April 2013

Physics 410 – Physics of the Solid Earth (3)
Course Outline

Gravity and the figure of the Earth. Body wave seismology, structure and composition of the Earth, heat flow and heat sources, Earth tides, rotational dynamics, the geomagnetic field and its source, paleomagnetism. 3 lectures. **Prerequisite:** PHYS 133 and MATH 244 or equivalent.

Learning Objectives and Criteria:
Students are expected to gain an understanding of the application of physical principles to questions of earth composition, structure, and phenomena such as the seismic wave propagation, the geomagnetic field, the gravitational field, and heat flow.

Students will calculate geophysical parameters based on actual geophysical datasets (e.g. seismic, magnetic, etc.) and assess agreement and/or deviation from theoretical predictions. Results will be interpreted against competing models of the geophysical phenomena under observation.

Written presentation of data, data analysis, and justification for a preferred interpretation of results using succinct and correct geological and geophysical terminology will be required in homework assignments and individual student projects.

Upon completion of the course the student is expected to have the following skills:

1. Explain the geological and geophysical evidence/observations supporting, and deviating from, the plate tectonic model.
2. Demonstrate mathematically seismic body waves as solutions of the seismic wave equation and derive their properties.
3. Calculate body wave propagation through the earth and compare with standard seismic velocity earth models. Derive geologically plausible interpretations of anomalous seismic wave observations in terms of chemical and/or temperature properties of the earth.
4. Compute earthquake magnitudes with an appropriate magnitude scale and preparation of raw seismic data.
5. Derive earthquake focal mechanisms and moment tensors. Apply this information to regional and global tectonic questions.
6. Understand the structure of earth's gravitational field and its mathematical representation. Apply regional gravity anomalies to determination of crustal structure.
7. Apply the induction equation to the origin of earth's magnetic field and understand the physical mechanisms for sustaining the magnetic field.
8. Understand the mathematical representation of earth's magnetic field and the application of the measured surface field to estimating the internal field.
9. Apply principles of paleomagnetism to plate tectonics.
10. Explain and evaluate competing models for reversals of the magnetic field.
11. Apply principles of isotopes and radioactivity to dating of rocks and evaluate results in the context of regional tectonics and geological processes.
12. Apply models of heat flow and temperature gradients in the earth to determining properties of mantle mineralogical phase transformations. Calculate the effect of phase transformations on seismic waves and chemical evolution of the earth.

Text and References:

Fowler, C.M.R., *Solid Earth: An Intro to Global Geophysics*, Cambridge University Science.
Stacey, F.D. and Davis, P.M., *Physics of the Earth*, Cambridge University Press (2008).
Lowrie, W., *Fundamentals of Geophysics*, 2nd ed., Cambridge University Press.

Content and Method:

Method: Physics 410 is offered in a traditional lecture format.

Content: Physics 410 will adhere to the following topics:

- Introductory observations: Earth composition and internal structure; plate tectonics as a unifying model of the earth; historical development and use of geophysical methods for interrogating the earth. (1 week).
- Elastic wave theory: the seismic wave equation; body waves; surface waves. (1 week).
- The relation of earth properties to seismic wave velocities. (0.5 weeks).
- Seismometry: recording and processing of seismic data. (0.5 weeks).
- The earthquake source: types of magnitude; focal mechanisms; moment tensors; application to regional and global tectonics. (1-1.5 weeks).
- Gravitational theory; measurements of gravity; significance of gravity anomalies to earth structure; earth tides. (1-1.5 weeks).
- Earth's magnetism: measurement of the geomagnetic field; earth's main magnetic field and its perturbations; origin of earth's magnetic field; paleomagnetism. (1.5-2 weeks).
- Radioactivity and dating of rocks. (0.5 weeks).
- Outflow of heat from the earth and the earth's temperature. (1-1.5 weeks).

Methods of Assessment (typical):

Midterm (~20%) and final (~25%) examinations, homework (~45%), and projects (~10%; written or class presentation according to instructor preference).