QUICK REFERENCE: Section 8 contains the calendar of topics and deadlines.

1. **Course information.**

GEOS 694	**Applied Seismology**, 3 credits, Spring 2012
Meeting times:	Tuesday and Thursday, 9:45–11:15
Meeting location:	TBA
Prerequisites:	MATH 314 (Linear Algebra) and MATH 202 (Calculus III) or permission of instructor

2. **Instructor information.**

Instructor:	**Carl Tape**
Office:	413D Elvey (Geophysical Institute)
Email:	`carltape@gi.alaska.edu`
Phone:	(907) 474-5456
Office hours:	Wednesday, 10:00–11:00, or by appointment

3. **Course materials.**

   (a) **Textbooks.** The required (R) and supplemental (S) textbooks are (see "References" at the end of this syllabus) listed in the following table.

Textbook	R	S	Availability			
			UAF bookstore	Mather reserve	PDF	UAF e-book
[1] Stein and Wysession	X			X		X
[2] Shearer	X			X		
[3, 4, 5, 6, 7, 8]		X		X		

   (b) Journal articles assigned as reading will be available as PDFs through the course website on UAF Blackboard.

   (c) Students will need computers for their homework. General-use computers in UAF labs will be made available to students if needed.

   (d) Matlab will be the primary computational program for the course. Matlab is available on computers in the student computer lab in Reichardt 316. If you need access to the lab, please follow the online lab instructions at `www.uaf.edu/geology/facilities/computer/computer-labs/`, and contact Chris Wyatt to set up an account (`wcwyatt@alaska.edu`). Note that it may be possible to obtain Matlab via OIT (`www.alaska.edu/oit/`).

4. **Course description.**

   Seismology combines observational data (seismograms) with numerical modeling methods to obtain powerful inferences about earthquake sources and the three-dimensional structure of Earth's interior. *Applied Seismology* will provide essential training for students' interested in academic, industrial, or governmental careers in seismology.

   Catalog description: Presentation of modeling techniques for earthquakes and Earth structure using wave propagation algorithms and real seismic data. Covers several essential theories and algorithms for applications in seismology, as well as the basic tools needed for processing and using recorded seismograms. Topics include the seismic wavefield (body waves and surface waves), earthquake moment tensors, earthquake location, and seismic tomography. Assignments require familiarity with linear algebra and computational tools such as Matlab.

5. **Course goals.**

   We will explore the study of earthquakes and Earth's interior structure using seismological theories and algorithms. The underlying physical phenomenon we will examine is the seismic wavefield: the time-dependent, space-dependent elastic waves that originate at an earthquake source (for example, a fault slips) and propagate though the heterogeneous Earth structure, then are finally recorded as time series at seismometers on Earth's surface. Students will examine real seismic data and use computational models to estimate properties about earthquake source and Earth structure. Students will acquire practical, advanced seismological training that will prepare them for seismological investigations in the future, whether in academic, industry, or government jobs.

6. **Student learning outcomes.**

   Upon completion of this course, students should be able to:

   (a) Understand the relevant temporal, spatial, and magnitude scales in the field of seismology.

   (b) Describe the physical quantities that govern seismic wave propagation.

   (c) Describe the seismic phases that arise in a regional or global layered Earth model.

   (d) Describe the seismic moment tensor, the fundamental model of an earthquake source.

   (e) Understand the basic framework of inverse problems within the context of seismology.

   (f) Describe several different seismological tools that can be used to investigate an individual earthquake.

   (g) Understand the connection between earthquakes, continental deformation, and plate tectonics.

   (h) Understand the distinction between one-dimensional and three-dimensional Earth structure, and how this affects theory and algorithms in seismology.

   (i) Read seismological journal articles and summarize the content efficiently.

   (j) Write, improve, and run simple computational algorithms in Matlab.

   (k) Plot and manipulate recorded seismograms.

7. **Instructional methods.**

   (a) Assignments and grades (along with general course information and handouts) will be posted on Blackboard: `classes.uaf.edu`.

   (b) Lectures will be the primary mode of instruction. Some lectures will be supplemented with computational examples to prepare students for homework problems.

   (c) Each student is expected to lead one brief discussion and review of an assigned journal article.

8. **Course calendar (tentative).**

	Day	Date	Topic	Reading Due†	Homework Due	Homework Assigned
1	Thurs	Jan-19	Seismology in 1911, 2011, and 2111	SW1	—	PS-1
2	Tues	Jan-24	Seismograms, signal, noise, measurements	S11, SW6.6		
3	Thurs	Jan-26	Basic analysis and processing of seismograms		PS-1	PS-2
4	Tues	Jan-31	Continuum mechanics	DT2.6		
5	Thurs	Feb-02	Equations of motion	DT3, SW2, S2	PS-2	PS-3
6	Tues	Feb-07	Solving the wave equation (3D)	DT2		
7	Thurs	Feb-09	Solving the wave equation (1D and 2D)	SW2, S3	PS-3	PS-4
8	Tues	Feb-14	Normal modes: theory and observations	SW2.9, S8.6, DT10.5		
9	Thurs	Feb-16	Surface waves: theory and observations	SW2.7-2.8, S8	PS-4	PS-5
10	Tues	Feb-21	Body waves, reflection, and transmission	S4, SW3		
11	Thurs	Feb-23	Waveform modeling	SW4.3	PS-5	PS-6
12	Tues	Feb-28	Wavefield modeling	[9, 10, 11]		
13	Thurs	Mar-01	Finite-frequency sensitivity kernels	[12, 13]	PS-6	PS-7
14	Tues	Mar-06	Ambient-noise tomography	[14, 15]		final project
15	Thurs	Mar-08	Preliminary Reference Earth Model	[16], DT8.2	PS-7	PS-8
	Tues	Mar-13	SPRING BREAK			
	Thurs	Mar-15	SPRING BREAK			
16	Tues	Mar-20	Forward problems and inverse problems	[16]		
17	Thurs	Mar-22	Earthquake location	SW4, S9	PS-8	PS-9
18	Tues	Mar-27	Seismic moment tensor	SW4.4, S9		
19	Thurs	Mar-29	Finite source models	S9.8, WS4.5	PS-9	PS-10
20	Tues	Apr-03	Seismic tomography: global	S5, SW7.3		
21	Thurs	Apr-05	Seismic tomography: crustal	SW3.2-3.3	PS-10	PS-11
22	Tues	Apr-10	Anisotropy and attenuation	SW3.6-3.7, S6.6,11.3		
23	Thurs	Apr-12	Adjoint methods in seismology	[17, 18]	PS-11	final project
24	Tues	Apr-17	Finite source inversion	S9.8, SW4.5		final project
25	Thurs	Apr-19	Seismology, geodesy, and deformation	WS5		final project
26	Tues	Apr-24	Seismology of volcanoes	[19]		final project
27	Thurs	Apr-26	Seismology of glaciers	[20, 21]		final project
28	Tues	May-01	Seismology in the oil industry	S7, WS3.3		final project
29	Thurs	May-03	Seismic monitoring for nuclear activity	[22]	REPORT	
		May-XX	FINAL PROJECT PRESENTATION			

†SW = Ref. [1]; S = Ref. [2]; DT = Ref. [5]

Some Important Dates:

First class:	Thursday	January 19
Last day to add class:	Friday	January 27
Last day to drop class:	Friday	Feb 3
Last day for student- or faculty-initiated withdraw:	Friday	March 23
Last class:	Thursday	May 3
Final project report due:	Thursday	May 3
Final project presentation:		TBD (May 7–10)

9. **Course policies.**

   (a) **Attendance**: All students are expected to attend and participate in all classes.

   (b) **Tardiness**: Students are expected to arrive in class prior to the start of each class. If a student does arrive late, they are expected to do so quietly and inform the instructor without disturbing the class.

   (c) **Participation and Preparation**: Students are expected to come to class with assigned reading and other assignments completed as noted in the syllabus.

   (d) **Assignments**:

      i. All assignments are due at the start of class on the due date noted in the Syllabus.

      ii. Late assignments will be accepted with a 20% penalty per day late; an assignment that is ≥ 5 days late will receive a zero.

      iii. The lowest homework assignment will be dropped when computing the course grade.

   Homework Tips: Please type or write neatly, keep the solutions in the order assigned and staple pages together. Include only relevant computer output in your solutions (a good approach is to cut and paste the relevant output for each problem into an editor such as MS Word or Latex). Also clearly circle or highlight important numbers in the output, and label them with the question number. I also suggest that you to include your Matlab code in your answers, both so that you can refer back to it for future assignments and so that I can identify where a mistake may have occurred. Display numerical answers with a reasonable number of significant figures and with *units* if the quantity is not dimensionless.

   Homework scores are based on clarity of work, logical progression toward the solution, completeness of interpretation and summaries, and whether a correct solution was obtained. I encourage you to discuss homework problems with other students, however the work you turn in must be your own.

   (e) **Graded Assignments**: Assignments will be graded for students within seven days of their receipt and returned at the end of the next class.

   (f) **Reporting Grades**: All student grades, transcripts and tuition information are available on line at `www.uaonline.alaska.edu`.

   (g) **Consulting fellow students**: Students are welcome to discuss with each other general strategies for particular homework problems. However, the write-up that is handed in—including any computer codes—must be individual work.

   (h) **Plagiarism:** Students must acknowledge any sources of information—including fellow students—that influenced their homework assignments or final project. Any occurrence of plagiarism will result in forfeiture of all points for the particular homework assignment. If the plagiarism is between two students, then both students will potentially receive the penalty.

   (i) All UA student academics and regulations are adhered to in this course. You may find these in the UAF Catalog.

10. **Evaluation.**

   (a) For students in the M.S. or Ph.D. program, you must receive a C or higher for this course for it to count toward your degree requirements.

   (b) Grading is based on:

10%	Attendance and participation
60%	Homework Assignments
30%	Individual Final Project

(c) Overall course grades are based on the following criteria:

A	$x \geq 93$	excellent performance:
A–	$90 \leq x < 93$	student demonstrates deep understanding of the subject
B+	$87 \leq x < 90$	strong performance:
B	$83 \leq x < 87$	student demonstrates strong understanding of the subject,
B–	$80 \leq x < 83$	but the work lacks the depth and quality needed for an 'A'
C+	$77 \leq x < 80$	average performance:
C	$73 \leq x < 77$	student comprehends the essential material
C–	$70 \leq x < 73$	as reflected by the average quality of assignments
D	$60 \leq x < 70$	below average performance:
		student demonstrates comprehension of some concepts
F	$x < 60$	Failure to complete work with 60% quality

(d) **Final Project.** The final project will constitute 30% of the course grade. The project will involve independent research into one aspect of seismology. It will require some computation and will be presented in the form of a written report, due on the last lecture class of the semester, and a short in-class presentation during the scheduled final exam. The report will be written in manuscript-submission style and format, using the guidelines for *Geophysical Research Letters*. Additional details, including project suggestions, will be provided by the instructor midway through the course.

11. **Support Services.**

The instructor is available by appointment for additional assistance outside session hours. UAF has many student support programs, including the Math Hotline (1-866-UAF-MATH; 1-866-6284) and the Math and Stat Lab in Chapman building (see `www.uaf.edu/dms/mathlab/` for hours and details).

12. **Disabilities Services.**

The Office of Disability Services implements the Americans with Disabilities Act (ADA), and it ensures that UAF students have equal access to the campus and course materials. The Geophysics Program will work with the Office of Disability Services (208 Whitaker, 474-5655) to provide reasonable accommodation to students with disabilities.

13. **References listed in syllabus.**

[1] S. Stein and M. Wysession, *An Introduction to Seismology, Earthquakes, and Earth Structure.* Malden, Mass., USA: Blackwell, 2003.

[2] P. M. Shearer, *Introduction to Seismology.* Cambridge, UK: Cambridge U. Press, 2 ed., 2009.

[3] B. L. N. Kennett, *The Seismic Wavefield: Introduction and Theoretical Development*, vol. 1. Cambridge, UK: Cambridge U. Press, 2001.

[4] B. L. N. Kennett, *The Seismic Wavefield: Interpretation of Seismograms on Regional and Global Scales*, vol. 2. Cambridge, UK: Cambridge U. Press, 2002.

[5] F. A. Dahlen and J. Tromp, *Theoretical Global Seismology.* Princeton, New Jersey, USA: Princeton U. Press, 1998.

[6] T. Lay and T. C. Wallace, *Modern Global Seismology.* San Diego, Calif., USA: Academic Press, 1995.

[7] K. Aki and P. G. Richards, *Quantitative Seismology.* San Francisco, Calif., USA: University Science Books, 2 ed., 2002. 2009 corrected printing.

[8] L. E. Malvern, *Introduction to the Mechanics of a Continuous Medium.* Upper Saddle River, New Jersey, USA: Prentice-Hall, 1969.

[9] T. Nissen-Meyer, A. Fournier, and F. A. Dahlen, "A two-dimensional spectral-element method for computer spherical-earth seismograms – I. Moment-tensor source," *Geophys. J. Int.*, vol. 168, pp. 1067–1092, 2007.

[10] D. Komatitsch and J. Tromp, "Spectral-element simulations of global seismic wave propagation—I. Validation," *Geophys. J. Int.*, vol. 149, pp. 390–412, 2002.

[11] D. Komatitsch and J. Tromp, "Spectral-element simulations of global seismic wave propagation—II. Three-dimensional models, oceans, rotation and self-gravitation," *Geophys. J. Int.*, vol. 150, pp. 308–318, 2002.

[12] F. A. Dahlen, S.-H. Hung, and G. Nolet, "Fréchet kernels for finite-frequency traveltimes—I. Theory," *Geophys. J. Int.*, vol. 141, pp. 157–174, 2000.

[13] S.-H. Hung, F. A. Dahlen, and G. Nolet, "Fréchet kernels for finite-frequency traveltimes—II. Examples," *Geophys. J. Int.*, vol. 141, pp. 175–203, 2000.

[14] N. M. Shapiro, M. Campillo, L. Stehly, and M. H. Ritzwoller, "High-resolution surface-wave tomography from ambient seismic noise," *Science*, vol. 307, pp. 1615–1618, 2005.

[15] J. Tromp, Y. Luo, S. Hanasoge, and D. Peter, "Geophys. J. Int.," *Geophys. J. Int.*, vol. 183, pp. 791–819, 2010.

[16] A. Dziewonski and D. Anderson, "Preliminary reference Earth model," *Phys. Earth Planet. Inter.*, vol. 25, pp. 297–356, 1981.

[17] Q. Liu and J. Tromp, "Finite-frequency kernels based on adjoint methods," *Bull. Seis. Soc. Am.*, vol. 96, no. 6, pp. 2383–2397, 2006.

[18] C. Tape, Q. Liu, and J. Tromp, "Finite-frequency tomography using adjoint methods—Methodology and examples using membrane surface waves," *Geophys. J. Int.*, vol. 168, pp. 1105–1129, 2007.

[19] S. R. McNutt, "Volcanic seismology," *Annu. Rev. Earth Planet. Sci.*, vol. 33, pp. 461–491, 2005.

[20] V. C. Tsai and G. Ekström, "Analysis of glacial earthquakes," *J. Geophys. Res.*, vol. 112, 2007.

[21] M. E. West, C. F. Larsen, M. Truffer, S. O'Neel, and L. LeBlanc, "Glacier microseismicity," *Geology*, vol. 38, no. 4, pp. 319–322, 2010.

[22] D. Bowers and N. D. Selby, "Forensic seismology and the Comprehensive Nuclear-Test-Ban Treaty," *Annu. Rev. Earth Planet. Sci.*, vol. 37, pp. 209–236, 2009.