Advance Solid State Physics
PHYSICS 6243
Fall 2008

Instructor: Kieran Mullen

Class time: MWF 3:00-4:00pm, 201 Nielsen Hall

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1 Goals:

The goal of this course is to give the student competence in solid state physics. My goals for the class include:

- Reviewing basic concepts as phonons, and band structure, giving you a feeling for the state of the art.
- Going beyond these simple pictures to discuss interactions of electrons with electron or with phonons.
- Discussing fundamental systems such as metals, insulators, and semiconductors.
- Examining simple manybody theory
- Looking at some topics of current interest. Possible topics include: the quantum Hall effect, Luttinger liquids, magnetic materials, or mesocopic physics.

I cannot lecture on *everything* in the reading. While I will focus on the difficult points, you are expected to work a fair bit on your own, and to ask questions about anything you don't understand.

This is the most advanced formal class most of you will have on topics that you have chosed for your career. That is a big responsibility for one graduate course! This means that we will move rapidly and you are expected to work hard. It also means that you must learn how to use many references to master the material, including other textbooks, faculty within our department as well as internet resources.

2 Prerequisites:

You are expected to have:

- A thorough understanding of Classical Mechanics in the Newtonian, Lagrangian, and Hamiltonian formulations.
- A mastery of thermodynamics and statistical mechanics at an undergraduate level including such concepts as entropy, kinetic theory, temperature, and distribution functions.
- A good background in quantum mechanics including the concepts of fermions and bosons, scattering, interference, and solving the Schrodinger equation.
- An undergraduate education in solid state physics including crystal symmetry, phonons, the tight binding model and the nearly free electron model. Typically this should be Kittel's *Introduction to Solid State Physics*, chapters 1-9.

If you feel weak in any of these areas, come see me. I'll help you decide if you need to brush up on anything or if it might be better to take this class at a later date.

3 Texts:

The text for the class is *Solid State Physics: Introduction to the Theory* by James D. Patterson and Bernard C. Bailey. This is a new edition of an established book. It's a bit rough on pedagogy and **very dense with information.** You will need to read carefully. It is an excellent source of reference materials to get you into any topic in solid state physics.

However, any text serves only as a starting point. Rather than require three or four textbooks, I will put a variety of books on reserve, and I may do some photocopying. These include:

- *Condensed Matter Physics,* by Michael Marder.

  I used this text the last time I taught the course. It has the advantage of being a modern book, and it covers a lot of modern topics. However, it can be a bit shallow on important topics while spending entire chapters on less vital material (semi-classical wavepacket analysis ?!). While parts of it are quite good, I didn't think that it gave enough sound foundational information.

- *Solid State Physics,* by N. Ashcroft and D. Mermin.

  One of *the* standard works in the field, and it's the one I've used in the past. However, if you look at the publication date, you'll note that it's 30 years old. That leaves out a lot of physics: BCS theory, density functional theory, quantum Hall physics, localization, liquid crystals, all topics of Nobel prizes. However, what A& M do cover is certainly still true. It remains a standard reference. It's also cleverly written. Every solid state physicist I know owns at least one copy.

- *Theory of Solids*, by Ziman.

  A second, standard book on the topic. It is a bit better than A& M on the optical properties of materials, but lacks their detail on metals, semicondutors and insulators.

- *Introduction to Solid State Physics*, by Kittel

  I *almost* used this book. The advantages: everyone who took the intro course here will have a copy, and we could just continue from where Prof. Santos (or Moore-Furneaux) left off. The disadvantages: it's aimed at undergraduates and you are better than that. It also doesn't go into enough detail, it just states results without proof.

- *Theoretical Solid State Physics*, by Jones and Marsh.

  An older, two volume series that covers traditional topics pretty well. It's published by Dover Press, so you can get your own copy for reference pretty cheaply.

- *Principles of Condensed Matter Physics* by Chaikin and Lubensky.

  This new book overlaps with some of the topics we'll discuss but is more of a statistical mechanics book. It's a bit weak on some of the more traditional topics. It's well written and pretty accessible, but sometimes does not give you all the mathematical details. It's great on correlation functions, and structure factors.

I will also photocopy some articles on more advanced topics. You will also be asked to read some papers in current research.

While this is not a course on MATHEMATICA, I do expect that we will use it at times throughout the semester. I will schedule a special introductory session or two on MATHEMATICA. If you've never used MATHEMATICA, I strongly recommend that you get a copy of *The Beginner's Guide to Mathematica* by Gray and Glynn. It is required in a number of Physics classes, so it should be in the bookstore. It will give you a quick introduction into everything you need to know.

4 Evaluation:

The tentative plan for grading is based on the following:

30%	Two Midterm exams
20%	Final Exam
50%	Homework and workshop problems

There are too few students to contemplate curving the grades. The scale will be on a slightly enlarged straight scale and grades will be given as follows:

A	87.5-100%
B	75-87.5%
C	62.5-75%
D	50-62.5%
F	0-50%

Exams will be **closed book**, but open notes. You will be allowed use anything in your own handwriting. Students who cannot take exams on scheduled dates should let me know at the earliest oppurtunity.

While students may wish to collaborate on homework, it should be stressed that simply copying the solutions of others will not prepare them for the exam. It is also cheating! Students are expected to turn in their own work. Homework will be assigned roughly weekly, with about 10 assignments over the semester. Homework turned in after it is due will be penalized. Late homework will not be accepted after the solutions are placed in the library.

"Any student in this course who has a disability that may prevent him or her from fully demonstrating his or her abilities should contact me personally as soon as possible so we can discuss accommodations necessary to ensure full participation and facilitate your educational opportunities."

"It is the policy of the University to excuse absences of students that result from religious observances and to provide without penalty for the rescheduling of examinations and additional required classwork that may fall on religious holidays."