Special Functions: Bessel functions of the first kind -derivation of the basic form- Recurrence relations - Fraunhofer diffraction and vibrations of membranes. Legendre and Associated Legendre functions - Recurrence relations and differential equations. Related problems and applications. 18 hours

References:

1. Mathematical Methods for Physicists – G Arfken (Academic Press,1968)
2. Elements of Group Theory for Physicists – A W Joshi (Wiley Eastern,1975)
3. Symmetry Groups and Their Applications – W Miller (Elsevier, 1972)
4. Mathematics of Physics and Chemistry – H Margenau and G M Murphy (Affiliated East West Press, 1966)
5. Matrices and Tensors in Physics – A W Joshi (Wiley Eastern, 1975)
6. Tensor Analysis – I S Sokolnikoff (Wiley, 1974)
7. Mathematical Methods in Physical Sciences – Mary L Boas (Wiley, 2011)
8. Mathematical Methods for Physics and Engineering – K F Riley (Cambridge University Press, 2012)
9. Formal Groups and Applications – Michel Hazewinkel (American Mathematical Society, 2017)

MSH 402 ELEMENTS OF MATERIALS SCIENCE (4 Credits)

Objectives: This course serves as a basic foundation for Materials Science programme. It aims to(i) develop an understanding of how the behaviour/properties of materials are intricately connected to their structure and the type of bonding at the atomic level (ii) correlate the relationship between the atomic structure and crystal energy leading to changes in properties (iii) connect the theories necessary for a deeper understanding of structure-property correlations.

Expected course outcomes: On completing this course, (i) students will be able to analyze the key concepts of structure and bonding in covalent, ionic, metallic, and coordination compounds. (ii) students will relate the fundamentals with the structure property correlations in materials (iii) students acquire the basics required to understand the properties of different class of materials which will be dealt with separately in the forthcoming semester courses (iv) students will be able to apply XRD techniques to identify the crystal structure, lattice parameter and purity of materials using XRD (v) students have opportunities to carry out fundamental research in crystallography/solid state physics.

Unit I

Formation and Structure of Materials: Condensed state of matter-crystalline and amorphous states. Bonding in Materials: Ionic bond - Lattice energy - Madelung constant. Covalent, metallic and molecular bonds. Bond angle, bond length and bond energy – simple problems. Hybridisation - Delocalised chemical bonding. Inert gas crystals - van der Waals' interaction - Lennard Jones' potential. Correlation between bonds and physical properties. Simple crystal structures - Sodium chloride, cesium chloride, diamond and zinc sulphide structures. Close packed structures in two and three dimensions- packing efficiency and density of materials, related problems. 18 hours

Unit II

Crystal Geometry and Structure Analysis: Crystal structure – lattice and basis, primitive and non-primitive unit cells. Variation from periodicity - Quasi crystals. Crystal morphology - symmetry elements - Crystal systems. Point group symmetry - derivation of point groups. Space groups and Bravais lattices. Crystal planes and directions - Miller indices - interplanar separations – related problems. Structure analysis by X-rays - Atomic scattering factor. Laue conditions for diffraction and Bragg's law – Lattice and Geometrical structure factor - systematic absences – simple cubic, body centered cubic, face centered cubic, NaCl and diamond structures. Reciprocal lattices - of cubic systems - Ewald's construction. Laue, Rotation and Powder methods of X-ray analysis, related experiments – structure analysis from powder XRD. 18 hours

Unit III

Structure of crystalline solids-alloys, structure of non-crystalline solids- silicates, alumino-silicates, polymers.

Metals-coordinate bond and metal complexes, Valence bond theory- Formation of octahedral complex - outer and inner orbital complex, Formation of tetrahedral and square planar complexes – Limitation of valence bond theory. VSEPR theory and shape of molecules. Crystal field theory – important features - crystal field splitting of d-orbitals in octahedral, tetrahedral, and square planar complexes, applications of CFT- Distortion of octahedral complex and Jahn – Teller theorem, crystal field stabilisation energy and its uses – Limitations of CFT. Molecular orbital theory – comparison of different theories. 18 hours

References

1. Elements of Materials Science and Engineering – Lawrence H van Vlack (Addision Wesley, 1975)
2. Materials Science and Engineering – V Raghavan (Prentice Hall India, 1993)
3. The Structure and Properties of Materials Vol. I-IV – Rose, Shepard and Wulff (Wiley Easterrn, 1987)
4. The Nature of Chemical Bond – L Pauling (Oxford & IBH, 1960)
5. Introduction to Solids – L V Azaroff (McGraw Hill, 1960)
6. X-Ray Crystallography – M J Buerger (John Wiley, 1942)
7. Introduction to Solids – A J Dekker (McMillan India, 1981)
8. Solid State Physics – R L Singhal (Kedarnath Ramnath, 1988)
9. Electronic Processes in Materials – L V Azaroff and J J Brophy (McGraw Hill, 1963)
10. Materials Science and Technology – A comprehensive treatment – R W Cahn, P Haasen & E J Kramer- Electronic and Magnetic properties of metals and ceramics, Vol. -3A & -3B (VCH Weinheim, 1992 & 1994)
11. Crystallography Applied to Solid State Physics – A R Verma and O N Srivastava (New Age Int., 2008)
12. Elements of X-ray Diffraction – B D Cullity (Addison Wesley, 1978)
13. Elementary Solid-State Physics; Principles and Applications – M A Omar (Addison Wesley, 2001)
14. Principle of Materials Science – William F Smith (McGraw Hill, 2014)
15. Materials Science and Engineering: An Introduction – William D Callister (Wiley, 2014)