VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE (HONOURS)

MAJOR IN PHYSICS

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes (CCFUP), 2023 & NEP, 2020

VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN PHYSICS
(under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	3rd	V	SEMESTER-V							
			Major-8	PHSHMJ08	T: Thermal Physics and Statistical Mechanics;	4	3-1-0	15	60	75
			Major-9	PHSHMJ09	T: Quantum Mechanics;	4	3-1-0	15	60	75
			Major-10	PHSHMJ10	T: Basic-Electronics;	4	3-1-0	15	60	75
			Major Elective-01	PHSHDSE1	Numerical Analysis II using Python OR Physics of Atmosphere and Space Weather	4	0-2-2/ 3-0-1	15	60	75
			Minor-5 (Disc.-I)	PHSMIN05	T: Digital-Electronics; P: Practical *(To be taken from other Discipline)*	4	3-0-1	15	60	75
		Semester-V Total				20				375
		VI	SEMESTER-VI							
			Major-11	PHSHMJ11	T: Nuclear and Particle Physics;	4	3-0-1	15	60	75
			Major-12	PHSHMJ12	T: Solid state physics;	4	3-0-1	15	60	75
			Major-13	PHSHMJ13	P: Practical	4	0-0-4	15	60	75
			Major Elective-02	PHSHDSE2	T: Advanced electronics OR Semiconductor-Device Physics-Laser-Optical-Fiber	4	3-1-0/ 3-0-1	15	60	75
			Minor-6 (Disc.-II)	PHSMIN06	T: Analog-Electronics; P: Practical *(To be taken from other Discipline)*	4	3-0-1	15	60	75
		Semester-VI Total				20				375
		YEAR-3				40				750
		Eligible to be awarded Bachelor of Science in Physics *on Exit*				126	Marks (Year: I+II+III)			2325

MJ = Major, MI = Minor Course, DSE = Discipline Specific Elective Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical

SEMESTER-V

MAJOR (MJ)

Major – 8
Thermal Physics and Elementary Statistical Mechanics

[THEORY; TOTAL CREDITS: 04; 60L]

Course contents:

Unit I: Thermal Physics (33L) Credit - 2

Molecular Collisions: Survival equation & Mean Free Path. Collision Probability. Expressions for Mean Free Path (derivation not required). [1L]

Distribution of Velocities: Maxwell-Boltzmann Distribution of Velocities in an Ideal Gas. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. [6L]

Transport Phenomenon in Ideal Gases: Viscosity, Thermal Conductivity and Diffusion. Brownian Motion and its Significance. [5L]

Conduction of heat:
Variable state and steady state, Fourier's equation for heat conduction and its solution for rectilinear heat flow. [3L]

Real Gases: Behaviour of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants with their expressions. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. [5**L]**

Thermodynamic Potentials

Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Adiabatic demagnetization, Joule-Thomson Effect. [4**L]**

Maxwell's Thermodynamic Relations

Derivations and applications of Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of C_p-C_v, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. [6**L]**

Phase transition

Classification of phase transitions; First order phase transitions: Clausius-Clapeyron equation, second latent heat equation; Continuous phase transitions: Ehrenfest's equation. [**3L]**

Unit II: Elementary Statistical Physics (27L) Credit – 2

Probability
Probability distribution functions. Binomial, Gaussian, and Poisson distribution with examples. Mean and variance. [5**L**]

Classical Statistical Mechanics:
Scopes and aims of Statistical Mechanics. Transition from thermodynamics to statistical mechanics: Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof)-Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. Grand canonical ensemble and chemical potential.

[**10L]**

Quantum Statistical Mechanics:

i) Bose-Einstein Statistics:

Thermodynamic functions of a strongly degenerate Bose gas. Bose derivation of Planck's law. Radiation as a photon gas and thermodynamic functions of photon gas. Chemical potential of photon gas. Bose-Einstein condensation and properties of liquid He-4 (qualitative description only), Lambda Transition. [6L]

ii) Fermi-Dirac Statistics:

Fermi-Dirac Distribution Law, Thermodynamic functions of a completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals (qualitative discussions). [6L]

Recommended Reading:

Thermal Physics-

- Heat and Thermodynamics (Special Indian Edition), M. Zemansky, R. H. Dittman, 7th Ed., Mcgraw Hill Education.
- Thermal Physics (Heat & Thermodynamics), A. B. Gupta & H. P. Roy, 2020, Books & Allied.

- A Treatise on Heat: Including Kinetic Theory of Gases, Thermodynamics and Recent Advances in Statistical Thermodynamics, Meghnad Saha, B. N. Srivastava (Indian Press, 1958)
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications
- Thermodynamics, Kinetic Theory, and Statistical Thermodynamics by Francis W. Sears & Gerhard L. Salinger, 1986, Narosa.
- Thermal Physics, S. C. Garg, R. M. Bansal and C. K. Ghosh, 2017, Tata McGraw-Hill.
- Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.

Statistical Mechanics:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGrawHill.
- Statistical Mechanics, 2nd edition - 1 January 2008; Kerson Huang.
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall.
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.
- Statistical Mechanics- an elementary outline, A. Lahiri, 2008, Universities Press.

Major – 9
Quantum Mechanics
[THEORY; TOTAL CREDITS: 04; 60L]

Course contents:

1. **Basics of Quantum Mechanics:** Deterministic versus probabilistic viewpoints, Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in one dimension. Fourier transforms and momentum space wave function. Position-Momentum uncertainty. Simultaneous measurements: Compatible and incompatible observables and their relation to commutativity. **(8L)**

2. **Hilbert Space and wave function:** Hilbert space, Bra & Ket vectors, Square integrable functions: Wave functions, Dirac notation, Properties of kets, bras and Brackets. State of a system, Probability density, observables and operators. **(5L)**

3. **Operators and Measurements:** Linear operators, Hermitian adjoint, Hermitian and Skew Hermitian operators, Projection operator, Identity operator, Commutator Algebra, Uncertainty relation between two operators, Functions of operators, Relations involving function operators, Unitary operator, Eigenvalues and eigenvectors of an operator, Some important theorems to the eigenvalue problems, Measurements in quantum mechanics, Collapse of wave function, Expectation value, Complete set of commutating operators. **(10L)**

4. **Representation in discrete and continuous bases**: (a) Discrete basis - Matrix representation of kets, bras and operators, (b) Continuous basis **-** Position representation, Momentum representation, connection between them, Momentum operator in position representation, position operator in momentum representation, Commutator relations. (c) Closure relation in discrete and continuous bases, Hamiltonian eigenvalue equation in discrete and continuous bases. **(6L)**

5. **Unitary Transformations**: Properties of unitary transformation, Change of bases, Infinitesimal and finite unitary transformations. **(3L)**

6. **Schrodinger Equation:** Schrodinger equation as a first principle. Equation of continuity (in 1-dimension). Time evolution of wave function. Stationary states. Time evolution of expectation values, Time independent Schrodinger equation as an eigenvalue equation. **(6L)**

7. **Application to one-dimensional systems:** General discussion of bound states in an arbitrary potential: Idea of bound states and scattering states, Continuity of wave function, Boundary conditions on wave functions and emergence of discrete energy levels. Free particle wave function. Particle in an infinitely rigid box: energy eigenvalues and eigenfunctions,

normalization, Particle in 2-d and 3-d box. Degeneracy of energy levels, Ground state energy and wavefunction for the 1D Delta function potential, Quantum mechanical tunnelling across a step potential and rectangular potential barrier. **(10L)**

8. **Harmonic Oscillator Problem:** Setting up the eigenvalue equation for the Hamiltonian. Energy eigenvalues and eigenstates of a 1-D harmonic oscillator using algebraic method (derivation with ladder operators). Expressions of Energy eigenvalues and eigenstates using Hermite polynomials (derivation not required). zero-point energy and uncertainty principle, Extension of the idea 1D to 3D and Degeneracy. **(6L)**

9. **Angular Momentum**: Forms of the angular momentum operators (Use the expressions of L_x, L_y, L_z and L^2), Eigenvalues and eigenstates, Commutation relations, Matrix representation of angular momentum, Spin angular momentum, Spin-1/2 and the Pauli matrices, Commutator relation, Properties and eigenvalues and eigenvectors of Pauli spin matrices. **(6L)**

Recommended Reading:

- Introductory Quantum Mechanics, S. N. Ghoshal, Calcutta Book House.
- Introduction to Quantum mechanics, D. J. Griffiths and D. F. Schroeter, 2019 Cambridge Univ. Press.
- Foundation of Quantum Mechanics, A. B. Gupta, 2023, Books & Allied.
- Quantum Mechanics: Concepts and Applications, Nouredine Zettili, 2nd Edition, Wiley.
- Quantum Mechanics, D. McIntyre, C. A. Manogue, J. Tate, 2016, Pearson Edu. India.
- Quantum Mechanics: An Introduction, Walter Greiner, Springer
- Quantum Mechanics, B.H. Bransden and C.J. Joachain, 2004, Pearson.
- Problems and Solutions on Quantum Mechanics by Swee Cheng Lim, Choy Heng Lai, Leong Chuan Kwek, 2022, World Scientific
- Quantum Physics, Resnick and Eisberg, 2014, Wiley.

Major – 10
Basic Electronics
[THEORY; TOTAL CREDITS: 04; 60L]

MJ-10: African and European Prehistoric Culture **Credits 04(Full Marks: 75)**

MJ-10T: African and European Prehistoric Culture (Theory) **Credits 03**

Course contents:

UNIT-I: ANALOG ELECTRONICS

1. **Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction. Derivation for Barrier Potential, Barrier Width and Current for abrupt Junction. Equation of continuity, Current Flow Mechanism in Forward and Reverse Biased Diode. **[6L]**

2. **Two-terminal Devices and their Applications:** Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and rectification efficiency, Capacitor filter, Avalanche Breakdown and Zener Breakdown, Zener diode characteristics and its use in voltage regulation and line regulation, construction of an LED, Principle of action and characteristics of LED. **[6L]**

3. **Bipolar Junction Transistor:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC configurations. Physical mechanism of current flow. Relations between the current gains of the three modes Active, Cut-off and Saturation Regions. Current gains α and β. Relations between α and β. **[4L]**

4. **Transistor Biasing and Stabilization Circuits:** Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of current flow. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. *h*-parameter Equivalent Circuit. Analysis of a single- stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C amplifiers. **[6L]**

5. **Operational Amplifiers:** Characteristics of an Ideal and Practical Op-Amp. Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator. **[8L]**

UNIT-2 DIGITAL ELECTRONICS

6. **Digital Circuits:** Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **[8L]**

7. **Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of SOP/POS Method. Minimization technique Karnaugh Map. **[5L]**

8. **Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **[5L]**

9. **Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **[8L]**

10. **Timers: IC 555:** Block diagram and applications, Astable multivibrator and Monostable multivibrator. **[4L]**

Suggested Readings:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Electronic Principles, A. Malvino, D.J. Bates, 7th Edition, 2018, Tata Mc-Graw Hill Education.
- Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI
- Microelectronic Devices & Circuits, David A.Bell, 5th Edn.,2015, Oxford University Press
- Basic Electronics: Principles and Applications, C.Saha, A.Halder, D.Ganguli, 1st Edition, 2018, Cambridge University Press

MAJOR ELECTIVE (DSE)

Major (Elective 1)
Numerical Analysis II using Python

PRACTICAL (4 Credits)

[In the Final PRACTICAL Examination, question will be framed with equal weightage in THEORY and PRACTICAL.]

MJ DSE-1P: Numerical Analysis II using Python

Theory Component

1. Numerical solution of ordinary differential equation: Runge – Kutta methods (order two and four)
2. Solve system of Linear Algebraic Equations by
   (i) Gauss Elimination and Back Substitution,
   (ii) Relaxation method by Gauss-Seidel
3. Curve fitting: Curve fitting by the method of least squares. Fitting of curves of the form y = ax + b, y = ax^b and y= ax^2 + bx + c
4. *Partial differential equation*: Finite difference approximations to partial derivatives ($O(h^2)$). Solution of one-dimensional heat conduction equation by explicit method. Qualitative idea of explicit and implicit methods. Laplace equation (2-d) using standard five-point formula, Successive relaxation technique. Solution of 1-d Wave equation.
5. Solve ODE with Boundary Value Problems (BVP) by Shooting method

Practical Component

1. Solution of 1st order and 2nd order ordinary differential equations (ODE) using RK4 method.
2. Solve first order and second order ODE by scipy.integrate.odeint()
3. Numerically verify the Gaussian Integral result
$$\int_{-\infty}^{\infty} \exp(-ax^2 + bx + c)dx = \sqrt{\frac{\pi}{a}}\exp\left(\frac{b^2}{4a} + c\right)$$
4. Verify $\int_{a-x_1}^{a+x_2} f(x)\,\delta\,(x-a)dx = f(a)$
5. Solution of linear system of equations by Gauss elimination method and Gauss Seidal method.
6. Solution of Partial differential equations, like:
   (i) Wave equation

(ii) Heat equation
(iii)Poisson's equation
(iv)Laplace's equation

7. Curve Fitting with user defined functions using scipy. Optimize module.
8. (i) Find eigen value and eigenfunctions of bound state particle using shooting method.
   (ii) Find eigen value and eigenfunctions of 1D harmonic oscillator by solving Schrodinger equation.
   (iii) Solve radial part of the Schrodinger equation for the ground state and the first excited state of the hydrogen atom
9. Compute the nth roots of unity for n=2,3 and 4
10. Find the two square roots of -5 +12j

Assessment / Evaluation**:** The End Semester practical examination will have two components-

(i) Theory based written test – 30 Marks (1.5 hrs.)
(ii) Practical (Assignments) - 30 Marks (1.5 hrs)

Recommended Reading:

Numerical Analysis-

- Numerical Methods, Arun Kr Jalan, Utpal Sarkar, 2015, University Press
- Numerical Python, Robert Johansson, 2018, Apress Publication
- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition
- Numerical Mathematical Analysis, J. B. Scarborough, OXFORD and IBH Co. Pvt. Ltd.
- Scientific Computing in Python. Abhijit Kar Gupta, Techno World
- Computational Physics, Mark Newman, Amazon Digital.
- Python Programming, Satyanarayana, Radhika Mani, Jagdesh, University Press
- Python 2.1 Bible Dave Brueck, Stephen Tanner, Hungry Minds Inc, New York
- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics-Field guide to research with Python, A. Scopatz and K.D. Huff, 2015, O'Rielly
- An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. PressComputational Physics, DarrenWalker,1st Edn., 2015, Scientific International Pvt. Ltd.

OR

Major (Elective 1)
Physics of Atmosphere and Space Weather

[Credits: 3 Credits for Lectures (45L), 1 Credit for Practical (30 Hours)]

MJ DSE-1T: Physics of Atmosphere and Space Weather (3 Credit; 45L)

Course Content:

Module 1: Earth's Atmosphere and Its Physics (12 Hours)

This module introduces the composition, structure, and physical principles governing the Earth's atmosphere.

(1) Structure and Composition of the Atmosphere:
- (a) Layers: Troposphere, stratosphere, mesosphere, thermosphere, and exosphere.
- (b) Chemical composition: Gases, aerosols, and ionized components.

(2) Atmospheric Thermodynamics:
- (a) Ideal gas law, hydrostatic equilibrium, and lapse rates.
- (b) Adiabatic and diabatic processes in atmospheric dynamics.

(3) Atmospheric Dynamics:
- (a) Circulation systems: Coriolis force, jet streams, and planetary waves.
- (b) Weather systems: Cyclones, anticyclones, and mesoscale circulations.

(4) Radiative Transfer and Energy Balance:
- (a) Solar radiation, absorption, reflection, and re-emission.
- (b) Greenhouse gases and their role in atmospheric heating.

Module 2: Basics of Space Physics (12 Hours)

This module introduces fundamental concepts of space physics, emphasizing the Sun and its influence on the near-Earth environment.

(1) The Sun and Solar Activity:
- (a) Solar structure: Core, radiative zone, convective zone, and corona.
- (b) Solar wind, sunspots, solar flares, and coronal mass ejections (CMEs).

(2) Interplanetary Medium:
- (a) Solar wind interaction with planetary environments.
- (b) Heliosphere and its dynamics.

(3) Earth's Magnetosphere:

(a) Structure: Bow shock, magnetosheath, magnetotail, and radiation belts.
(b) Interaction of solar wind with Earth's magnetic field.

Module 3: Ionosphere and Coupled Atmosphere-Space System (10 Hours)

This module focuses on the ionosphere and its role as the interface between Earth's atmosphere and space weather systems.

(1) Ionosphere Structure and Dynamics:

(a) Layers: D, E, F1, and F2 regions.
(b) Ionization processes and electron density variations.

(2) Coupling Mechanisms:

(a) Energy transfer between the magnetosphere and ionosphere.
(b) Ionospheric currents: Equatorial electrojet and auroral electrojet.

(3) Space Weather Impacts on the Ionosphere:

(a) Effects of solar storms on ionospheric dynamics.
(b) Disruptions in communication and navigation systems.

Module 4: Space Weather Phenomena (8 Hours)

This module explores space weather events and their impacts on Earth and human technology.

(1) Geomagnetic Storms:

(a) Causes: Interaction of CMEs with Earth's magnetosphere.
(b) Effects: Auroras, power grid failures, and satellite malfunctions.

(2) Solar Energetic Particles (SEPs):

(a) Origin and characteristics.
(b) Impacts on astronauts and high-altitude flights.

(3) Radiation Belts and Their Variability:

(a) Van Allen belts and their role in space weather phenomena.
(b) Impacts on satellite operations.

(4) Space Weather Monitoring and Prediction:

(a) Observational platforms: Ground-based and space-based instruments.
(b) Space weather models and forecasting techniques.

Module 5: Implications and Applications of Space Weather (3 Hour)

This module examines the implications of space weather for technology, society, and future exploration.

(1) Impacts on Technology:
- (a) Satellite operations, communication systems, and power grids.
- (b) Mitigation strategies for space weather effects.

(2) Space Weather and Exploration:
- (a) Protection of astronauts and spacecraft during solar events.
- (b) Role of space weather in planning future missions to the Moon and Mars.

MJ DSE-1P: Physics of Atmosphere and Space Weather (Practical) (1 Credit; 30 Hrs.)

The practical component provides students with the opportunity to analyze atmospheric and space weather data, simulate physical processes, and interpret results.

(1) Analysis of Atmospheric and Space Data:
- (a) Using data from meteorological and space observatories (e.g., NOAA, NASA).
- (b) Studying atmospheric temperature, pressure, and ionospheric variations.

(2) Simulation of Atmospheric Processes:
- (a) Modeling adiabatic and radiative transfer processes in the atmosphere.
- (b) Simulations of atmospheric circulation patterns.

(3) Space Weather Data Analysis:
- (a) Interpreting data from solar wind and magnetosphere observations.
- (b) Identifying geomagnetic storm events and their effects on Earth's systems.

(4) Ionospheric Study:
- (a) Analyzing ionospheric disturbances during solar storms.
- (b) Understanding total electron content (TEC) variations using GPS data.

(5) Case Studies:
- (a) Historical space weather events (e.g., Carrington Event, 1989 Quebec blackout).
- (b) Their impacts on technology and society.

Recommended Reading:

- Atmospheric Science: An Introductory Survey by John M. Wallace and Peter V. Hobbs.
- Essentials of Atmospheric Physics by A Chandrasekar.

- Physics of the Space Environment by Tamas I. Gombosi.
- Space Weather and Solar Physics by K. V. Subramaniam
- Introduction to Space Physics by Margaret G. Kivelson and Christopher T. Russell.
- Space Weather by Jean Lilensten and Thierry Dudok de Wit.
- The Sun and Space Weather by A Jayraman.
- The Upper Atmosphere by S. K. Mitra, The Asiatic Society.
- An Introduction to Atmospheric Physics - Atmospheric Physics by Kamsali Nagaraja
- Online resources:
  NOAA Space Weather Prediction Center (www.swpc.noaa.gov)
  NASA Heliophysics (www.nasa.gov/heliophysics)

MINOR (MI)

Minor-5
DIGITAL ELECTRONICS

[THEORY & PRACTICAL, CREDITS: 04; FM-75]

Minor (MI)-5: Digital Electronics **Credits 04(Full Marks: 75)**

Minor (MI)-5T: Digital Electronics **Credits 03 (45L)**

Course contents:

1. **Digital Circuits:** Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR & XNOR Gates. Realization of OR, AND, NOT using diodes and transistors. **[12L]**

2. **Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Product term and sum term in logical expression; SOP, POS and mixed expression. Minterm and Maxterm in the expressions. Conversion between truth table and logical expression. Simplification of logical expression using Karnaugh maps (4 variables). [**12L**]

3. **Arithmetic Circuits:** Binary numbers, decimal to binary and reverse conversions. Binary addition and subtraction (1's Complement and 2's complement method), signed and unsigned number representation of binary system; representation of negative numbers. Half and Full Adders. [**11L**]

4. **Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **[10L]**

Suggested Readings:

- Digital Logic and Computer Design, M. Morris Mano, 2016, Pearson Education
- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw-Hill
- Digital Circuits, Part I & II, D. Raychaudhuri, 2015, Platinum Publishers
- Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata McGraw-Hill
- Fundamental of Digital Circuits, A. Anand Kumar, 2016, Prentice Hall India Learning.
- Fundamentals Principles of Electronics, B. Ghosh, 2010, Books & Allied.
- Modern Digital Electronics, R. P. Jain, 2009, Tata McGraw-Hill

Minor (MI)-5P: Digital Electronics (Practical) Credits 01 (30 Hrs.)

1. Construction of OR, AND, and NOT gates using diode and transistors.
2. To verify the truth tables of basic gates and De-Morgan's theorem using IC-chips
3. To construct Half and Full Adder using IC-chips
4. Construction of SR and D Flip Flop circuits using NAND gates
5. Construction of a half adder and a full adder.

Suggested Readings:

- Advanced Practical Physics, B. Ghosh, K. G. Majumder, Sreedhar Publication
- Physics in Laboratory (Semester III), Mandal, Chowdhury, Das, Das, Santra Publication.
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Limited
- Laboratory Manual of Physics, Vol 2, M. Jana, 2020, Books and Allied (P) Ltd.

SEMESTER-VI

MAJOR (MJ)

Major-11
Nuclear and Particle Physics
[Credits 04; Full Marks: 75]

Course contents: **Credits 04 (60L)**

1. **Bulk properties of nuclei and nuclear structure [15L]:** Nuclear charge, mass, size, mass defect, binding energy, binding fraction, Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle, Spin, magnetic dipole moment, electric quadrupole moment, isospin, Isotopes, Isobars & isotones, Bainbridge mass spectrograph (principle only), Nature of nuclear force, Basic properties of nucleon-nucleon interaction, Stability and binding, N-Z plot, Nuclear models: Liquid Drop model, Bethe Weizsäcker semi-empirical mass formula and binding energy: Application of mass formula to stability consideration, mass parabola, α decay of heavy nuclei, β–decay by mirror nuclei, Nuclear shell model and magic numbers, ground state spin parity, Single particle states in nuclei. [15L]

2. **Unstable nuclei [18L]:**
   (a). Radioactivity: Survival equation, Half-life, Mean-life, Transient and secular equilibrium, radioactive dating. [3L]
   (b). $\boldsymbol{\alpha}$ - decay: Alpha ray spectra – velocity and disintegration energy of α-particles, Range of α-particles, Straggling of Range, Geiger-Nuttal law, Gamow's theory of α- decay, Fine structure of the α-ray spectra. [5L]
   (c). $\boldsymbol{\beta}$ - decay: Detection of the β-energy, Characteristics of β-ray spectra, Pauli's prediction of neutrino, energy levels & decay schemes, positron emission & electron capture, selection rules, beta absorption & range of beta particles, Kurie plot. [6L]
   (d). $\boldsymbol{\gamma}$-decay: Origin of γ-rays, nuclear isomerism, internal conversion, γ -absorption in matter – photoelectric process, Compton scattering, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. [4L]

3. **Nuclear Reactions (10L):** Types of nuclear reactions, Conservation laws, Q value and threshold energy, reaction cross-sections, Bohr's postulate of compound nuclear reaction, Ghoshal's experiment. Resonance reaction, fission and fusion: mass deficit and generation of energy, Reaction characteristics, explanation based on liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements [8L]

4. **Cosmic ray:** Nature and origin of primary and secondary rays, latitude and altitude variations, hard & soft components, Cosmic Ray shower, Effect of Earth's magnetic fields: East-West Effect, Van Allen radiation belt, Aurora Borealis. [3L]

5. **Elementary particles:** Fundamental interactions in nature and their relative strengths, Elementary particles and their families, Symmetry and conservation laws: energy and momentum, angular momentum, parity, baryon number, lepton number, isospin, hypercharge, and strangeness, Wu's experiment and basic idea of parity violation, Gell-Mann–Nishijima formula, The baryon and meson octet and baryon decuplet diagrams (qualitative discussion only), Quark model, Quark structure of hadrons, color quantum number and gluons (qualitative discussion only). [10L]

6. **Particle accelerators and detectors:** Linear accelerator, cyclotron, synchrotron, Accelerator facilities available in India, Gas filled detectors – ionization chamber, Proportional Counter, GM Counters, Semiconductor detectors. [6L]

Recommended Readings:

(A) For Nuclear Physics

- Modern Atomic and Nuclear Physics, A. B. Gupta, Books & Allied (p) Ltd. Kolkata.
- Nuclear Physics, S. N. Ghoshal, 2019, S Chand Publishing.
- Nuclear Physics: An Introduction, S.B. Patel, 2021, New Age International Private Limited.
- Nuclear Physics, D. C. Tayal, Himalaya Publishing House.
- Nuclear Physics: Present and Future by Walter Greiner, 2016, Springer International Publishing AG.
- Nuclear Physics: Theory and Experiments, R. R. Roy, and B. P. Nigam, 2014, New Age International Pvt Ltd.
- Introductory Nuclear Physics, 1998, Samuel S. M. Wong, Wiley-VCH.
- Basic ideas and concepts in Nuclear Physics: An introductory approach, K. Heyde, 2010, IOP Publishing House.
- Introductory Nuclear Physics, K. S. Krane, 2008, Wiley.
- Nuclear Physics: Principles and applications, J. Lilley, 2006, Wiley.
- Concepts of Nuclear Physics, B. L. Cohen, 1976, McGraw Hill Higher Education.
- Radiation detection and measurement, G. F. Knoll, 2010, John Wiley & Sons Inc.
- Nuclear and Particle Physics, S. Bhattacharyya, 2020, Universities Press.
- Nuclear Physics, Irving Kaplan, 2002, Narosa.

(B) **For Particle Physics**

- Introduction to elementary particles, D. J. Griffiths, 2008, Wiley-VCH, 2008
- Textbook of Particle Physics, Surinder Kaur, Kusam Devgan, 2019, Medtech.

- Nuclear and Particle Physics, A. B. Gupta, 2022, Books & Allied (p) Ltd., Kolkata.
- Modern Particle Physics, M. Thompson, 2013, Cambridge University Press.
- An Introductory Course of Particle Physics, P. B. Pal, 2014, CRC Press.
- Introduction to High Energy Physics, D. H. Perkins, 2000, Cambridge University Press.
- Quarks and Leptons, F. Halzen and A. D. Martin, 1984, John Wiley & Sons Inc.

References for Tutorial:

- Problems and Solutions on Atomic, Nuclear and Particle Physics by Yung-Kuo Lim, Sarat Book Distributors, 2002
- Problems and Solutions in Nuclear and Particle Physics, S. Petreta, Springer Nature Switzerland AG, 2019
- Schaum's Outline of Modern Physics, 1999, McGraw-Hill
- Schaum's Outline of College Physics, E. Hecht, 11th edition, 2009, McGraw Hill

Major-12
Solid State Physics
[THEORY, Credits 04; Full Marks: 75]

Course contents:

1. **Crystal Structure**: Solids: Amorphous and Crystalline Materials. Elements of crystals, Lattice Translation Vectors. Lattice with a Basis, Primitive Cell & Unit Cell. Symmetry elements / operations, Types of Lattices. Crystal planes & Miller Indices. Reciprocal Lattice. Diffraction of X-rays by Crystals. Bragg's Law. Brillouin Zones. Atomic Form / Scattering Factor and Geometrical Structure Factor (derivation not required), Identification of SC, BCC, FCC structures by using Geometrical Structure Factor. **[11L]**

2. **Elementary Lattice Dynamics**: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids, T^3 law. **[10L]**

3. **Free Electron Model**: Free electron gas in metals, effective mass, drift current, mobility and conductivity, Hall effect in metals and Hall Coefficient. Thermal conductivity. Lorentz number. **[5L]**

4. Elementary band theory: Origin of Energy Band and Band Gap. Bloch Theorem (no proof required). Kronig-Penney model. Conductor, Semiconductor (p- and n- types) and insulator. Conductivity of Semiconductor, mobility, Measurement of conductivity (04 probe method). **[9L]**

5. **Dielectric properties of materials**: Polarization. Local Electric Field. Electric Susceptibility. Polarizability- various types. Clausius Mosotti Equation. Variation of different polarizabilities with frequency, Concept of Dielectric Loss, Lorentz Theory of dispersion. Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. **[11L]**

6. Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia– and Para- magnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **[9L]**

7. Superconductivity: Experimental Results. Critical Temperature. Meissner effect. Critical magnetic field. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation) and Concept of Cooper pair. **[5L]**

Suggested Readings:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt.. Ltd.
- Elementary Solid State Physics, M. Ali Omar, 1999, Pearson India.
- Solid State Physics, N.W. Ashcroft and N. D. Mermin, 1976, Cengage Learning.
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill.
- Solid State Physics, M. A. Wahab, 2011, Narosa Publications.
- Solid State Physics, J. Guha, 2018, Books and Allied (P) Ltd.

MJ-13: PRACTICAL
Credits 04 (Full Marks: 75)
[PRACTICAL; TOTAL CREDITS: 04; 60L]

Course Outline:

Unit - I

1. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
3. Determination of e/m of electrons by using a bar magnet / magnetron method.
4. Measurement of magnetic susceptibility of a paramagnetic material by Quincke's method.
5. Determination of the band gap of a semiconductor by four probe method.
6. To find the Energy Band Gap of a semiconductor material (Thermistor).
7. To determine the Hall coefficient of a semiconductor sample.
8. To show the tunneling effect in tunnel diode using I -V characteristics
9. Determination of the dielectric constant of given solid material/materials using fixed frequency ac source studying the resonance condition in a LC rejector circuit
10. Determination of energy loss from the B-H loop for a ferromagnetic material

Unit - II

6. To study the forward and reverse characteristics of a Zener diode and use it as a voltage regulator.
7. To study the static characteristics and the frequency response of the BJT amplifier in CE mode.
8. To study OP-AMP: inverting amplifier, non-inverting amplifier, adder, subtractor, integrator, differentiator.
9. To design a Wien bridge oscillator for given frequency using an OP-AMP.
10. To design an astable and a monostable multivibrator of given specifications using 555 Timer.
11. Construction of OR, AND, and NOT gates using diode and transistors.
12. Construction of SR, D, JK, FF circuits using NAND gates.
13. Construction of a half adder and a full adder.
14. Construction of a Half Subtractor, a Full Subtractor, an Adder-Subtractor using Full Adder IC.
15. To build a JK Master-slave flip-flop using Flip-Flop ICs.

CA: 15, Practical Test: 60 (Exam. – 40, LNB – 5 + 5, Viva – 5 + 5)

Recommended Reading:

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Laboratory Manual of Physics, Vol. 1 & 2 Madhusudan Jana, Books & Allied (P) Ltd., 2022, Kolkata.
- Practical Physics, G. L. Squires, 2015, 4th Edition, Cambridge University Press
- B. Sc. Practical Physics, C. L. Arora, S Chand and Company Limited
- Physics in Laboratory, Mandal, Chowdhury, Das, Das, Santra Publication
- Advanced Practical Physics Vol 1 & 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
- Practical Physics, P.R. Sasi Kumar, PHI Learning Private Limited
- B.Sc. Practical Physics, Harnem Singh, P.S. Hemne, S Chand and Company Limited

MAJOR ELECTIVE (DSE)

Major (Elective 2)
Advanced Electronics

[Credits: 3 Credits for Lectures (45L), 1 Credit for Practical (30 Hours)]

MJ DSE-2T: Advanced Electronics (Theory) (Credits 03: 45L)

Course contents:

Special purpose diodes: Principle of action, and characteristics of Photodiode, Solar Cell, Schottky diode and Tunnel Diode. **(4L)**

eedback in amplifiers and Oscillators: Positive and Negative Feedback. Effect of negative feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and noise. Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(8L)**

Applications of Op-Amps: Schmidt trigger, Log amplifier, Comparator and Zero crossing detector, Wein bridge oscillator, Digital to Analog converter (DAC) and Analog to Digital convertor (ADC). **(4L)**
Basic principle of communication-amplitude modulation (AM) and frequency modulation (FM). AM, FM spectrum and band width, Detection of modulated signal. Brief introduction (idea only) to radar and antenna. **(6L)**

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. (**3L**)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in Parallel-out Shift Registers (only up to 4 bits). **(4L)**

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(5L)**

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. **(5L)**

Introduction to Digital communication: Signal sampling, sampling theorem, Nyquest rate, aliasing effect, sample and hold system, quantization processes and error calculation. Pulse modulation and demodulation. **(6L)**

MJ DSE-2T: Advanced Electronics (Practical) (Credit-1: 30 Hours)

1. To study construct a temperature controller using a semiconductor (NTC thermistor), comparator and relay switch.
2. To calibrate a thermocouple to measure temperature in a specified Range using Op-Amp and to determine Neutral Temperature.
3. To design a circuit to simulate the solution of a 1st/2nd order differential equation.
4. Construction of a series regulated power supply from an unregulated power supply.
5. Applications of OPAMP: Schmidt trigger, Log amplifier, Comparator and Zero crossing detector, Wein bridge oscillator, Digital to Analog converter (DAC) and Analog to Digital convertor (ADC)
6. Design of an Active high pass/Low pass 1st order Butterworth filter.
7. To design a phase shift oscillator of given specifications using OP-AMP.
8. Construction of 1×8 demultiplexer using basic gates and IC
9. Construction of a 4×1 multiplexer using basic gates and IC 74151 H
10. Construction of a 4-bit binary counter using D-type/JK Flip-Flop and study timing diagram.
11. Construction of 4-bit shift registers (serial and parallel) using D type FF IC 7476.
12. To study the zero-crossing detector and comparator
13. Design and implement a 3×8 decoder and 8×3 encoder.
14. Design and implement a 8 bit parity generator.

Recommended Reading:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Electronic Principles, A. Malvino, D.J. Bates, 7th Edition, 2018, Tata Mc-Graw Hill Education.
- Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI
- Microelectronic Devices & Circuits, David A.Bell, 5th Edn.,2015, Oxford UniversityPress
- Basic Electronics: Principles and Applications, C.Saha, A.Halder, D.Ganguli, 1stEdition, 2018, Cambridge University Press
- R S Gaonkar – Microprocessor Architecture, Programming and Applications with 8085/ 8085A (2nd Ed.).
- R P Jain, Modern digital electronics, Tata McGraw Hill.
- Anand Kumar, Fundamentals of Digital Circuits, PHI
- Taub & Schilling, Principles of Communication Systems, Tata McGraw Hill.
- G.K. Kharate, Digital Electronics, Oxford
- Digital Circuits and Design, D. P. Kothari and J. S. Dhillon (Pearson)

OR

Major (Elective 2)
Semiconductor Device Physics, Laser & Optical Fiber
[Theory, 60 Lectures, 4 Credits]

MJ DSC -2T: Semiconductor Device Physics, Laser & Optical Fiber   Credits 04(FM: 75)

1. Semiconductor Device Physics (60 L)

1.1. Semiconductor Fundamentals: Classification of solids: conductors, semiconductors, insulators, Crystal structure of Si and Ge, Concept of Brillouin zone and band gap, Formation of energy bands and band diagrams, Direct vs. indirect semiconductors, effective mass approximation. Intrinsic semiconductors, electric charge neutrality condition, n- type and p-type semiconductors. Density of states, density of electrons and holes for non-degenerate semiconductors. Hall Effect and Hall coefficient, determination of carrier type and mobility, numerical illustrations on carrier type and mobility. Conductivity measurement of a non-degenerate semiconductor from low temperature to high temperature. **(10L)**

1.2 Carrier Dynamics and Recombination: Carrier generation and recombination mechanisms, Radiative and non-radiative recombination, Lifetime and diffusion length, Continuity equation (steady and transient states), Quasi-Fermi levels and non-equilibrium carrier concentration, Photoconductivity Growth of carrier, Excess carrier decay. **(6L)**

1.3 PN Junction Diode: p-n Junction in equilibrium, Depletion region and built-in potential, Energy-band diagrams at equilibrium and under bias, Drift and diffusion currents and their balance, Einstien releation, Contact potential, Diffusion length, Derivation of diode equation, Forward and reverse characteristics of a diode, Abrupt junction, Linearly graded junction (concept and application), Junction capacitances: depletion and diffusion, Breakdown mechanisms: Zener and avalanche breakdown, Varactor diode characteristics. **(10L)**

1.4 Bipolar Junction Transistor: Structure and operation (n-p-n and p-n-p) with band diagram, CB, CE and CC Modes of operation: cut-off, active, saturation, Ebers–Moll model and current components (in CE mode), Base transport factor, current gain, and output characteristics, Early effect and base-width modulation; Small-signal equivalent circuits (hybrid-π model), Frequency response and switching behaviour, Temperature dependence of current gain and saturation current; thermal runaway and stabilization methods (negative feedback, heat sinking). **(12L)**

1.5 Optoelectronic Devices: Light-emitting diode (LED) – spontaneous emission and efficiency, Photodiodes – working principle and simple I–V characteristic, Solar cell – photovoltaic effect, I–V curve, and efficiency; Schottky diode and tunnel diode: basic idea of principle of action, and negative resistance behaviour. **(5L)**

1.6 Semiconductor Fabrication (Basic concepts): Crystal growth techniques, Wafer preparation and oxidation, Diffusion, ion implantation, photolithography, and thin-film deposition. **(5L)**

2. Laser: Stimulated emission and A, B coefficients, Laser resonator, population inversion, active and passive laser resonator, Threshold condition, saturation condition, Quality factor, Classification of laser: Three level laser and four level laser system (basic concepts only), Ruby laser, He-Ne laser, Application of laser. **(6L)**

3. Optical Fiber: Comparison with traditional communication systems, Core, cladding, and buffer layers, Total internal reflection and acceptance angle, Numerical aperture, Step-index and graded-index fibers, Single-mode and multimode fibers, Absorption and loss, Applications.

(6L)

Suggested Readings

- **S. M. Sze & Kwok K. Ng**, *Physics of Semiconductor Devices*
- **Donald A. Neamen**, *Semiconductor Physics and Devices*
- **Ben G. Streetman & Sanjay Banerjee**, *Solid State Electronic Devices*
- **S. O. Kasap**, *Principles of Electronic Materials and Devices*
- **Millman & Grabel**, *Microelectronics*
- **A. Ghatak & K. Thyagarajan**, *Lasers: Theory and Applications*, 2010, Springer Science
- **A. Ghatak & K. Thyagarajan**, *Introduction to Fiber Optics*, 2017, Cambridge University Press

MINOR (MI)

Minor-6

ANALOG ELECTRONICS

[THEORY & PRACTICAL, CREDITS: 04; FM-75]

Minor (MI)-6: Analog Electronics **Credits 04(Full Marks: 75)**

Minor (MI)-6T: Analog Electronics (Theory) **Credits 03 (45l)**

Course contents:

1. **Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction. Idea on Barrier Potential and Barrier Width and Current for abrupt Junction. Equation of continuity, Forward and Reverse Biased characteristics of a diode. **[10L]**

2. **Two-terminal Devices and their Applications:** Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and rectification efficiency, Capacitor filter, Zener Diode characteristics and its use as a regulator. Structure. Principle of action, and characteristics of LED. **[8L]**

3. **Bipolar Junction Transistor:** n-p-n and p-n-p Transistors. Characteristics of CB and CE Configurations. Active, Cutoff and Saturation Regions. Current gains α and β. Relationsbetween α and β. **[6L]**

4. **Transistor Biasing and Stabilization Circuits:** Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of current flow. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. *h*-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. [**10L]**

5. **Operational Amplifiers:** Characteristics of an Ideal and Practical Op-Amp. Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. **Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder. [**11L]**

Suggested Readings:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

- Learning OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall India Private Ltd.
- Electronic Principles, A. Malvino, D.J. Bates, 7th Edition, 2018, Tata Mc-Graw Hill Education.
- Fundamental Principles of Electronics, B. Ghosh, 2nd ed, 2008, Books & Allied (P) Ltd.
- Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

Minor (MI)-6P: Analog Electronics (Practical) **Credits 01 (30Hrs.)**

1. To study the performance of a capacitor filter.
2. To study the forward and reverse characteristics of a p-n junction diode.
3. To study the forward and reverse characteristics of a Zener diode and use it as a voltage regulator.
4. To study the static characteristics and the frequency response of the BJT amplifier in CE mode.
5. To study OP-AMP as: (i) inverting amplifier, (ii) non-inverting amplifier, (iii) adder, (iv) subtractor.
6. To study OP-AMP as: (i) integrator, (ii) differentiator.

Suggested Readings

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, McGraw Hill
- Advanced Practical Physics Vol 2, B. Ghosh, K. G. Majumder, Sreedhar Publisher
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency
- Laboratory Manual for Operational Amplifiers and Linear ICs, David A. Bell, 2006, Prentice Hall of India
- B. Sc. Practical Physics, C. L. Arora, S Chand and Company Limited
- Laboratory Manual of Physics, Madhusudan Jana, Books & Allied (P) Ltd., 2022, Kolkata.