Ph135a (2017 -- 2018): "Applications of Quantum Mechanics to Condensed Matter Physics"

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SCHEDULE: Tuesday & Thursday 1:00 – 2:30 PM

LOCATION: Downs 119

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INFORMATION: http://www.yehgroup.caltech.edu/Ph135a_2017

I. Introduction

-- Overview of condensed matter physics.

II. Crystalline Structures & Phonons

-- Translational symmetry & periodic wave functions.
-- The reciprocal lattice.
-- Bloch theorem & the Brillouin zone.
-- Classification of Bravais lattices and crystalline structures.
-- Lattice dynamics and lattice waves.
-- Lattice specific heat and spectra.
-- Phonons.
-- Diffraction by a crystal with lattice vibrations.

III. Electronic States and Band Structures

-- The nearly-free-electron model.
-- The tight-binding method.
-- The **k** • **p** perturbation theory.
-- Other band structure theories: cellular method; augmented-plane-wave (APW) method; orthogonalized-plane-wave (OPW) method; pseudo-potential method; Green function method.

IV. Fermi Statistics of Electrons & Electron-Electron Interactions

-- Classifications of solids in terms of band and bond pictures.
-- Fermi statistics and specific heat of conduction electrons.
-- Perturbative approximations.
-- Screening effects and the dielectric constant.

-- The Friedel sum rule and Friedel oscillations.
-- Plasma oscillations.
-- Mott transitions and Wigner's hypothesis.

V. Symmetries & Group Theory

-- Groups and representation theory.
-- Point groups and the selection rules for optical transitions.
-- Space groups.

VI. Optical Properties of Solids

-- Macroscopic theory.
-- Microscopic theory for dispersion and absorption.
-- Photon-phonon interaction.
-- Interband transitions and excitons.

VII. Transport Properties of Solids & the Fermi Surface

-- The Boltzmann equation.
-- Scattering mechanisms and longitudinal resistivity in solids.
-- Thermal transport properties.
-- Effects of high magnetic fields & quantization of orbits.
-- High-field magnetoresistance and quantum oscillations.
-- Transverse resistivity and the Hall effects.
-- Quantum Hall effects in semiconductors.

Reference Books:

1. "*Principles of the Theory of Solids*", J. M. Ziman, Cambridge University Press (1972).
   [Link to Caltech Library e-book can be found at http://caltech.tind.io/record/902799?ln=en]

2. "*Solid State Physics*", N. W. Ashcroft and N. D. Mermin, W. B. Saunders Company, (1976).