PHYS207  Physics of Music  Autumn 2015

General Information: This course is for anyone interested in the interplay of Physics and Music. There are no prerequisites, apart from the desire to learn something new and willingness to work on it. We cover a very broad range of topics, from the basic properties of vibrations and waves, through the almost-miraculous sound perception by the cochlea and analysis by the brain, all the way to the issues of consonance and dissonance, tuning and temperament. We also include some discussions of the sound technology (microphones, speakers, room acoustics etc) as well as the use of modern computers (MIDI sequencers, sound analysis and synthesis, CDs and MP3, computer analysis of music scores and more).

Throughout the course the course, considerable emphasis is put on the Music aspects, so that students will learn about counterpoint and fugues and other musical concepts as they relate to musical acoustics. Consequently, the enrollment usually represents a rich mix of students from Humanities as well as from Math and Science departments. Since we start with everything from scratch, and a large part of the grade comes from an essay on student's choice (see below), the grades come out quite independent of the student's previous exposure to science or music.

Lectures will complement rather than regurgitate the text. Also, there will be many demonstrations, both physical and musical. Therefore, it will be essential for students to come to class – this is not a course where you can stay home and just read the textbook. Near the end of the course, we will make a “field trip” to experience the UW pipe organ in the Kane Hall.

Lectures: Monday Wednesday Friday 11:30 AM - 12:20 PM in Physics/Astronomy bldg. room A118

Instructor: Vladimir ("Vladi") Chaloupka, Professor of Physics Emeritus
past Adjunct Professor, School of Music
past Affiliate, Virginia Merrill Bloedel Hearing Research Center
past Affiliate faculty in DXARTS,
and an amateur organist
(all these attributes will be obvious in just about every lecture ....)
+ past Adjunct professor at the Jackson School (in this course: in TGIF moments …)

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website: http://faculty.washington.edu/vladi/phys207
office hours: after each class, and by appointment

Teaching Assistants:  TBA

Textbook: Manuscript of a textbook by the Instructor scheduled to be published in 2016
Additional (optional) Readings:

Note: The “instructional” value of the texts decreases as you go down the list, but the educational value does not!

“The Science of Sound” by Rossing/Moore/Wheeler (3rd ed.). Used as a textbook in the past (on and off, alternating with Hall - see below). Quite complete but a little dry.

Musical Acoustics by Donald E Hall (3rd edition). Similar level to that of Rossing; used off and on in the past. Excellent section on tuning and temperament. Both Hall and Rossing have excellent bibliographies at the end of each chapter, suitable for further research, term papers etc.


Why do we hear what we hear by Eric Heller. A rather advanced and somewhat strange book with a strange title; with some very interesting bits and pieces. It could be valuable for physics / math / engineering majors.

Measured Tones by Ian Johnston (2nd edition). Even less math than the Instructor's manuscript or the first 4 optional books above, but very good discussions of the interplay of music with physics. Not really a textbook (although there is a website with exercises) so it is mainly a good read.

Measure for Measure by Thomas Levenson. No math at all, and not much physics as such, but excellent historical treatment of the parallels between music and science. It may be too “philosophical” for some readers (but just right for others ...).

Goedel Escher Bach by D. Hofstadter. Brilliant synthesis of mathematical logic, paradoxical drawings and contrapuntal music of J.S. Bach (and much more). I recommend this book to every class I teach.

The Sleepwalkers by A. Koestler. I recommend this book, too, to just about every class I teach. Although it is really about the history of science (astronomy in particular), it reads like a suspense novel. Discussions of Pythagoras' concepts of small-integer ratios in music consonance, and of Kepler's "Music of the Spheres" make the book particularly relevant to this course.

Class Assignments and Grading:

Homework will be assigned but not collected/graded; solutions will be available, and the midterms and the Final exam will be closely based on the homework. It is of utmost importance to attempt to solve each problem BEFORE the solutions become available on the website. In general, the book is larger than we can cover, and contains more than I will expect you to learn. The goal of the course is to teach you enough fundamental knowledge and skills to be able to study specific topics on your own, even after the course is over. It will be the Homework which should guide you as to what topics you should master, and what skills will be tested on Exams.
An individual term project will cover a topic of student's interest. The topics should be approved by the Instructor, and the project should roughly correspond to one and half credits (i.e. to about 30 hours of effort). A proper list of references should be included in every paper, and the use of the Science Citation index is highly encouraged. A sample list of past topics can be found below, together with topics of particular interest to the Instructor. Papers should not be long (5-7 single-spaced pages of good, thoughtful text should be enough) and should reflect your personal findings / opinions / research / summary of literature etc. Please submit an electronic version (EMAIL as Word, HTML or PDF) and a hardcopy - please keep your own copy (I need to keep your paper.)

20% of the course grade will come from the better of two midterms, 40% from a comprehensive (2-hour) Final Exam and 40% from the term paper. There will be no make-up exams. All exams are closed book, with one letter-format sheet (both sides) of handwritten notes permitted.

How (not) to succeed in the course:

It will be hard not to do well in this course, but it can be done, if you
[ ] don’t come to lectures
[ ] wait for the HW solutions when they become available; then just read them
[ ] wait until before the exams to seek help from TAs / Instructor
[ ] wait until the end of the quarter with starting on your term paper

PHYS207: Examples of past / possible projects:

- analysis of your favorite instrument/room/equipment
- Single reed for an oboe
- Role of the attack transients in instrument identification
- Acoustics in the Walker Ames room / Suzallo graduate reading room
- Acoustics of Benaroya Hall / Seattle Opera
- Minimally-intrusive room acoustics measurement
- Building (and testing) speakers for very low frequencies
- Psycho-physical experiments (explorations of tuning, absolute pitch,..)
- The Effectiveness of High Frequency Sound Against a Common Flea
- Ear operating near the Quantum Mechanical limits ...
- Visualization of Sound.
- Oralization of Complex Events.
- Countertenors with and without surgery.
- TAOS hum
  - Influence of Complex Music on Children's Brain Development: Is the Mozart Effect real?
Subjects of particular interest to the Instructor:

- [ ] non-linear effects in organ pipes (mode locking/coupling between pipes): “(1000+1001)/2 = 1002” :-)

- [ ] musical psychophysics: correlations between the subjective and the objective attributes of musical sound
  
  (loudness <-> intensity    pitch <-> frequency    timbre (sound color) <-> spectrum)

- [ ] what makes an excellent violin <-> ?

- [ ] what makes great music <-> ???

- [ ] future of Music (and future of Humanity)

- [ ] investigations of absolute pitch -> hearing research

- [ ] advanced methods of musical signal analysis / modif. / synthesis

- [ ] advanced methods in large-room acoustics (cf. the Saint Mark’s project)

- [ ] quantification of aspects of musical performance

- [ ] consonance/dissonance tuning/temperament scales / harmony: how much is Physics vs. how much is Culture?

- [ ] What imperfections are necessary to achieve the perception of perfection?

- [ ] How important is sound for Music?

- [ ] physicist’s Piano Roll (requires C#/ C++)

- [ ] Internet-based pitch test + color perception

- [ ] JAVA-based interactive audio-visual demos/research software

- [ ] build pipe organ sound fonts with balanced scaling and timbre (requires good musical judgment / work with a sound editor / soundcard / MIDI sequencer such as the FLStudio). Assist the Instructor with producing “The Definitive Recording” of Bach's “Kunst der Fuge”