

SIOG 229 - Gravity and Geodesy - Borsa [WI25]

SIO 229 is an introduction to geodesy at a level suitable for the advanced nonspecialist in geophysics. A large fraction of the course considers geodesy at the global scale, including various topics on gravity. This includes a deep and somewhat mathematical dive into potential theory, with the goal of familiarizing you with spherical harmonics. Topics we cover include the shape of Earth from various perspectives, coordinate systems and transformations, Earth reference frames and reference ellipsoids, in situ and remote geodetic measurements, Earth's gravity field, the geoid and vertical datums, and time-varying deformation of the solid Earth via various geophysical mechanisms.

Lectures: Tu/Th 9:30~10:50 am in IGPP 303 (Munk Conference Room). Lectures begin promptly at 9:30 and we will always let out on time.

Instructors and Office Hours: Adrian Borsa (aborsa@ucsd.edu (<mailto:aborsa@ucsd.edu>)), office hours after class on Tu/Th and by appointment. Yehuda Bock (ybock@ucsd.edu (<mailto:ybock@ucsd.edu>)), office hours TBD. Although he is not listed in the course catalog, Dr. Bock is contributing multiple guest lectures on fundamental geodesy topics.

Grading: Grading for SIO229 will be based on homework assignments (50%), class project (25%), and class participation (25%). The class project will be group-based, and all group members will receive the same score. Class participation consists of showing up to lectures, engaging with peers via in-class discussions and projects, and providing feedback to the instructors on our effectiveness via regular Canvas surveys. Be ready to engage!

Assignments: Instructions and scoring rubrics for homework assignments will be posted under Canvas Assignments. Students can share insights with each other on the technical aspects of homework assignments, but each student must write their own code and turn in their own individual written response to each question. Any code written to complete assignments (e.g., Matlab routines) should be submitted along with results. The Group Project will be fully collaborative within groups, which will each submit a single write-up for all group members.

Reading: Any required reading will be posted before lecture under the Canvas Modules tab and will be noted on the syllabus below. Lecture notes and lecture presentations will be posted (after class, if not before) under Modules as well. Resources on SIO229 topics:

Geodesy, 5th Edition

Wolfgang Torge, Jürgen Müller, Roland Pail

De Gruyter, Oldenbourg, 2023

Lecture 1: (1/7/2025) AB

Introduction to SIO229

Lecture 2: (1/9/2025) YB

History of Geodesy

Geometry of the Spheroid

Lecture 3: (1/14/2025) YB

Reference Ellipsoids

Celestial and Terrestrial Reference Frames

Geodetic and Cartesian Coordinate Systems

Lecture 4: (1/16/2025) YB

Geodetic Datums

Rotations and Transformations

Lecture 5: (1/21/2025) YB

Satellite Orbit Determination

Geodetic Measurements

Geodetic Positioning and Error Analysis

Lecture 6: (1/23/2025) YB

International and National Resources

Software and Tools

Lecture 7: (1/28/2025) AB

Introduction to the gravity portion of the course

A brief look at gravity via the Earth and Moon

Formal definitions for gravity and gravitational potential

Coordinate systems and the ∇ (gradient) operator

Lecture 8: (1/30/2025) AB

Moment of inertia for an arbitrary body

The inertia tensor and its principal axes

A natural coordinate system for Earth based on moments of inertia

Angular momentum and Earth's spin rate, spin axis, and Chandler Wobble

Lecture 9: (2/4/2025) AB

Multipole expansion of the gravitational potential of an arbitrary body
MacCullagh's Formula for the gravitational potential of Earth

Lecture 10: (2/6/2025) AB

A flip from Cartesian to spherical coordinates
The infamous J2

Lecture 11: (2/11/2025) AB

A first look at the geoid and confirmation of an ellipsoidal Earth
A simple geoid from Clairaut's Formula

Lecture 12: (2/13/2025) AB

Potential fields and Laplace's equation
Spherical harmonics as a general solution to Laplace's equation
Spherical harmonics as a generalization of coordinate systems in Euclidean space

Lecture 13: (2/18/2025) AB

Spherical Harmonics adapted to Earth's gravitational potential field

Lecture 14: (2/20/2025) AB

Earth reference ellipsoids
Determination of the geoid from gravity observations (aka gravity anomalies)

Lecture 15: (2/25/2025) AB

Global Gravity Models and how to use them

Lecture 16: (2/27/2025) YB

Geodetic applications
Tectonic plate motions
Earthquakes and crustal deformation

Lecture 17: (3/4/2025) AB

Sea level change, oceanography, ice mass change from altimetry
Mass transport from satellite gravimetry, GNSS, and InSAR
Grand Challenges of Geodesy

Lecture 18: (3/6/2025) AB/YB

Class Project I






Lecture 19: (3/11/2025) AB/YB

Class Project II

Lecture 20: (3/13/2025) AB/YB

Class Project III

Course Summary:

Date	Details	Due
Tue Jan 7, 2025	 SIO229 Lecture 1 - Introduction (https://canvas.ucsd.edu/calendar?event_id=1168833&include_contexts=course_62683)	9:30am to 10:50am
Wed Jan 8, 2025	 Feedback on SIOG229 Lecture 1 (https://canvas.ucsd.edu/courses/62683/assignments/910734)	due by 11:59pm
Thu Jan 9, 2025	 SIO229 Lecture 2 - Geometrical Geodesy 1 (https://canvas.ucsd.edu/calendar?event_id=1168834&include_contexts=course_62683)	9:30am to 10:50am
Tue Jan 14, 2025	 SIO229 Lecture 3 - Geometrical Geodesy 2 (https://canvas.ucsd.edu/calendar?event_id=1181355&include_contexts=course_62683)	9:30am to 10:50am
Thu Jan 16, 2025	 SIO229 Lecture 4 - Geometrical Geodesy 3 (https://canvas.ucsd.edu/calendar?event_id=1181356&include_contexts=course_62683)	9:30am to 11:50am

6d You are currently logged into Student View

Resetting the test student will clear all history for this student, allowing you to view the course as a brand new student.