



PHYS 731: Solid State Physics

Spring 2016

Tues. and Thurs., 11-12:15, Toll 1204



Prof. James Williams

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PSC 2160

Office Hours: On demand

(301) 314-2161

Course Description and Structure: This course will survey a variety of topics from modern condensed matter physics. Focus will be given to electronic phenomena in solids. Specifically, we will focus on departures from free, three-dimensional electron behavior in quantum devices and materials. The course will consist of a series of lectures given by Prof. Williams followed by in-class presentations/discussions of papers on current research topics that complement the material discussed in the lectures. The class will break up in the beginning of the term into groups of 2-4 students (depending on class size). At the beginning of each class when a paper will be presented, one of these groups will be chosen at random to lead the discussion. Prof. Williams will present the first paper to demonstrate how this should be done. A final paper that elucidates further a topic discussed in the class will allow the each student to propose a novel line of research into the chosen topic.

Prerequisite(s): Undergraduate quantum mechanics (PHYS 401, 402)

Credit Hours: 3

Text(s): There is no required text for this course. However, there are many good books that cover the topics of this course.

1. *Solid State Physics*, Ashcroft and Mermin
2. *Introduction to Solid State Physics*, Kittel
3. *Many-Body Quantum Theory in Condensed Matter Physics*, Bruus and Flensberg
4. *Mesoscopic Physics of Electrons and Photons*, Ackermans and Montambaux
5. *Topological Insulators and Topological Superconductors*, Bernevig

Grade Distribution:

Homework	20%
In-class presentations and participation	40%
Final Paper	40%

Tentative Course Outline:

The weekly coverage might change as it depends on the progress of the class.

Week	Topic
Week 1	<ul style="list-style-type: none">• Free-electron theory• Energy band structure and Bloch's Theorem
Week 2	<ul style="list-style-type: none">• Electron-electron interactions• Hartree-Fock Theory• <i>Homework 1</i>
Week 3	<ul style="list-style-type: none">• Papers and presentations
Week 4	<ul style="list-style-type: none">• Luttinger Liquids• Discussion of upcoming papers
Week 5	<ul style="list-style-type: none">• Papers and presentations
Week 6	<ul style="list-style-type: none">• Mesoscopic physics• Weak localization• <i>Submit first abstract for final paper</i>
Week 7	<ul style="list-style-type: none">• Papers and presentations
Week 8	<ul style="list-style-type: none">• One-dimensional structures: Quantum wires and point contacts• <i>Homework 2</i>
Week 9	<ul style="list-style-type: none">• Zero-dimensional structures: Quantum Dots• Discussion of upcoming papers
Week 10	<ul style="list-style-type: none">• Papers and presentations
Week 11	<ul style="list-style-type: none">• Quantum Hall effect• <i>Submit revised abstract for final paper</i>
Week 12	<ul style="list-style-type: none">• Papers and presentations
Week 13	<ul style="list-style-type: none">• Graphene• Carbon Nanotubes• <i>Homework 3</i>
Week 14	<ul style="list-style-type: none">• Topological Insulators• Discussion of upcoming papers
Week 15	<ul style="list-style-type: none">• Papers and presentations