MANGALORE UNIVERSITY

Department of Physics

MSc Physics

PHS 553: CONDENSED MATTER PHYSICS III

(52 Hrs.)

Course outcome

CO1 On completion of this course, the candidate would be able to deal with ferromagnetism and applications.

CO2On completion of this course, the candidate will have an understanding of antiferro and ferrimagnetism.

CO3 The candidate will be well versed in Paramagnetic relaxation and Magnetic resonance.

CO4 The candidate will have a sound knowledge of nanomaterials and nanostructures.

CO5 The knowledge of nanomaterials and structures would enable the students to gain employment in R&D laboratories and in industry.

Unit I Ferromagnetism

Classical molecular field theory. Heisenberg exchange interaction. Ising model. Spin waves and magnons. Bloch $T^{3/2}$ law. Band theory of ferromagnetism. Magnetisation of ferromagnets. Crystalline anisotropy. Domains. Bloch wall. Ferromagnetic materials. Neutron diffraction - magnetic structure. [13 hrs]

Unit II Antiferro and ferrimagnetism

Molecular field theory. Indirect exchange interaction. Antiferromagnetic materials. Helimagnetism.

Molecular field theory for ferrimagnetic materials. Spinels and garnets. Magnetic bubbles. [13 hrs]

Unit III Paramagnetic relaxation and Magnetic resonance

Paramagnetic relaxation: Susceptibility in alternating magnetic field. Thermodynamic theory of Casimir and Dupre for spin lattice relaxation. Spin - spin relaxation.

Electron paramagnetic resonance: Introduction. Phenomenological theory of resonance. line width, hyperfine structure. Spectra of transition group ions. ESR spectrometer.

Nuclear magnetic resonance (NMR): Elements of the theory of NMR – Bloch equations. Solutions of the Bloch equations weak RF filed. NMR line shape and width. Resonance in non- metallic solids. Influence of nuclear motion on NMR line width. Chemical shift. Quadrupole effect in NMR. NMR Experimental aspects.

[13 hrs]

Ferromagnetic resonance. Introduction, shape effects in ferromagnetic resonance.

Unit IV Nanomaterials and nanostructures

Introduction. Physical properties of the materials at the nanoscale:

Melting points and lattice constants. Mechanical properties. Optical properties-Surface plasmon resonance, Quantum size effects in optical absorption and photoluminescence. EIectrical conductivity-Surface scattering, Quantum transport.

Bottom-Up and Top-Down Approaches of nanomaterials synthesis.

Zero-Dimensional nanostructures - nanoparticles: Introduction, Nanoparticles through homogeneous nucleation. Nanoparticles through Heterogeneous Nucleation.

One-Dimensional Nanostructures:- Nanowires and Nanorods: Intoruduction, Synthesis of one-dimensional nanostructures.

A brief introduction on carbon fullerenes and nanotubes, graphine, ordered mesoporous materials, organic-inorganic hybrids, intercalation compounds, and oxide-metal core-shell structures.

Fabrication of nanoscale structures with physical techniques :Lithographic techniques, Nanomanipulation and nanolithography, Soft lithography, Self-assembly of nanoparticles or nanowires.

Characterization of Nanomaterials:Structural and morphological characterization. Chemical and optical Characterization.

Applications of Nanomaterials: Molecular Electronics and Nanoelectronics.

Band Gap Engineered Quantum Devices. Biological and medical Applications of Nanoparticles, Catalytic applications. Nanomechanics. [13 hrs]

Text Books:

1. A. H. Morrish, 'The Physical Principles of Magnetism' (Robert E Kreiger, 1980)
2. J. Crangle, 'Solid State Magnetism' (Edmond-Arnold, 1991).
3. C. Kittel, 'Introduction to Solid State Physics', $4^{th}$to 8^{th} Edition.
4. A. J. Dekker, 'Solid State Physics' (Macmillan India)
5. C. P Slichter 'Principles of Magnetic Resonance' (Springer, 1996).
6. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications' (Imperial College Press in 2004 and World Scientific, 2011).
7. C. P. Poole and F. J. Owens, 'Introduction to Nanotechnology' (Wiley, 2006).

Reference Books:

1. Ibach H & Luth H 'Solid State Physics' II Edn. (Springer, 2000)
2. K. Yosida, 'The Theory of Magnetism' (Springer, 1998).
3. Ashcroft N W and Mermin N D, 'Solid State Physics' (Harcourt, 1976)
4. Rogalski M S and Palmer S B 'Solid State Physics' (Gordon & Breach, 2000)
5. YuryGogotsi Ed., 'Nanomaterials Hand Book' (CRC Press, Taylor & Francis Group, 2006)