Spring 2-1-2017

# GEO 595.01: ST - Geophysical Theory and Methods

Hilary Martens

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# Geo 595 – Special Topics: Geophysical Theory and Methods

### Instructor information

Instructor: Dr. Hilary Martens
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Phone: 406.243.6855
Lecture hours: MWF 2pm-2:50pm
Office hours: Tuesday 11am-12noon; Thursday 10am-11am; By appointment

### Course description:

We will explore modern topics in geophysics, with a focus on seismology and geodesy. The course will begin with an overview of important concepts, discoveries, methods, and applications in geophysics. More detailed lectures and discussions will cover selected topics, including continuum mechanics, inverse theory, seismic wave propagation, earthquake location, tidal analysis and prediction, GNSS theory and analysis, spheroidal Earth deformation, and surface mass loading. Students will have the opportunity to engage directly with real seismic and geodetic datasets using computational tools, as well as to investigate problems of personal interest through individual research projects.

### Learning Outcomes:

By the end of the course, students should be able to:

1. * Describe the causes and consequences of plate tectonics
2. * Visualize and explain how the solid Earth responds to loading and gravitational forcing
3. * Solve basic geophysical inverse problems
4. * Quantify stress and strain relationships in solids
5. * Assess the advantages and disadvantages of various geophysical methods used to probe Earth structure and dynamics
6. * Acquire, process, visualize, and interpret seismic and geodetic data using computational tools
7. * Apply geophysical theory and methods to problems in their own research areas
8. * Appreciate the importance and relevance of geophysics to society

### Required textbooks:

*No textbooks are specifically required for the course*. Applicable reading materials may be provided throughout the semester.

Suggestions for further reading include:

- Lowrie, W. (2007), *Fundamentals of Geophysics*, 2nd Ed., Cambridge University Press.
- Stacey, F.D., and P.M. Davis (2008), *Physics of the Earth*, 4th Ed., Cambridge University Press.
- Turcotte, D.L., and G. Schubert (2002), *Geodynamics*, 2nd Ed., Cambridge University Press.
- Mussett, A.E., and M.A. Khan (2000), *Looking into the Earth: An Introduction to Geological Geophysics*, Cambridge University Press
- Lai, W.M., D. Rubin, and E. Krempl (2010), *Introduction to Continuum Mechanics*, 4th Ed., Elsevier Ltd.
- Shearer, P.M. (2009), *Introduction to Seismology*, 2nd Ed., Cambridge University Press.
- Aster, R.C., B. Borchers, and C.H. Thurber (2013), *Parameter Estimation and Inverse Problems*, 2nd Ed., Academic Press.
- Jaeger, J.C., N.G.W. Cook, and R. Zimmerman (2007), *Fundamentals of Rock Mechanics*, 4th Ed., Wiley.

### Course Calendar:

| Dates | Topic | Assignment | Due Date |
|---|---|---|---|
| 23 January | Welcome and pre-quiz | | |
| 25 January | Earth Structure and Dynamics 1 | | |
| 27 January | Earth Structure and Dynamics 2 | | |
| 30 January | Earth Structure and Dynamics 3 | Problem Set 1 (Structure) | Thurs., 9 February, 3pm |
| 1 February | Linux Lab (and homework demo) | | |
| 3 February | Rock Mechanics 1 | | |
| 6 February | Rock Mechanics 2 | | |
| 8 February | Rock Mechanics 3 | Problem Set 2 (Stress/Strain/Heat) | Thurs., 16 February, 3pm |
| 10 February | GMT Lab 1 | | |
| 13 February | Seismology 1 | | |
| 15 February | Seismology 2 | Problem Set 3 (Earthquakes) | Thurs., 23 February, 3pm |
| 17 February | GMT Lab 2 | | |

| Dates | Topic | Assignment | Due Date |
|---|---|---|---|
| 20 February | **Presidents' Day (no class)** | | |
| 22 February | Seismology 3 | | |
| 24 February | Earthquake Presentations and Iceland/Montana Seismicity | Project 1 (Seismological Method) | Topic by Mon. 27 Feb. beginning of class; Report by Mon. 13 March, 2pm |
| 27 February | Seismic Data Acquisition and Analysis 1: Instrumentation, Deployment, Data | | |
| 1 March | Seismic Data Acquisition and Analysis 2: Tools for Data Analysis | | |
| 3 March | SAC Lab 1 | | |
| 6 March | SAC Lab 2 | | |
| 8 March | HypoInverse / ObsPy Lab | | |
| 10 March | Gravity, Geodesy and the Geoid | Project 2 (Geophysical Method) | Topic by Friday, 17 March, 2pm; Introduction by Thurs. 6 April at 3pm; Final report by Thurs. 27 April at 3pm |
| 13 March | Seismological Methods Presentations 1 | | |
| 15 March | Seismological Methods Presentations 2 | | |
| 17 March | Seismological Methods Presentations 3 | | |
| 20-24 March | **Spring Break (no classes)** | | |
| 27 March | Fundamentals of Inverse Theory 1 | | |
| 29 March | Fundamentals of Inverse Theory 2 | | |
| 31 March | Tidal Analysis and Prediction 1 | | |
| 3 April | Tidal Analysis and Prediction 2 | | |
| 5 April | Tidal Analysis and Prediction 3 | Problem Set 4 (Tides/Inversions) | Thurs., 13 April, 3pm |
| 7 April | Fundamentals of GNSS 1 | | |
| 10 April | Fundamentals of GNSS 2 | | |
| 12 April | GIPSY Lab 1 | Problem Set 5 (GNSS/Deformation) | Thurs., 20 April, 3pm |
| 14 April | GIPSY Lab 2 | | |
| 17 April | Loading and Earth Deformation 1 | | |
| 19 April | Loading and Earth Deformation 2 | | |
| 21 April | Loading and Earth Deformation 3 | | |
| 24 April | Earth and Planetary Paper Discussions 1 | | |
| 26 April | Earth and Planetary Paper Discussions 2 | | |
| 28 April | Earth and Planetary Paper Discussions 3 | | |
| 1 May | Geophysical Methods Presentations 1 | | |
| 3 May | Geophysical Methods Presentations 2 | | |
| 5 May | Geophysical Methods Presentations 3 | | |
| 8-12 May | Finals Week | | |

**Required assignments and tests:**

1. Problem Set 1: Earth structure, hydrostatic equilibrium, and the Adams-Williamson equation
2. Problem Set 2: Stress and strain in solids
3. Problem Set 3: "Adopt an earthquake"; USGS earthquake plotting and analysis; focal mechanism worksheet
4. Problem Set 4: Tidal harmonic analysis; basic inverse problems
5. Problem Set 5: GNSS analysis; Earth deformation
6. Project 1: Seismological methods and applications
7. Project 2: Geophysical methods and applications
8. Tutorials: Linux, shell scripting, Vi text editor, Python, GMT, SAC, HypoInverse, GIPSY

## Course guidelines and policies:

### Student Conduct Code

All students are expected to abide by The University of Montana's Student Conduct Code:
https://www.umt.edu/vpsa/policies/student_conduct.php

### Attendance

Regular attendance is encouraged and expected. If you need to miss a class, please inform the instructor in advance.

### Course withdrawal

Please refer to Institute policy on adding, dropping, and withdrawing from courses:
https://www.umt.edu/registrar/students/dropadd.php

### Disability modifications

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. If you think you may have a disability adversely affecting your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or call 406.243.2243. I will work with you and Disability Services to provide an appropriate modification.

### Assignment expectations

Assignments are expected to be completed thoughtfully and on-time.

Honor code (borrowed from Caltech): "No member of the community shall take unfair advantage of any other member of the community."

Plagiarism: Reproducing the work of someone else, and representing the work as your own, without appropriate citation and attribution is forbidden. Plagiarism extends beyond tangible material to also include ideas. When in doubt, cite.

Collaboration: Collaboration on problem sets, projects, and tutorials is encouraged. You may consult external references (e.g., internet, books, journal papers, etc.) with appropriate citations and attributions. You may also work with other students and consult with the instructor provided that all solutions that you submit are your own work (written up individually and reflecting your own understanding of the material). As a general guideline, you should be able to reproduce solutions from your submitted problem sets without help from anyone else.

More information on UM's academic policies and procedures:
http://archive.umt.edu/catalog/14_15/academics/academic-policy-procedure.php

### Grading policy

Project 1: 15% (written report and oral presentation) *
Project 2: 25% (written report and oral presentation) *
Problem sets: 40% *
Tutorials/Labs: 20% (all labs and Moodle tutorials must be completed and submitted by 8 May at 5pm to avoid penalties) *

Late assignments: *
Assignments submitted within 24 hours of due date: 10% reduction in credit *
Assignments submitted within 48 hours of due date: 50% reduction in credit *
Assignments submitted more than 48 hours past due date: No credit for the assignment *
Saturday and Sunday do not count toward the calculated hours past due (for example, if the assignment is due at 3pm on Thursday, 48 hours past due would be at 3pm the following Monday) *

**Additional Information and resources:**

Student Academic Resources

Disability Services for Students (DSS): http://www.umt.edu/dss/ *
The Writing Center: http://www.umt.edu/writingcenter/ *
Office for Student Success: http://www.umt.edu/oss/ *
Career Services: http://www.umt.edu/career/ *
Mansfield Library: http://www.lib.umt.edu *

Student Health and Wellbeing *

Curry Health Center (mental health, physical health, pharmacy, health promotion): http://www.umt.edu/curry-health-center/ *
Campus Recreation: http://www.umt.edu/crec/ *
DiverseU: http://www.umt.edu/diverseu/ *
Student Activity Groups: http://www.umt.edu/asum/student_groups/ *