Course	**GEOS 6396 Seismic Inversion**
Professor	George McMechan
Term	Fall 2006
Meetings	WT 2.210, Tuesday 2:00 – 5:00

Professor's Contact Information

Office Phone	972-883-2419
Other Phone	
Office Location	WT 2.204
Email Address	Mcmec@utdallas.edu
Office Hours	Monday 2:00 – 5:00 pm, or by appointment
Other Information	

General Course Information

Pre-requisites, Co-requisites, & other restrictions	At least 2 prior graduate courses in seismology
Course Description	Theory and application of the major techniques for inversion of seismic data. Topics include linear and non-linear matrix methods, Wiechert-Herglotz integration, extremal inversion for velocity models, migration, wavefield imaging of body and surface waves, tomography, imaging of VSPs, and Born inversion. There is no textbook for this course; readings are drawn from the literature.
Learning Outcomes	To explain and carry out the main procedures for extracting information from seismic data. To be able to evaluate the strengths and weaknesses of alternative procedures and thereby choose an appropriate one for any particular problem or data set. To demonstrate these abilities by doing them in the term project.
Required Texts & Materials	There is no textbook for this course; readings are drawn from the literature.
Suggested Texts, Readings, & Materials	

READING LIST

The papers on this list give both a historical perspective (via the earliest papers on the topic) and a state-of-the-art perspective

(via recent papers). You are expected to read some, but not all of these. Read enough on each topic that you are confident that you understand it well; read more than those on this list on the topics that are related to your term project (enough that you feel 'expert' on that subject).

Linear Inversion Methods

Golub & Kahan (1965) J. SIAM Numer. Anal. 2, 205-224
Lee & Stewart (1981) Principles & Applications of Microearthquake Networks, Academic Press
Lawson & Hanson (1974) Solving Least Squares Problems, Prentice-Hall
Bjorck (1996) Numerical Methods for Least Squares Problems, SIAM
Jackson (1972) G.J., 28, 97-109
Jackson & Matsu'ura (1985) J. Geophys. Res., 90, 581-591
Menke (1984) Geophys. Data Analysis, Academic Press
Franklin (1970) J. Math. Anal. Appl. 31, 682-716
Shewchuk (1994) anonymous FTP to WARP.CS.CMU.EDU (128.2.209.10) file quake-papers/painless-conjugate-gradient.ps

Linear Inversion Applications

Wiggins (1972) Rev. Geophys. Space Phys. 10, 251-285
Grechka & McMechan (1996) Geophysics 62, 1884-1895
Crossen (1976) J.G.R., 81, 3036-3046
Hileman (1979) BSSA 69, 387-396
Novotny (1981) J. Geophys. 69, 7-15
Aki et al. (1977) J.G.R. 82, 277-296
Pavlis & Booker (1980) J.G.R., 88, 4801-4810
Spencer & Gubbins (1980) G.J. 63, 95-116
Wiggins et al. (1976) Geophysics 41, 922-938
Sun & McMechan (1988) Geophysics 53, 1295-1303
McAuley (1986) Geophysics 51, 1789-1800
Marsden (1993) TLE 43-49 and 115-120

Non Linear Inversion (Simulated annealing, genetic) Applications

Rothman (1985) Geophysics 50, 2784-2796
Rothman (1986) Geophysics 51, 332-346
Calderon et al. (2000) Geophys. Prosp. 48, 21-48

Sen & Stoffa (1991) Geophysics 56, 1624-1638
Stoffa & Sen (1991) Geophysics 56, 1794-1810

Acoustic Inversion

Walker & Ulrych (1983) Geophysics 48, 1338-1350
Aki & Richards, Quantitative Seismology 659-669
Claerbout (1976) Fund. Geophys. Data Proc.
Robinson (1967) Multichannel Time Series Analysis Holden-Day
Oldenburg et al (1983) Geophysics 48, 1318-1337
Newton (1981) G.J. 65, 191-215
Hildebrand & McMechan (1994) Geophysics 59, 782-800
Lu & McMechan (2002) Geophysics 67, 582-593

Body Wave Inversions

Gerver & Markushevich (1966) G.J. 11, 165-173
McMechan & Wiggins (1972) G.J. 28, 459-473
Aki & Richards, Quantitative Seismology 459-473
McMechan (1979) BSSA 69, 379-385
Garmany (1979) G.R.L. 6, 277-279
McMechan (1979) BSSA 69, 1439-1444

Surface Wave Inversions

Dziewonski & Hales (1972) Methods in Comp. Phys. 12, 39-85
McMechan & Yedlin (1981) Geophysics 46, 869-874
Lee & McMechan (1987) G. J. R Astr. Soc. 90, 649-667

Source Functions

Langston & Helmberger, Geophys. J. 42, 117-130
Stump & Johnson BSSA 67, 1489-
Burridge & Knopoff BSSA 54, 1875-1888
Mendiguren (1977) J.G.R. 82, 889-894
Romanowicz & Suarez (1983) BSSA 73, 1513-1526
Hu & McMechan (1988) Geophys. JRAS 95, 303-313
Chang & McMechan (1991) G.J. Int. 106, 85-98
Fehler & Phillips (1991) BSSA 81, 553-575
Ramos-Martinez and McMechan (2001) BSSA 91, 276-291

Tomography

Kjartansson (1979) PhD Thesis, Stanford
Mason et al. (1980) Geophysics 45, 1131-1143
Mason (1981) Geophysics 46, 298-308
McMechan (1983) G.J. 74, 601-612
Dines & Lytle (1979) Proc, IEEE 67, 1065-1073
Menke W. (1980) notes
Tanabe (1971) Numer. Math. 17, 203-214
Ivansson (1983) G.J. 75, 855-860
Censor (1981) SIAM Rev. 23, 444-466
McMechan et al. (1987) BSSA 77, 1945-1960
Stewart (1988) Geophysics 53, 1613-1615
Gilbert (1972) J. Theor. Biol 36, 105-117
Zhu & McMechan (1989) BSSA 79, 873-887
Brzostowski & McMechan (1992) Geophysics 57, 396-403
Zhang & McMechan (1994) Geophysics 59, 1620-1630
Pratt & Worthington (1990) Geophys. Prosp. 38, 287-310
Liao & McMechan (1997) Geophysics 62, 1804-1811
Fei & McMechan (2006) Geophysics 71, U21-U28
Fei & McMechan (2006) Geophysics 71, S161-S167

Migration

Gazdag (1978) Geophysics 43, 1342-1351
Lowenthal & Mufti (1983) Geophysics 48, 627-635
Claerbout (1976) Fund. Geophys. Data Proc. 236-246
Levin (1984) notes
Stolt (1978) Geophysics 43, 23-48
Hubral (1984) Prakla-Seismos report
McMechan (1983) Geophys. Prosp. 31, 413-420
Berkhout et al. (1980) Geophys. Prosp. 28, 372-383
Berkhout (1983) Seismic Migration, Elsevier
Clayton & Engquist (1980) Geophysics 45, 895-904
Western Geophysical (brochures)
Schneider (1978) Geophysics 43, 49-76
Sun & McMechan (1986) Proc. IEEE 74, 457-465
Rajasekaran & McMechan (1995) G.J. Int. 121, 255-266
Chang et al. (1998) Geophysics 63, 546-556.
Hua & McMechan (2005) Geophys. Prosp. 53, 507-522
Hua & McMechan (2003) Geophysics 68, 1043-1051

Slant Stacking

McMechan & Ottolini (1980) BSSA 70, 775-789
Clayton & McMechan (1981) Geophysics 46, 860-868
McMechan & Yedlin (1981) Geophysics 46, 869-874
Tatham et al. (1982) notes
McMechan et al. (1982) J.G.R. 87, 927-935
Trietel et al. (1982) Geophysics 47, 1375-1401
Chapman (1981) Geophys. J. 66, 445-453
Hu & McMechan (1987) Geophysics 52, 307-321
Hua & McMechan (2001) Geophysics 66, 1497-1503

Born Inversion

Bleisein & Cohen (1979) Geophysics 44, 1034-1040
Cohen & Bleistein (1979) Geophysics 44, 1077-1087
Cohen & Bleistein (1977) SIAM J Appl. Math 32 787-799
Clayton & Stolt (1981) Geophysics 46, 1559-1569
Newton (1981) Geophys. J. 65, 191-215

Full Wave Inversion

Jurkevics & Wiggins (1980) Geophys. J. 63, 75-93
Tarantola (1984) Geophysics 49, 1259-1266
Stolt & Weglein (1985) Geophysics 50, 2458-2472
Pan & Phinney (1989) Geophysics 54, 368-380
Martinez & McMechan (1990) Geophys. Prosp. 39, 141-156
Bourgois et al. (1989) Geophys J. 99, 435-445
Sun & McMechan (1991) G.J. Int. 106, 67-75
Mora (1989) Geophysics 54, 1575-1586
Sun & McMechan (1992) G.J. Int. 111, 1-10
Xu et al. (1995) Geophysics 60, 1805-1818
Liao & McMechan (1996) Geophysics 61, 1371-1378
Madiba & McMechan (2003) Geophysics 68, 837-848

Assignments & Academic Calendar

[Topics, Reading Assignments, Due Dates, Exam Dates]

Insert Week Number OR Range of Dates for week

1) Introduction, linearized inversion

2) reflection statics

3) simulated annealing

4) earthquake moment tensor inversion

5) estimation of acoustic impedance

6) Wiechert-Herglotz inversion, including low velocity zones

7) slant stacking for refraction velocity imaging

8) tomography for velocity and attenuation

9) diffraction tomography

10) migration methods (Kirchhoff, reverse time, F-K)

11) estimation of phase and group velocities

12) full wave inversion

13) elastic inversion

14) 3-D earthquake source imaging

15) Born inversion

Insert Exam Date(s), Time(s)	Aug 22	First class
	Oct 10	Quiz # 1
	Nov 21	Term Project Due
	Nov 21	Last Class
	Nov 28	Quiz # 2

Course Policies

Grading (credit) Criteria	**Aug 22 First class** **Oct 10 Quiz # 1 20%** **Nov 21 Term Project Due 60%** **Nov 21 Last Class** **Nov 28 Quiz # 2 20%** **----** **Total 100%** **Final grades will be adjusted depending on exam difficulty and the overall performance of the class; there is not a predetermined specific % need to obtain a specific grade level.** **Material covered by quizzes is not cumulative; each will cover only topics since the previous quiz.** **The term project is on any topic of your choice related to seismic inversion or imaging. It should involve operating on synthetic or real seismic data to solve a problem or investigate a phenomenon. It should be of a research nature, not just a repetition of a text-book problem, and should demonstrate your understanding of the technique(s) you have chosen to use.** **IDEALLY, THE TOPIC SHOULD BE DIRECTLY RELATED TO YOUR THESIS.** **This is a term project, not a weekend project; grading will reflect an assumption that three months work are involved.** **The project MUST involve writing some software and SHOULD IDEALLY run with more than one processor on the cluster 'miraclon'.** **The format for the term project report is like a research paper (consult your favorite research journal for examples). Make sure that you clearly state your assumptions and conclusions as well as describing the method and testing it with examples.**
Make-up Exams	**Only for legitimate non-academic reasons**

Extra Credit	**none**
Late Work	**Accepted only for legitimate non-academic reasons**
Special Assignments	**none**
Class Attendance	**Expected, but not mandatory (at student's own risk of not understanding and not having an opportunity to ask questions for clarification**
Classroom Citizenship	**Civil interaction is expected**
Field Trip Policies	**No field trips**
Student Conduct and Discipline	The University of Texas System and The University of Texas at Dallas have rules and regulations for the orderly and efficient conduct of their business. It is the responsibility of each student and each student organization to be knowledgeable about the rules and regulations which govern student conduct and activities. General information on student conduct and discipline is contained in the UTD publication, *A to Z Guide*, which is provided to all registered students each academic year. The University of Texas at Dallas administers student discipline within the procedures of recognized and established due process. Procedures are defined and described in the *Rules and Regulations, Board of Regents, The University of Texas System, Part 1, Chapter VI, Section 3*, and in Title V, Rules on Student Services and Activities of the university's *Handbook of Operating Procedures*. Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations (SU 1.602, 972/883-6391). A student at the university neither loses the rights nor escapes the responsibilities of citizenship. He or she is expected to obey federal, state, and local laws as well as the Regents' Rules, university regulations, and administrative rules. Students are subject to discipline for violating the standards of conduct whether such conduct takes place on or off campus, or whether civil or criminal penalties are also imposed for such conduct.
Academic Integrity	The faculty expects from its students a high level of responsibility and academic honesty. Because the value of an academic degree depends upon the absolute integrity of the work done by the student for that degree, it is imperative that a student demonstrate a high standard of individual honor in his or her scholastic work. Scholastic dishonesty includes, but is not limited to, statements, acts or omissions related to applications for enrollment or the award of a degree, and/or the submission as one's own work or material that is not one's own. As a general rule, scholastic dishonesty involves one of the following acts: cheating, plagiarism, collusion and/or falsifying academic records. Students suspected of academic dishonesty are subject to disciplinary proceedings.

	Plagiarism, especially from the web, from portions of papers for other classes, and from any other source is unacceptable and will be dealt with under the university's policy on plagiarism (see general catalog for details). This course will use the resources of turnitin.com, which searches the web for possible plagiarism and is over 90% effective.
Email Use	The University of Texas at Dallas recognizes the value and efficiency of communication between faculty/staff and students through electronic mail. At the same time, email raises some issues concerning security and the identity of each individual in an email exchange. The university encourages all official student email correspondence be sent only to a student's U.T. Dallas email address and that faculty and staff consider email from students official only if it originates from a UTD student account. This allows the university to maintain a high degree of confidence in the identity of all individual corresponding and the security of the transmitted information. UTD furnishes each student with a free email account that is to be used in all communication with university personnel. The Department of Information Resources at U.T. Dallas provides a method for students to have their U.T. Dallas mail forwarded to other accounts.
Withdrawal from Class	The administration of this institution has set deadlines for withdrawal of any college-level courses. These dates and times are published in that semester's course catalog. Administration procedures must be followed. It is the student's responsibility to handle withdrawal requirements from any class. In other words, I cannot drop or withdraw any student. You must do the proper paperwork to ensure that you will not receive a final grade of "F" in a course if you choose not to attend the class once you are enrolled.
Student Grievance Procedures	Procedures for student grievances are found in Title V, Rules on Student Services and Activities, of the university's *Handbook of Operating Procedures*. In attempting to resolve any student grievance regarding grades, evaluations, or other fulfillments of academic responsibility, it is the obligation of the student first to make a serious effort to resolve the matter with the instructor, supervisor, administrator, or committee with whom the grievance originates (hereafter called "the respondent"). Individual faculty members retain primary responsibility for assigning grades and evaluations. If the matter cannot be resolved at that level, the grievance must be submitted in writing to the respondent with a copy of the respondent's School Dean. If the matter is not resolved by the written response provided by the respondent, the student may submit a written appeal to the School Dean. If the grievance is not resolved by the School Dean's decision, the student may make a written appeal to the Dean of Graduate or Undergraduate Education, and the deal will appoint and convene an Academic Appeals Panel. The decision of the Academic Appeals Panel is final. The results of the academic appeals process will be distributed to all involved parties. Copies of these rules and regulations are available to students in the Office of the

	Dean of Students, where staff members are available to assist students in interpreting the rules and regulations.
Incomplete Grades	As per university policy, incomplete grades will be granted only for work unavoidably missed at the semester's end and only if 70% of the course work has been completed. An incomplete grade must be resolved within eight (8) weeks from the first day of the subsequent long semester. If the required work to complete the course and to remove the incomplete grade is not submitted by the specified deadline, the incomplete grade is changed automatically to a grade of **F**.
Disability Services	The goal of Disability Services is to provide students with disabilities educational opportunities equal to those of their non-disabled peers. Disability Services is located in room 1.610 in the Student Union. Office hours are Monday and Thursday, 8:30 a.m. to 6:30 p.m.; Tuesday and Wednesday, 8:30 a.m. to 7:30 p.m.; and Friday, 8:30 a.m. to 5:30 p.m. The contact information for the Office of Disability Services is: The University of Texas at Dallas, SU 22 PO Box 830688 Richardson, Texas 75083-0688 (972) 883-2098 (voice or TTY) Essentially, the law requires that colleges and universities make those reasonable adjustments necessary to eliminate discrimination on the basis of disability. For example, it may be necessary to remove classroom prohibitions against tape recorders or animals (in the case of dog guides) for students who are blind. Occasionally an assignment requirement may be substituted (for example, a research paper versus an oral presentation for a student who is hearing impaired). Classes enrolled students with mobility impairments may have to be rescheduled in accessible facilities. The college or university may need to provide special services such as registration, note-taking, or mobility assistance. It is the student's responsibility to notify his or her professors of the need for such an accommodation. Disability Services provides students with letters to present to faculty members to verify that the student has a disability and needs accommodations. Individuals requiring special accommodation should contact the professor after class or during office hours.
Religious Holy Days	The University of Texas at Dallas will excuse a student from class or other required activities for the travel to and observance of a religious holy day for a religion whose places of worship are exempt from property tax under Section 11.20, Tax Code, Texas Code Annotated. The student is encouraged to notify the instructor or activity sponsor as soon as possible regarding the absence, preferably in advance of the assignment. The student,

	so excused, will be allowed to take the exam or complete the assignment within a reasonable time after the absence: a period equal to the length of the absence, up to a maximum of one week. A student who notifies the instructor and completes any missed exam or assignment may not be penalized for the absence. A student who fails to complete the exam or assignment within the prescribed period may receive a failing grade for that exam or assignment. If a student or an instructor disagrees about the nature of the absence [i.e., for the purpose of observing a religious holy day] or if there is similar disagreement about whether the student has been given a reasonable time to complete any missed assignments or examinations, either the student or the instructor may request a ruling from the chief executive officer of the institution, or his or her designee. The chief executive officer or designee must take into account the legislative intent of TEC 51.911(b), and the student and instructor will abide by the decision of the chief executive officer or designee.
Off-Campus Instruction and Course Activities	Off-campus, out-of-state, and foreign instruction and activities are subject to state law and University policies and procedures regarding travel and risk-related activities. Information regarding these rules and regulations may be found at http://www.utdallas.edu/BusinessAffairs/Travel_Risk_Activities.htm. Additional information is available from the office of the school dean.

These descriptions and timelines are subject to change at the discretion of the Professor.