Geological Sciences GLY5468, Terrestrial Gravity and Magnetism

Time: M-W 12:50-14:45
Place: Williamson Hall 218
Instructor: R. M. Russo
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Course Description: Introduction to the theory and applications of potential fields to the study of the Earth. Topics include Laplace's equation, Newtonian potential, magnetostatic and electrostatic fields as applied to the Earth; spherical harmonic analysis of the Earth's magnetic field and gravity; applications to calculation and interpretation of regional gravity and magnetic anomalies; forward and inverse methods for determining Earth structure using potential fields; analytical continuation for use in airborne or spaceborne observations; and spectral analysis of the Earth's potential fields.

Prerequisites: Math MAP2302 or Physics PHY2048 or PHY2060, or equivalents, and Geology GLY5455, or consent of instructor.

Grading Method: Homework (70%) and term paper (30%).

Textbook: Potential Theory in Gravity and Magnetic Applications, by Richard J. Blakely (Cambridge)

Week 1 – The potential: Fields, energy, and work; equipotential surfaces; harmonic functions; Laplace's equation; Green's identities.

Week 2 – Consequences of the potential: Gauss's theorem of the arithmetic mean; Helmholtz theorem; Green's functions.

Week 3 – Newtonian potential: potential and gravitational attraction; Gauss's Law for gravity fields; Green's equivalent layer.

Week 4 – Magnetic potential: Magnetic induction; Gauss's Law for magnetic fields; vector and scalar potentials; dipole moment; dipole field.

Week 5 – Magnetization: magnetic field intensity; permeability and susceptibility; Poisson's relation; annihilators.

Week 6 – Spherical harmonic analysis: zonal harmonics; surface harmonics; normalized functions; tesseral and sectoral surface harmonics; Laplace's equation; Euler's equation.

Week 7 – Regional gravity fields: gravity anomalies; free-air, tidal, Eötvös, and Bouguer corrections; isostatic residuals.

Week 8 – Geomagnetic field: internal and external fields; the dipole and nondipole field; secular variation; crustal magnetic anomalies.

Week 9 – Forward and Inverse methods: two- and three-dimensional gravity and magnetic models.

Week 10 – Linear and nonlinear inverse problems.

Week 11 – Fourier-domain modeling; Fourier transform.

Week 12 – Convolution; two- and three-dimensional sources; Earth filters.

Week 13 – Upward continuation; directional derivatives; phase transformations.

Week 14 – Pseudogravity transformation; analytic signals, Hilbert transforms, and applications to potential fields.