Course Name : Advanced Condensed Matter Physics
Course Number : PH603
Credits : 3-0-0-3
Prerequisites : PH301 Quantum Mechanics-I , PH 501 Introductory Solid State Physics or faculty consent.
Intended for : PG and UG
Distribution : Elective
Semester : Odd/Even

Course Preamble: The aim of the proposed course is to introduce the basic notion of the condensed matter physics and to familiarise the students with the various aspects of the interactions effects. This course will be bridging the gap between basic solid state physics and quantum theory of solids. The course is proposed for postgraduate as well as undergrad students.

Course Outline *:* The course begins with the review of some of the basic concepts of introductory condensed matter physics and then sequentially explore the interaction effects of electron-electron/phonon, optical properties of solids, interaction of light with matter and finally the superconductivity.

Course Modules :

1. [6 Lectures]
Second quantization for Fermions and Bosons. Review of Bloch's theorem, tight binding Model, Wannier orbitals, density of states.

2. [6 Lectures]
Born-Oppenheimer approximation. Effects of electron-electron interactions - Hartree- Fock approximation, exchange and correlation effects. Fermi liquid theory, elementary excitations, quasiparticles.

3. [7 Lectures]
Dielectric function of electron systems, screening, random phase approximation, plasma oscillations, optical properties of metals and insulators, excitons, polarons, fluctuation-dissipation theorem.

4. [7 Lectures]
Review of harmonic theory of lattice vibrations, anharmonic effects, electron-phonon interaction -mass renormalization, effective interaction between electrons, polarons.

5. [8 Lectures]
Metal-Insulator transition, Mott insulators, Hubbard model, spin and charge density waves, electrons in a magnetic field, Landau levels, integer quantum Hall effect.

6. [8 Lectures]
Superconductivity: phenomenology, Cooper instability, BCS theory, Ginzburg-Landau theory.

Text books:

1. Solid State Physics by N. W. Ashcroft and N. D. Mermin. (*Publisher* - Holt, Rinehart and Winston, 1976).
2. Quantum Theory of Solids by C. Kittel.(Wiley, 1987).
3. Condensed Matter Physics by M. P. Marder. (John Wiley & Sons, 2010).
4. Solid State Physics by H. Ibach and H. Luth. (Springer Science & Business Media, 2009).

References:

1. Theoretical Solid State Physics by W. Jones and N. H. March.(Courier Corporation, 1985).
2. Advanced Solid State Physics by Phillips. (Cambridge University Press, 2012).
3. Many Particle Physics by G. D. Mahan. (Springer Science & Business Media, 2000).
4. Elementary Excitations in Solids by D. Pines. (Advanced Book Program, Perseus Books, 1999).
5. Lecture Notes on Electron Correlation and Magnetism by Patrik Fazekas. (World Scientific, 1999).
6. Quantum Theory of the Electron Liquid by Giuliani and Vignale. (Cambridge Uni. Press, 2005).