PHY 5111: Condensed Matter Physics
Academic Session: 2019-2020

3 Hours/week	Credits: 3.0	Examination Duration: 3 Hours

1. Bloch theorem and band structure methods: Plane wave and LCAO formulation of Bloch theorem, Periodicity and gap openings, band structure methods, Density of States (DOS), k-point sampling.

2. The Many-Electron Problem: N-electron interacting and non-interacting wavefunctions, 1- and 2-body probability densities, The Many-Body System and Born-Oppenheimer (BO) Approximation, The variational approach, Hartree-Fock (HF) equations, shortcomings of HF, derivation of the exchange functional.

3. Density Functional Theory: Hohenberg-Kohn Theorem, Kohn-Sham Scheme, Exchange and Correlation Energy and Holes, Adiabatic Connection, Formal Properties of Functionals, Local Density Approximation, Gradient Expansion and Generalized Gradient Approximations, N-representability and V-representability.

4. Plasmons, Polaritons, Polarons and Phonons: Dielectric function of the electron gas, Dispersion relation for electromagnetic waves, Plasma oscillations, Plasmons, Electrostatic screening, Screening & phonons in metals, Polaritons and L.S.T relation, Electron-electron interaction, polaron and electron phonon interaction.

5. Characterization of Surfaces and Interfaces: Auger Electron Spectroscopy (AESO), X-ray Photoemission Spectroscopy (XPS), Electron Energy Loss Spectroscopy (EELS), Low Energy Electron Diffraction (LEED), Reflection High Energy Electron Diffraction (RHEED), Scanning Probe Microscopy: STM, AFM.

Books recommended:

1. Condensed Matter Physics by M. P. Marder
2. Density-Functional Theory of Atoms and Molecules by Robert G. Parr and Weitao Yang
3. Electronic structure by Richard M. Martin
4. Introduction to Solid State Theory by O. Madelung
5. Introduction To Solid State Physics by Charles Kittel
6. Modern Techniques of Surface Science by D.P. Woodruff and T.A. Dechar