Physics 120: The Physics of California: Waves, Weather, and Quakes

Prof. S. Peng Oh, Fall Quarter 2008
Lectures: Tuesday and Thursday 12:30-1:45 pm in Phelps 3515

This is a one quarter physics course, with prerequisites of Physics 1-4 or Physics 21-24. We will survey the classical physics of natural phenomena common to California. The course will be structured around learning and then applying classical physics. I will lecture on the fundamental aspects of the physics and then apply it in different contexts. This will include fluid mechanics and the macroscopic properties (e.g. viscosity, conductivity) of solids, liquids and gases. Examples are wave motion in solids, liquids and the atmosphere (e.g. seismology of the Earth and ocean waves); why trees have a maximum height; tidal effects and tsunamis from earthquakes, animal motion in liquids and air, life at low Reynolds numbers and turbulence in boundary layers.

You are lucky enough to be residing in a location that allows you to see classical physics in action every single day! This course finally offers you a chance to learn classical physics (mostly fluid and solid mechanics with some thermodynamics) and apply it to the natural world around you. The breadth of physics needed for understanding some of these phenomena and the impossibility posed by trying to do it “exactly right” will force you to learn to make estimates, carry out dimensional analysis and get the units right. These are all crucial skills for a practicing scientist.

Structure and Work-Load, Textbooks and Contact Information

Your grade for this course will be based on 8 homework sets (50%), a midterm on Nov 4 (25%) and your research project (25%). The homework is crucial to learning the material, as you most likely know by now. We encourage you to start the HW sooner, rather than later. Homework is due on Tuesdays: Oct 7, 14, 21, 28, Nov 4, 11, 18, 25, Dec 2. The HW will always be due at the beginning of class, NO LATE HOMEWORKS WILL BE ACCEPTED. The lectures will contain much material that is not in the books and will be needed for the homework. We therefore strongly urge you to attend all the lectures!

Your research project will be graded from your weekly reports (5%), your final oral presentation (5%) and your final written report (15%). Starting as soon as possible, you should begin finding a topic that you find most intriguing (we will hand out ideas, but please start looking at the world around you. Remember, the only constraint is a natural phenomena in California that needs classical physics for an explanation) and begin researching it, reporting weekly (starting with HW Set 3 on Oct 21) as part of your homework sets. Your final presentation will be a 15 minute description of the California phenomena that you have explained and the physics that proved relevant. These will be held in class on Thursday, Dec 4 and (if time requires) during the scheduled day of the final exam, Tuesday Dec 9 from 12-3 pm. The written reports are due on Tuesday Dec 9 at 12 noon.


My office is Broida 2015J, and office hours are 2-3 pm on Tuesday and Thursday (immediately after class), or by appointment. Note that there is no discussion section for this class, so do make use of office hours. I am best reached by email at peng@physics.ucsb.edu. The grader for the course is Idse Heemskerk (idse@physics.ucsb.edu).

The class website is at http://www.physics.ucsb.edu/~phys120. I will post homework solutions and lecture notes there.
COURSE SYLLABUS

This is the course syllabus. It may change mildly as we adjust the topics to better match your interests. The HW handouts will be explicit about which parts of the books you should read in order to be prepared for the lectures and do the HW problems.

1. BASIC FLUID MECHANICS AND THE OCEAN
   (a) Derivation of the fluid equations from conservation of mass, momentum and energy
   (b) Bernoulli’s equation for incompressible flow, physics of lift
   (c) Vorticity, flow around a vortex line
   (d) Surface Waves, Tsunamis, physics of the swell
   (e) Origin of need for viscosity, incorporating into basic equations and no slip conditions. Navier-Stokes equation
   (f) Random walk, momentum diffusion, heat transport, definition of Reynolds number
   (g) Low Re flow in a pipe, fluid flow in trees and arteries
   (h) High Re flow, turbulence and drag coefficients.

2. IDEAL GASES AND ATMOSPHERIC PHYSICS
   (a) Ideal gas equation of state, thermodynamics of perturbations and sound waves.
   (b) Heat transport, greenhouse effect.
   (c) Convective Stability of Atmospheres and Inversion Layers. Role of water vapor.
   (d) Geostrophic Balance, Highs and Lows, circulation patterns
   (e) Sound waves in the Ocean, circulation, Ekman.

3. SOLID PHYSICS AND GEOLOGY
   (a) Properties of solids, first principles of characteristic density, transport
   (b) Origin of shear modulus and elastic equations, stress strain relation, buckling columns,
   (c) Wave derivations for solids, including surface waves
   (d) Earthquakes: origin and wave propagation