Geology 341: Geophysics

Prof. Nick Holschuh
10:00-10:50, M/W/F
8:00:11:00 Tu / 1:00-4:00 Tu Lab

Before the boundaries between physics and geology were drawn, those who studied the Earth system were "natural philosophers" -- scientists who sought order in the cosmos through quantitative description of the world around us. Despite the modern disciplinary labels, physics and geology are still intertwined, as physical laws form the basis for explaining and exploring Earth's most fundamental systems. In this course, we will use the physicist's tool kit to investigate questions in tectonics, seismology, hydrology, and climate. We will collect data using concepts in acoustics, electromagnetics, and gravitation, which allow us to characterize the Earth in four dimensions. Finally, we will use these observations to understand energy and mass flow at all scales, exploring questions about the interior of our planet, the top of our atmosphere, and everything in between. This class will be a quantitative exploration of the Earth system, and is designed to help build physics-based intuition in the geosciences. Specific math, physics, and/or geology course work is not required; these skills will be built during the course. Three hours of class and three hours of lab each week.

[Given the unpredictability of the semester, some aspects of the syllabus are subject to change]

Useful Textbooks:

- Mussett & Kahn (2000) *Looking into the Earth: An Introduction to Geological Geophysics*
- Lehmann (2007). *Seismic traveltime tomography for engineering and exploration applications*
- Grotzinger, Jordan, Press, Siever (2007). *Understanding Earth*

Office Hours [Beneski 318]:

Monday, 12:00-1:00 pm or By Appointment

Subject Matter to be Covered:

Unit 1 – Solid Earth Geophysics
Unit 2 – Near Surface Geophysics
Unit 3 – Remote Sensing + Frontiers in the Field

Classroom culture:

We continuously strive to be inclusive. Members of this class must recognize that we can all contribute in making our shared spaces welcoming, accessible, and inclusive. We will do this by listening deeply, and by staying engaged and curious in other's perspectives, even during challenging conversations. If you feel like this community standard is not met, please feel free to reach out to me, the geology department chair (djones@amherst.edu), or the center for restorative practices.

Geophysical principles permeate our daily lives – how might an earthquake and lightbulb be similar? The global seismic network and a CT scanner?

Physical laws allow us to relate quantities we know how to measure (like the intensity of sound, the intensity of light) to those geologic properties we want to measure.

Course Goals and Learning Objectives:

- Develop a sense for the planet as a physical system, with properties that vary systematically in space and time, measurable and describable using first principles in physics.
- Develop an appreciation for mathematics as a descriptive language, and skill in using it to deconstruct relationships between Earth system variables.
- Develop skill in collecting and analyzing geophysical data.
- Develop a sense for the range of scientific questions that can be addressed with concepts in geophysics, and the broad applications and careers in the field.

Assignment Overview:

The cadence of the class is meant to be simple – deliverables are assigned / released on Monday, and typically due the following Monday. Details about assignment structure and expectations are provided on the individual prompts, but work will generally be assigned as follows:

[Weekly Reading] Each week there is a textbook section to be read by Friday (on Moodle)

[Participation] To get into the practice of reading and thinking mathematically, you are asked to deconstruct a provided equation (or an equation from the reading) each week, due by class time on Friday. In addition, occasional half-sheet exercises will be done in class, contributing to your participation grade

[Labs] Your primary deliverable for this class will be lab reports, typically due 1 week after the lab meeting. Some labs will not be due until two weeks after they are assigned (to allow time for data collection and analysis).

[Exams] Each unit ends with a team-based exam. Units 1 + 2 end with in-class exams, unit 3 ends with a project-based practicum exam.

Grade Breakdown:

Timing			Topic	[Lab]
Intro	W1	[3 days]	**Math as the language of the Earth**	[Geophysics Origins]
Unit 1	W2	[3 days]	**Geodesy**	[Stereophotogrammetry]
	W3	[3 days]	**Tectonics and the Unifying Theory of Geology**	[GNSS]
	W4	[3 days]	**Understanding the Source – EQ Seismology**	[EQ Location]
	W5	[3 days]	**Understanding the Path – Seismic Tomography**	[Wave Splitting]
Unit 2	W6	[3 days]	**Heat Flow**	***Midterm 01***
	W7	[3 days]	**Refraction Imaging**	[Heat Flow Modeling]
			Spring Break	
	W8	[3 days]	**Reflection Imaging**	[Seismic Refraction]
	W9	[3 days]	**Gravity**	[Reflection Imaging]
	W10	[3 days]	**Magnetics**	[Gravimetry]
Unit 3	W11	[3 days]	**InSAR**	***Midterm 02***
	W12	[2 days]	**Major Geophysics Initiatives**	
	W13	[3 days]	**Student Presentations**	[Lab Practicum Introduction]
	W14	[1 day]	**Review**	[Lab Practicum Work Time]

Course Policies and Campus Resources:
Below are documented resources and policies that you can refer back to over the course of the semester. These are in place to standardize our practice, to make sure you all get equitable and fair treatment from me, and to make sure my expectations are as clear as possible.

Late Work Policy:
For the typical lab, you will have a full week to complete your work before submission. This schedule is designed to give you flexibility, as lab writeups should each only take you a few hours outside of the lab period. Please let me know in advance if there are circumstances that interfere with getting your homework turned in – I tend to be very flexible if you submit a request for an extension more than 48 hours ahead of the deadline. To request a late submission without penalty, please use this form. Work that is turned in late without talking to me will lose 10% for every calendar day it is late.

To ensure that late homework is received and your grade is updated, I require that you submit late assignments using this form. It can be very difficult to keep track of late assignments, so I do this to standardize the process, and to ensure that you get the credit you deserve for the work you submit.

Attendance Policy:
I want you to have a rich experience in this class, which is best done by having all of us show up and actively engage during the lecture period. To incentivize this, occasional in class activities will contribute to your participation grade. These cannot be made up after the fact, but can be waived for excused absences discussed with me in advance by email.

Field Policy:
This class is meant to bring you out into the world for your own data collection. Even more than in the classroom, we need an environment of mutual respect and trust in the field, to make sure that it is a place we can all learn and our safety and the safety of the instrumentation is preserved. Do not hesitate to talk to me if you feel unsafe in the field for any reason.

Disability Accommodation:
The office of Accessibility Services at Amherst College works hard to ensure equitable treatment for students by standardizing our accommodation practices. This process is designed to protect you, so that you are not forced to share personal or private information with your faculty in order to get the resources you need for success. To maintain that standard of care, please identify yourself to Accessibility Services if you need accommodation in this class, and I will make sure it is provided once I am notified.

Plagiarism and Intellectual Responsibility:
My role as a professor is to emphasize the expectations for scholarly work, to set you up for success in the rest of your time here at Amherst and beyond. Much of what you learn in your life will take place through creation – writing, calculating, presenting your own ideas. When you miss out on that act of creation, you cheapen your own experience, and in the context of this class, you leave me in a position where I can't tell whether you've gotten what you need to out of any given exercise. You are welcome to work together and share thoughts on assignments, and even consult or ask questions of large language models like ChatGPT to stimulate your thinking, but what you turn in must ultimately be your own version. If you submit work or words that are not your own, I cannot give you a grade for the associated assignment, and it will default to a zero. If you have questions about acceptable practices at any time, do not hesitate to ask, but do so *before* you submit your work. ***Anybody can quote the internet*** – leaving Amherst I want you to be able to be critical of what you read, make connections and find consistency across multiple sources, and be able to distill your own insights about climate and climate change. Push yourself to do more, I know you can!