Syllabus, Spring Quarter, 2008

FRS 002, Sec. 011--Freshman Seminar
Applications of Waves—From Music to Imaging Atoms

CRN 48139

Class Meeting: Tues. and Thurs. 3:10 - 4:00 p.m.

First Class: April 1, 2008, 432 Physics/Geology

Instructor: **Shirley Chiang, 215 Physics/Geology, tel: 752-5989 (office), FAX: 752-4717**
e-mail: **chiang@physics.ucdavis.edu**
Office hour: **Tues. 4:00-4:30 p.m., in 215 Physics/Geology; and by appointment**

Class web page: http://www.physics.ucdavis.edu/, then follow link under **Class Web Pages** to **Freshman Seminar 002, Sec. 11**
(Full URL for class web page is:
http://www.physics.ucdavis.edu/Classes/FRS2/S2008/Frs2_Sec11.html)

Prerequisite: High school algebra is required. High school physics is helpful, but not required.
Required Textbook:
* *Horns, Strings and Harmony*, by Arthur H. Benade, (Dover, 1992). ML 3805.B33

Seminar goals:
The objective of the course is for students to see how physical principles can be used to explain the world around them. Wave theory will be applied to two very different topics, one classical and one modern: music and quantum mechanics. The course will use physics to study the properties and production of musical sounds. Students will also learn how modern quantum mechanics applies to the operation of the scanning tunneling microscope (STM), which is used to make atomic resolution images of surfaces. Students will read and discuss how physics applies to musical instruments and the operation of the STM. They will use the scientific method to design and construct their own musical instrument, which they will present to the class.

Grading:
Students will be graded on the quality of their participation in class discussion (1/3), on the quality of the oral presentation of their project(1/6), and on the execution of the final project and the final paper (1/2).

Course requirements:
1. Reading assignments are listed below. Please do required reading before the class indicated so that you are prepared to discuss it in class.
2. An independent project, presentation, and paper are required. See instructions and dates below.

Topical Outline, Course Schedule, and Reading Assignments:

HSH=Benade book (required), which will be on 2 hour reserve in Shields Library.

Week	Class Dates	Topics	Assignment
1	Apr. 1	What is Physics? Introduction to course.	
1-2	Apr. 3, 8	How do physical principles explain properties of devices? Introduction to wave properties and their relationship to musical properties—pitch, loudness, timbre.	HSH Chapters 1,2,4
2-3	Apr. 10, 15	Further discussion of waves and demonstration of properties such as reflection, refraction, diffraction, beats, interference and resonance.	HSH Chaps. 7; handout
3-4	Apr. 17, 22	Harmonic analysis (why do different instruments playing the same note sound different to your ear Discussion of musical scales and their relationship to the mathematical ratios of frequencies of sound waves. Operation of piano and how to tune it.	HSH Chap.3, 5
4	Apr. 24	Stringed instruments.	HSH Chap. 6
4	**Proposal due Apr. 24**	E-mail note to Prof. Chiang describing proposed project.	
5	Apr. 29	Woodwind instruments. Guest lecturer with demonstrations of many woodwind instruments, both ancient and modern.	HSH Chap. 9
5	May 1	Brass and percussion instruments	HSH Chap. 8
6	May 6	Room acoustics	
6-7	May 8, 13	Computers -- what's inside and how do they work? Discuss operation of computerized music and stereo systems.	References to be given
7-8	May 15,20	Wave theory and probability related to quantum mechanics.	Handouts of articles.
8-9	May 22, 27	Operation of the STM,	Handouts of articles.

		imaging atoms, and relevance to new advances in computer technology. Discussion of other real-space microscopies and how they are used to study surfaces.	
9	**May 29**	Tour of Instructor's Laboratory Room 10 Physics/Geology (basement)	
10	**June 3-5**	Students' presentation of their final projects involving construction of a musical instrument.	
	Paper Due June 12, 5 p.m.		

Independent Project, Presentation, and Paper:

You must do a project in which you build or modify a musical instrument. A list of suggestions will be provided. See HSH, Chap. 10 for additional ideas on homemade wind instruments. You should use the scientific method to plan and execute experiments which will aid you in building your instrument. Analyze the properties of your instrument in terms of the concepts discussed in class (e.g., frequencies produced, loudness, etc.) You will spend 5-10 minutes to present your project to the class during the last two class meetings on **June 3-5**. You must write a paper describing in detail the building of your instrument, including what you did and what results you obtained. The expected length of the final paper is about 1000-1500 words (4-6 pages typewritten). Your paper will be graded both on exposition and content.

You are required to send the instructor an e-mail note describing your topic and your plan of attack in several sentences by **April 24.** The instructor will be happy to read a draft of your paper at any time and offer suggestions for improvement. The final paper is due **June 12, 5 p.m.**. You may e-mail a Word or PDF file, or hand in a hardcopy.

Other Books on 1-day Reserve in Shields Library (in addition to HSH):

1. Johnston, Ian. *Measured Tones: The Interplay of Physics and Music* (Institute of Physics Publishing, 2002), 2nd edition. ML3805.J63 2002 (First edition from 1986 is also acceptable).
2. Taylor, Charles. *Exploring Music: The Science and Technology of Tones and Tunes,* (Institute of Physics Publishing, 1992). ML3807.T39 1992.
3. Backus, John. *The Acoustical Foundations of Music*. New York: W. W. Norton (1969). ML3805.B245A3. (textbook)
4. Rossing, Thomas D. *The Science of Sound.* Reading, MA: Addison-Wesley Publishing Co. (1982). QC225.15.R67. (textbook)
5. Hall, Donald E. *Musical Acoustics*. 2nd Ed. Pacific Grove, CA: Brooks-Cole Publishing Co. (1991). (textbook)

About the Instructor: Professor Shirley Chiang is a condensed matter physicist who specializes in surface science studies using high resolution microscopy techniques. She received her Ph.D. degree from U.C. Berkeley and was a Research Staff Member at the IBM Almaden Research Center before coming to U.C. Davis in 1994. Her current research interests include imaging small molecules on metal surfaces and studying thin metallic magnetic and alloy films. She is an advanced amateur pianist and an intermediate violinist. She is also the current Chair of the Department of Physics.