3rd Semester (Minor-II)

Course Title: Mathematical Physics
Course Code: PHY MIN 3.2
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc.) =20

Course objective: The objective of the course is to equip students with the essential mathematical tools—vector calculus, differential equations, and tensor analysis—required for rigorous understanding and application in theoretical and applied physics.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Vector algebra	Vector algebra, scalar and vector product with illustration from physics, vector triple products. Vector calculus: scalar field and vector field with examples, space curve, differentiation of a vector with respect to a scalar, gradient of a scalar, divergence and curl of a vector with examples from physics.	12	12	12
Unit 2: Integrals	Ordinary integration of vectors, Line integral, surface integral and volume integral, Gauss's theorem, Stoke's theorem and Green's theorem and their applications.	10	10	10
Unit 3: Coordinate systems	Curvilinear coordinate system, coordinate line and coordinate surface, unit normal vectors and unit tangent vectors, scale factor, orthogonal curvilinear coordinates, cylindrical polar coordinates and spherical polar coordinate systems.	11	11	11
Unit 4: Differential equation	**First-order differential equations**: Separable, homogeneous, exact, and linear equations with illustrative physical examples (e.g., radioactive decay, RC circuits). **Second-order linear differential equations** with constant coefficients: Homogeneous and non-homogeneous cases, method of undetermined coefficients and variation of	15	15	15

	parameters. **Applications in physics:** Simple harmonic oscillator, damped and driven harmonic motion, LC circuits. **Brief introduction to partial differential equations (PDEs)**: Classification (elliptic, parabolic, hyperbolic), with examples like heat equation, wave equation, and Laplace's equation.			
Unit 5: Tensor Analysis	**Introduction to tensors**: Scalars, vectors, and tensors; transformation properties under rotation and general coordinate transformations. Rank of a tensor, symmetric and antisymmetric tensors. Metric tensor, Kronecker delta, Levi-Civita symbol.	12	12	12
Total		**60**	**60**	**60**

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

CO1: Understand and apply vector algebra and vector calculus to analyze physical phenomena such as fields, forces, and fluid flow.

CO2: Perform and interpret line, surface, and volume integrals, and apply Gauss's, Stokes', and Green's theorems to physical problems.

CO3: Use curvilinear coordinate systems (cylindrical and spherical) and compute scale factors, tangent and normal vectors in orthogonal systems.

CO4: Solve ordinary and basic partial differential equations and relate them to physical systems like oscillations and wave propagation.

CO5: Grasp the basics of tensor algebra and apply tensor concepts in mechanics and field theory, including stress and electromagnetic tensors.

Suggested Readings:

1. Spiegel, M. R. (1968). *Vector Analysis*. Schaum's Outline Series, McGraw-Hill.
2. Gupta, A. B., & Ghosh, D. (1993). *Atomic & Nuclear Physics*. Pragati Prakashan.
3. Arfken, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier Academic Press.
4. Riley, K. F., Hobson, M. P., & Bence, S. J. (2010). *Mathematical Methods for Physics and Engineering* (3rd ed.). Cambridge University Press.
5. Mathews, J. & Walker, R. L. (1970). *Mathematical Methods of Physics* (2nd ed.). Benjamin-Cummings.
6. Simmons, G. F. (1972). *Differential Equations with Applications and Historical Notes* (2nd ed.). McGraw-Hill.
7. Chatterjee, A. W. (2005). *Tensor Calculus*. University Press.

4^{th} Semester (Minor-II)

Course Title: Solid State Physics
Course Code: PHY MIN 4.2
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc.) =20

Course Objective: The objective of the course is to provide a fundamental understanding of the physical principles governing the properties of solids, focusing on crystal structure, bonding, lattice dynamics, electronic properties, and magnetic and dielectric behavior of materials.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Introduction to Crystalline Solids	Types of solids: Crystalline vs. amorphous, Crystal lattice, unit cell, basis, Crystal systems and Bravais lattices (2D & 3D), Miller indices (basic concept, visual understanding), Common crystal structures: SC, BCC, FCC, HCP. Atomic packing, coordination number, density calculation. Types of bonding in solids: Ionic, covalent, metallic, van der Waals, hydrogen bonding	12	12	12
Unit 2: X-Ray Diffraction and Structure Determination	Basics of X-ray production and properties, Bragg's Law and its simple applications, Laue and powder diffraction (qualitative understanding), Structure factor and how it determines diffraction patterns, Concept of reciprocal lattice (basic idea only), Applications: Material characterization by XRD.	12	12	12
Unit 3: Lattice Vibrations and Thermal Properties	Atomic vibrations in solids – idea of lattice waves, Monoatomic and diatomic linear chains (conceptual only), Phonons – vibrational energy quanta. Specific heat: Classical theory, Einstein and Debye models (qualitative). Thermal conductivity of solids – role of phonons. Thermal expansion and anharmonicity (basic idea)	12	12	12

Unit 4: Electronic Properties of Solids	Free electron theory (Drude model – concept only), Electrical conductivity of metals and its limitations, Fermi energy and distribution (qualitative introduction), Energy bands in solids: Band formation concept. Classification: Metals, insulators, semiconductors. Applications of semiconductors in diodes, transistors (brief overview).	12	12	12
Unit 5: Magnetic and Dielectric Properties of Solids	Magnetism in solids: Diamagnetism, paramagnetism, ferromagnetism (basic ideas), Magnetic hysteresis and magnetic materials in applications. Dielectrics and electric polarization: electronic, ionic, orientational (qualitative). Dielectric constant and polarizability, Ferroelectric and piezoelectric materials – simple applications. Use of magnetic and dielectric materials in daily life.	12	12	12
Total		**60**	**60**	**60**

Course Outcomes: Upon successful completion of this course students will be able to
CO1: Identify and describe crystal structures and bonding types in solids.
CO2: Understand the principle of X-ray diffraction and its role in crystal structure determination.
CO3: Explain how atoms vibrate in solids and how this affects heat capacity and thermal conduction.
CO4: Understand basic electronic behavior of solids and the role of energy bands in conductivity.
CO5: Describe the magnetic and dielectric properties of materials with examples from real-world applications.

Suggested Readings:

1. Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley.
2. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Cengage Learning.
3. Dekker, A. J. (1965). *Solid State Physics*. Macmillan.
4. Singhal, M. L. (2005). *Solid State Physics*. Kedarnath Ramnath & Co.
5. Omar, M. A. (1993). *Elementary Solid State Physics*. Pearson Education.
6. Pillai, S. O. (2015). *Solid State Physics*. New Age International.
7. Blakemore, J. S. (1985). *Solid State Physics*. Cambridge University Press.

4th Semester (Minor-II)

Course Title: Solid State Physics
Course Code: PHY MIN 4.2
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc.) =20

Course Objective: The objective of the course is to provide a fundamental understanding of the physical principles governing the properties of solids, focusing on crystal structure, bonding, lattice dynamics, electronic properties, and magnetic and dielectric behavior of materials.

Course Outlines

Units	Content	L	M	Hours
Unit 1: Introduction to Crystalline Solids	Types of solids: Crystalline vs. amorphous, Crystal lattice, unit cell, basis, Crystal systems and Bravais lattices (2D & 3D), Miller indices (basic concept, visual understanding), Common crystal structures: SC, BCC, FCC, HCP. Atomic packing, coordination number, density calculation. Types of bonding in solids: Ionic, covalent, metallic, van der Waals, hydrogen bonding	12	12	12
Unit 2: X-Ray Diffraction and Structure Determination	Basics of X-ray production and properties, Bragg's Law and its simple applications, Laue and powder diffraction (qualitative understanding), Structure factor and how it determines diffraction patterns, Concept of reciprocal lattice (basic idea only), Applications: Material characterization by XRD.	12	12	12
Unit 3: Lattice Vibrations and Thermal Properties	Atomic vibrations in solids – idea of lattice waves, Monoatomic and diatomic linear chains (conceptual only), Phonons – vibrational energy quanta. Specific heat: Classical theory, Einstein and Debye models (qualitative). Thermal conductivity of solids – role of phonons. Thermal expansion and anharmonicity (basic idea)	12	12	12
Unit 4: Electronic Properties of Solids	Free electron theory (Drude model – concept only), Electrical conductivity of metals and its limitations, Fermi energy and distribution (qualitative introduction), Energy bands in solids: Band formation concept. Classification: Metals, insulators, semiconductors. Applications of semiconductors in diodes, transistors (brief overview).	12	12	12
Unit 5: Magnetic and Dielectric Properties of Solids	Magnetism in solids: Diamagnetism, paramagnetism, ferromagnetism (basic ideas), Magnetic hysteresis and magnetic materials in	12	12	12

	applications. Dielectrics and electric polarization: electronic, ionic, orientational (qualitative). Dielectric constant and polarizability, Ferroelectric and piezoelectric materials – simple applications. Use of magnetic and dielectric materials in daily life.			
Total		**60**	**60**	**60**

Course Outcomes: Upon successful completion of this course students will be able to
CO1: Identify and describe crystal structures and bonding types in solids.
CO2: Understand the principle of X-ray diffraction and its role in crystal structure determination.
CO3: Explain how atoms vibrate in solids and how this affects heat capacity and thermal conduction.
CO4: Understand basic electronic behavior of solids and the role of energy bands in conductivity.
CO5: Describe the magnetic and dielectric properties of materials with examples from real-world applications.

Suggested Readings:

1. Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley.
2. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Cengage Learning.
3. Dekker, A. J. (1965). *Solid State Physics*. Macmillan.
4. Singhal, M. L. (2005). *Solid State Physics*. Kedarnath Ramnath & Co.
5. Omar, M. A. (1993). *Elementary Solid State Physics*. Pearson Education.
6. Pillai, S. O. (2015). *Solid State Physics*. New Age International.
7. Blakemore, J. S. (1985). *Solid State Physics*. Cambridge University Press.