MANGALORE UNIVERSITY

Department of Materials Science

MSc Materials Science

MSH 551: **MAGNETIC MATERIALS & MAGNETIC RESONANCE** (4 Credits)

Objectives: Magnetic materials is an important class of materials particularly in the present day technology apart from its importance in understanding the basic phenomena in condensed matter. This course introduces to the different class of magnetic materials, their origin, and the theories to understand their behaviour. The magnetic resonance concept is introduced with the rigour of the theory for making it useful in research and other applications.

Expected course outcomes: The student is expected to get an understanding of the basic differences and causes of various types of magnetic materials, magnetic resonance and magnetic interactions. Student should be able to calculate the different parameters to get a feel of the subject.

Unit I

Introduction to magnetic materials – magnetic susceptibility and permeability. Classification – dia- para- and ferro-magnetic materials. Amperian concepts. Langevin's theory of diamagnetism. Origin of magnetic moments. Quantum theory of paramagnetism- Curie law- Effective number of Bohr magneton- Quenching of orbital magnetic moments- Experimental determination of diamagnetic and paramagnetic susceptibility- anisotrophy in susceptibility. Cooling by adiabatic demagnetization. Ferromagnetism – Characteristic features- hysteresis loop. Weiss concepts- Curie-Weiss law. 18 hours

Unit II

Exchange interaction and spontaneous magnetization in ferromagnetic materials - temperature dependence- Heisenberg's theory- gyromagnetic experiments. Ferromagnetic domains - origin of domains - anisotropy energy - Bloch wall - magnetostriction. Hard and soft magnetic materials – iron loss – applications - Transforamers, Electromagnets, permanent magnets – magnetic recording - memory devices.

Antiferromagnetism - sub lattice model - Neutron diffraction in magnetic structure analysis – Super-exchange phenomena - Ferrimagnetism and structure of ferrites and their applications. Spin waves - quantisation of spin waves - magnons. 18 hours

Unit III

Magnetic Resonance and material analysis - Nuclear Magnetic Resonance - Elements of theory - rate of energy absorption – Spin-lattice and spin-spin relaxation processes -Bloch equations – Wide line NMR – applications of NMR – Paramagnetic resonance – principles and comparison of PMR with NMR. Electron spin resonance - areas of applications.

Mossbauer effect - Elements of theory – Mossbauer spectroscophy – centre shift, chemical shift, Zeeman shift, Experimental techniques and applications.
18 hours

References

1. Modern Magnetism – L F Bates (Cambridge University Press, 1963)
2. Elements of Materials Science and Engineering – L H van Vlack (Addison Wesley, 1975)
3. Introduction to Properties of Materials – D Rosenthal and R M Asimov (East West, 1974)
4. Introduction to Solid State physics –C Kittel (II & IV Ed. Wiley & sons, 1961 & 1964)
5. Solid State Physics – A J Dekker (McMillan, 1971)
6. Advances in Solid State Physics, Vol.II & V – Seitz and Turnbull (Ed) (Academic, 1957)
7. Mossbauer Effect and its Applications – V G Bhide (Tata McGraw Hill,1973)
8. Magnetic Resonance – C P Slichter (Harper and Row, 1985)
9. Solid State Chemistry – C N R Rao (Ed) (Marcel Dekker, 1974)
10. Solid State Physics Source Book – Sybil P Parker (Ed) (McGraw Hill, 1987)
11. Materials Science and Technology – A comprehensive treatment – (ed.) R W Cahn, P Haasen & E J Kramer - Electronic and Magnetic properties of metals and ceramics, Vol 3A & 3B (VCH Weinheim, 1992 & 1994)