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

Last compiled: January 30, 2014

1. **Course information.**

GEOS 626	**Applied Seismology**, 3 credits, Spring 2014
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. The G.I. Mather library is located in the IARC/Akasofu building.

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, 9]		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 via a UAF-wide license.

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.

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

	Day	Date	Topic	Reading Due†	Homework Due	Homework Assigned
1	Thurs	Jan-16	Seismology in 1914, 2014, and 2114	SW1	—	HW-1
2	Tues	Jan-21	LAB: linux and Matlab			
3	Thurs	Jan-23	Linear algebra	SW-A, S-B	HW-1	HW-2
4	Tues	Jan-28	Linear algebra			
5	Thurs	Jan-30	Seismic moment tensor	SW4.4, S9	HW-2	HW-3
6	Tues	Feb-04	LAB: Processing and visualizing seismic data	[10]		
7	Thurs	Feb-06	LAB: Fourier transform, seismic spectra	SW6, S-E	HW-3	HW-4
8	Tues	Feb-11	The 2004 Sumatra earthquake	[11, 12, 13, 14]		
9	Thurs	Feb-13	LAB: Sumarta earthquake		HW-4	HW-5
10	Tues	Feb-18	LAB: Sumarta earthquake			
11	Thurs	Feb-20	Preliminary Reference Earth Model	[15], DT8.2	HW-5	HW-6
12	Tues	Feb-25	Least-squares inverse theory	T3, T6.22		
13	Thurs	Feb-27	Least-squares inverse theory		HW-6	HW-7
14	Tues	Mar-04	LAB: least squares, Netwon algorithm			
15	Thurs	Mar-06	LAB: earthquake location			
16	Tues	Mar-11	Surface waves: theory and observations	SW2.7-2.8, S8	HW-7	
17	Thurs	Mar-13	LAB: surface wave dispersion			
	Tues	Mar-18	SPRING BREAK			
	Thurs	Mar-20	SPRING BREAK			
18	Tues	Mar-25	Normal modes: theory and observations	SW2.9, S8.6, DT10.5		HW-8
19	Thurs	Mar-27	LAB: toroidal modes			
20	Tues	Apr-01	Seismic tomography: global	S5, SW7.3	HW-8	HW-9
21	Thurs	Apr-03	LAB: Love waves			
22	Tues	Apr-08	Seismic tomography: crustal	SW3.2-3.3	HW-9	HW-10
23	Thurs	Apr-10	LAB: tomography			
24	Tues	Apr-15	Adjoint methods in seismology	[16, 17]	HW-10	
25	Thurs	Apr-17	Finite source models	S9.8, WS4.5		
26	Tues	Apr-22	Seismology in the oil industry	S7, WS3.3		
27	Thurs	Apr-24	Seismic monitoring for nuclear activity	[18]		
28	Tues	Apr-29	CLASS CANCELLED (SSA Anchorage)			
29	Thurs	May-01	CLASS CANCELLED (SSA Anchorage)			

†SW = Ref. [1]; S = Ref. [2]; DT = Ref. [5]; T = Ref. [19]

For example, "SW2.9" means Section 2.9 of Stein and Wysession (Ref. [1])

Some Important Dates:

First class:	Thursday	January 16
Last day to add class:	Friday	January 24
Last day to drop class:	Friday	January 31
Last day for student- or faculty-initiated withdraw:	Friday	March 14
Last class:	Thursday	May 1

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.

      ii. Late assignments will be accepted with a 10% penalty per day late, up to five days late; an assignment that is ≥ 5 days late will receive a zero. (An assignment that is "one day late" would be handed in less than 24 hours after the start time of class on the due date.)

      iii. No digital submission of assigments will be accepted (e.g., email or Blackboard).

   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.

   Furthermore, the UAF catalog states: "The university may initiate disciplinary action and impose disciplinary sanctions against any student or student organization found responsible for committing, attempting to commit or intentionally assisting in the commission of ... cheating, plagiarism, or other forms of academic dishonesty..."

   (i) All UA student academics and regulations are adhered to in this course. You may find these in the UAF catalog (section "Academics and Regulations").

10. **Evaluation.**

   (a) Grading is based on:

5%	Attendance and participation
95%	Homework Assignments

(b) 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+	$77 \leq x < 80$	mediocre performance:
C	$73 \leq x < 77$	student demonstrates comprehension of some
C–	$70 \leq x < 73$	essential concepts only
D	$60 \leq x < 70$	poor performance:
		student demonstrates poor comprehension of concepts
F	$x < 60$	Failure to complete work with 60% quality

(c) **Research Project.** Students have the option of of substituting a research project for any 2 homework assignments. 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 at the end of the semester. 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] R. C. Aster, B. Borchers, and C. H. Thurber, *Parameter Estimation and Inverse Problems.* Waltham, Mass., USA: Elsevier, 2 ed., 2012.

[10] C. G. Reyes and M. E. West, "The Waveform Suite: A robust platform for manipulating waveforms in MATLAB," *Seis. Res. Lett.*, vol. 82, pp. 104–110, 2011.

[11] T. Lay, H. Kanamori, C. J. Ammon, M. Nettles, S. N. Ward, R. C. Aster, S. L. Beck, S. L. Bilek, M. R. Brudzinski, R. Butler, H. R. DeSchon, G. Ekström, K. Satake, and S. Sipkin, "The great Sumatra-Andaman earthquake of 26 December 2004," *Science*, vol. 308, pp. 1127–1133, 2005.

[12] C. J. Ammon, C. Ji, H.-K. Thio, D. Robinson, S. Ni, V. Hjorleifsdottir, H. Kanamori, T. Lay, S. Das, D. Helmberger, G. Ichinose, J. Polet, and D. Wald, "Rupture process of the 2004 Sumatra-Andaman earthquake," *Science*, vol. 308, pp. 1133–1139, 2005.

[13] J. Park, T.-R. A. Song, J. Tromp, E. Okal, S. Stein, G. Roult, E. Clevede, G. Laske, H. Kanamori, P. Davis, J. Berger, C. Braitenberg, M. V. Camp, X. Lei, H. Sun, H. Xu, and S. Rosat, "Earth's free oscillations excited by the 26 December 2004 Sumatra Andaman earthquake," *Science*, vol. 308, pp. 1139–1144, 2005.

[14] S. Ni, D. Helmberger, and H. Kanamori, "Energy radiation from the Sumatra earthquake," *Nature*, vol. 434, p. 582, 2005.

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

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

[17] 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.

[18] 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.

[19] A. Tarantola, *Inverse Problem Theory and Methods for Model Parameter Estimation.* Philadelphia, Penn., USA: SIAM, 2005.