# ME609 Functional Materials

Credit: 3-0-0-3 Approval: Approved in 2nd Senate

Prerequisite:

Students intended for: B.Tech.

Elective or Core: Elective Semester: Odd/Even

**Course content:**

- **Introduction:** Definition of functional materials, Different kind of functional materials; Use of functionalities of materials in fabricating devices, Causes for observed functionality in a material; Functionality arising due to (i) electronic, (ii) spin, and (iii) ionic degrees of freedom; Exploitation of combined effects in designing new functional materials. [3 lectures]
- **Functionality driven by electronic degrees of freedom:** Atoms and crystalline solids; electronic states of atoms and crystalline solids; Formation of bands in crystalline solids; Band dispersions; Density of states; Metals, semiconductors and insulators; Direct and indirect band gap semiconductors; Formation of impurity bands in the p-type and n-type semiconductors; Electrons effective mass in a semiconductor; Transport and optical properties of a semiconductor; Opto-electronic materials.

  [12 lectures]
- **Functionality driven by spin degrees of freedom:** Formation of magnetic moment in an atom; Spin and orbital part of magnetic moment in a solid; Magnetization of a solid; Diamagnetic, paramagnetic, ferromagnetic and antiferromagnetic materials; Different kind of antiferromagnetic structures; Exchange interaction; Determination of magnetic transition temperature using mean-field theory; Formation of domain wall in ferromagnetic material; Soft and hard ferromagnets; CMR/GMR materials.

  [10 lectures]
- **Functionality driven by ionic degrees of freedom:** Covalent, ionic and metallic solids; Formation of dipole moment; Polarization of a material; Paraelectric, ferroelectric, antiferroelectric, piezoelectric, and pyroelectric materials; formation of domain wall in ferroelectric material; Multiferroic materials.

  [5 lectures]
- **Project:** Brief overview of density functional theory; Different kinds of exchange-correlation functional; Use of full-potential LMTO and LAPW methods in designing functional materials.

  [12 lectures]

**Bioliography**


Solid State Physics by N.W.Ashcroft and N.D. Mermin, Harcourt College Publishers

The Physics of Semiconductors: An Introduction Including Devices and Nanophysics by Marius Grundmann, Springer Berlin Heidelberg New York

Electronic Structure: Basic Theory and Practical Methods by R.M.Martin, Cambridge University Press

Multiferroicity: the coupling between magnetic and polarization orders by K.F. Wang, J. – M. Liu, and Z.F.Ren, Advances in Physics **58,** 321 (2009)


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