EPS52: Introduction to Global Geophysics

This course provides a comprehensive introduction to global geophysics and serves as a bridge between introductory Earth science courses and higher-level courses in tectonics, seismology and planetary sciences. Topics include: plate tectonics, the Earth's composition and thermal state, rheology, seismology, ice age dynamics, mantle convection, the Earth's gravity field and geodesy, sea-level changes from deep time to modern, and (if time permits) Earth rotation.

Grading: 4 problem sets (40%), 1 mid-term (20%), and a final exam/project (TBD; 40%).

Prerequisites: MAT 21a or equivalent; PHY 12a or equivalent; or permission of the instructor.

1) The Dynamic Planet

Earth Structure and Composition

A review of the major internal divisions of the planet (inner core, outer core, upper and lower mantle, lithosphere and crust). Plate boundaries and the plate tectonic system (subduction zones, mid-ocean ridges, transform faults).

Plate Motions on a Sphere

A quantitative description of rigid motions on a sphere beginning with Euler’s equations. An examination of the geometry of plate boundaries, predicting (and retrodicting) plate tectonic motions.

2) Isostasy

The application of Archimedes principle to the behavior of the crust in the fluid limit. A summary of Airy and Pratt isostasy. Relevance of isostasy to crustal density variations and topography.

3) The Earth’s Thermal Regime - Past and Present

The Energy Equation

A quantitative analysis of the basic equations governing conductive heat flow with variable boundary conditions and internal heat generation. The continental geotherm. Ocean floor bathymetry and heat flow. An estimate of the importance of radiogenic heat generation from early Earth to present.

Mantle Convection

An extended energy equation. Analysis of the stability of the Earth’s mantle to convective disturbances. A description of high Rayleigh number viscous flow. Tectonic plates as a boundary layer phenomenon.

4) Earth Rheology

Introduction and Theory

General descriptions of Hookean elastic and Newtonian viscous materials as end members of linear viscoelastic materials. Quantitative treatment of the dependence of the rheological response of a material to the time scale and amplitude of the applied forcing and the temperature of the material.

Examples

- Seismology
- Ice age dynamics/Glacial isostatic adjustment
- Mantle convection Redux

5) The Earth's Gravity Field

Introduction and Theory

A description of the basic elements of the Earth's gravity field beginning with Clairout's theorem.

Gravity Anomalies and the Earth's Geoid

Definitions of various gravity anomalies (Bouger, Free-air, etc) and the geoid. Satellite-geodesy.

6) Paleoclimate and Sea Level

From the Ice Age to the Modern World

Ice age sea level change, sea level fingerprints

Deep time

Long-term sea level change - causes and controversies.

7) Earth Rotation

Short-Term Variations

Variations in the Earth's rotational state (length-of-day, polar wander, wobble and nutation) on time scales extending from seconds to decades. A review of the geophysical forcings that give rise to these variations, including tidal and atmospheric excitations and core-mantle coupling.

Long-Term Variations

A discussion of secular changes in the Earth's rotational state. True polar wander and paleomagnetism. Changes in the Earth's rotation rate (length-of-day) and tidal dissipation. Connections to glacial isostatic adjustment and mantle convection.