COURSE SYLLABUS – *Solid State Physics* (*COMBINED* Physics 4309 & Physics 5304), Fall, 2009

9:00-9:50 am, Monday, Wednesday, and Friday, Science Room 112

Instructor: Dr. Charles W. Myles, Professor, Department of Physics. **Office:** Sc. Rm 18. **Phone:** 742-3768.

Office Hours: 10am – noon + 3pm – 4pm MWF & ***by appointment***.

Web Page: http://www.phys.ttu.edu/~cmyles/. **Email:** Charley.Myles@ttu.edu**.** A class distribution list will be developed & we can have email discussions. I make announcements by email! Please make sure that I have your correct email address, that you check email ***DAILY*** & that you tell me if you change email addresses!

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

Objective: To introduce students to the field of ***Solid State Physics.*** A student will be exposed to the standard approximations, models & methods of Solid State & to the common features in the physics of crystalline materials. This ***ISN'T*** a semiconductor physics course!! It's 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'll try to briefly discuss superconductors & ferromagnets. A general approach will often be used, with most discussion applying to metals, insulators, & semiconductors. This course is designed to ***complement & supplement*** **Phys 5335** (semiconductors) ***NOT*** replace it! If you want to learn more about semiconductors, take **Phys 5335**. It's 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 (**k**-space lattice, Brillouin Zone)
3. Construct electronic energy band structures E(k) & phonon dispersion curves ω(k) in simple models
4. Model electrical & energy transport at several levels of mathematical sophistication
5. Examine the properties of semiconductor materials, doping requirements for use in electronics
6. Explore the optical properties of solids & optical characterization of electronic excitations
7. Encounter special material properties such as superconductivity, magnetism, piezo-electricity, etc

By the end of the course a ***student should have developed*** a basic working knowledge of the concepts and methods used to study crystalline solids, and to 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 the homework & the exams. Homework is designed so that a student performs model calculations in each area of the above learning goals. Exam problems & questions are designed to probe knowledge developed through this process, with emphasis on how well a student has understood the underlying physical ideas. Graduate students (**Phys 5304**) are also evaluated on whether they have developed a capacity to extract useful content from research literature. This is 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! It is designed for upper level Undergraduate Physics Majors & Physics Graduate students who either will do Solid State Physics research or who would like to broaden their education in Physics beyond their own research area. Upper level Undergraduates or Graduate Students in fields related to physics are also welcome! A knowledge of ***elementary quantum mechanics*** & ***statistical physics*** is assumed. **This is an *UPPER LEVEL* course!!** The primary text is at the upper undergraduate level. The supplements are somewhat more advanced.

Textbook: ***Introduction to Solid State Physics***, by Charles Kittel, ***8th Edition!*** (Wiley, 2005). ISBN-10: 047141526X. ISBN-13: 9780471415268. Major portions of the lectures will come this book. Topics will be discussed in approximately the same order as in it's table of contents. Material from the 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 $131.95!

I urge you to shop for it & to find the best price for you!!!

Book 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. ***4th 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&disciplinenumber=13&codeid=71E2&codeFlag=true

Lectures: Will usually be from the book by Kittel, supplemented by material from the supplemental texts, research notes, published papers & web resources.

Other Possible Supplements: There are ***many*** books on solid state physics at various levels of depth & difficulty. In Rm. 18, I have shelves full of them! The library has many more. Mine are available to look at & to 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 research notes). The text & the supplements have extensive bibliographies for each chapter. ***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, as an overview, selected topics in Chs. 1-10 of the text by Kittel. Some material will also be taken from the supplemental books, & from many other sources. Detailed topic coverage will be announced as we go. ***An approximate*** schedule of topics is on the next page.

Grades are 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: Will be assigned regularly. Doing it is your 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 assignments as soon as material is covered. 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 will have in class portions with qualitative questions aimed at evaluating the students' grasp of the physics & identification of the most 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 all (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: Students are to assist in maintaining an environment conducive to learning. To assure that all students have an opportunity to gain from class time, students are prohibited from using cell phones/texting, eating/drinking in class, making offensive remarks, reading newspapers, sleeping or engaging in any other form of distraction.

Inappropriate behavior in the classroom shall result in, minimally, a request to leave class.

Any student who, because of disabling conditions, may require some special arrangements in order to meet the course requirements should contact the instructor as soon as possible so that necessary accommodations can be made. Proper documentation must be presented from the Dean of Students Office!!!

Approximate Lecture Schedule

(Chapter numbers refer to the book by Kittel)

Topics:	Chapter	*Approx.* # of Lectures
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.

IMPORTANT DATES

Tues., Sept. 1: Last day to add a course.

Mon., Sept. 7: Labor Day, *NO CLASSES!*

Mon., Sept. 14: Last drop date with a refund.

Thurs., Sept. 24: Last withdrawal with refund.

Mon.,Oct. 13 - Tues, Oct. 14: "Fall Break", *NO CLASS!*

Mon., Oct. 26: Mid-Semester. Mid-term Exam!

Mon., Nov. 2: Last drop date.

Wed., Nov. 25-Sun., Nov. 29: Thanksgiving, ***NO CLASS!***

Wed., Dec. 9: Last class.

Fri., Dec. 11-Wed., Dec.16: Final Exam Time: *Student Presentations to be scheduled!*

Mon, Dec. 14: Final Exam! (*7:30-10:00am!*)

Mon, Dec. 21: Grades are due!

Thurs., Oct. 22-Sat., Oct. 24: *I will be out of town!* I may also be out of town a few other times. I'll try to arrange a substitute for **Fri., Oct. 23** & 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].
12. M. Ali Omar, *Elementary Solid State Physics*, (Addison Wesley, 1978) [UG, good on semiconductors].
13. J.M. Ziman, *Principles of the Theory of Solids*, (Cambridge, 1964) [Graduate].
14. J.M. Ziman, *Electrons and Phonons*, (Oxford, 1960) [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 for Solid State Physics. I have not had time to check out the details of most of these. I am listing some here just to give you an idea what is out there and 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 and find some sources that are interesting and useful, please let me and / or the rest of the class know by email or orally in class. Thanks!

A. General Physics resources which might give useful Solid State Physics.

1. **THE AMERICAN PHYSICAL SOCIETY.** Go to the http://www.aps.org/. There is a Search Engine near the top right corner. Type in "Solid State Physics". This gives 1820 documents!! "Condensed Matter" gives 2740 documents and "Materials Physics" gives 8600 documents!! **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. Type in "Solid State Physics". This gives many documents!!
3. **THE MATERIALS RESEARCH SOCIETY.** Go to http://www.mrs.org/. There is a Search Engine near the top right corner. Typing in "Solid State Physics", "Condensed Matter" and "Materials Physics" each give ~100 documents. **NOTE:** MRS is also a worthwhile professional organization to join for professional materials researchers. It is multidisciplinary & has members whose background is in physics, electrical engineering, mechanical engineering, chemical engineering, chemistry, materials science, and others.
4. **PHYSICS WORLD:** 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:** http://www.google.com/. 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!***)