KUVEMPU UNIVERSITY

Bachelor of Science (B.Sc.) – Semester Scheme

Curriculum Structure for Undergraduate Programme

V and VI SEMESTER (2026-27)

Sl. No	Course/ Paper Code	Title of the Paper	Subject Category	Teaching Hours/ Week	Semester End Exam	Internal Assessment	Total Marks	Credits	Duration of Exam
V Semester									
1	24MCP-T5	Relativity, Classical Mechanics and Quantum Mechanics	Theory	04	80	20	100	03	3 Hrs
2	24MCP-T6	Atomic and Molecular Physics, Spectroscopy and Astrophysics	Theory	04	80	20	100	03	3 Hrs
3	24MCP-P5	Laboratory Experiments in Classical and Modern Physics, Atomic and Molecular Physics, Spectroscopy, and Laser Physics	Practical	04	40	10	50	02	3 Hrs
4	24SECPh2	Computational Physics with Python	Skill Enhance ment Course	04	40	10	50	02	3 Hrs
VI Semester									
1	24MCP-T7	Condensed Matter Physics & Electronics	Theory	04	80	20	100	03	3 Hrs
2	24MCP-T8	Nuclear Physics, Particle Physics & Statistical Mechanics	Theory	04	80	20	100	03	3 Hrs

3	24MCP-P6	Laboratory Experiments in Condensed Matter Physics, Nuclear Physics and Electronics	Practical	04	40	10	50	02	3 Hrs
4	24SECPh3	Research Oriented Project Work in Physics	Skill Enhancement Course	04	40	10	50	02	3 Hrs

THEORY PAPER

Semester – V

24MCP-T5: Relativity, Classical Mechanics and Quantum Mechanics

No. of Teaching Hours/Week: 4 Hrs/Week Total Teaching Hours: 64Hrs
Maximum Marks: 100 (80 Semester End + 20 Internal Assessment) Credits: 03

Course Learning Objectives

- To understand the fundamental concepts of space, time and relativity from classical to modern perspectives.
- To study the principles and implications of Special and General Theory of Relativity.
- To learn the formulation and applications of Lagrangian mechanics in dynamical systems.
- To examine the limitations of classical physics and the emergence of wave mechanics.
- To understand the principles and mathematical formulation of quantum mechanics.
- To develop problem-solving skills in relativity and quantum physics.

Course Outcomes

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

- To explain Galilean and Lorentz transformations and derive relativistic effects such as time dilation and length contraction.
- To apply the principles of relativity to obtain mass-energy relation and energy-momentum relation.
- To describe key predictions of General Relativity such as gravitational red shift and black holes.
- To formulate and apply Lagrange's equations to simple mechanical systems.
- To explain the concept of matter waves and interpret fundamental experiments like Davisson-Germer experiment.
- To apply Heisenberg's uncertainty principle and explain its physical implications.
- To derive and solve Schrödinger equation for simple systems like particle in a box.
- To interpret eigenvalues, eigenfunctions and operators in quantum mechanics.
- To analyze quantum mechanical systems using wave functions and expectation values.

UNIT - 1

1. **SPECIAL THEORY OF RELATIVITY**

Newtonian concept of space, time and mass. Frames of reference. Newtonian Principle of relativity, Galilean transformation equations. The Ether hypothesis, Michelson-Morley Experiment (qualitative only). Postulates of Special theory of relativity. The Lorentz transformation equations (derivation). Inverse Lorentz transformation equations. Consequences: Length contraction, Time Dilation, Relativity of simultaneity, Twin Paradox (qualitative only). Relativistic velocity addition theorem (derivation). Variation of mass with velocity (qualitative). Mass-energy relation (derivation). Energy-momentum relation (derivation). Minkowski's space-time, space-time interval, four vectors (qualitatively). Problems. **(16Hrs)**

UNIT - 2

2. GENERAL THEORY OF RELATIVITY

Postulates of General theory of relativity – principle of equivalence. Curved space-time. Experimental verification: Deflection of light in a gravitational field, Advance of the perihelion of Mercury's orbit. Gravitational red shift (derivation). Black holes, Schwarzschild radius. Problems. **(5Hrs)**

3. LAGRANGIAN MECHANICS

Degrees of Freedom. Constraints. Types of constraints. Generalized coordinates. Generalised displacement, velocity and momentum. Lagrangian and action. Hamilton's Principle. Lagrange's equations using Hamilton's principle (derivation). Applications of Lagrange's equations: (a) Simple pendulum (b) Linear harmonic oscillator (c) Atwood's machine (d) Compound pendulum. **(11Hrs)**

UNIT – 3

4. INTRODUCTION TO QUANTUM MECHANICS

Inadequacy of classical mechanics: (a) Blackbody radiation (b) Photoelectric effect (c) Compton effect (d) Bohr model and the hydrogen atom. Expression for Compton shift (derivation). Matter waves, de Broglie hypothesis. Davisson-Germer Experiment (experimental arrangement, procedure and theory). Two slit Interference Pattern with electrons (principle, experimental arrangement and result). Heisenberg's uncertainty principle, Illustrations: Determination of position with γ-ray microscope. Energy-time uncertainty relation. Non-existence of electron in the nucleus. Bohr's complementarity principle and its illustration. Problems. **(16Hrs)**

UNIT - 4

5. FOUNDATIONS OF QUANTUM MECHANICS

Time-dependent Schrödinger Equation (derivation), Time-independent Schrödinger equation using TDSE (derivation). Eigenvalues, eigenfunctions, degeneracy. Properties of the wave function: Born interpretation of wave function. Normalised wavefunction. Requirements of wave function. Particle in a 1d-box: Infinite square well potential (derivation of E_n and ψ_n), expectation value of position and momentum for infinite square well potential. Qualitative discussions of (a) The square well in three dimensions, expression for energy, degeneracy. (b) Barrier penetration problem, Transmission coefficient, tunnel effect. (c) Linear harmonic oscillator – Energy levels, zero-point energy. Introduction to operators and commutators.

(16Hrs)

Note: Sufficient number of problems that would enhance the understanding of the subject are to be worked out in each section

REFERENCE BOOKS:

1. *Modern Physics – R. Murugeshan and K. Sivaprasath*
2. *Introduction to Special Relativity – Robert Resnick*
3. *University Physics – H.D. Young and R.A. Freedman*
4. *Fundamentals of Physics – Halliday, Resnick and Walker*
5. *Mechanics – D.S. Mathur*
6. *Refresher Course in B.Sc. Physics (Vol. 1) – C.L. Arora*
7. *Classical Mechanics – Herbert Goldstein*
8. *Classical Dynamics of Particles and Systems – Marion and Thornton*
9. *Analytical Mechanics – G.R. Fowles and G.L. Cassiday*
10. *Introduction to Classical Mechanics – David Morin*
11. *Mechanics – L.D. Landau and E.M. Lifshitz*
12. *Concepts of Modern Physics – Arthur Beiser*
13. *Modern Physics – Kenneth S. Krane*
14. *Introduction to Quantum Mechanics – David J. Griffiths*
15. *Quantum Mechanics: Concepts and Applications – Nouredine Zettili*
16. *Principles of Quantum Mechanics – R. Shankar*
17. *Quantum Mechanics – Satya Prakash*
18. *Quantum Mechanics – V.K. Thankappan*
19. *A Textbook of Quantum Mechanics – P.M. Mathews and K. Venkatesan*
20. *Special Relativity – A.P. French*
21. *Spacetime Physics – Edwin F. Taylor and John A. Wheeler*
22. *Introduction to Electrodynamics (Relativistic aspects) – David J. Griffiths*

THEORY PAPER

Semester – V

24MCP-T6: Atomic and Molecular Physics, Spectroscopy and Astrophysics

No. of Teaching Hours/Week: 4 Hrs/Week Total Teaching Hours: 64Hrs
Maximum Marks: 100 (80 Semester End + 20 Internal Assessment) Credits: 03

Course Learning Objectives

- To understand the development of atomic models from Rutherford to Sommerfeld and their limitations.
- To study the vector atom model and the role of quantum numbers in atomic structure.
- To analyze atomic spectra and the effects of external fields such as Zeeman and Stark effects.
- To explore molecular spectra and the underlying principles of rotational, vibrational and Raman spectra.
- To understand the principles, construction and applications of lasers.
- To gain knowledge of stellar structure, evolution and fundamental concepts of astrophysics and cosmology.

Course Outcomes

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

- To describe Rutherford scattering experiment and derive expressions related to Bohr's atomic model and hydrogen spectra.
- To explain quantum numbers, electron spin, and apply Pauli exclusion principle to determine electronic configurations.
- To analyze atomic spectra using selection rules and explain fine structure, Zeeman and Stark effects.
- To explain the origin of molecular spectra and interpret rotational, vibrational and Raman spectra.
- To describe the principles of laser operation and explain working of different laser systems.
- To interpret stellar properties using H-R diagram and explain stages of stellar evolution.
- To derive basic astrophysical relations such as mass-luminosity relation and photon diffusion time.
- To explain cosmological concepts such as Hubble's law and Big Bang theory with observational evidence.

UNIT – 1 & 2

1. BASIC ATOMIC MODELS

Thomson atomic model, Rutherford α-particle scattering experiment (Experimental arrangement, result), Rutherford nuclear atom model. Bohr's Atom Model – postulates, radii of the stationary orbits (derivation), total energy of the electron in the orbit (derivation). Bohr's interpretation of the Hydrogen spectrum. Spectral series of hydrogen atom, energy-level diagram. Effect of finite mass of nucleus on atomic spectra (derivation). Ratio of mass of electron to the mass of proton (derivation). Sommerfeld's relativistic atom model (quantitative), conditions for allowed elliptical orbits (qualitative). **(11Hrs)**

2. VECTOR ATOMIC MODEL

Vector atom model – introduction, spatial quantisation and spinning electron hypothesis. Magnetic dipole moment due to orbital motion of the electron (derivation), magnetic dipole moment due to spin, Stern-Gerlach experiment (Principle, theory, experimental arrangement, results), Quantum numbers associated with the vector atom model. Coupling schemes – L-S coupling and j-j coupling. Pauli exclusion principle, applications, maximum number of electrons in a shell (derivation). Electronic configuration, examples. **(11Hrs)**

3. ATOMIC SPECTRA

Spectral terms. Spectral notation. Selection rules. Intensity rules. Fine structure of sodium D-lines. Zeeman effect: experimental arrangement for the study of Zeeman effect, Zeeman shift. Quantum mechanical explanation of the normal Zeeman effect. Quantum mechanical explanation of the anomalous Zeeman effect. Lande g-factor. Paschen-Back effect and Stark effect (qualitative). Problems. **(10Hrs)**

UNIT – 3

4. MOLECULAR SPECTRA

Introduction, origin of molecular spectra, nature of molecular spectra. Born–Oppenheimer approximation. Theory of origin of pure rotational spectrum of a molecule (diatomic molecule as a rigid rotator). Pure rotational spectrum for determining the properties of a molecule. Vibrating diatomic molecule as a harmonic oscillator (theory). Qualitative discussion of vibrational-rotational spectrum, P-branch and R-branch. Qualitative discussion of electronic spectra of diatomic molecules; Franck–Condon principle – explanation. Raman Effect - experimental Study of Raman effect, characteristics of Raman lines. Quantum theory of Raman effect. Applications of the Raman effect. Problems. **(11 Hrs)**

5. LASERS

Induced absorption, spontaneous emission and stimulated emission with rate equations. Relation between Einstein's A and B coefficients (qualitative). Principle of laser. Requirements for laser action: population inversion, pumping, optical resonators, active medium. Ruby laser and He-Ne laser. Applications of lasers. Problems. **(5 Hrs)**

UNIT – 4

6. ASTROPHYSICS

Stars – Distance of a star - stellar parallax method. Units: AU, light year, parsec and their relations. Stellar brightness and luminosity; apparent and absolute magnitudes of a star and their relation. Spectral classification of stars based on surface temperature; H–R diagram and its interpretation. Basic stellar parameters - mass, radius, mean density, and surface temperature of the Sun. Expressions for internal temperature of a star (derivation) and internal pressure (no derivation); photon diffusion time (derivation). Mass–luminosity relation (derivation) and its implications; relation between stellar mass and lifetime; sources of stellar energy (qualitative). Stellar evolution - formation and characteristics of main sequence stars, red giants, white dwarfs, neutron stars, and black holes. **(13 Hrs)**

7. COSMOLOGY

Expansion of universe, Hubble's law - statement and explanation, age of the universe using Hubble's law. Big Bang theory - explanation, experimental evidence for Big Bang model - CMBR. **(3 Hrs)**

Note: Sufficient number of problems that would enhance the understanding of the subject are to be worked out in each section

REFERENCE BOOKS:

1. *Modern Physics – R. Murugeshan and K. Sivaprasath*
2. *Concepts of Modern Physics – Arthur Beiser*
3. *Atomic Physics – J.B. Rajam*
4. *Introduction to Atomic Spectra – H.E. White*
5. *Physics of Atoms and Molecules – Bransden and Joachain*
6. *Atomic and Nuclear Physics – Brijlal and Subrahmanyam*
7. *Quantum Physics of Atoms, Molecules and Photons – Robert Eisberg and Robert Resnick*
8. *Atomic Physics – Max Born*
9. *The Theory of Atomic Structure and Spectra – Robert D. Cowan*
10. *Basic Atomic and Molecular Spectroscopy – J.M. Hollas*
11. *Fundamentals of Molecular Spectroscopy – C.N. Banwell and McCash*
12. *Molecular Spectra and Molecular Structure – G. Herzberg*
13. *Spectra of Diatomic Molecules – G. Herzberg*
14. *Optics and Spectroscopy – K.K. Sharma*
15. *Lasers and Non-Linear Optics – B.B. Laud*
16. *Laser Fundamentals – William T. Silfvast*
17. *Principles of Lasers – Orazio Svelto*
18. *Astrophysics: Stars and Galaxies – K.D. Abhyankar*
19. *An Introduction to Astrophysics – Baidyanath Basu*
20. *An Introduction to Modern Astrophysics – Bradley W. Carroll and Dale A. Ostlie*
21. *Astrophysics for Physicists – Arnab Rai Choudhuri*
22. *Introduction to Cosmology – Barbara Ryden*

PRACTICAL PAPER

Semester – V

24MCP-P5: 25 Laboratory Experiments in Classical and Modern Physics, Atomic and Molecular Physics, Spectroscopy, and Laser Physics

No. of Teaching Hours/Week: 4 Hrs/Week Total Teaching Hours: 64Hrs
Maximum Marks: 50 (40 Semester End + 10 Internal Assessment) Credits: 02

Note: A minimum of two experiments shall be performed from each category. A minimum of eight experiments shall be performed during the semester.

Classical, Quantum and Modern Physics

1. Determination of the acceleration of gravity using an Atwood's machine.
2. Determination of Planck's constant using photoelectric effect
3. Determination of Planck's constant using LED method
4. Determination of work function using photocell (cut-off method)
5. Determination of e/m of electron – Thomson method
6. Determination of e/m of electron – Magnetron method
7. Determination of ionization potential of mercury
8. Study of thermionic emission – work function determination
9. Study of I–V characteristics of tunnel diode
10. Study of photodiode characteristics & quantum efficiency
11. Study of solar cell characteristics (I–V and efficiency)

Atomic and Molecular Physics, Spectroscopy

12. Determination of Rydberg constant using hydrogen spectrum
13. Determination of wavelength of H_α line of hydrogen
14. Determination of refractive index of material of the prism using spectrometer
15. Determination of the force constant and vibrational constant for the iodine molecule from its absorption spectrum.
16. Study of Raman scattering by CCl4 using laser and spectrometer/CDS.
17. Determination of rotational/vibrational constants of iodine molecule.
18. Determination of fine structure constant using sodium D-lines

Laser Physics

19. Determination of wavelength of laser using single slit diffraction
20. Determination of wavelength of He–Ne laser using diffraction grating
21. Verification of Malus' Law using laser light
22. Determination of beam divergence/angular spread of laser
23. Numerical aperture and attenuation coefficient of optical fibre.

Note: The experiments performed are expected to be well distributed across the prescribed syllabus, and repetition of experiments is to be avoided. Any suitable experiment of appropriate academic standard may be included subject to the availability of experimental apparatus. One experiment per week per batch shall be conducted, each of four hours duration.

SKILL ENHANCEMENT COURSE

V Semester

24SECPh2: Computational Physics with Python

No. of Teaching Hours/Week: 4 Hrs/Week Total Teaching Hours: 64Hrs
Maximum Marks: 50 (40 Semester End + 10 Internal Assessment) Credits: 02

Course Learning Objectives

- To apply Python programming for solving problems in various areas of physics.
- To develop numerical models for physical systems governed by differential equations.
- To simulate and analyze dynamical systems using computational methods.
- To visualize physical phenomena using appropriate graphical representations.
- To interpret computational results and relate them to theoretical concepts.

Course Outcomes

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

- Develop Python programs to simulate physical systems across different domains of physics.
- Apply numerical methods to model motion, oscillations, waves, circuits, and thermal systems.
- Analyze physical behavior using computational techniques and graphical outputs.
- Model basic phenomena in electricity, magnetism, statistical, and modern physics.
- Interpret simulation results and validate them with theoretical predictions.

LIST OF EXPERIMENTS

Required software: Python 3 or Google Colab

1. **Motion of a Falling Body (Tennis Ball):** Simulation of motion under gravity with and without air resistance; plot position and velocity as functions of time.
2. **Motion with Viscous Drag (Falling Raindrops):** Numerical study of motion under gravity with linear drag; determine terminal velocity.
3. **Motion of a Hanging Block (Mass–Spring System):** Simulation of oscillatory motion of a mass–spring system; extend to include damping.
4. **Motion of a Boat on a Flowing River:** Simulation of two-dimensional motion using vector addition of velocities; plot trajectory.
5. **Comet Trajectory under Central Force:** Simulation of motion under inverse-square gravitational force; study orbital trajectories.
6. **Pendulum with Air Resistance:** Numerical solution of nonlinear pendulum motion with damping; compare with ideal motion.
7. **Projectile Motion in Two Dimensions:** Simulation of projectile motion with and without air resistance; plot trajectory and range.
8. **Block Sliding on an Inclined Plane with Friction:** Numerical study of motion under gravity and friction; compare static and kinetic friction.
9. **Roller-Coaster Motion using Energy Conservation:** Simulation of motion along a track using energy principles; analyze variation of speed and energy.

10. **Elastic and Inelastic Collisions (Two-Body System):** Simulation of collisions; study conservation of momentum and energy loss.
11. **Motion of a Charged Particle in an Electric Field:** Simulation of motion under a uniform electric field; analyze trajectory, velocity, and energy variation.
12. **Motion of a Charged Particle in a Magnetic Field:** Simulation of circular and helical motion in a uniform magnetic field; determine radius and cyclotron frequency.
13. **RLC Circuit (Damped Oscillations):** Simulation of current in an RLC circuit; study underdamped, critically damped, and overdamped responses.
14. **Doppler Effect Simulation:** Simulation of frequency shift due to motion of source or observer; visualize wavefronts and observed frequency.
15. **Maxwell–Boltzmann Distribution:** Numerical generation of velocity distribution of gas particles; compare with theoretical distribution.
16. **Quantum Tunneling (Potential Barrier):** Simulation of transmission probability of a particle through a potential barrier using numerical methods.
17. **Compton Scattering:** Simulation of wavelength shift of photons as a function of scattering angle; verify theoretical relation.
18. **Electric Field and Potential of Point Charges:** Numerical calculation of electric field and potential due to single and multiple point charges; visualize electric field lines and equipotential surfaces.
19. **Wave Propagation on a String (Finite Difference Method):** Numerical solution of the one-dimensional wave equation; simulate propagation and reflection of waves under different boundary conditions.
20. **Heat Conduction in a Rod (1D Heat Equation):** Finite difference solution of the heat equation; study temperature distribution and its evolution over time.

Note: The experiments performed are expected to be well distributed across the prescribed syllabus, and repetition of experiments is to be avoided. Any suitable experiment of appropriate academic standard may be included. A minimum of eight experiments shall be performed during the semester. One experiment per week per batch shall be conducted, each of four hours duration.

Evaluation:

- Internal Assessment (IA) shall carry 10 marks. The End-Semester **Practical Examination** shall carry 40 marks.
- Students must execute one given **program on computer** and obtain the corresponding outputs for evaluation.

References:
[1] Elementary Mechanics Using Python - Anders Malthe-Sørenssen
[2] Programming with Python - Shubhakanta Singh
[3] Physics with Excel and Python - Dieter Mergel

THEORY PAPER

Semester – VI

24MCP-T7: Condensed Matter Physics & Electronics

No. of Teaching Hours/Week: 4 Hrs/Week — Total Teaching Hours: 64Hrs
Maximum Marks: 100 (80 Semester End + 20 Internal Assessment) — Credits: 03

Course Learning Objectives

- To understand crystal structure, X-ray diffraction, and specific heat of solids.
- To explain free electron theory and band theory of solids.
- To study magnetic properties and superconductivity.
- To understand semiconductor devices and electronic circuits.
- To develop basic knowledge of digital electronics and logic circuits.

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

- Explain crystal structures and X-ray diffraction.
- Apply theories of specific heat and free electrons.
- Analyze band theory and semiconductor properties.
- Explain magnetic properties and superconductivity.
- Analyze electronic devices and basic circuits.
- Apply Op-Amp and digital logic concepts to simple circuits.

UNIT – 1

1. **CRYSTALLOGRAPHY & X-RAYS**

Crystal structure - introduction; crystal lattice and translation vectors; unit cell; Bravais lattices (2D and 3D); crystal systems. Lattice directions and planes; Miller indices; interplanar spacing and its relation to (h, k, l) and intercepts. X-rays: introduction; production (brief); types of X-rays (soft and hard). X-ray Diffraction: Bragg's law and derivation of $2d \sin \theta = n\lambda$. Bragg's x-ray spectrometer. X-ray spectra: Types of x-ray spectra. Origin of continuous x-ray spectrum, Duane–Hunt law. Origin of characteristic x-ray spectrum; Moseley's law and its explanation using Bohr's theory; significance of Moseley's law. Problems. (**11 Hrs**)

2. **SPECIFIC HEAT OF SOLIDS**

Dulong–Petit law - statement and classical derivation. Einstein's theory - assumptions; expression for specific heat (no derivation); merits and demerits. Debye's theory—assumptions and derivation of Debye's formula; Limiting cases: high temperature (Dulong–Petit law) and low temperature (Debye T^3 law). Problems. **(5 Hrs)**

UNIT – 2

3. FREE ELECTRON THEORY OF METALS

Free Electron Theory of Metals: Limitations of classical theory. Quantum free electron theory - Sommerfeld model: assumptions; energy states of electrons. density of states; Fermi energy: derivation of Fermi energy at absolute 0K; average kinetic energy of free electrons at 0 K $\left(E_0 = \frac{3}{5}E_F\right)$; Fermi velocity, Fermi temperature, Fermi momentum. Electrical conductivity - qualitative explanation; relaxation time $\tau(E_F)$; expression for conductivity $\sigma = \frac{ne^2\tau(E_F)}{m}$ (derivation). Problems. **(7 Hrs)**

4. BAND THEORY OF SOLIDS

Origin of energy bands in solids; classification of solids (conductors, semiconductors, insulators). Intrinsic semiconductors - charge carrier concentration in conduction and valence bands (qualitative); law of mass action $(np = n_i^2)$; Electrical conductivity - derivation of $\sigma = ne(\mu_e + \mu_h)$. Fermi level (derivation). Extrinsic semiconductors - n-type and p-type; formation of acceptor and donor levels. Derivation of expression for Fermi level in both the cases. Temperature and impurity dependence of Fermi level. Hall Effect: Theory; Hall voltage and Hall coefficient (expressions); relation between Hall coefficient $(R_H)$and mobility (μ). Applications (brief). Problems. **(9 Hrs)**

UNIT – 3

5. MAGNETIC PROPERTIES OF MATERIALS

Diamagnetic, Paramagnetic and Ferromagnetic Materials. Origin of diamagnetism, paramagnetism and ferromagnetism. Variation of susceptibility with temperature. Langevin's classical theory of diamagnetism and paramagnetism. Curie's law. Ferromagnetism - Weiss theory of Ferromagnetism. Domains - origin and effect due to magnetic field, application of ferromagnetic materials. **(10 Hrs)**

6. SUPERCONDUCTIVITY

Experimental observations – Transition temperature, persistent current, Isotope effect, Meissner effect. M vs H graph – critical magnetic field. Type-I and Type-II super conductors. BCS theory – qualitative explanation – formation of cooper pair, exchange of phonons. Josephson effects (qualitative). Applications of superconductors. **(6 Hrs)**

UNIT – 4

7. SOLID STATE ELECTRONICS

Transistor configurations (CE, CB, CC – mention only), comparison between CE, CB and CC configurations. CE configuration in detail. Biasing methods: voltage divider (self-bias) –

circuit and working (qualitative). Transistor as an amplifier (CE mode): single-stage practical CE amplifier, circuit operation, DC load line and Q-point. AC load line. Frequency response and bandwidth. Oscillators: Concept of feedback, types of feedback, Barkhausen criterion for sustained oscillations. Types of oscillators. Phase-shift oscillator (in detail). Field Effect Transistors (FET): Types of FET. N-channel JFET (construction and principle of operation). Applications of FET and comparison with BJT. Operational Amplifiers: Characteristics of an ideal Op-Amp. Open-loop and closed-loop gain (basic concept); Concept of virtual ground. Applications of Op-Amp (mention). Inverting amplifier (gain derivation), non-inverting amplifier (gain derivation). **(12 Hrs)**

8. DIGITAL ELECTRONICS

Logic Gates: Basic logic gates: AND, OR, and NOT (brief review). Universal gates: NAND and NOR; realization of basic gates using NAND and NOR. Exclusive-OR (X-OR) gate. Boolean Algebra: Basic laws of Boolean algebra. De Morgan's theorems (with proof). Boolean expressions: Realization of laws of Boolean algebra using Logic gates. **(4 Hrs)**

NOTE: Sufficient number of problems that would enhance the understanding of the subject are to be worked out in each section

REFERENCE BOOKS:

1. *Introduction to Solid State Physics – Charles Kittel*
2. *Solid State Physics – A.J. Dekker*
3. *Solid State Physics – S.O. Pillai*
4. *Solid State Physics – P.K. Palanisamy*
5. *Elements of Solid State Physics – J.P. Srivastava*
6. *Solid State Physics – Ashcroft and Mermin*
7. *Introduction to Solid State Physics – H.P. Myers*
8. *X-ray Diffraction – B.E. Warren*
9. *Elements of X-ray Diffraction – B.D. Cullity*
10. *Crystallography and Crystal Defects – Anthony Kelly and Kevin M. Knowles*
11. *Introduction to Magnetic Materials – B.D. Cullity and C.D. Graham*
12. *Magnetism and Magnetic Materials – J.M.D. Coey*
13. *Superconductivity, Superfluids and Condensates – James F. Annett*
14. *Introduction to Superconductivity – Michael Tinkham*
15. *Electronic Principles – Albert Malvino and David Bates*
16. *Electronic Devices and Circuits – Millman and Halkias*
17. *Microelectronic Circuits – Sedra and Smith*
18. *Solid State Electronic Devices – Ben G. Streetman and Sanjay Banerjee*
19. *Principles of Electronics – V.K. Mehta and Rohit Mehta*
20. *Digital Principles and Applications – Malvino and Leach*
21. *Digital Electronics – Morris Mano*
22. *Modern Digital Electronics – R.P. Jain*

THEORY PAPER

Semester – VI

24MCP-T8: Nuclear Physics, Particle Physics & Statistical Mechanics

No. of Teaching Hours/Week: 4 Hrs/Week Total Teaching Hours: 64Hrs
Maximum Marks: 100 (80 Semester End + 20 Internal Assessment) Credits: 03

Course Learning Objectives

- To understand nuclear structure, forces, and models.
- To explain radioactivity and nuclear decay processes.
- To study interaction of radiation with matter and detectors.
- To learn nuclear reactions, fission, fusion, and reactor physics.
- To introduce particle accelerators and elementary particles.
- To apply statistical methods to physical systems.

Course Outcomes

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

- Explain nuclear properties, stability, and models.
- Apply radioactive decay laws to solve problems.
- Describe nuclear decay processes and radiation interaction.
- Explain nuclear reactions and reactor principles.
- Describe particle accelerators and elementary particles.
- Apply Maxwell–Boltzmann, Bose–Einstein, and Fermi–Dirac statistics.

UNIT – 1 & 2

1. NUCLEAR STRUCTURE, FORCES AND MODELS

General properties of nuclei: Constituents and intrinsic properties; nuclear size and density; empirical radius relation $R = R_0 A^{1/3}$; binding energy, binding energy per nucleon; variation of binding energy with mass number and its significance; N/Z ratio and nuclear stability. Nuclear forces: Characteristics: short range, saturation, charge independence, and spin dependence. Yukawa's meson theory (quantitative). Nuclear models: Liquid drop model - basic assumptions and semi-empirical mass formula (qualitative significance of terms); nuclear stability. Shell model - basic assumptions, evidence for shell structure, and magic numbers. **(11 Hrs)**

2. RADIOACTIVITY AND NUCLEAR DECAY PROCESSES

Radioactivity: Law of radioactive decay; decay constant, mean life, and half-life; successive disintegration (derivations); transient and secular equilibrium (derivations). Applications: carbon dating, age of the earth. Modes of decay: Alpha, beta, and gamma decay. Alpha decay: Basic features; discrete energy spectrum; Geiger–Nuttall law. Gamow theory (qualitative). Beta decay: Basic concepts; positron emission, electron capture; neutrino hypothesis. Gamma decay: Gamma emission and internal conversion. **(12 Hrs)**

3. INTERACTION OF RADIATION WITH MATTER AND DETECTION

Interaction of radiation with matter: Energy loss of charged particles; stopping power and range; interaction of gamma rays—photoelectric effect, Compton scattering, and pair production (qualitative). Radiation detectors: Classification; gas-filled detectors - Geiger–Müller counter (construction, working, characteristics, applications); scintillation detectors – construction and working; semiconductor detectors (brief). Advantages and disadvantages of detectors. **(9 Hrs)**

UNIT – 3

4. NUCLEAR REACTIONS, FISSION, FUSION AND REACTORS

Nuclear reactions: Types; conservation laws; Q-value (derivation), exoergic and endoergic reactions; threshold energy (derivation); cross section and reaction rate; compound nucleus (basic idea); artificial transmutation (brief). Nuclear fission: Mechanism, energy release; spontaneous and induced fission; chain reaction and criticality; fissile and fertile materials. Nuclear reactors: Basic principle; components (fuel, moderator, control rods, coolant, shielding); four-factor formula, power generation; critical, subcritical, and supercritical states (qualitative). Nuclear fusion: Principle and conditions; thermonuclear reactions; stellar energy (p–p chain and CNO chain (in brief); controlled fusion (concept). **(11 Hrs)**

5. PARTICLE ACCELERATORS

Particle accelerators: Linear accelerator (qualitative); cyclotron—construction, principle, and working; Betatron—construction, principle, and working; synchrotron—basic principle (qualitative). **(5 Hrs)**

UNIT – 4

6. PARTICLE PHYSICS

Cosmic rays: Brief discussion on cosmic rays

Elementary particles: Classification of elementary particles. Leptons and Hadrons. Antiparticles. Fundamental interactions: Gravitational, electromagnetic, weak, and strong forces - comparison between them; exchange particles (qualitative). Conservation of energy, momentum, angular momentum, and charge; baryon number, lepton number, and parity (parity violation in weak interactions). Quark flavours; baryons and mesons; colour charge and confinement (qualitative); the Standard Model (with chart).

(7 Hrs)

7. STATISTICAL MECHANICS

Need for statistics in many-particle systems; microscopic and macroscopic states; phase space; equal apriori probability; thermodynamic probability and entropy—Boltzmann relation (no derivation). Classical statistics: Maxwell–Boltzmann statistics—assumptions, distribution function (qualitative), and limitations. Quantum statistics: indistinguishability, Bose-Einstein statistics-features, physical significance, distribution law (derivation), and Planck's radiation law (derivation); Fermi–Dirac statistics - features and significance (derivation); comparison of MB, BE, and FD statistics. **(9Hr)**

NOTE: Sufficient number of problems that would enhance the understanding of the subject are to be worked out in each section

REFERENCE BOOKS:

1. *Modern Physics – R. Murugeshan and K. Sivaprasath*
2. *Atomic and Nuclear Physics – S.N. Ghoshal*
3. *Introductory Nuclear Physics – Kenneth S. Krane*
4. *Concepts of Nuclear Physics – Bernard L. Cohen*
5. *Nuclear Physics: An Introduction – S.B. Patel*
6. *Nuclear Physics – Irving Kaplan*
7. *Radiation Detection and Measurement – Glenn F. Knoll*
8. *Introduction to Nuclear Engineering – John R. Lamarsh and Anthony J. Baratta*
9. *Elements of Nuclear Reactor Theory – Samuel Glasstone and Milton C. Edlund*
10. *Introduction to Elementary Particles – David J. Griffiths*
11. *Introduction to High Energy Physics – D.H. Perkins*
12. *Quarks and Leptons – Francis Halzen and Alan D. Martin*
13. *Particle Physics – B.R. Martin and G. Shaw*
14. *Statistical Mechanics – B.K. Agarwal and M. Eisner*
15. *Fundamentals of Statistical and Thermal Physics – F. Reif*
16. *Statistical Mechanics – Gupta and Kumar*
17. *Statistical Physics – L.D. Landau and E.M. Lifshitz*
18. *An Introduction to Thermal Physics – Daniel V. Schroeder*
19. *Heat and Thermodynamics – Zemansky and Dittman*
20. *Concepts of Modern Physics – Arthur Beiser*
21. *Nuclear and Particle Physics – W.S.C. Williams*
22. *Basic Ideas and Concepts in Nuclear Physics – K. Heyde*

PRACTICAL PAPER

Semester – VI

24MCP-P6: Laboratory Experiments in Condensed Matter Physics, Nuclear Physics and Electronics

No. of Teaching Hours/Week: 4 Hrs/Week Total Teaching Hours: 64Hrs
Maximum Marks: 50 (40 Semester End + 10 Internal Assessment) Credits: 02

Note: A minimum of two experiments shall be performed from each category. A minimum of eight experiments shall be performed during the semester.

Condensed Matter Physics

1. Hall Effect in semiconductor – determination of Hall coefficient and mobility
2. Determination of energy gap of semiconductor (diode/transistor method)
3. Determination of energy gap using thermistor
4. Determination of Fermi energy of copper
5. X-ray diffraction (XRD) – determination of lattice parameter
6. Determination of particle size using XRD (Debye–Scherrer method)
7. Determination of dielectric constant of a material/liquid
8. Determination of dipole moment of a polar liquid
9. Measurement of magnetic susceptibility (Quincke's method – liquid)
10. Measurement of magnetic susceptibility (Gouy's method – solid)

Nuclear Physics

11. GM Counter characteristics – plateau, operating voltage
12. Verification of inverse square law using GM counter
13. Absorption of beta particles in aluminium – mass attenuation coefficient
14. Absorption of gamma rays in lead – mass attenuation coefficient
15. Determination of end-point energy of beta particles

Electronics

16. CE transistor characteristics – input and output characteristics
17. FET characteristics – drain and transfer characteristics
18. CE amplifier – frequency response and bandwidth
19. OP-AMP (IC 741) – inverting and non-inverting amplifier, gain-bandwidth
20. OP-AMP circuits – integrator and differentiator
21. Logic gates (IC 7400 series) – AND, OR, NAND, NOR verification
22. Zener diode as voltage regulator – line and load regulation

Note: The experiments performed are expected to be well distributed across the prescribed syllabus, and repetition of experiments is to be avoided. Any suitable experiment of appropriate academic standard may be included subject to the availability of experimental apparatus. One experiment per week per batch shall be conducted, each of four hours duration.

SKILL ENHANCEMENT COURSE

VI Semester

24SECPh3: Research Oriented Project Work in Physics

No. of Teaching Hours/Week: 4 Hrs/Week   Total Teaching Hours: 64Hrs
Maximum Marks: 50 (40 Semester End + 10 Internal Assessment)   Credits: 02

Course Learning Objectives

- To equip students with the skills required to systematically plan, organize, and document academic and project-based work.
- To develop competency in scientific and academic writing, including effective data presentation, citation, and referencing practices.
- To enhance students' ability to produce clear, coherent, and structured reports adhering to standard academic conventions.

Course Outcomes

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

- Plan and execute a project/dissertation systematically, either individually or in a team.
- Collect, analyze, and interpret relevant scientific information and data.
- Prepare a well-structured technical report/dissertation following standard academic conventions.
- Apply appropriate scientific writing, citation, and referencing practices.
- Present the work effectively through oral presentation and viva-voce.
- Demonstrate independent learning, critical thinking, and problem-solving skills.

Project work may be carried out by students either individually or in groups of 3-4 students, under the guidance and supervision of a faculty member. Students shall work on an approved topic and submit a project report of about 30-40 pages to the Head of the Department at the end of the semester. Evaluation shall be based on the quality of work, report writing, presentation, and viva-voce examination.

Evaluation: Internal Assessment shall carry 10 marks. The End-Semester Practical Examination shall carry 40 marks, distributed as follows:

Project Report / Dissertation	15 Marks
Presentation & Slides	10 Marks
Viva-Voce Examination	10 Marks
Quality of Work	5 Marks
Total	**40 Marks**