Physics 471 - Solid State Physics Fall 2022

Instructor: Professor Micky Holcomb
Office hours: Unless class conflicts exist, Wednesdays 1:30 – 2:30 pm
Phone: 293-5196; Email: mikel.holcomb@mail.wvu.edu
My preferred method of contact is by the class discussion board on GroupMe.

Course Format:
- Two 75 minutes lectures per week – MWV 11:30 am – 12:20 pm
- PPT lectures and useful class materials will be posted at http://community.wvu.edu/~miholcomb/

Course Texts: *Introduction to Solid State Physics* by Charles Kittel (required, available online) and *Understanding Solid State Physics* by Sharon Holgate (highly recommended). Also recommended (available online) *Solid State Physics* by Ashcroft and Mermin (parts are overwhelming, but it is good.)

Other Reference Texts (**not** required): There are so many books on condensed matter physics and they all have different strengths and weaknesses. I recommend you read more than one, which is one reason why I so strongly encourage Kittel. Here are a few others I like. **Remember that repetition assists learning!**
- *The Solid State* by H. M. Rosenburg
- *Structure and Dynamics* by Martin Dove
- *The Structure and Properties of Materials* by Rose, Shepard and Wulff

Course **Pre**requisites:
PHYS 314: Minimum Grade of D- and MATH 251: Minimum Grade of D-.
It is not required to have taken or be taking Phys 451 or 461.

Course Description:
This course will focus on the fundamental properties of solids. Topics to be studied include chemical bonding, structures of solids, and the properties of phonons and electrons and how they affect physical properties such as heat capacity and conductivity.

Expected Learning Outcomes:
Students who complete this course will be able to:
1. Understand why solids form and the symmetries of different crystal structures.
2. Understand the properties of phonons and their role in the properties of solids.
3. Calculate fundamental properties of metals using the free electron approximation.
4. Explain the nature and role of the electronic band structure in solids.
5. Understand the principles behind selected experimental techniques relevant to solid state physics.
6. Communicate and apply their knowledge of the above topics in written and oral form.

Academic Honesty: You are permitted to discuss homework problems with each other, but actual work must be independent. That is, sharing of ideas while working on homework is allowed and encouraged, but sharing of final solutions is not. Similar copies of results from current or past students or internet resources will be treated as plagiarism, which constitutes academic dishonesty. Please refer to the Graduate Student Handbook and to the appropriate University guidelines regarding the dire consequences of being convicted of academic dishonesty.

If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with Accessibility Services (293-6700). For more info on West Virginia University's Diversity, Equity, and Inclusion initiatives, please see http://diversity.wvu.edu.

Course Grade	Homework	20%
	Exam 1	30%
	Exam 2	30%
	In Class Discussion/Participation	6%
	Holcomb's Grade of Your Presentation	5%
	Class Grade of Your Presentation	4%
	Grading of Your Feedback of Other's Presentations	1%
	Show and Tell Diffraction Day	2%
	Online Class Discussion on GroupMe	2%

This grading scale will apply: A (>85%), B (70% - 84%), C (60% - 69%), D (50% - 59%), F (<49%)

Homework Policy: Homework problem sets will be assigned as indicated on the course calendar. Late assignments will be counted off 20% for every day late. **If** you have a **good** reason, I may decide to lower this penalty. I must be made aware of this reason no later than the due date of the assignment. Repeated requests for extensions will likely be denied.

In Class Discussion: You are expected to **do the reading prior to coming to class** in order for us to be able to focus on the more complicated aspects or misconceptions of the material. As scientific research on education shows that students learn best when they work in small groups and are coached by the professor, we will sometimes take this approach during class time. For you to learn the most out of this experience, you must be willing to be an active participate in problem solving. Thus, your effort (not your correctness) will be graded in these discussions. We often learn more from being wrong than right.

Exams: There will be two in class exams. Both conceptual and quantitative skills will be tested. Most problems will be on a similar level of the in class or homework problems (thus those are study tools).

Presentation: At the end of the semester, each of you will give one 12 minute presentation on a topic of your choice. This topic must be approved by me and I will not approve two people with the same topic so request your topic early. For example, topics might include superconductivity, topological insulators, some aspect of magnetism, or spintronics. In your presentation, you should start with why taxpayers are paying for this research (in other words, what are the potential benefits). You should also present at least one important finding (and why it is important), what are some remaining questions in the field and any connections to material we have learned in class (you should be able to make at least one). Make sure you reference any papers in your Powerpoint files (author, journal, page, year). You should use Powerpoint for most of your presentation. Your peers will be graded on their evaluation of your presentation, which should include both positive and negative *constructive* criticism. This peer evaluation will be provided to you (after names are removed) so that you can improve your presentation style in the future. Afterwards, these presentations must be made available to the class.

Show and Tell Day: After having lectured on diffraction, each student will bring some diffraction results from a recent paper and be ready to lead a discussion for ~5 minutes on what is learned from their specific results and **how we know that**. Plan to talk for about 2 minutes and the rest of the time be spent on questions. Also be prepared for potential questions as to why anyone should care about the particular material. Bring a one page copy of the diffraction results and any *necessary* supporting visuals.

Attendance Policy: While not formally graded (except through the discussion points), you will likely find that attendance in class is necessary in order to do well in the course. Success also depends heavily on your work outside of the classroom. It is expected that you will spend at least 8-10 hours per week outside of class time on the lecture material and the assigned problems. The homeworks are significantly longer during the first third of he course, but you also have more time to do them. I recommend that you do not put the work off to the last minute.

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Planned Schedule

(Topics and homework deadlines may move as needed.)

Week	Dates	Topics	Required Kittel	Extra Resource Holgate	HW Due
1	Aug 17 & 19	Welcome; What is Solid State Physics and Why Is it Important?			
		What does it Mean to Define a Crystal Structure? (Lattice & Basis)	2-11	24-39	
2	Aug 22-26	Identifying Crystal Directions & Planes; Distance Between Planes	11-13	52-57	
		Specific Crystal Examples (**Warning: First two HWs are LONG!**)	13-18	40-51	
3	Aug29-Sep2	Complex Oxides	19-20	Kittel	
		Bragg's Law and Von Laue Formulation & Diffraction Techniques	25-35	126-9,133-9	8/31
4	Sept 7 & 9	Reciprocal Lattice Vectors and Brillouin Zones	34-40	Kittel	
		Structure Factors and Interrepting XRD Patterns	40-43	129-132	
5	Sept 12-16	Diffraction Techniques (Commonly Used Experimental Technique)	112-124	Ashcroft	
	Sept 14	**Diffraction Show and Tell (Mini Student Presentations)**			
	Sept 16	**In Class Test 1 ("cheat sheet" allowed to reinforce learning)**			
6	Sept 19-23	Definition of a Group; Brief Introduction to Group Theory	112-124	Ashcroft	9/21
		Crystal Binding and the Pauli Exclusion Principle	49-60	1-11	
7	Sept 26-30	Ionic, Covalent and Metallic Materials; Brief Topic of Strain	60-73	12-23	
		Phonons are Lattice Vibrations (Analogy with Springs)	91-95	139-144	
8	Oct 3 & 5	Phonons in 2D & 3D, Dispersion Relations	95-100	Kittel	10/5
		Experimentally Measuring Phonons	100-102	Kittel	
9	Oct 10-14	Density of States Applied to Heat Capacity	107-119	Kittel	10/12
		Thermal Expansion and Thermal Conductivity	119-126	149-153	
10	Oct 17-21	Drude Model, Conductivity and Hall Effect	133,147-57	165-174	10/19
		Quantum Free Electron Model and the Fermi-Dirac Distribution	133-145	158-165	
11	Oct 24-28	Heat Capacity of Metals	141-147	Kittel	10/26
		The Origin of the Band Gap; Bloch's Theorem	162-176	174-185	
12	Oct 31-Nov 4	Empty Lattice Bands & Discussion of How Real Bands Differ	177-182	Kittel	11/2
		Intrinsic Semiconductors and Effective Mass	187-207	185-189, 234	
13	Nov 7-11	Catchup			
	Nov. 11	**In Class Test 2 (test dates will not change unless announced)**			
14	Nov 14-18	Growth and Defects; Even Perfectly Grown Materials Have Defects	585-595	62-77, 81-85	
		Surface and Interface Physics and How to Study Them	489-497	Kittel	
	Nov 21-25	Thanksgiving Break			
15	Nov 28-Dec 2	**Student Presentations**			
16	Dec 5 & 7	Catchup and/or Student Requests			
		There will be no class final for this course.			