Solid-State Physics I is a first course for graduate and undergraduate students interested in physics, electrical and computer engineering, materials science, and magnetic data recording. We cover the classical and quantum theories of the conducting, insulating, and semi-conducting states, elastic properties of crystals, lattice vibrations, and thermal characteristics of solids. The course is the prerequisite for Solid-State II (PHZ 6426) and for a new course offered this year for the first time in Materials Science (PHY 6938). (For information about the new Materials-Science course, please contact Dr. Sarath Witanachchi).

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MEETING TIMES: Mondays, Wednesdays, and Fridays Noon to 12:50 P.M. in room 108, Physics-Mathematics building (PHY). Official OFFICE HOURS will be announced; I am also usually available during the day, evenings, and weekends. You may give away notes for free but may not sell them or tapes. The first four textbooks listed below are on reserve at the library.

| primary textbooks | Ashcroft and Mermin, Solid-State Physics, Saunders College, $97. This is the standard graduate-level textbook in the subject, although undergraduates also often use it. The tables, footnotes, and appendices are especially helpful, and you may find some surprises in the index. Ashcroft and Mermin introduce the field clearly without sacrificing rigor and yet also without excessive mathematical formalism. According to reviews posted at the Amazon bookstore, students prefer this book to the alternative introductory text by Kittel. |
| recommended       | Hook and Hall, Solid-State Physics, Wiley, $68. This book is more recent than Ashcroft and Mermin and so treats current developments, such as the quantum Hall effect. It is also intended for an undergraduate course. If you have not seen the material before and would like a different perspective, I recommend it. Warning: SI units. |

The solid state is a big field, one we shall not succeed in surveying completely in this two-semester sequence. Here are some other books you may find useful along the way and in the future. The list is necessarily idiosyncratic.

| general            | Madelung, Introduction to Solid-State Theory, Springer. More mathematical than Ashcroft and Mermin. At a similar level, the two volumes by Jones and March, Theoretical Solid-State Physics, are available cheaply as Dover paperbacks. If you liked Ziman’s short treatise on the Fermi surface, you should also read his Principles of the Theory of Solids, at the level of A&M (but shorter and a little less complete). Two more advanced tomes, Ziman’s Electrons and Phonons and Kittel’s Quantum Theory of Solids (also known as “big Kittel,” not to be confused with “baby Kittel,” or Introduction to Solid-State Physics), are unfortunately out of print. |
You should have some exposure to the Fermi-Dirac and Bose-Einstein distributions from quantum statistical mechanics and be familiar with thermodynamic ideas such as specific heat. Good undergraduate textbooks include Reif, *Statistical Physics*, Kittel, *Thermal Physics*, and Goodstein, *States of Matter* (which begins with my favorite introductory paragraph of any science textbook).

David Mermin points out that practitioners of the trade are really *condensed-matter* physicists, as they study not just the solid but also the liquid state and various things in between (biophysics is sometimes referred to as “squishy-state physics”). In *Principles of Condensed-Matter Physics*, Chaikin and Lubensky explicitly complement Ashcroft and Mermin, covering a well-considered set of ideas absent from all the standard solid-state books but equally interesting and important.

Perturbative field theory and Green’s functions are almost as important to solid-state theorists as to high energy. Among the introductory textbooks are those by Abrikosov, Gorkov, and Dzyaloshinskii, by Pines, by Fetter and Walecka, and by Rickayzen. The huge work by Mahan (list price over $150) is probably more of a reference than a textbook. More modern techniques are described by Fradkin, by Parisi, and by Negele and Orland.

The second semester of this course will deal largely with magnetism. My favorite introduction is Mattis’s *Theory of Magnetism* (Springer), especially volume one. The historical preface alone is worth the price. Some recent developments are treated in Auerbach, *Interacting Electrons and Quantum Magnetism*.


Old standards include textbooks by Tinkham, Schrieffer, and de Gennes, as well as the two-volume collection edited by Parks. Many monographs describe what’s known about high-temperature superconductivity, but a microscopic theory still eludes us.


There’s vastly more condensed-matter outside my area of expertise. Dr. Witanachchi is currently offering a new course on *materials science*, which deals with the design, manufacture, and characterization of solids; he can recommend some books. *Semiconductors*, naturally, are a field in their own right, for which I’m told a standard textbook is by S.M. Sze. I have left off books on experimental methods only because I know so little about them. Just to have one on the list: Richardson and Smith, eds., *Experimental Techniques in Condensed-Matter Physics at Low Temperatures*.

### Tentative and Approximate Course Outline

no lecture on the Rev. Dr. Martin Luther King Jr. Day, 1/17; **midterm examination** 3/6

week of

1/10 The Drude model (A&M 1, S&D 6)
1/17 Sommerfeld (A&M 2, S&D 7, H&H 3); failures of the free-electron model (A&M 3) [MLK]
1/24 Structure of solids in direct and reciprocal spaces (A&M 4–5, S&D 2–3, H&H 1)
1/31 Crystallography, determination of structure (A&M 6–7, S&D 2–3, H&H 1,12)
2/7 Bloch waves and band structure (A&M 8–9, S&D 8, H&H 4)
2/14 continue band structure
2/21 semiclassical electron dynamics (A&M 12–13, S&D 9–10, H&H 13)
2/28 measuring the Fermi Surface (A&M 14–15, H&H 13)
3/6 beyond the $\tau$ and independent-electron approximations (A&M 16–17, H&H 13) [EXAM]

spring break
Dr. Witanachchi’s new course on Materials Science takes over where we leave off, with the p/n junction of inhomogeneous semiconductors and with applications to device physics. That course also treats materials characterization and the particular physics of two-dimensional surfaces. The second semester of this course, Solid State II, will deal with magnetism and possibly superconductivity and the quantum Hall effect.

Colloquium

Many of the physics colloquia this semester will relate to this course, not only because I’m running the colloquium but also because we plan to interview several candidates for a materials-science position. Except for unavoidable conflicts, I expect to see everyone at the physics colloquia.

Computing facilities

The Solid-State Simulations of Silsbee and Dräger will be available through the open-use computer laboratories maintained by the College of Arts and Sciences (warning: they run limited hours). You may if you prefer run them instead on our Linux server, physics.cas.usf.edu; see me for an account. Except for the simulations, no computing is required, but you are free to use CAS or physics-department computers for typesetting, graphing, and calculation.

Grading

Grades will be based on approximately ten assigned homework sets, on an in-class midterm examination (6 March), and on the take-home final examination. Homework assignments will be announced in class and, unless otherwise indicated, will be due in class Wednesday morning of the following week. Graduate students (and undergraduates who have already taken a solid-state course) will do a few extra homework problems. Some of the exercises, particularly out of Silsbee and Dräger, are somewhat open-ended and will require coherent written explanations. Even derivations and numerical calculations must be accompanied by enough words that I can figure out what you have done. Since good communication is essential to science and to your professional development, grammar, organization, and style count. Students are encouraged to discuss homework, but cooperation must not include plagiarism.

Homework for Week 1
Due Wednesday, 19 January

Read Ashcroft and Mermin chapter 1 and Silsbee and Dräger chapters 1 (introduction) and 6. (Skim all the problems in the books, even if you don’t attempt all of them.)

1. Ashcroft and Mermin (A&M) 1.1
2. A&M 1.2
3. A&M 1.4 (optional for undergraduates taking solid state for the first time)
4. Silsbee and Dräger (S&D) 6.40
5. S&D 6.55