Output Statements. (Programs to read any two numbers through keyboard and to perform simple arithmetic operations and to display the result). • Program based on Control Statements a) Program based on if-else statement b) Program based on nested if statement • Program based on for loop, while loop and do-while loop. • **C++ Programming Lab Experiments** • **Experiment 1: Input and Output Operations** Write and execute a C++ program to accept user input using cin and display the output using cout. • **Experiment 2: Arithmetic Operations Program** Develop a program to read two numbers from the keyboard and perform basic arithmetic operations (addition, subtraction, multiplication, division) and display the results. • **Experiment 3: Conditional Statements (if-else)** Write a C++ program using if-else statements to solve decision-making problems (e.g., check whether a number is even or odd). • **Experiment 4: Nested if Statement** Develop a program using nested if statements to find the largest among three numbers. • **Experiment 5: Looping using for Loop** Write a program using a for loop to compute the sum of first N natural numbers or generate a multiplication table. • **Experiment 6: Looping using while Loop** Develop a program using a while loop to calculate factorial of a number. • **Experiment 7: Looping using do-while Loop** Write a program using a do-while loop to display a menu-driven program (e.g., simple calculator). • **Experiment 8: Debugging and Validation** Execute and debug previously written programs, identify syntax and logical errors, and validate outputs with different test cases.
Learning	1. LO1. Understand Multi-way Decision Making: Students will be

Outcomes		able to explain and differentiate between switch statements and if-else ladder constructs in C++.
	2.	LO2. Implement Decision-Based Programs: Students will be able to develop programs using switch statements and if-else ladder to solve multi-condition problems (e.g., menu-driven applications).
	3.	LO3. Apply Function Concepts: Students will be able to define, declare, and call functions to perform specific tasks in a modular programming approach.
	4.	LO4. Use Function Prototypes Effectively: Students will be able to write and utilize function prototypes for proper program structure and compilation.
	5.	LO5. Develop Modular Programs: Students will be able to design and execute C++ programs by dividing problems into smaller functions, improving code readability and reusability.
Content Outline		• Program using switch statements and if-else ladder. • Program to study function declaration, function calling and function prototype. • **C++ Programming Lab Experiments (Switch & Functions)** • **Experiment 1: Switch Statement (Basic Use)** Write a C++ program using a switch statement to perform simple operations (e.g., display day of the week based on user input). • **Experiment 2: Switch Statement (Menu-Driven Program)** Develop a menu-driven program using a switch statement to perform arithmetic operations (addition, subtraction, multiplication, division). • **Experiment 3: If-Else Ladder** Write a C++ program using an if-else ladder to classify a student's grade based on marks. • **Experiment 4: Function Declaration and Calling** Develop a program to define and call user-defined functions for performing arithmetic operations. • **Experiment 5: Function Prototype** Write a C++ program demonstrating the use of function prototypes and proper function definition. • **Experiment 6: Modular Programming using Functions** Create a program that divides a problem into multiple functions (e.g., calculate area of different shapes using separate functions). • **Experiment 7: Comparison of Control Structures** Write programs to solve the same problem using both switch and

	if-else ladder and compare their outputs and usability.

(Theory) Reference books:

1. EB: Object Oriented Programming with C++ by E Balagurusamy, Third /Fourth Edition, Tata McGraw-Hill Publishing Company Limited. Additional references:
2. Programming with C++ by D. Ravichandran, Tata McGraw-Hill Publishing Company Limited.
3. Starting out with C++ by Tony Gaddis, Third Edition, Addison Wesley Publishing Company.