Physics 771 - Solid State Physics Fall 2020

Instructor: Professor Micky Holcomb
Office hours: Tuesdays & Thursdays 11:15 to 11:45 AM via Blackboard
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My preferred method of contact is by email, however, I do not guarantee
that I will check it on evenings and weekends.

Course Format:

- Two 75 minute lectures per week – TuTh 10 – 11:15 AM, https://us.bbcollab.com/guest/6b24f8f37d344546bc92adc10b16eddc
- Lectures and useful class materials will be posted at http://community.wvu.edu/~miholcomb/

Course Text: *Introduction to Solid State Physics* by Charles Kittel (required)

Other Resources (good references but not required): There are so many books on condensed matter physics and they all have different strengths and weaknesses. I highly recommend that you look at other books as well. Learning material from different viewpoints is critical to learning and there are several ways to approach this course. Not all may make sense to you. Below are a few other books I like.

- *Understanding Solid State Physics* by Sharon Holgate (recommended, excellent conceptually)
- *Solid-State Physics, Essential Concepts* by Ashcroft & Mermin (thorough, perhaps a bit too much)
- *Solid-State Physics, Essential Concepts* by David Snoke (advanced, great quasiparticle approach)
- *Solid State Physics* (Dover, 1980) by Walter Harrison (nice but doesn't cover all topics)
- *Condensed Matter in a Nutshell* by Gerald Mahan (good motivation but not much detail)
- *A Quantum Approach to Condensed Matter Physics* by Taylor & Heinonen (a nice approach)
- *Principles of the Theory of Solids*, by J. M. Ziman (more advanced)
- *Quantum Theory of Solids* 2nd Revised Printing (Wiley & Sons, 1987), by Charles Kittel

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:	25%
	Exam 2:	25%
	Final Exam:	25%
	Online Discussion (When Requested):	5%

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.

During 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 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. You do not have to be present at all lectures to get full discussion points, but you should be at most of them. If this is not possible for some reason, you should discussion your situation with the professor.

Student Discussion: I would like to encourage you to discuss with each other. I will discuss different discussion board options in class, such as Facebook. We may decide to adopt such a practice, and if so, you will be encouraged to post your questions there for I and your classmates to discuss.

Exams: The two midterms and final will be take home (see dates on schedule). Both conceptual and quantitative skills will be tested. You will be expected to email me your legible solutions by the identified due time.

Sick Policy: If a student becomes sick, they should notify the instructor as soon as possible. The student should work with the instructor to develop a plan to complete the course learning outcomes.

Synchronous Learning: It is my intention to teach live during the scheduled course time. You are very strongly encouraged to attend all lectures during the course time, however, the lectures will be recorded if you miss the course for whatever reason. These recordings may also be useful for review.

771	Planned Schedule			
	(Topics and homework deadlines may move as needed.)		Extra	
		Required	Resource	**HW**
Date	**Topic**	**Kittel**	**Holgate**	**Due**
26-Aug	Welcome; What is Solid State Physics and Why Is it Important?	N/A	N/A	
1-Sep	What does it Mean to Define a Crystal Structure? (Lattice & Basis)	2-11	24-39	
3-Sep	Identifying Crystal Directions and Planes; Distance Between Planes	11-13	52-57	
8-Sep	Specific Crystal Examples	13-19	40-51	
10-Sep	Bragg's Law and Von Laue Formulation & Diffraction Techniques	25-35	126-9,133-9	HW 1
15-Sep	Reciprocal Lattice Vectors and Brillouin Zones	34-40	Kittel	
17-Sep	Structure Factors and Interrepting XRD Patterns	40-43	129-132	
18-Sep	**Optional**: MSE Seminar on Holcomb Group Research			
22-Sep	Definition of a Group; Brief Introduction to Group Theory	112-124	Ashcroft	HW 2
24-Sep	Crystal Binding and the Pauli Exclusion Principle	49-60	1-11	
29-Sep	Ionic, Covalent and Metallic Materials	60-73	12-23	HW3
1-Oct	Stress and Strain (only basics on test)	73-85	96-111	
6-Oct	**Class Test 1** (Crystal & Reciprocal Lattices and Diffraction)			HW4
8-Oct	Phonons are Lattice Vibrations (Analogy with Springs)	91-95	139-144	
13-Oct	Phonons in 2D & 3D, Dispersion Relations & Neutron Scattering	95-101	Kittel	
15-Oct	Density of States Applied to Heat Capacity	107-119		
20-Oct	Thermal Expansion and Thermal Conductivity	119-126	149-153	HW5
22-Oct	Drude Model, Conductivity and Hall Effect	133,147-57	165-174	
27-Oct	Quantum Free Electron Model and the Fermi-Dirac Distribution	133-145	158-165	HW6
29-Oct	Heat Capacity of Metals	141-147		
3-Nov	No Class; Election Day; Vote and/or Encourage Others To!			
5-Nov	**Class Test 2** (Phonons, Density of States, Drude, Heat Capacity)			
10-Nov	The Origin of the Band Gap; Bloch's Theorem	162-176	174-185	
12-Nov	Empty Lattice Bands and Number of k States per Band	177-182	Kittel	
17-Nov	Intrinsic Semiconductors and Effective Mass	187-207	185-189, 234	
19-Nov	Tight Banding Method for Energy Bands	223-235		HW7
24-Nov	Other Methods of Calculating Energy Bands	236-242	189-196	
1-Dec	Growth and Defects; Even Perfectly Grown Materials Have Defects	585-595	62-77, 81-85	
3-Dec	Surface and Interface Physics and How to Study Them	489-497	Kittel	

Cumulative Final (Open book)

Kittel references become much more useful in second half of the course.