Administrative details:
Instructor: Neil Johnson     njohnson@physics.miami.edu
Office: Room 307          Phone: 8-7121
Class hours: MWF 2:30-3:30pm in Room 203
Office hour: Tuesday 1:30-2:30pm

Background:
Solid State Physics is a vast field which is still growing. It was traditionally linked with areas of materials science, chemistry and engineering, but has more recently developed common interests with biology, biochemistry, biotechnology and medicine. Solid State Physics deals with the properties (e.g. electrical, mechanical, optical) of collections of objects (e.g. atoms) in solid matter -- but given that most things around us (including us) are more or less solid, you can begin to see why it has become such a big field.
Indeed, the current research questions in Solid State Physics lie at the frontiers of fundamental physics, applied science and next-generation technologies. After all, Solid State Physics is the field that gave us the semiconductor chip -- and hence modern computers, cellphones etc. -- but is also the field which gave us exotic quantum phenomena such as the Fractional Quantum Hall Effect and Superconductivity.

In many ways, Solid State Physics is the opposite of Particle Physics. Solid State Physics deals with the emergent properties of collections of objects in materials which are either naturally occurring, artificially-made, or as-yet hypothetical. By contrast, Particle Physics focuses on the intrinsic properties of individual particles which occur naturally. Particle physicists tend to break open composite objects into their fundamental building blocks, while Solid State physicists are interested in what fundamentally new properties emerge when these building blocks are grouped together.

Plan for this course:
There is no perfect Solid State book, but the newest (i.e. 2005) version of Kittel does a good job of covering a lot of material quite efficiently, including new sections on nanoscience. It is ambitious of us to plan
covering the entire book in one course -- but it will be well worth it if we can manage, even if this means scratching the surface of some chapters. The latter chapters are the most relevant to current frontiers of research, yet the initial chapters are needed to lay the groundwork. We will therefore work through Kittel, covering the material through a mix of classes, homeworks, additional readings, student presentations and possibly even student projects. We may deviate occasionally to focus on state-of-the-art topics and challenges -- in particular, I will try to introduce you to the current interdisciplinary frontier of solid-state/nanoscience/biology/medicine which is sometimes referred to as nanobiotechnology, nanomedicine, systems biology, or some other hybrid.

**Topics to be covered (time permitting):**
1. Crystal structure
2. Wave diffraction and the reciprocal lattice
3. Crystal binding and elastic constants
4. Phonons I: crystal vibrations
5. Phonons II: thermal properties
6. Free electron Fermi gas
7. Energy bands
8. Semiconductor crystals
9. Fermi surfaces and metals
10. Superconductivity
11. Diamagnetism and paramagnetism
12. Ferromagnetism and antiferromagnetism
13. Magnetic resonance
14. Plasmons, polaritons and polarons
15. Optical processes and excitons
16. Dielectrics and ferroelectrics
17. Surfaces and interface physics
18. Nanostructures
19. Noncrystalline solids
20. Point defects
21. Dislocations
22. Alloys
Grading:
We will use a variety of learning tools in order to deepen and broaden our understanding of this subject. For example, students will be asked to make in-class presentations and prepare reports on particular topics. The final grade will reflect the overall performance in homework, written exams, presentations, projects and class participation. Specifically, homework and exams will comprise 2/3 of the final grade while presentations, projects and class participation will comprise 1/3.

IMPORTANT NOTICE: Since this is my first semester teaching at UM, please let me know at any stage if there is anything about the class which concerns you. I am keen to learn and adapt my style, at the same time as wanting to explore fresh methods of teaching. If I hear no adverse comments, I will tend to carry on along my planned trajectory. So please let me know if something bothers you, either by talking to me during or after class, office hours, email, phone. You can also drop anonymous notes in my departmental mailbox if you prefer.