Summary of the new W4300 course in DEES: “The Earth's Deep Interior”

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This course emphasizes the geophysical study of Earth structure below the crust, drawing upon geodesy, geomagnetism, gravity, thermal studies, seismology, and some geochemistry.

It covers the principal techniques by which discoveries have been made in deep Earth structure, and describes particular features of the mantle, and fluid and solid cores, such as:

- the upper mantle beneath old and young oceans and continents
- the transition zone in the mantle between about 400 and 700 km depth
  (within which density and elastic moduli increase anomalously with depth),
- the lowermost mantle and core/mantle boundary
  (across which density doubles and sound speed halves), and
- the outer core/inner core boundary
  (discovered by seismology, and profoundly affecting the Earth's magnetic field).

The course is part of the core curriculum for graduate students in solid Earth geophysics and marine geophysics, is an elective for solid Earth geochemistry and geology, and is accessible to undergraduate science majors with adequate math and physics.

The course, together with EESC W 4950x (Math Methods in the Earth Sciences), replaces the previous W 4945x – 4946y (Geophysical Theory I and II). It includes parts of previous courses (no longer listed) in seismology, geomagnetism, and thermal history. Emphasis is on current structure, rather than evaluation of dynamic processes (such as convection).

Prerequisites

calculus, differential equations, a year of college physics

W 4950x (Math Methods in the Earth Sciences), or equivalent knowledge of wave propagation, and of stress and strain.

Content

Earth's bulk composition; its shape, mass, and moment of inertia; comparison with the Moon

Earth's formation and setting in the solar system; element abundances
basic principles of gravity theory; effects of Earth rotation
measurement of Earth flattening, and its rate of change

The Moho, and core/mantle boundary

how interfaces/discontinuities inside the Earth are discovered
gross features of the crust, the mantle, the outer and inner cores

Earth magnetism

dipole field dominates; changes with time
spectrum of geomagnetic phenomena and inferences about source depth
basic dynamo theory, and energy sources

Thermal structure

- distribution of heat sources in the Earth; primordial heat
- variation of temperature with depth
- thermal boundary layers
- inferences from electrical conductivity

Seismological methods

- uses of travel-time to infer velocities as a function of depth --- for *P*-waves and *S*-waves
- uses of surface waves, normal modes

Earth's mantle

- upper mantle, low velocity zone, features at depths around 410 km and 660 km
- the transition zone, lower mantle, and lowermost mantle

Methods of determining density distribution in the Earth

- density at the top of the mantle
- Adams-Williamson equation -- its strength and weakness
- principles underlying the Jeffreys-Bullen (J-B) Earth model
- improvements on the J-B model, including
  - phase transformations
  - determination of chemical and mineral composition

Earth's cores, and chemical evolution of the planet

- the fluid outer core and its constituents
- the solid inner core: observations, current speculations

Overview of methods for studying lateral heterogeneities of deep Earth structure

- evidence for subducted structures and plume structures in the deep mantle

Energy and power associated with geophysical fields/phenomena

Texts

No suitable textbook now covers this material. Together with handouts, readings will be assigned from

- *Geophysical Theory*, William Menke and Dallas Abbott, Columbia University Press, 1990
- *Fundamentals of Geophysics*, William Lowrie, Cambridge University Press, 2001
- *Modern Global Seismology*, Thorne Lay and T. C. Wallace, Academic Press, 1995
- *Introduction to Seismology*, Peter M. Shearer, Cambridge University Press, 1999