Physics 424—Solid State Physics
Section 1, MWF 11:00 a.m.
Course Description, Spring 2015

Instructor:	Andrew Dougherty
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Web Page:	http://workbench.lafayette.edu/∼doughera/courses/phys424/

Office Hours: Beyond my posted office hours, I will usually be either in my office or lab during the free times indicated on my schedule. Please feel free to call, e-mail, or stop by at any time and ask a question or set up an appointment.

Classes on Snow Days and Other Emergencies: If I am unable to make it to class, I will leave a message on my voice mail (610-330-5212).

Description: This course is an introduction to the properties of crystalline solids. We will consider their structure, as well as their electrical, thermal, and magnetic properties. One of the emerging themes will be understanding how macroscopic behavior emerges from the underlying microscopic physics. Topics will include the basic principles of quantization and matter waves, Fermi statistics, crystal structures, diffraction phenomena in crystals, conduction electrons in metals, the concept of conduction by holes, and the basic physics of electrons and holes in both homogeneous and doped semiconductors.

The student work in this course is in full compliance with the federal definition of a four credit hour course. Please see the Registrar's Office web site `http://registrar.lafayette.edu/additional-resources/cep-course-proposal/` for the full policy and practice statement.

Prerequisites: Phys 335 (Thermal Physics) and Phys 351 (Quantum Theory).

Student Learning Outcomes: After completing this course, you should be able to

- predict the specific heat of metals using the free electron model,
- characterize different types of bonds that hold solids together,
- describe the geometry of common three-dimensional crystals, both in terms of the lattice and the reciprocal lattice,
- calculate materials properties based on the scattering of neutrons or X-rays,
- explain the origin and importance of energy bands in solids
- characterize the behavior of electrons and holes in both intrinsic and doped semiconductors, and
- describe the common magnetic properties of solids.

Text: *The Oxford Solid State Basics* (1st. ed.) by Stephen H. Simon, published by Oxford University Press (ISBN: 978-0-19-968077-1) Additional texts will be placed on reserve in the library. The most commonly-used text is probably *Sold State Physics* by Charles Kittel, but the library only has very old editions. A second text that was explicitly designed to be particularly accessible, but is now a bit dated, is *Elementary Solid State Physics: Principles and Applications* by M. A. Omar. The library also has access to additional electronic resources. Links to several texts are given on the course web page.

Your Responsibilities:

Read the text. You should read the text ahead of time. I have included a detailed daily syllabus so you know what the assigned readings for each day will be.

Ask questions. If you are confused, it is important that you stop me and try to sort it out rather than falling behind. *Please* interrupt and stop the class whenever anything isn't clear. Remember that if you are confused, there are almost certainly many others who are confused as well, and they would welcome your question.

Keep up. A typical college class at Lafayette ought to take about 12 hours per week (including class time). Plan ahead. I am here to help. If you start on your homework ahead of time, I will be available to help you if you get stuck. Don't wait until the night before an assignment is due before starting it.

Participate in class. Class time will be used to go beyond merely reading the text. Your active engagement during class can play an important part in helping you to master the material. Class time will also be used to announce changes to the syllabus. It is *your* responsibility to keep up.

Grades: There will be weekly homework, two in-class tests as indicated on the syllabus, and a comprehensive final exam. Your final grade will be determined from the homework (35%), problem presentations (5%), tests (30% total—20% for the higher test score, and 10% for the lower one), and final exam (30%). The lowest homework grade will be dropped.

Homework Problems:

- Problems will be due at the *beginning* of class.
- One homework set may be submitted late without penalty, but any additional sets submitted late will be penalized 10% (out of 100%) for each weekday following the due date. Homework sets submitted after the start of class on the due date will be considered one day late.
- *Problem Presentations:* We will occasionally have student presentations of problems. The specific problems will be announced at least one class meeting in advance. One purpose of these presentations is to help yourself and others understand particularly difficult problems. A second equally important purpose is to gain practice explaining technical work to others.
  These presentations will only be helpful if you have *already* tried to solve the problems *before the class presentation*. You may use the results of these in-class presentations in your own homework solutions, provided you acknowledge the help.
- For written homework, please staple your pages together. This ensures your pages don't get lost.
- **Illegible papers will not be accepted**. If I have difficulty reading or understanding your work, I may return it to you ungraded for re-submission. You may resubmit a legible version (along with the original) by the next class meeting, but that version must not have any new content—it must simply be a legible version of the original.

Academic Honesty: The fabric of science, and indeed any intellectual endeavor, is built on the integrity of all involved. Accordingly, I take academic honesty very seriously. I

expect that you will abide by the "Principles of Intellectual Honesty" appearing in the Lafayette College Student Handbook.

Working with others is often a helpful way to learn physics. I encourage you to collaborate with each other on homework, but unless specifically directed otherwise, all work you turn in as your own should be your own.

Academic dishonesty can hurt you in many different ways. First, of course, it is wrong to turn in someone else's work as your own. If you get caught, the penalties can be severe. Second, it hurts your grade. Learning to do problems by yourself is the best preparation for the tests. Students who take the "easy" way out and get excessive or inappropriate help from others tend to get significantly lower grades on the tests.

There are a variety of resources available to help you in your study of physics. These include my office hours, and working with classmates. Some students also find it useful to consult other texts, friends, and even a variety of on-line sources. In all cases, though the principles of academic honesty apply: All collaborators must be acknowledged (apart from your instructor), and all work you turn in must be your own.

Please read the department's Academic Honesty policy for the rules regarding collaboration. Feel free to ask if you have any questions about this policy.

Final Exam: There will be a comprehensive final exam at a time to be arranged by the registrar. *Please do not make travel plans that conflict with the scheduled exam time.*

Andrew Dougherty Spring 2015
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Time	Mon.	Tues.	Wed.	Thurs.	Fri.
8:00 8:30	*prep*		*prep*		*prep*
9:00 9:30	**Phys 218** HSC 017		**Phys 218** HSC 017		**Phys 218** HSC 017
10:00 10:30	*prep*		*prep*		*prep*
11:00 11:30	**Phys 424** HSC 017		**Phys 424** HSC 017		**Phys 424** HSC 017
12:00 12:30					*Physics Club*
1:00 1:30	*prep*				
2:00 2:30	**Phys 218 Lab** HSC 042		*Office Hours*	*Office Hours*	
3:00 3:30					
4:00 4:30	Department Meeting	Committee Meeting	*Physics Club*		

ACADEMIC HONESTY GUIDELINES
Department of Physics

It is expected that each student taking courses in the Department of Physics is familiar with the statement "Principles of Intellectual Honesty" appearing in the Lafayette College Student Handbook. The following guidelines are intended to indicate how that statement pertains to your work in physics. Your instructor may have further guidelines for your specific course. We assume that students are honest; if you are not certain as to what is expected of you, consult your instructor before proceeding.

I. EXAMINATIONS:

1. Bring only those materials specifically authorized by your instructor. Frequently in the elementary courses, you will be permitted to bring in a formula sheet or you will be provided with one.
2. If you find that the seating arrangement is such that you can see someone else's paper, don't look! Better yet, ask if you can sit in another seat.
3. If you use a calculator, clear the answer before setting the calculator aside.
4. If you fail to hand in your paper at the end of the period you will be awarded a grade of zero for that test.

II. TAKE-HOME EXAMINATIONS: Take-home examinations are often assigned in some courses. Specific rules governing such tests will be announced by your instructor. The overriding principle, however, is that any work submitted be your own or be specifically credited to its source. There should be no discussion of the test questions with *anyone* other than the instructor.

III. HOMEWORK: You must acknowledge *all* collaborators. You are encouraged to learn from one another. You should first try to do homework problems on your own; after all you will have to do similar problems on your own in tests. However, discussion of difficult problems with others can help you to develop your own analytical skills and is encouraged, provided that, *after discussion* you write up solutions *on your own.* Do *not* borrow or lend homework papers. There is an important difference between discussing a problem with someone and copying his or her work. There have been students who have loaned papers to friends for a few minutes to "check answers", and been horrified to find themselves charged with academic dishonesty because their "friends" copied their solutions.

Please Note: The same ethical standards of academic integrity and honesty apply to the on-line homework as to the written homework, except that there is no place for you to specifically acknowledge collaboration. However, the same general rules apply.

IV. LABORATORY: Usually two or more students will work together in performing experiments and will submit reports of their work. In some courses, a single joint report may be submitted. Specific instructions will be announced by your instructor. If the words used to describe some part of the experiment are taken from some other source (such as the lab manual), then the source should be cited. (Reference to the lab manual can usually substitute for laborious copying.) If you consult with *anyone* about the experiment (e.g. students in your lab class other than your lab partner), that consultation should be acknowledged in your report. Do *not* borrow or lend a completed lab book or any portion of one.

V. PAPERS: Refer to the statement "Principles of Intellectual Honesty" in the Student Handbook.

Syllabus		Physics 424	Spring 2015
Jan.	26	Introduction	Ch. 1
	28	Specific Heats	Ch. 2
	30	Specific Heats; Debye; HW #1 ;	Ch. 2
Feb.	2	Electrons in Metals: Drude Theory	Ch. 3
	4	Thermal Transport	Ch. 3
	6	Free Electron Model; HW #2	Ch. 4
	9	Magnetic Susceptibility	Ch. 4
	11	Periodic table	Ch. 5
	13	Bonding – Ionic and Covalent; HW #3	Ch. 6
	16	Bonding – Van der Waals and Metallic	Ch. 6
	18	Types of Matter	Ch. 7
	20	One-Dimensional Models; HW #4	Ch. 8
	23	One-Dimensional Monatomic Chain	Ch. 9
	25	Phonons	Ch. 9
	27	One-Dimensional Diataomic Chain; HW #5	Ch. 10
Mar.	2	Normal Modes of the Diataomic Solid	Ch. 10
	4	Tight Binding Model in One Dimension	Ch. 11
	6	Bands; HW #6	Ch. 11
	9	**Hour Test I**	Chs. 1–11
	11	Lattices and Unit Cells	Ch. 12
	13	Packing	Ch. 12
	16–20	*Spring Break*	
	23	Reciprocal Lattice in Three Dimensions	Ch. 13
	25	Brillouin Zones	Ch. 13
	27	Electronic and Vibrational Waves; HW #7	Ch. 13
	30	Scattering: Laue and Bragg conditions	Ch. 14
Apr.	1	Scattering Amplitudes	Ch. 14
	3	Scattering Experiments; HW #8	Ch. 14
	6	Nearly Free Electrons	Ch. 15
	8	Bloch's Theorem	Ch. 15
	10	Energy Bands; HW #9	Ch. 16
	13	Tight Binding	Ch. 16
	15	Band Structure and Optical Properties	Ch. 16
	17	Semiconductors, electrons, and holes; HW #10	Ch. 17
	20	Doping; Statistical Mechanics of Semiconductors	Ch. 17
	22	Semiconductor Devices	Ch. 18
	24	**Hour Test II**	Chs. 12–18
	27	Magnetic Properties of Atoms	Ch. 19
	29	Paramagnetism and Diamagnetism	Ch. 19
May	1	Atoms in Solids; HW #11	Ch. 19
	4	Spontaneous Magnetic Order	Ch. 20
	6	Breaking Symmetry	Ch. 20
	8	Domains and Hysteresis; HW #12	Ch. 21
		Final Exam (cumulative)	