

ESS 412/512 – Introduction to Seismology

Course Description

This course offers a basic introduction to quantitative seismology, including the basics of stress and strain, wave propagation, Earth structure, and earthquake source characterization. Students will gain an understanding of which features of seismic waves we can use to learn about the structure of the Earth or the characteristics of earthquakes and other sources.

Learning objectives

- develop analytical and quantitative skills useful for solving theoretical and observational problems in seismology.
- recognize common notations and concepts of seismology
- gain the background necessary to put research in the context of modern seismology, and better understand current research seminars.

Course Outline

1. Stress and strain
 - A. Stress tensor, traction
 - B. Strain tensor - deformation, strain, rotation
 - C. Linear stress-strain relation
 - D. Lamé's parameters –relation to shear modulus, bulk modulus, Young's modulus, Poisson's ratio, etc.
2. Wave propagation
 - A. Wave equation – plane waves, spherical waves, polarization
 - B. Surface waves – Love waves, Rayleigh waves, dispersion
 - C. Ray theory - travel times, ray tracing, ray nomenclature
 - D. Ray theory - wave amplitude and phase
 - E. Reflection seismology – zero-offset sections, common-midpoint stacking, migration
 - F. Noise seismology
3. Earthquake source theory
 - A. Earthquake location
 - B. Source mechanisms (radiation patterns, near vs. far-field waveforms)
 - C. Magnitude, size and moment, seismic radiated energy
 - D. Source dynamics: stress drop, source time functions

Textbooks

Required:

Introduction to Seismology, 3rd Ed., P. Shearer, Cambridge Univ. Press, 2019.

Recommended:

An Introduction to Seismology, Earthquakes and Earth Structure, S. Stein and M. Wyssession, Blackwell Publishing, 2003.

Reading Schedule

| Date | Topic | Reading schedule |
|--------|--|--|
| Jan 6 | Seismograms | |
| Jan 10 | Strain and Stress | |
| Jan 13 | Elasticity, momentum balance | Chapters 2.2, 2.3 |
| Jan 15 | wave equation | Chapters 3.1, 3.2, 3.3 |
| Jan 17 | body-wave polarization, potentials | Chapters 3.3, 3.4, 3.5 |
| Jan 22 | solutions to the wave equations (cartesian/planar and spherical) | Chapters 3.4, 3.5+review of chapters 2.2, 2.3 |
| Jan 24 | computing exercise | |
| Jan 27 | surface waves I - Rayleigh waves | SteinWyession Chapter 2.7.2 in PDF. Option: Chapter 8.2, |
| Jan 29 | surface waves II - Love waves and practice | SteinWyession Chapter 2.7.3. Option: Chapter 8.1 |
| Jan 31 | Ray Theory: ray tracing | Chapter 4.1, 4.2 |
| Feb 3 | Travel-time curves and the Moho | Chapter 4.3 |
| Feb 5 | Travel-time tomography | Chapter 5.6 |

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| Feb 7 | Ray Theory: phase and amplitude | Chapter 6.1 |
| Feb 10 | Ray Theory: Reflection coefficients | Chapter 6.3 |
| Feb 12 | Ray Theory: Reflection Seismology | Chapters 7.1, 7.2, 7.3, 7.5 |
| Feb 14 | Ray Theory: Attenuation | Chapter 6.6 |
| Feb 19 | Ambient noise seismology | Chapter 12 (3rd edition, in class practice) |
| Feb 21 | Earthquake Source: earthquake location | Chapter 5.6 |
| Feb 24 | Earthquake sources: Green's functions * source term | Chapter 9.1 |
| Feb 26 | Earthquake Sources: Moment tensor, radiation pattern | Chapter 9.2, 9.3 |
| Feb 28 | Earthquake Source: Magnitudes | Chapter 9.7 (in class practice) |
| March 3 | Earthquake source: dynamics (stress drop, directivity, | Chapters 9.4, 9.5, 9.6 |
| March 5 | BackProjection | Chapter 7.7 (in class practice) |
| March 7 | End2end : Catalog building | |
| March 10 | Student presentations | |

Format

This will be a fairly traditional class. Lectures with a mix of powerpoint and white board use, in-class exercises, quizzes, and possibly a few guest lectures. We will use computer programming in addition to pen and paper exercises to practice and gain insight into the material.

Course Logistics

Instructor: Marine Denolle

Rm. 204 ATG

mdenolle@uw.com

MWF 10:30-11:20 AM JHN 170

Office hours: Monday 1:00pm. JHN 375

Communication

Use the Canvas emailing system to contact me.

Evaluation

Grading policy 512:

- Homeworks: 45%
- Final: 20%
- programming projects: 35%
- final presentation: 10%
- All assignments must be turned in for a passing grade.

Grading policy 412:

- Homeworks: 45%
- Final: 20%
- programming projects: 35%
- All assignments must be turned in for a passing grade.

Homeworks

Provided on canvas, taken from the textbook.

Programming projects

Project 1: Write a computer program to calculate and plot a travel time curve for an oceanic crustal model using ray tracing: Shearer Chapter 4, Exercise 8. The assignment is due approximately mid-term. Assignments will be made available on GitHub.

Project 2: Write a computer program to locate earthquakes and estimate their magnitude.

Midterm/Exam/Final

In lieu of a final and midterm, we will have an open book exam on Wednesday, March 12th, from 10:30 AM - 12 PM.

Similar in style to the exercises in the textbook.

Final for 512:

512 requirement:

Pick one peer-reviewed research article from the list below to read closely and present its basic premise and findings to the class using PowerPoint or Google slides during the last week of instruction. **Relate the techniques used in the paper to the course material** you have learned in class. Please place this study in the context of a classic "scientific method" that includes hypothesis thinking and of "scientific discovery" that includes curiosity-based science.

List of publications to choose may inspired by a previous list available [here](#).

Collaboration policy

Religious accommodation

Washington state law requires that UW develop a policy for the accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at [Religious Accommodations Policy](#)

(<https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/>).

Accommodations must be requested within the first two weeks of this course using the [Religious Accommodations Request Form](#)

(<https://registrar.washington.edu/students/religious-accommodations-request/>).

Code of Conduct and Academic Integrity

Do your own work. Hand it in on time. Do not copy from the internet or other sources without proper attribution when you do a group project, hand in your own analysis.

The University of Washington Student Conduct Code [WAC 478-121](http://www.washington.edu/admin/rules/policies/WAC/478-121TOC.html) (<http://www.washington.edu/admin/rules/policies/WAC/478-121TOC.html>) defines prohibited academic and behavioral conduct and describes how the University holds students accountable. The college of the environment defines the process to report misconduct (<http://coenv.washington.edu/intranet/academics/academic-policies/academic-misconduct/>). We expect that you will know and follow university policies regarding all forms of academic and other misconduct.

Acts of academic misconduct include:

- Cheating:
 - unauthorized assistance in person and/or online for assignments, quizzes, tests, or exams
 - using another student's work without permission and instructor's authorization
 - allowing anyone to take a course, assignment, or exam for you without the instructor's authorization
- Falsification: intentional use of falsified data, information, or records
- Plagiarism: representing the work of others as your own without giving appropriate credit to the original author(s)
- Unauthorized collaboration: working with other students in the course on assignments, quizzes, or exams without permission
- Engaging in behavior prohibited by an instructor
- Multiple submissions of the same work in different courses without instructor's permission
- Deliberately damaging or destroying student work to gain an advantage
- Unauthorized recording, and/or subsequent dissemination of instructional content

Access, Accommodation, and Disability

A positive experience in this class is our top priority. If you have already established accommodations with Disability Resources for Students (DRS), please communicate your approved accommodations to me at your earliest convenience so we can discuss your needs in this course.

If you have not yet established services through DRS but have a temporary health condition or permanent disability that requires accommodations (conditions include but are not limited to; mental health, attention-related, learning, vision, hearing, physical or health impacts), you are welcome to contact DRS at 206-543-8924 or uwdrs@uw.edu or disability.uw.edu, and visit their website (<http://depts.washington.edu/uwdrs/>).

DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between you, your instructor(s), and DRS. It is the policy and practice of the

University of Washington to create inclusive and accessible learning environments consistent with federal and state law.

Please request accommodation by contacting the Disability Resources for Students office at uwdrs@uw.edu *BEFORE ATTENDING CLASS*.

Diversity, Equity, and Inclusion

The University of Washington supports an inclusive learning environment where diverse perspectives are recognized, respected, and seen as a source of strength. In this course, I will strive to create welcoming spaces where everyone feels included and engaged regardless of their social and cultural backgrounds. There are additional resources (<https://environment.uw.edu/about/diversity-equity-inclusion/>).

The College of the Environment [Student Academic Grievance Procedures](#) provide mechanisms for enrolled students to address academic problems or grievances in an equitable, respectful and timely manner. Academic grievances are defined as those involving conflicts between a student or students and their course instructors (including faculty and teaching assistants) or research mentor(s) with respect to differences arising within credit-bearing work and while the student is registered at the University of Washington. If you have or are experiencing such a conflict in this class and have not, cannot, or do not wish to attempt resolution with me, I encourage you to explore additional options by accessing the website [Safety](#).

If you feel unsafe or at risk while taking this or any course, please contact, SafeCampus at 206-685-7233 anytime, where you can anonymously discuss safety and well-being concerns for yourself or others. SafeCampus can provide individualized support, discuss short- and long-term solutions, and connect you with additional resources when requested. For a broader range of resources and assistance, see the [Husky Health & Well-Being](#) website.

Recording Zoom Class Sessions

The first week of this course is scheduled to run synchronously at our scheduled class time via Zoom. These Zoom class sessions will be recorded. The recording will capture the presenter's audio, video and computer screen. Student audio and video will be recorded if they share their computer audio and video during the recorded session. The recordings will only be accessible to students enrolled in the course to review materials. These recordings will be deleted after the course ends.

The University and Zoom have [FERPA \(https://registrar.washington.edu/students/ferpa/\)](https://registrar.washington.edu/students/ferpa/).

Students who do not wish to give consent to being recorded should:

1. Choose a Zoom profile name that does not include any personally identifying information like their name or UW Net ID, and not upload a profile picture
2. Not share their computer audio or video during class Zoom sessions.

All students enrolled in this class may use recorded course material stored on the Canvas course page to achieve the learning objectives of this course at any time. However, students may not personally record (including still images, video, or audio recordings) lectures or other class activities without written permission from the instructor, except as necessary as part of an approved accommodation plan from the Disability Resources for Students office (DRS). Any approved recordings may only be used for the student's own academic use, such as for studying or completing assignments. No student may distribute recorded material or upload the recordings to other platforms.