



UNIVERSITY OF CALGARY

DEPARTMENT OF GEOSCIENCE COURSE OUTLINE WINTER 2016

1. **Course:** GOPH 667, Theoretical Seismology

Lecture Sections:

L01: January 4-January 8, 2016, 10:00-18.00, ES 443

Instructor: Dr. D. Eaton, Office ES 214, Tel. No. 403-220-4233, e-mail address, eatond@ucalgary.ca,
Office Hours: Tu 2:30-3:30 Th 2:30-3:30

Geoscience Department ES 118, 403-220-5841, geoscience.ucalgary.ca, geoscience@ucalgary.ca

Course Background. Microseismic methods are increasingly used as a surveillance technology during hydraulic-fracture treatment of tight reservoirs. This course will provide an overview of the methods for acquiring, processing and interpreting microseismic data. Methods for picking events, determining hypocentre location and magnitude, and interpretation of the stimulated rock volume will be considered. These methods have similarities to techniques used to investigate natural earthquakes.

Interactive computer exercises will be included in the course to aid in understanding, using matlab-based microseismic processing and modeling software developed by the Microseismic Industry Consortium.

Course notes and other information will be posted on Desire to Learn (<https://d2l.ucalgary.ca>).

2. **Prerequisites:** Consent of the department. See section 3.5.C in the Faculty of Science section of the online Calendar (www.ucalgary.ca/pubs/calendar/current/sc-3-5.html)

3. **Grading:** The University policy on grading and related matters is described in sections F.1 and F.2 of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Course Project (due 31 January, 2016)	100%
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The course project will be assigned a letter grade.

4. **Missed Components of Term Work:** The regulations of the Faculty of Science pertaining to this matter are found in the Faculty of Science area of the Calendar in [Section 3.6](#). It is the student's responsibility to familiarize himself/herself with these regulations. See also [Section E.6](#) of the University Calendar.

5. **Course Materials:**

A set of printed course notes provided by the instructor.

Other materials: documents posted on D2L.

6. **Writing across the curriculum statement:** In this course, the quality of the student's writing in assignments will be a factor in the evaluation of those assignments. See also [Section E.2](#) of the University Calendar.

7. **OTHER IMPORTANT INFORMATION FOR STUDENTS:**

(a) **Misconduct:** Academic misconduct (cheating, plagiarism, or any other form) is a very serious offence that will be dealt with rigorously in all cases. A single offence may lead to disciplinary probation or suspension or expulsion. The Faculty of Science follows a zero tolerance policy regarding dishonesty. Please read the sections of the University Calendar under [Section K](#). Student Misconduct to inform yourself of definitions, processes and penalties.

- (b) **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on [assembly points](#).
- (c) **Student Accommodations:** Students needing an Accommodation because of a Disability or medical condition should contact Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities available at http://www.ucalgary.ca/policies/files/policies/procedure-for-accommodations-for-students-with-disabilities_0.pdf. Students needing an Accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, preferably in writing, to the Associate Head of Geoscience, Dr. E.S. Krebs by email krebs@ucalgary.ca or phone 403-220-5850.
- (d) **Safewalk:** Campus Security will escort individuals day or night (<http://www.ucalgary.ca/security/safewalk/>). Call 220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.
- (e) **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). As one consequence, students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information see also <http://www.ucalgary.ca/secretariat/privacy>.
- (f) **Student Union Information:** VP Academic Phone: 403 220-3911 Email: suvpaca@ucalgary.ca
SU Faculty Rep. Phone: 403 220-3913 Email: science1@su.ucalgary.ca, science2@su.ucalgary.ca and science3@su.ucalgary.ca;
Student Ombuds Office: 403-220-6420 Email: ombuds@ucalgary.ca; <http://ucalgary.ca/provost/students/ombuds>
- (g) **Internet and Electronic Device Information:** You can assume that in all classes that you attend, your cell phone should be turned off unless instructed otherwise. Also, communication with other individuals, via laptop computers, Blackberries or other devices connectable to the Internet is not allowed in class time unless specifically permitted by the instructor. If you violate this policy you may be asked to leave the classroom. Repeated abuse may result in a charge of misconduct.
- (h) **U.S.R.I.:** At the University of Calgary, feedback provided by students through the Universal Student Ratings of Instruction (USRI) survey provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses (www.ucalgary.ca/usri). Your responses make a difference – please participate in USRI Surveys.

Department Approval: ORIGINAL SIGNED

Date: December 21 2015

Associate Dean's Approval for
Alternate final examination arrangements: ORIGINAL SIGNED

Date: January 7 2016

Tentative Lecture Schedule

Day 1: Fundamentals of passive seismology

- P and S waves in elastic media
- Attenuation and anisotropy
- Full waveform modeling methods
- Seismic sources including moment tensors
- Spectral characteristics of seismic sources
- Magnitude and moment
- Statistical seismology
- Sensor basics

Day 2: Geomechanics and Data Acquisition

- Stress and strain
- Mohr diagram
- Coulomb stress field
- Modes of rock failure
- Pore-pressure diffusion
- Hydraulic fracture treatment
- Microseismic data acquisition
- Continuous microseismic monitoring

Day 3: Microseismic data processing

- Review of signal processing
- Anatomy of a microseismic event
- Event detection algorithms
- Velocity model construction
- Microseismic catalogs
- Hypocentre location
- Polarization analysis
- Imaging methods using surface microseismic data
- Real-time processing
- Methods for calculating traveltimes (ray tracing, ray bending, eikonal)
- Uncertainty analysis
- Multiplet analysis and double-difference location algorithms
- Ambient-noise recording

Day 4: Microseismic interpretation

- Event classification
- Moment-tensor inversion
- Estimated stimulated reservoir volume
- Spectral analysis
- Spatio-temporal analysis
- Anisotropy and shear-wave splitting

Day 5: Induced Seismicity

- Review of previous published work on induced seismicity
- Coulomb failure and fault parameters
- Pore pressure diffusion
- Fault slip