Physics 195 + Applied Physics 195
— Introduction to Solid State Physics —
Professor Donhee Ham

Fall 2017, Harvard University
Wednesday and Friday, 1pm - 2:30pm, Rm 256, Jefferson Building.

Teaching Staffs

Professor: Donhee Ham, PhD. Gordon McKay Professor of Applied Physics and EE
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— (office hours) TBD

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Course Description

Introduction to the physics of crystalline solids. See Topics in the next page.

Prerequisite

Undergraduate-level quantum mechanics (Physics 143 or equivalent).

Materials

Throughout the semester I will hand out lecture notes as main materials for the course. There is no required textbook, while Kittel's *Introduction to Solid State Physics* is a recommended reference. The presentation order of subject materials and their detailed technical exposition will be substantially different between the lecture notes and the book, while both will cover a similar knowledge basis.

Grading

1. Homework (100%).

2. Late grading policy: Homework will be handed out in class on Friday, due 12:45pm next Friday with a grace period of 10 minutes sharp at the black drop box outside my office (Maxwell-Dworkin Room 131). Late work will be reduced 50% per week. There is **no exception** to this rule, other than University-established emergency cases (a letter from authorized official is required). This late grading policy will be strictly enforced for fairness to all.

3. Cooperation policy: You should work on problems marked with "no collaboration" on your own, without discussing any aspect of them with other students; in other words, you should treat these problem strictly as take-home exam problems. For the rest problems, cooperation is permitted, but you should turn in your own solution — You can discuss these problems with other students taking the course, but final solutions should not be exchanged. You should make it sure that you understand the solution you turn in, and write up the solution in your own words. Basic guideline is not to take undue advantage of any other student.

Topics

Crystal binding.

Free electron Fermi gas.

Drude theory of electrical conduction.

Crystal lattice waves (phonons).

Crystal structure; direct lattice; reciprocal lattice; Brillouin zone.

Diffraction (of X-ray, neutrons, and valence electrons) by an ideal crystal.

Electrons in crystals; Bloch's theorem; band structures (via tight binding and nearly free electron model); band picture of solids.

Various band calculation techniques.

Semiclassical dynamics of Bloch electrons.

Metals and Fermi surfaces.

Semiconductor band structures and optical and electronic properties; excitons.

pn junctions; bipolar junction transistors; field-effect transistors.

Semiconductor quantum wells — bands and sub-bands; engineering of optical properties; spin injection.

Polaritons, plasmons, and screening.

Mott transition.

Diamagnetism; paramagnetism; ferromagnetism; spin waves.

Magnetic resonance.

Solid-state masers and lasers.

Superconductivity.

Josephson junctions and their applications (classical and quantum signal processing).

Brief intro to electron transport in low-dimensional systems — resonant tunneling; conductance quantization; magnetoresistance; quantum Hall effect