GEOL-552 Advanced Seismology

Fall Semester, 2024

Course Syllabus

Course Description: Systematic review of seismological theory that begins with the continuum mechanics of elastic and anelastic media and develops the main theoretical models used to describe seismic sources (Volterra dislocations, moment tensor fields) and the wavefields they produce (ray fields, traveling waves, normal modes). The course will delve into several topics of active research, include effective-media models of 3D self-affine heterogeneity, apparent dissipation by self-affine elastic scattering, Rytov theory as the basis full-3D tomography, and the representation of complex seismic sources by moment-tensor fields.

Prerequisite: GEOL-551 or an equivalent course in basic seismology.

Learning Objectives: Graduate students in geophysics and related fields who take this course will gain theoretical understanding of advanced seismological methods and an improved ability to apply the theory in formulating and solving seismological inverse problems, including the modeling of Earth structure and seismic sources.

Instructor: Prof. Thomas H. Jordan (tjordan@usc.edu, ZHS-267, x1-1237); office hours: Tuesday 07:00-08:30 or by appointment.

Class Time and Location: Class will be taught in-person at 09:00-10:20 on Tuesdays & Thursdays in ZHS-118.

Textbooks: Most written course material will be in the form of lecture notes by T. Jordan, which will be posted on Blackboard in advance of the lectures. On occasion, students will be asked to consult the following references for reading assignments:

- K. Aki & P. G. Richards (2002). *Quantitative Seismology*, 2nd edition, University Science Books, 700 pp.
- F. A. Dahlen & J. Tromp (1998). *Theoretical Global Seismology*, Princeton, 1025 pp.
- P. Shearer (2019). *An Introduction to Seismology*, 3rd Edition, Cambridge, 442 pp., ISBN: 978-1107184473.
- S. Stein & M. Wysession (2003). *An Introduction to Seismology, Earthquakes, and Earth Structure*, Blackwell, 498 pp.
- Sato, H., Fehler, M. & Maeda, T. (2012). *Seismic Wave Propagation and Scattering in the Heterogeneous Earth*, 2nd ed., Springer, 493 pp.

Course Design & Format: On-line, 3-unit class with a "flipped" design. Written lecture material will be posted on Blackboard in advance of the class meeting. During the class, the

instructor and students will review the pre-assigned materials and engage in discussions of key theoretical concepts.

Class participation: Students are expected to have studied the lecture materials and be knowledgeable enough to participate in class discussions of key theoretical issues. Student participation in these class discussions will be the main component of the class participation grade.

Homework: Students are expected to spend approximately 6 hours per week on reading the assigned material, answering study questions, and working on their term projects.

Term project: Each student will prepare a 10-page paper on a seismological topic approved by the instructor, ideally one with significant theoretical content and of relevance to the student's research. Draft papers are due two weeks before the end of classes (Nov 21). Students will describe their projects orally in 15-minute presentations during the last two days of classes (Dec 3 & 5). Final drafts of the term papers will be due on Monday, Dec 9. Term-project grades will be based on the written paper (60%) and oral presentation (40%).

Grades: The term grade will be based on class participation (30%), homework (20%), and term project (50%).

Course Topics and Tentative Schedule:

Lecture	Dates	Topics
1	Aug 27	Course introduction and organization
2	Aug 29	Continuum mechanics and conservation laws
3	Sept 3	Elastic media
4	Sept 5	Equations of motion
5	Sept 10	SCEC Annual Meeting (no class)
6	Sept 12	Seismic attenuation and anelasticity
	Sept 17	Plane waves in homogeneous, anisotropic media
7	Sept 19	Point sources and moment tensors
8	Sept 24	Finite sources and stress gluts
9	Sept 26	Wave propagation in stratified media
10	Oct 1	Surface waves and leaky modes
11	Oct 3	Ray theory I
12	Oct 8	INGV Lecture (no class)
13	Oct 10	Fall Recess (no class)
14	Oct 15	Ray theory II
	Oct 17	Hanks Symposium (no class)
	Oct 22	Wavefield representation by normal-mode superposition
	Oct 24	Free oscillations of a spherical Earth I
15	Oct 29	Free oscillations of a spherical Earth II
16	Oct 31	Free oscillations of a rotating, aspherical Earth I
17	Nov 5	Free oscillations of a rotating, aspherical Earth II
18	Nov 7	Seismological inverse problems
19	Nov 12	Waveform tomography
20	Nov 14	Earthquakes I
21	Nov 19	Earthquakes II
22	Nov 22	Earthquake forecasting
23	Nov 26	Seismic hazard and risk analysis
	Nov 28	Thanksgiving holiday (no class)
24	Dec 3	Student presentations
25	Dec 5	Student presentations