EAS 4316/6316 - Earthquake Physics

The Georgia Institute of Technology

August 22 - December 5, 2023
Tues., Thurs. 9:30 - 10:45 am in ES&T L1118

Professor: Andrew Newman
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`https://avnewman.github.io/teaching/Earthquakes` and on Canvas.

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General

This course consists of a series of in-depth lectures, discussion and presentations of the current status of geophysical and mechanical understanding of processes that control earthquakes. We will explore the structural, thermal, and compositional make-up of faults and how geophysical and geological observation, laboratory experiments, and theoretical models have shaped our ideas about these perplexing processes. While earthquakes remain a significant societal issue that can destabilize populations, and cause massive long-term, and sometimes unforeseen economic and environmental effects (e.g. the Fukashima Daiichi nuclear disaster following the 2011 Japan Earthquake and Tsunami), there remains numerous fundamental scientific questions about how, when, and where earthquakes happen.

Structurally, the first half of the class is lecture-based, with quizzes and a Mid-term, and the second half is composed of paper reading and writing. For grad students in the course, we will also have a final project.

Office Hours: Mondays from 12 - 1pm, or by appointment.

Prerequisites: For 4316: EAS 3610 *Intro. Geophysics*, or equivalent. For 6316: EAS 8803 *Intro. Geophys.* (co-req.).

Text: Order at online book sellers, digitally(?), or friendly grad student (*consider getting your own copy*).

- **Required:** Scholz, C.H., The Mechanics of Earthquakes and Faulting, 3^{rd} Ed., Cambridge Univ. Press, 493 pp., 2019. (If you already have the 2^{nd} edition, we'll work with you, but all referencing will be with the 3rd.)
- **Recommended:** Stein, S.A., & M. Wysession, An Introduction to Seismology, Earthquakes, and Earth Structure, Blackwell Pub., 498 pp., 2003.
- **Recommended:** Udias, A., R. Madariaga, & E. Buforn, Source Mechanisms of Earthquakes: Theory and Practice, Cambridge University Press, 2014.
- **Additional digital handouts on 1st day:**
  - Ben-Zion, Y. (2003). Appendix 2 Key formulas in earthquake seismology. *International Geophysics*, 81, 1857–1875. https://doi.org/10.1016/S0074-6142(03)80304-2.
  - Kanamori, H., & Brodsky, E. E. (2004). The physics of earthquakes. *Reports on Progress in Physics*, 67(8), 1429–1496. https://doi.org/10.1088/0034-4885/67/8/R03.
  - Additional material will be assigned through semester.

Absentee Policy: I will not officially be counting absences. However, during the second part of this class a significant part of your score is based on participation. You cannot participate if you are not here, physically or virtually. Any unexcused absences will lose all participation points for that portion of the course and will likely diminish your ability to synthesize your work. A virtual presence is only allowed with prior authorization to account for illness, school-related travel, etc.

Online Resources and Communication: The course webpage (listed above) and Canvas are the primary organizational resources for information about the class.
All email associated with this class should be identified with `[EAS EQPhysics]` as the beginning of the subject line. In addition to putting this in the subject line of your emails to the instructors, please add `[EAS EQPhysics]` to your email whitelist in order to avoid getting email communications deemed as spam. I will not consider the argument that an important email notification was sent to SPAM as an appropriate excuse for missed information.

Students Disabilities and Mental Wellness: If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at `https://disabilityservices.gatech.edu` as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

If you think you may be experiencing issues with your mental health or well being please do not hesitate to reach out either to me, or to one of the resources provided through GT. A comprehensive list of these can be found along the left-hand side of the Canvas pages for most courses.

Student-Faculty Expectations

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgment, and responsibility between faculty and students. Please see `https://catalog.gatech.edu/rules/22/` for some basic expectation that we should have of each other. Ultimately, we should respect each others time, hard work, and quest for knowledge. We all should strive to build an environment for cordial and effective interaction.

Course Outline (tentative)

Week/Date	Topic
Lectures:	
Aug 22 - 24	Brittle Fracture of Rocks
Aug 29 - 31	Rock Friction
Sept 5 - 7	Mechanics and Quantification of Faulting
Sept 12 - 19	Mechanics and Quantification of Earthquakes
(*No Class Sept 21*: Research-related Travel)	
Sept 26 - 28	The Seismic Cycle
Oct 3 - 12	Seismotectonics
(*No Class Oct 10*: Fall Break)	
Oct 17	**Exam over lectures**
Discussion of Emergent Research:	
Oct 19	Intro Modern Topics
Topics to be chosen for weekly discussion.	*Proposed Topics Include:*
Oct 24 - 26	Earthquake Precursors?
Oct 31 - Nov 2	Structural Asperities?
Nov 7 - 9	Stress Shadows?
Nov 14 - 16	
Nov 21, 28	New Ruptures on Old Faults?
(*No Class Nov 23*: Thanksgiving break)	
Nov 30 - Dec 5	Project Presentations
	no final exam
* *Topics and timing are subject to change during the semester.*	

Evaluation

Students taking 4316: Grade is 35% exam, 15% Quizzes, 50% paper reading, synthesis and discussion (below).
Students taking 6316: Grade is 25% exam, 15% Quizzes, 40% paper reading, synthesis, and discussion, and 20% final project.

Course Grade:

- Letter Grade: A $\geq$ 90% > B $\geq$ 80% > C $\geq$ 70% > D $\geq$ 60% > F

- Satisfactory/Unsatisfactory: S $\geq 70\% >$ U

Exam: There will be one exam covering all material presented during the lecture portion of the course. If you are having difficulties understanding topics, please discuss this with me outside of class, when it arises. Do not expect to do well by cramming just before the exam. Reading and preparing throughout should help.

Quizzes: Quizzes are meant to be brief 15 minute exercises aimed to evaluate your learning and development during this section of the class. Three to four quizzes in total will be administered, with one approximately every two weeks (announced the prior class period). These will serve as a preparation for the half-point exam.

Discussion: Half of this class will be comprised of detailed discussion of five topics of modern research in the field of earthquake physics (listed in the course outline). Before each discussion, you will be expected to read the assigned papers and submit (electronically) a 1-2 page summary of the topic (12 pt font, single spaced). After discussion is completed on that topic, you will submit a new 3-4 page synthesis of your understanding of the current state-of-the-art of that topic. Discussion grade is comprised of 1/3rd each, pre-discussion topic summary, post-discussion synthesis, and in-class participation, including during the project presentations. Any unexcused late submission without prior authorization will get a zero.

Project: For your class project, you will review and present on a topic of your choosing in Earthquake Physics using relevant research and review articles from peer-reviewed scientific literature (journals like *Science, Nature, Journal of Geophysical Research*, *Earth and Planetary Science Letters*). In order to receive full credit for the project you must read and synthesize no less than 5 papers on the subject. You will have the opportunity to receive 20% extra credit on the project if you 1) outline a new approach to addressing an unresolved problem; 2) uniquely solve a problem; 3) perform significant unique numerical calculations to determine parameter sensitivities and/or feasibility of measurement; or 4) perform an appropriate unique physical analog or unique computational experiment to test hypothesis.

You will write your final project in a form suitable for *Geophysical Research Letters* (GRL), and will be presented in a 15 minute AGU-style talk (12 minute presentation with 3 minutes of questions). For guidelines on GRL document preparation go to `https://publications.agu.org/author-resource-center/text-requirements/`. Your project grade is based on the quality of the paper (50%), presentation (40%), and in-class participation (10%).

Academic Honesty

General: It is expected that all students are aware of their individual responsibilities under the Georgia Tech Academic Honor Code, which will be strictly adhered to in this class. The complete text of the Honor Code may be found at: `https://honor.gatech.edu`.

Topics Papers and Project: Pre-discussion summaries, post-discussion syntheses, and Project papers, are expected to be the original work of the individual student. Hence, any papers that appear overly similar will be investigated and appropriate actions will be taken, if necessary. Likewise, Plagiarism is strictly forbidden. *Plagiarism* is the act of appropriating the literary composition of another, or parts of passages of his or her writings, or language or ideas of the same, and passing them off as the product of one's own mind. It involves the deliberate use of any outside source without proper acknowledgment. Plagiarism is scholarly misconduct whether it occurs in any work, published or unpublished, or in any application for funding[1]. This means that even rewording the ideas of someone else's work without proper attribution, in any form, is plagiarism. Lastly, you cannot republish your own writings in multiple places verbatim, as this is called "self-plagiarism".

Exam and Quizzes: All information required for exams will be supplied. Reference to texts or other documents during exams is strictly forbidden. The use of electronic devices (e.g. mobile phones, computers, smart watches, etc.) other than non-programmable calculators during exams and quizzes is not allowed.

[1] as defined by the Georgia Tech Academic Honor Code (`https://policylibrary.gatech.edu/student-affairs/academic-honor-code`)