

# Physics 213a-2011

## Waves and Optics

### Walter Smith

### Syllabus

#### Course Requirements:

Three one-hour class meetings per week. Class periods will usually be devoted to lecture and discussion. Evaluation will be based on two exams, a final, and weekly problem sets.

#### Course Description:

The second year of the physics curriculum focuses on oscillations waves, covering coupled oscillators and waves in the first semester and matter waves (quantum mechanics) in the second. Physics 213 introduces oscillations and waves in mechanical, electronic, and optical systems. The course also presents the relevant mathematical methods, including functions of complex variables, Fourier analysis and the eigenvalue problem. Topics include: free and driven oscillations, resonance, superposition, coupled oscillators and normal modes, traveling waves, Maxwell's equations and electromagnetic waves, interference, and diffraction. Despite the course title, we will only have time for brief coverage of optics. The accompanying laboratory, Physics 211, consists of experiments in the areas of electronics, waves and optics. Although it need not be taken concurrently with Physics 213, all physics majors are required to complete the laboratory.

Two applications of vibrations and waves are shown here--surfing a monster wave, and string theory, the potential theory of everything. It is not an exaggeration to say that a thorough understanding of oscillators, coupled oscillators, and waves is central to virtually every area of

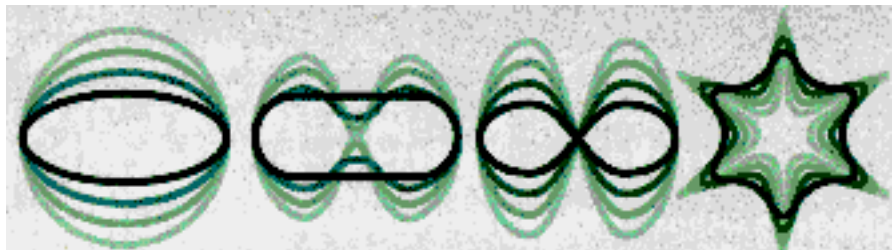


*A prize contender*

#### EL NIÑO

### The Ride of Your Life

Surfboard company K2's "BIG WAVE CHALLENGE" concluded Sunday. But isn't offering a \$50,000 prize to the surfer who bagged the biggest wave during the turbulent 1997-98 El Niño storm season sort of like a reward for the most creative suicide note? Contest organizer Bill Sharp says that this year was actually one of the safest on record, and the competition was open only to registered professionals. Would K2 have given the prize to the estate of a dead surfer: "That's a very cynical question," says Sharp. Contestants did have to complete the wave to be eligible and presumably a surfer mangled by a killer wave wouldn't be able to finish.



DIVERSE MODES of vibration can be induced in any string. Quantum mechanics allows the waves to be interpreted as particles. If loops of string about  $10^{-33}$ cm long are fundamental constituents of matter, then their vibrational energies are the masses of elementary particles such as electrons, quarks and photons.

M. Mukerjee, Scientific American, Jan., 1996, p. 88

Two applications of vibrations and waves are shown here--surfing a monster wave, and string theory, the potential theory of everything. It is not an exaggeration to say that a thorough understanding of oscillators, coupled oscillators, and waves is central to virtually every area of

physics, and to many areas of engineering. In addition, the mathematical methods you will study in this class are exactly what you will need next semester, when you begin your study of quantum mechanics.

## Course Information:

### Instructor:

- Walter Smith KINSC Link 110 896-1332 (office) wsmith@haverford.edu  
896-1565 (home) (No later than 10:30, except for emergency)

Office hours: M 10-11, Tu 11-12, Th 10-11, F 10-11, or by appointment

If the above hours are not convenient, feel free to email me or phone me to set up a specific meeting time.

### Location and times:

- Lecture: MWF 11:30 – 12:30 in KINSC E309. Attendance and participation are expected. Lecture will begin promptly at 11:35; please be on time.
- Laboratory (Physics 211) Th 1:15 - 4:00 p.m. in KINSC H206. 1st meeting will be *this* Thursday. **Please arrive prepared (including having answered pre-lab questions) to do the 1st experiment (DC Circuits) at that time. Contact Joseph Ochoa (jochoa,) or Scott (sshelley, x1310) beforehand if you have questions**

### Assignments and Tests:

- Written work will be due each Friday at 4 pm. There will also be assigned readings to prepare you for class discussion. It is **essential** for your understanding that you stay **ahead** of class in your readings; I design our classes with the assumption that you've completed the relevant reading, and you can only achieve an adequate level of understanding if you come to class well-prepared. Some assignments will include *individual* problems. It is expected that you work on these problems without collaborating with other students, but you may ask questions of the instructor.
- There will be two time-limited, take-home exams and a self-scheduled, cumulative final. The schedule below gives coverage and dates. Exams will cover both concepts and problem solving. Time pressure in exam settings, while not the goal of the instructor, is not entirely avoidable. You should prepare to be able to work efficiently on the material covered and avoid poor time management choices during the exams.

### Grading procedures:

- Written exercises – **We will use an unusual procedure for handling problem sets – please read carefully! Please do not use blue or red ink or pencil for your problem sets** (pencils, black ink, purple ink, etc. are fine). After you turn in a problem set, the grader will grade it. 50% of the grade for the homework will be based on this first grading pass.

Your paper will then be turned back to you **at your next class meeting**, along with “skeleton” solutions. (These are not complete written-out versions of the problems, but rather guidelines and waypoints to help you along.) At this point, consulting the skeleton solutions as needed **and using blue ink or blue pencil** and writing on the same paper you originally turned in, you will complete any problems which you were unable to do at first, and write out complete corrections to problems which you did incorrectly. The goals of doing the grading this way are to ensure that you understand each problem fully, and also to give you a “second chance” on problems that you muffed. You will then turn in your revised problem set on the following Friday at 4 pm. **(Note that I strongly suggest that you complete your revisions ASAP after getting**

**your assignment back; this will allow you to focus entirely on the new assignment thereafter.** The grader will check over your revisions, and assign the remaining 50% of the grade.

**To make this whole scheme work, it is essential that you leave space on your problem set to write in corrections.** You may wish to leave space at the bottom of each page, or to use the back of the preceding page.

**You should turn your assignments in to the envelope on the windowsill across from my office. Do not hand them to me, except as noted below.**

- Late policy -- You may have two “free extensions” during the course of the semester. If you take one of these extensions on a first grading pass (rather than a rewrite), you automatically get an extension on the rewrite; this doesn’t count as a second extension. No other extensions will be granted, except for significant illness, serious family matters, etc.; in such cases, you must obtain the extension in advance of the due date.

- Exams -- understanding is the key. Partial credit will be given for sensible efforts even if the answer is not exactly correct. Multi-part problems will usually be designed in such a way that a mistake early on will not prevent you from doing the rest of the problem.

- Course grade -- will be computed using the following weighting:

Written exercises	40%	(Note the very high weighting assigned.)
Midterm 1	13%	
Midterm 2	17%	
Final exam	30%	

A separate grade is given for Physics 211a, the associated laboratory.

## Readings:

### Require Text:

*Waves and Oscillations: A Prelude to Quantum Mechanics*, by W. F. Smith

### Other useful sources on reserve in Science Library:

A. P. French, *Vibrations and Waves* (Norton, 1971). If you find a presentation in the main text confusing, this is a good place to go for a different take on the same material.

H. J. Pain, *The Physics of Vibrations and Waves*, 5th ed. (Wiley, 1999).

Pain is one of the few authors to cover all the correct material for this course at the correct level with emphasis on phenomena and applications. Although you may find the treatment very dry and overly formal, this is an excellent reference work.

Howard Georgi, *The Physics of Waves* (Prentice-Hall, 1993) [elegant and theoretical]

Grant R. Fowles, *Introduction to Modern Optics* 2nd ed. (Holt, Rinehart & Winston, 1975). [best treatment of optics available at the level of this course]

Thomas D. Rossing and Neville H. Fletcher, *Principles of Vibration and Sound* (Springer-Verlag, 1995) [excellent on sound, music and musical instruments]

K. U. Ingard, *Fundamentals of Waves and Oscillations* (Cambridge University Press, 1988) [not that useful, but it does have some computer program listings]

Eugene Hecht, *Optics*, 3rd ed. (Addison-Wesley, 1998) [the bible of optics texts]

K. D. Möller, *Optics* (University Science Books, 1988)

E. G. Steward, *Fourier Optics: An Introduction* (Wiley, 1983) [complete coverage of Fourier aspects of optics]

S. G. Lipson and H. Lipson, *Optical Physics*, 3rd ed. (Cambridge University Press, 1995) [good if you like very succinct treatments]

### Exam schedule:

Exam #1 due Friday Sept. 23

Exam #2 due Friday, November 4

Final exam covers all the material with some extra emphasis on the material covered after exam #2.

### Honor Code Issues:

As an instructor I value Haverford's Honor Code for the integrity it fosters and the pedagogical flexibility it affords. *The important guiding principle of academic honesty is that you must never represent the work of another as your own.* The following guidelines should govern your behavior in the course; please request clarification if you find yourself in any doubtful situations.

- You may seek assistance from the instructor or work together with other students (except on individual problems) in doing the weekly assigned exercises and in preparing for class discussions. If working with other students, avoid situations in which you are either contributing too much or too little to the collaborative effort. (Neither results in optimal learning, but are not violations of the honor code.) While working together is permitted and even expected and therefore does not need to be acknowledged, merely copying the work of another student without indicating that you have done so is clearly a representation of his or her work as your own and so is a violation of the code.
- The exams must be entirely your own work. You must also follow all procedures and respect time limits without deviation.