

## COURSE SYLLABUS – *Solid State Physics (COMBINED Physics 4309 & 5304), Fall, 2011*

9:00-9:50 am, Monday, Wednesday, and Friday, Science Room 204

**Instructor:** Dr. Charles W. Myles, Professor of Physics. **Office:** Science Room 18. **Phone:** 742-3768.

**Office Hours:** 10am – noon, M-F & *by appointment*. **Web Page:** <http://www.phys.ttu.edu/~cmyles/>

**Email:** [Charley.Myles@ttu.edu](mailto:Charley.Myles@ttu.edu). A distribution list will be developed for email discussions as needed. I make *important announcements* by email! *Please be sure that I have your email address & check email DAILY!!*

**Course Web Page:** <http://www.phys.ttu.edu/~cmyles/Phys4309-5304/4309-5304.html> *Under Construction!!*

**Course Objective:** To introduce students to the large, broad field of *Solid State Physics*. Students will be exposed to the standard approximations, models & methods of *Solid State Physics* (Condensed Matter Physics, Materials Physics,...) & to the common features in the physics of crystalline materials. This *ISN'T* a semiconductor physics course!! It is about *many kinds* of solids (semiconductors are a special category). We'll discuss the microscopic physics of mostly, *Crystalline* solids. We'll study metals, insulators, & semiconductors. Near the end, we may briefly discuss superconductors & ferromagnets. A general approach will often be used, with most discussion applying equally well to metals, insulators, & semiconductors. This course is designed to *complement & supplement Phys. 5335* (semiconductors) *NOT* to replace it! If you want to learn more about semiconductors, take *Phys. 5335*. It is taught in the Fall of even numbered years.

**Learning Goals:** Through regular homework & classroom discussion, students in this course will

1. Explore the relationships between chemical bonding & crystal structure.
2. Map periodic structures (lattice, unit cells) onto reciprocal space ( $\mathbf{k}$ -space lattice, Brillouin Zone).
3. Construct electronic energy band structures  $E(\mathbf{k})$  & phonon dispersion curves  $\omega(\mathbf{k})$  in simple models.
4. Have a general idea of the physics behind the various computational methods to calculate realistic energy band structures  $E(\mathbf{k})$  & phonon dispersion curves  $\omega(\mathbf{k})$ .
5. Model electrical & energy transport at several levels of mathematical sophistication.
6. Examine the properties of semiconductor materials, and the doping requirements for their use in electronics.
7. Explore the optical properties of solids & the optical characterization of electronic excitations.
8. Encounter special material properties such as superconductivity, magnetism, piezo-electricity, etc.

By the end of the course *students should have developed* a basic, working knowledge of the theoretical & experimental concepts & methods used to study crystalline solids, & should have built up the necessary background to begin to understand the language encountered in research publications or presentations on solid state topics.

**Assessment:** How well students have mastered the concepts & techniques covered in this course will be evaluated by their performance on homework & exams. Homework is designed so that students perform model calculations in each area of the learning goals. Exam problems & questions are designed to probe knowledge developed through this process, with emphasis on how well students have understood the underlying physical ideas. Graduate students will also be evaluated on whether they have developed a capacity to extract useful content from research literature. This will be demonstrated by their special project report & presentation.

### Student Responsibilities

*Come to class prepared, do the homework, read the material before I lecture over it, keep up as we go.*

**Physics Level:** This is a combined Undergraduate/Graduate Course, for upper level Physics Majors & Physics Graduate students who will do Solid State Physics research or who would like to broaden their education beyond their own research area. Upper level Undergraduates & Graduate Students in Physics-related fields are welcome! Knowledge of *elementary quantum mechanics & statistical physics* is assumed. **This is an UPPER LEVEL course!!** The text is at the upper undergrad level. Supplements are more advanced.

**Textbook:** *Introduction to Solid State Physics*, by C. Kittel, *8<sup>th</sup> Edition!* (Wiley, 2005). ISBN-10: 047141526X. ISBN-13: 9780471415268. Portions of the lectures will come from this book. Topics will be discussed in approximately the same order as in its table of contents. Material from supplements & from many other sources will also be used. This book has been the world-wide standard introductory solid state text for 50+ years! It emphasizes physics rather than formal mathematics. It is available in hardbound or paperback. New, used, & "international" versions are possible. The publisher's price is *the absurd amount* of \$152.95! *I urge you to shop for it & to find the best price for you!!!*

**Webpage:** <http://he-cda.wiley.com/WileyCDA/HigherEdTitle/productCd-047141526X.courseCd-PH1900.html>.

**Supplemental Texts:** Having these is optional. Portions of the course will use some of the information in them.

1. ***Elementary Solid State Physics: Principles and Applications***, by M. Ali Omar. *4<sup>th</sup> Edition*. (Addison Wesley, 1994). ISBN-10: 0201607336, ISBN-13: 9780201607338. **Book Webpage:**  
<http://www.pearsonhighered.com/educator/product/Elementary-Solid-State-Physics-Principles-and-Applications/9780201607338.page>
2. ***Solid State Physics***, by Neil W. Ashcroft & N. David Mermin. (Thomson Brooks/Cole, 1976). ISBN-10: 0030839939, ISBN-13: 978-0030839931. **Book Webpage:**  
<http://www.cengage.com/cengage/catalog.do?courseid=PC09&disciplinenummer=13&codeid=71E2&codeFlag=true>

**Lectures:** These will often come from the book by Kittel, supplemented by material from the supplements, research notes, published papers & web resources.

**Other Supplements:** There are *many* solid state physics books at various levels of depth & difficulty. In Rm. 18, I have shelves full of them! The library has more, as does the internet. Mine are available to look at & check out. In an **upper level** course, ***I expect you to go to sources other than the texts*** to obtain different treatments of the material! I'll sometimes lecture from outside the text (e.g. from the literature or my own notes). The text & supplements have extensive bibliographies for each chapter. ***PLEASE USE THEM!***

**Course Topics:** The basics of solid state physics will be surveyed. As a survey, topics must be covered rapidly. A goal is to cover an overview of selected topics in Chs. 1-10 of the text by Kittel. Some material will also be taken from the supplemental books, & many other sources. Detailed topic coverage will be announced as we go.

**Approximate Lecture Schedule** (Chapter numbers refer to the book by Kittel)

<b>Topics:</b>	<b>Chapter</b>	<b>Approx. # of Lectures</b>
1. Crystal Structures	1	3
2. Chemical Bonding, Crystal Binding Energies	3	3
3. Wave Diffraction, Reciprocal Lattice, Brillouin Zone	2	3
4. Elastic Properties, Phonons, Thermal Properties	3,4,5	6
5. Electronic Properties, Energy Bands, Band Structures	6,7	5
6. Semiconductors, Doping, Carrier Statistics	8	3
7. Fermi Surfaces, Metals	9	3
8. Excitations, Optical Properties	14,15	6
9. Electron Scattering, Carrier Mobility, Transport		3
10. Impurities, Defects, Surfaces, Interfaces	17	3
11. Other Topics as time permits?		3?

**TOTAL # of Lectures = 41**

*This is not meant to be rigid, but to give us an idea where we are going. Some topics in some chapters may be omitted; some topics from outside sources will be included*

**Grades Will Be Determined as Follows**

**Undergraduates (Phys. 4309):** **Homework = 30%, Mid-Term Exam = 35%, Final Exam = 35%**

**Graduate Students (Phys. 5304):** **Homework = 25%, Mid-Term Exam = 25%, Final Exam = 25%**

**Project = (Paper + Presentation) = 25%.**

**HOMEWORK:** Problems will be assigned regularly. Doing them is the best means of learning physics! It is impossible to do this without working problems! Homework is due at 5pm on the due date. To keep up, do the assignments as soon as the material is covered. The problems are ***NON-TRIVIAL!*** If you wait to the last day, you likely will run into trouble! ***No late homework will be accepted.*** Homework may be done individually or in consultation with others. ***The latter is encouraged; this is how scientists work in real situations!***

**EXAMS:** There will be a **Mid-Term Exam** & a **Final Exam**. They may have in class portions with qualitative questions to evaluate the students' grasp of the physics & identification of the relevant physical processes. They may also have take home portions with problems to assess progress in using relevant math tools.

**SEMESTER PROJECT:** (Graduate Students in Phys. 5304!) **A Library Research Paper + Presentation:**

On an advanced topic or application of Solid State Physics that we don't have time for in class. The paper is due near the end of the semester. Oral presentations on the same subject will take place then. ***You should have the topic picked by mid-semester. Topics must be approved by me before you begin.*** The paper should be 5-10 typed pages & written in the style of a scientific paper, with several sources properly cited. The presentation should be about 0.5 hour long. It can be (but isn't required to be!) done in Power Point.

**Approximate Grade Scale: 100 ≥ A ≥ 88 > B ≥ 76 > C ≥ 64 > D ≥ 52 > F ≥ 0**

**NOTE: I reserve the right to slightly alter these cutoffs! I reserve the right to assign a higher grade to anyone whose efforts may not be reflected in their total points. This decision is mine alone to make.**

**ACADEMIC INTEGRITY:** Academic dishonesty (cheating, etc.) won't be tolerated. Students caught in this type of behavior will be punished to the fullest extent allowed by TTU. See TTU Catalogue.

### **CLASSROOM CIVILITY AND ETIQUETTE**

Students are expected to assist in maintaining an environment which is conducive to learning. To assure that everyone has an opportunity to gain from the lecture, you are expected to adhere to the following

#### **Simple Rules of Classroom Etiquette**

1. In the classroom, students are prohibited from using cell phones (**talking OR texting!**), eating, drinking, making offensive remarks, reading newspapers or other unrelated material, visiting with your neighbor, sleeping or engaging in other forms of distraction. Inappropriate behavior of this kind shall result in, minimally, **a request to leave the room.**
2. It is **EXTREMELY RUDE**, both to me & to other students, to leave during a lecture or to arrive very late. Please do not come to the lecture if you are unable to attend for the full duration or if you are not able to **arrive on time!** Physical illness is an obvious exception to this rule. If you have an expected reason to leave early, please tell me **BEFORE** I begin the lecture & sit in a convenient location for leaving without disturbing the class.

### **DISABILITY STATEMENT**

***Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services. Please note that instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For more information, contact Student Disability Services in 335 West Hall or 806-742-2405.***

### **IMPORTANT DATES**

**Tues., Aug. 30:** Last day to add a course.

**Mon., Sept. 5:** Labor Day, ***NO CLASSES!***

**Mon., Sept. 12:** Last drop date with a refund.

**Thurs., Sept. 22:** Last withdrawal with refund.

**Mon., Oct. 10 – Tues., Oct. 11:** “Fall Break”, ***NO CLASS!***

**Mon., Oct. 24:** Mid-Semester. Mid-term Exam (!)?

**Mon., Oct. 31:** Last drop date.

**Wed., Nov. 23 - Sun., Nov. 27:** Thanksgiving, ***NO CLASS!*** **Wed., Dec. 7:** Last class.

**Fri., Dec. 9-Wed., Dec.14:** Final Exam Time: ***Student Presentations to be scheduled!***

**Tues., Dec. 13:** Final Exam! (4:30-7:00pm!)

**Sat., Dec. 17:** Grades are due!

**Thurs., Oct. 6 - Sat., Oct. 8:** ***I'll be out of town!*** (Texas Section APS Meeting, Texas A&M – Commerce) I may also be out of town a few other times. I'll try to arrange a substitute for **Fri., Oct. 7** & for any other times I am gone.

### A PARTIAL listing of some books on Solid State Physics

1. A.O. Animalu, *Intermediate Quantum Theory of Crystalline Solids*, (Prentice Hall, 1977) [Advanced].
2. N.W. Ashcroft and N.D. Mermin, *Solid State Physics*, (Holt, Rinehart & Winston, 1976) [Graduate].
3. M Balkanski, RF Wallis, *Semiconductor Physics and Applications*, (Oxford, 2000) [Excellent math details].
4. J.S. Blakemore, *Solid State Physics*, (Cambridge, 1985) [Undergrad, strong semiconductor sections].
5. G. Burns, *Solid State Physics*, (Academic, 1985) [Undergrad/Graduate].
6. J.R. Christman, *Fundamentals of Solid State Physics*, (Wiley, 1988) [Undergrad/Graduate].
7. W.A. Harrison, *Electronic Structure and the Properties of Solids*, (Dover, 1989). [Graduate, various levels]  
(Harrison also has several other advanced solid state texts)
8. W Jones and N.H. March, *Theoretical Solid State Physics*, 2 vols, (Dover, 1985) [Advanced].
9. C. Kittel, *Quantum Theory of Solids*, (Wiley, 1963) [Advanced].
10. R.A. Levy, *Principles of Solid state Physics*, (Academic, 1968) [Undergrad].
11. O. Madelung, *Introduction to Solid State Theory*, (Springer-Verlag, 1978) [Advanced]

### PARTIAL listing of some World Wide Web resources on Solid State Physics

**NOTE:** There is a lot of material on the web which is potentially useful as Solid State Physics references. I have not had time to check out the details of most. I list some here just to give you an idea what is out there & to help you to get started searching yourself. For example, you might want to search on particular Solid State Physics topics as we get to them in class. If you do this & find some sources that are interesting & useful, please let me and/or the rest of the class know by email or orally in class. Thanks!

1. **THE AMERICAN PHYSICAL SOCIETY.** Go to <http://www.aps.org/>. There is a Search Engine near the top right corner. Typing in “Solid State Physics”, “Condensed Matter Physics” & “Materials Physics” gives 3,030 documents, 264 documents, & 1,080 documents respectively!! **NOTE:** APS is a 50,000 + member organization of professional physicists from around the world. **Everyone who wants to be a professional physicist should join!** If you are not a member yet, you should join. There is **NO** excuse for not doing this! ***For students, the first year's membership is free*** (You can do this online. The application form must be signed by the Chairman). You get free Physics Today, APS News, & discounted journals.
2. **THE AMERICAN INSTITUTE OF PHYSICS.** Go to <http://www.aip.org/>. There is a Search Engine near the top right corner. Typing in “Solid State Physics”, “Condensed Matter Physics” & “Materials Physics” gives 2,900 documents, 2,640 documents, & 1,150 documents respectively!!
3. **THE MATERIALS RESEARCH SOCIETY.** Go to <http://www.mrs.org/home/>. There is a Search Engine near the top right corner. Typing in “Solid State Physics”, “Condensed Matter Physics” & “Materials Physics” gives 77,382 documents, 77,334 documents, & 77,384 documents respectively!! **NOTE:** MRS is also a worthwhile organization for professional materials researchers. It is multidisciplinary & has members in physics, electrical engineering, mechanical engineering, chemical engineering, chemistry, materials science, & others.
4. **PHYSICS WORLD:** Go to <http://physicsworld.com/>. (This is based in the U.K., so it has a U.K.–European flavor). Near the top, there is a category: **Browse by Subject Area**. Click on “Condensed Matter”. This leads to numerous links about Condensed Matter Physics, Materials Physics, & Solid State Physics. These range from very elementary to very advanced resources, including some research journals. There is a Search Engine near the upper right corner. Type in “Solid State Physics”. This alone leads to 3,814 hits!
5. **GOOGLE:** Type “Solid State” into this and you will get 7,070,000 web pages!
6. **An Amusing Solid State Physics site:** “Britney Spears' guide to Semiconductor Physics”: <http://britneyspears.ac/lasers.htm>. (**Not a joke!**)