COURSE INFORMATION

Physics 5701, Solid State Physics for Scientists and Engineers

Course Prerequisites: Some previous exposure to quantum mechanics and thermodynamics of the type provided in a sophomore level modern physics class (the more the better). Knowledge of partial differential equations and Fourier series.

This class is a survey course in solid state physics. It covers more material (but with less rigor) than PHYS 4211. The intended audience for PHYS 5701 is graduate students or advanced undergraduates in fields outside condensed matter physics who need to know some solid state physics for their research. Please see the instructor if you are wondering whether you should be enrolled in PHYS 4211 or 5701.

Although I am not making any strong assumptions about the background of students enrolled in the class, I will assume that they are highly motivated to learn about solid state physics and are capable of filling in background knowledge as necessary. In this sense, PHYS 5701 is clearly a graduate course, even if it is does not have the same attention to rigor as our other classes on the subject.

Instructor: Paul Crowell
Office: PAN 220
Phone: 4-4828
Email: crowell@umn.edu
Office hours: TBD

Grader (Homework and Quizzes): To be determined
Office:
Email:

Course Web Page (Canvas):
https://canvas.umn.edu/courses/99560

Course announcements and assignments will be posted on this page. You are responsible for any announcements or assignments made on the web page, in class, or by email. The course email list will be based on the official list generated by the university. Please do not ask us to change to any other email address.

Lectures: T and Th: 9:45 – 11:00. Note that this is a four-credit class, although there are three hours of lecture.

TEXTBOOK

The required textbook is “An Introduction to Solid State Physics (8th edition)” by Charles Kittel. Any recent edition of this book is probably fine as long as you have access to the problems in the current edition. Kittel assumes a minimal background in quantum mechanics and statistical mechanics, although I will fill in some holes for those who have not seen these at the advanced undergraduate level.
Additional readings will be assigned from either textbooks or the current literature. The research interests of students in the class will provide me with some guidance as to what topics will be chosen.

Everyone has their favorite (and least favorite) solid state physics textbook. Quite honestly, Kittel is probably not at the top of any lists. It tries to cover too much material in too few pages, and in some cases the explanations are poorly written. It is also a bit dated. However, it is a comprehensive book and just about any solid state physicist has some version of it on his or her shelf.

The other “established” solid state physics book is that of Ashcroft and Mermin (A&M). It is also dated (published in 1975 and never revised), but it is written at a higher level than Kittel. If you know all of undergraduate physics, then you will do fine with Ashcroft and Mermin. Although it can be dense, A&M uses more pages than Kittel to cover roughly the same topics at a higher level. The quality of the writing is better than that of Kittel. All physics graduate students should acquire a copy of A&M.

Both of the above books are missing more modern topics, and condensed matter physics is now so broad that it is impossible to cover the topic in one book. Here are some books that I may consult when preparing lectures:

**Simon, “The Oxford Solid State Basics.”** This is more selective in choice of topics and somewhat more modern in focus. The writing is witty. It also has the advantage of being available online from a UMN-based ip address:


There also exist a series of online lectures which (having seen a couple of Simon’s talks) I can guess are probably good:

https://podcasts.ox.ac.uk/series/oxford-solid-state-basics

The weighting of topics is not what I would choose, but this is a decent effort aimed clearly at physicists. The book contains virtually none of the sort of background real-world knowledge that fills (some would say clutters) the pages of Kittel and A&M.

**Ibach and Luth “Solid State Physics.”** The German standard. At approximately the same level as A&M but a bit more modern. Unlike either Kittel or A&M, there are ongoing revisions.

**Ziman, “Theory of Solids”** - Even older than Kittel and A&M, and focused on the fundamentals. This classic text is well-written but reasonably advanced. Ziman is my textbook of choice for the basic theory of metals.

**Ziman, "Electrons and Phonons,"** – Advanced but old-fashioned treatment of transport.

**Yu and Cardona, “Fundamentals of Semiconductors.”** - Depending on the interests of the class, I will probably refer to this book when covering semiconductors.

**Sze, “Physics of Semiconductor Devices.”** – Really thick, really old, really boring, and I consult it regularly. If you want to know how a transistor works, this is where to go.

**Davies, “The Physics of Low-Dimensional Semiconductors”** – This is a well-written book that I will use to address nanostructures.
Morrish, “The Physical Principles of Magnetism” - A one-volume introduction to magnetism from the 1960’s – about the last time that could have been done. I consult this book regularly.


Tinkham, “Introduction to Superconductivity” – I will probably not cover superconductivity, and if so only at a superficial level. Tinkham’s book is where you would go next.

Chaikin and Lubensky, “Principles of Condensed Matter Physics,” emphasis on soft matter. Although I may change my mind once I know who is taking the class, I will not be covering much soft condensed matter this semester. I will probably not use this book at all.

You will be expected to dig in on reading assignments. If you cannot understand something in Kittel, go out and look at any of the alternatives. You can always ask for suggestions. Because I intend to address topics of interest to the class (with topics to be determined after discussion), expect to consult review articles and/or original research articles.

HOMEWORK and EXAMS

Homework will be assigned approximately weekly. Like any other topic, solid-state physics can be learned only by doing problems. You will need occasional access to Mathematica, MatLab, or some other programming/graphics environment of your choice.

Homework must be turned in on the date it is due.

There will be two quizzes and a final exam. The quiz dates are to be determined – most likely late February and early April. The quizzes and final are likely to be take-home (but timed).

GRADING

Your grade in this course will be based on the following:

Homework: 40 %
Midterms: 40 %
Final Exam: 20 %

Grades will conform to University-wide policy:
A - Represents achievement that is outstanding relative to the level necessary to meet course requirements (typically 85 – 100 on my exams)
B - Represents achievement that is significantly above the level necessary to meet course requirements (typically 70 – 85 on my exams)
C - Represents achievement that meets the course requirements in every respect (typically 50 – 70 on my exams).
D - Represents achievement that is worthy of credit even though it fails to meet fully the course requirements.
Over my twenty year career, I have never given a grade below C- in an upper level course to anyone who has completed ALL of the homework with a grade of 80% or higher. This is an observation and not a promise, but the primary reason for this is the strong correlation between doing homework and succeeding on exams.

**Remarks on grading** - Problems on homework and quizzes will be graded based on your success in communicating a logical and organized path towards their correct solution, grounded in a correct assessment of the underlying physics. Diagrams, written explanations and especially a logical algebraic development done neatly and including well-defined variables and a consistent notation are key elements of the correct solution of problems. You are expected to use software (for computations and graphics) when necessary. Disconnected diagrams, equations or answers simply written down without explanation will not receive credit. Partial credit will be given for steps of an organized solution up to the point where a departure from the correct solution path occurs, but only if these steps can be clearly understood by looking at the paper you submitted. Again: a grader looking at your paper must be able to understand what you have done, how and why you did it, and to discern the correctness of your reasoning.

I do not ask graders to find and correct mistakes, but rather to grade based on whether a written solution is correct, mostly correct, or otherwise worthy of some credit. Please consult the posted solutions (not your graded paper) for guidance on how a problem should have been done.

**ACADEMIC CONDUCT**

Students in this course must adhere to all policies of the University of Minnesota and the College of Science and Engineering with respect to scholarship and conduct. These policies are available for review at:


In particular, you are encouraged to read the statements on scholastic dishonesty, disruptive behavior, and the use of electronic devices during exams (see detailed policy descriptions below). Violations of these policies will lead to penalties, up to and including a failing grade “F” in the course and expulsion from the University.

**Note that copying solutions to homework problems from a fellow student or a solution manual (printed or online) is a violation of the student conduct code. Collaborating on homework is fine, but the written solution you hand in must be your own work.**

**Classroom etiquette:** Cell phones must be turned off. Computers may be used only for notetaking, accessing your textbook, or accessing online course resources as required during the lecture (this will be rare). All other forms of electronic communication and web access are not allowed at any time. Note that the use of any electronic devices, except handheld calculators without wireless capability, is forbidden during exams. Lectures will require active
verbal communication (both ways!) between students and the instructor. Anything that impedes this process (from web browsing to reading the newspaper) is rude and disruptive.

SCHEDULE

The exact order of topics will be determined after discussion with the class, but my intention is to cover the core topics (structure, phonons, electrons, band structure, semiconductors, and metals) accompanied by special topics of interest to members of the class.

Depending on the background of individuals in quantum mechanics and statistical mechanics, I may set aside some lectures to address those topics. Depending on your background, you might choose to skip those lectures.

DEPARTMENTAL POLICIES

ATHLETES must provide their official University of Minnesota athletic letter containing the approved competition schedule to their instructor and the staff in Williamson Hall 145. Away exams will be arranged with the athletic adviser traveling with the team. Accommodations will be made for official university sports only (i.e. no accommodations will be made for intramurals, club sports, etc.)

DISABILITY SERVICES: If you have accommodations for this course (see policy below), please provide the staff in Williamson Hall 145 with a copy of your accommodation letter for the current semester. Exams will be arranged according to accommodations and sent to the testing center for administration.

UNIVERSITY POLICIES

- Student conduct code

- Scholastic Dishonesty
  See student conduct code

- Disability Accommodations
  http://ds.umn.edu/student-services.html

- Use of Personal Electronic Devices in the Classroom
  https://policy.umn.edu/education/studentresp

- Makeup Work for Legitimate Absences
  https://policy.umn.edu/education/makeupwork

- Appropriate Student Use of Class Notes and Course Materials
https://policy.umn.edu/education/studentresp

- Grading and Transcripts
  http://policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html

- Sexual Harassment
  https://policy.umn.edu/hr/sexualharassment

- Equity, Diversity, Equal Opportunity, and Affirmative Action
  https://diversity.umn.edu/eoaa/policiesanddirectives

- Mental Health and Stress Management
  http://www.mentalhealth.umn.edu

Student Conduct Code

The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University. Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected adhere to Board of Regents Policy: Student Conduct Code. To review the Student Conduct Code, please see:

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor’s ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

Use of Personal Electronic Devices in the Classroom

Using personal electronic devices in the classroom setting can hinder instruction and learning, not only for the student using the device but also for other students in the class. To this end, the University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. For complete information, please reference: http://policy.umn.edu/education/studentresp.

Scholastic Dishonesty

You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on
assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis. (Student Conduct Code: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf)

If it is determined that a student has cheated, he or she may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see: http://policy.umn.edu/education/instructorresp.

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: http://www1.umn.edu/oscai/integrity/student/index.html. If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class—e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.

**Makeup Work for Legitimate Absences**

Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see: http://policy.umn.edu/education/makeupwork.

**Appropriate Student Use of Class Notes and Course Materials**

Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see: http://policy.umn.edu/education/studentresp.

**Grading and Transcripts**

The University utilizes plus and minus grading on a 4.000 cumulative grade point scale in accordance with the following:
<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>GPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Represents achievement that is outstanding relative to the level necessary to meet course requirements</td>
<td>4.000</td>
</tr>
<tr>
<td>A-</td>
<td>Jacobson</td>
<td>3.667</td>
</tr>
<tr>
<td>B+</td>
<td>Represents achievement that is significantly above the level necessary to meet course requirements</td>
<td>3.333</td>
</tr>
<tr>
<td>B</td>
<td>Jacobson</td>
<td>3.000</td>
</tr>
<tr>
<td>B-</td>
<td>Jacobson</td>
<td>2.667</td>
</tr>
<tr>
<td>C+</td>
<td>Represents achievement that meets the course requirements in every respect</td>
<td>2.333</td>
</tr>
<tr>
<td>C</td>
<td>Jacobson</td>
<td>2.000</td>
</tr>
<tr>
<td>C-</td>
<td>Jacobson</td>
<td>1.667</td>
</tr>
<tr>
<td>D+</td>
<td>Represents achievement that is worthy of credit even though it fails to meet fully the course requirements</td>
<td>1.333</td>
</tr>
<tr>
<td>D</td>
<td>Jacobson</td>
<td>1.000</td>
</tr>
<tr>
<td>S</td>
<td>Represents achievement that is satisfactory, which is equivalent to a C- or better.</td>
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</tr>
</tbody>
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For additional information, please refer to: [http://policy.umn.edu/education/gradingtranscripts](http://policy.umn.edu/education/gradingtranscripts).

**Sexual Harassment**

"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy: [http://regents.umn.edu/sites/regents.umn.edu/files/policies/SexHarassment.pdf](http://regents.umn.edu/sites/regents.umn.edu/files/policies/SexHarassment.pdf)

**Equity, Diversity, Equal Opportunity, and Affirmative Action**

The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or
gender expression. For more information, please consult Board of Regents Policy: 

Disability Accommodations

The University of Minnesota is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact Disability Resource Center at 612-626-1333 to arrange a confidential discussion regarding equitable access and reasonable accommodations.

If you are registered with Disability Resource Center and have a current letter requesting reasonable accommodations, please contact your instructor as early in the semester as possible to discuss how the accommodations will be applied in the course.

For more information, please see the Disability Resource Center website, 
https://diversity.umn.edu/disability/.

Mental Health and Stress Management

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: http://www.mentalhealth.umn.edu.

Academic Freedom and Responsibility: for courses that do not involve students in research

Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.*

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact the instructor, the Department Chair, your adviser,
the associate dean of the college, or the Vice Provost for Faculty and Academic Affairs in the
Office of the Provost. [Customize with names and contact information as appropriate for the
course/college/campus.]

* Language adapted from the American Association of University Professors "Joint Statement
on Rights and Freedoms of Students".