Physics 218—Oscillatory and Wave Phenomena
Section 1, MWF 9:00 a.m.
Lab: Monday 2:10–3:00 p.m.
Course Description, Spring 2015

Instructor:	Andrew Dougherty
Office:	HSC 030 610-330-5212
Lab:	HSC 019 610-330-5212
E-mail:	doughera@lafayette.edu
Web Page:	http://www.lafayette.edu/∼doughera/phys218/

Office Hours: Please feel free to e-mail, call or stop by at any time and ask a question or set up an appointment. I will be available during my office hours and on most other days during the free times indicated on my schedule.

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 a continuation of the study of oscillations and waves begun in the fundamental courses, with a significant emphasis on experimental and computational approaches as well as traditional analytical work. The course will explore oscillatory and wave phenomena found throughout nature. Phenomena studied will include vibrations of mechanical systems, oscillations in electrical circuits, the general behavior of damped oscillations and resonance, normal mode analysis, Fourier analysis, standing wave phenomena, wave propagation, and optics.

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: Physics 132, 133, or 152. Corequisite: Math 264 (Differential Equations). A familiarity with *Mathematica* will also be assumed.

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

- Identify systems where simple harmonic motion is an appropriate model for motion,
- Use complex numbers to solve problems involving damped, driven harmonic oscillators and traveling waves,
- Recognize and solve for normal modes of oscillation in coupled oscillator systems,
- Apply Fourier analysis to oscillating systems, and
- Apply the basic principles and practices of error analysis in experimental physics.

Texts: *Waves and Oscillations*, by Walter Fox Smith (Oxford University Press), and *An Introduction to Error Analysis*, by John R. Taylor. Additional material will be drawn from your introductory physics text. We will use *Mathematica* extensively in this class. If you would like a good, relevant introductory book I recommend *Getting Started with Mathematica*, by C-K. Cheung, Gerard E. Keough, Robert H. Gross, and Charles Landraitis.

Attendance: Regular attendance is expected. It is **your** responsibility to keep advised of all assignments. If you will be absent for several classes, you should let me know in advance if possible.

Homework: Homework plays a central role in the study of physics. Assignments are designed both to give you deeper exposure to the ideas of the course, and to help you become fluent with the tools and techniques required for the mastery of the subject. Assignments will be given regularly and will ordinarily be due one week after they are given out. The following guidelines will be in effect:

- 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 points (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.
- 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.

Tests: There will be three tests on the dates indicated on the syllabus. Tests may consist of both an in-class and an out-of-class portion. There will also be a comprehensive final exam at the time determined by the registrar.

Labs: The experimental study of nature is an important part of this course as well. A significant portion of the course will be devoted to laboratory experiments. In addition to performing experiments on specific topics, you will also gain experience in computer acquisition and analysis of data, error analysis, and modern instrumentation techniques.

Numerical Simulations: We will also explore numerical simulations of oscillatory and wave phenomena. Such explorations can provide a different, but important, perspective on natural phenomena. They allow you to change parameters more quickly and conveniently than is usually possible in real experiments. You will also be able to visualize and study phenomena that are difficult to observe directly in the laboratory.

Lab Notebook and Reports: You are required to keep an accurate and complete log of your lab work in this course in a laboratory notebook. This notebook will not be graded, but it must contain all the information needed to analyze the experiment, as was the case in your introductory physics course.

For each experiment, you must submit a *brief* report by the due date indicated on the schedule below. This report should not duplicate material in the original hand-out or in your text, but it should include the following:

1. Introduction. Give a *brief* introduction both to the theory and experiment. Specific references to a text or the lab handout should be used instead of laborious copying. Be sure, however, to clearly state the main idea of the experiment and the basic technique to be used.

2. Procedure. It is not necessary to discuss the procedure unless you make any modifications to the experiment. Sometimes, this section can be skipped.

3. Data. Give a clear presentation of your data.

4. Results and Discussion. This is the heart of the report. You need not reproduce algebra steps, but be sure that enough information is given that another student in a course similar to Phys 218 could understand what you have done. All graphs should be clearly labeled. All quantities should have appropriate units and uncertainties, where applicable. There is no fixed format for this section, but it is important that it be clear, accurate, and complete.

   NOTE: It is often convenient to combine the data and results sections. If you find yourself duplicating information, go back and think about reorganizing your report.

Lab reports will be graded on a scale of 0-100. The key points you will be graded on are:

1. Evidence that you have identified and understood the key physical concepts involved in the experiment.
2. Quality of data taken—within the limits of the apparatus, this reflects the care with which you performed the experiment.
3. Analysis and interpretation of data.
4. Clarity and organization of your presentation.

Late Penalties for Reports: For each class meeting that a report is late, I will normally deduct 10 points from the maximum possible grade of 100%. I will, of course, allow for extenuating circumstances such as illness.

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.*

Grades: The final grade will be determined from the homework (30%), lab reports (20%), tests (30%), and final exam (20%). Please feel free to ask any questions about how your grade is determined.

Academic Honesty: You are encouraged to work together on homework assignments and lab reports, but collaborations should not be one-way only. You are also encouraged to consult other texts for help in homework assignments. You must fully understand whatever work you turn in, and it must be your own work. Consult the separate handout for the department's Academic Honesty policy. Please ask if you have any questions.

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.

Andrew Dougherty Spring 2015
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<table>
<tr><th>Time</th><th>Mon.</th><th>Tues.</th><th>Wed.</th><th>Thurs.</th><th>Fri.</th></tr>
<tr><td>8:00
8:30</td><td>prep</td><td></td><td>prep</td><td></td><td>prep</td></tr>
<tr><td>9:00
9:30</td><td>Phys 218
HSC 017</td><td></td><td>Phys 218
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<tr><td>10:00
10:30</td><td>prep</td><td></td><td>prep</td><td></td><td>prep</td></tr>
<tr><td>11:00
11:30</td><td>Phys 424
HSC 017</td><td></td><td>Phys 424
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<tr><td>12:00
12:30</td><td></td><td></td><td></td><td></td><td>Physics Club</td></tr>
<tr><td>1:00
1:30</td><td>prep</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2:00
2:30</td><td>Phys 218 Lab
HSC 042</td><td></td><td rowspan="2">Office Hours</td><td rowspan="3">Office Hours</td><td></td></tr>
<tr><td>3:00
3:30</td><td></td><td></td><td></td></tr>
<tr><td>4:00
4:30</td><td>Department Meeting</td><td>Committee Meeting</td><td>Physics Club</td><td></td></tr>
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Physics 218 Lab Schedule, Spring 2015				
Date		**Title**	**Due**	
Jan.	26	*Introduction*		
Feb.	2	A.C. Circuits and Filters I		16
	9	The Pendulum		23
	16	The Torsional Oscillator: Part 1		
	23	The Torsional Oscillator: Part 2	**Mar.**	2
Mar.	2	Resonance		
	9	Resonance *continued*	**Mar.**	23
	16	*Spring Break*		
	23	Coupled Oscillators		
	30	Coupled Oscillators *continued*	**Apr.**	6
Apr.	6	Fourier Analysis with *Mathematica*		20
	13	A.C. Circuits and Filters II		
	20	A.C. Circuits and Filters *continued*		27
	27	Lock-in Techniques	**May**	8

Syllabus		**Physics 218**	**Spring 2015**
Jan.	26	Introduction & Overview	Smith 1.1–1.5
	28	Expansions and Complex Numbers	Smith 1.6–1.9
	30	AC Circuits; HW #1	Smith 1.10
Feb.	2	*continued*	
	4	*continued*	
	6	Wavefunctions and Uncertainty; HW #2	Smith 1.11–1.12
	9	Examples of Oscillation	Smith 2.1–2.5
	11	More Examples of Oscillation	Smith 2.6
	13	Brief Introduction to Error Analysis; HW #3	Taylor Ch. 1–4
	16	Damping	Smith 3.1–3.4
	18	Types of Damping	Smith 3.5–3.6
	20	Propagating Uncertainties; HW #4	Taylor Ch. 4,5
	23	**Hour Test I**	
	25	Resonance	Smith 4.1–4.4
	27	Curve-fitting	Taylor Ch. 8
Mar.	2	Resonance Applications	Smith 4.5–4.8
	4	Coupled Oscillators	Smith 5.1–5.4
	6	Normal Modes; HW #5	Smith 5.5
	9	Hilbert Space	Smith 5.6
	11	Energy Levels	Smith 5.7
	13	Damped, Driven Coupled Oscillators; HW #6	Smith 5.8–5.9
	16–20	*Spring Break*	
	23	Eigenvalues and Matrices	Smith 6.1–6.3
	25	*continued*	Smith 6.4–6.5
	27	*continued*; HW #7	Smith 6.6–6.7
	30	**Hour Test II**	
Apr.	1	Beaded String	Smith 7.1–7.3
	3	Normal Modes for Strings	Smith 7.4–7.6
	6	k-space	Smith 7.7–7.8
	8	Fourier Analysis	Smith 8.1–8.4
	10	Fourier Transform; HW #8	Smith 8.5–8.6
	13	Applications	Smith 8.7
	15	AC Circuits and Filters	
	17	Traveling Waves; HW #9	Smith 9.1–9.5
	20	Waves in Media	Smith 9.6–9.11
	22	Dispersion & Group Velocity	Smith 9.12
	24	*continued*; HW #10	
	27	**Hour Test III**	
	29	Lock-in Techniques	
May	1	Boundaries	Smith 10.1–3
	4	Reflection and Transmission	Smith 10.5–7
	6	Refraction; Evanescent Waves	Smith 10.8–9
	8	Nonlinearities and Solitons; HW #11	
		Final Exam (cumulative)	