



UNIVERSITY OF
CALGARY

UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF GEOSCIENCE
COURSE OUTLINE

1. **Course:** GOPH 667, Intro to Microseismic Methods -- Spring 2018

Instructor Name	Email	Phone	Office	Hours
<i>L01:</i> (MTWRF 09:00 - 17:00 in ES 443)				
David Eaton	eatond@ucalgary.ca	(403) 220-4233	ES 214	Mo 2:30 - 3:30 We 2:30 - 3:30

Course Location and Schedule:

- Lectures: May 14 – May 18, 2018, 9:00-13.00, ES 443
- Labs: May 14 – May 17, 2018: 13:00-17:00, ES 924

Course project submission deadline: May 31, 2018

Description:

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.

Learning Objectives:

By the end of this course, students should be able:

1. **to explain** wave propagation in elastic media, brittle deformation processes on a joint or fault, techniques of hydraulic fracturing, stress determination, acquisition and processing of microseismic data;
2. **to interpret** microseismic data to infer characteristics of induced fracture systems such as fracture height, length, azimuth, estimated stimulated volume, seismic moment tensor, reservoir permeability and microseismic facies;
3. **to apply** computer algorithms for processing downhole microseismic data and to simulate wave propagation;
4. **to calculate** magnitude, hypocentre location, seismic moment and source type using microseismic observations;
5. **to perform** error analysis on all relevant calculations in order to characterize parameter uncertainty;
6. **to communicate** the results of numerical analysis to peers in the scientific community;
7. **to evaluate** critically published research on microseismic methods and the work of peers.

Lab Component:

This course has a lab/tutorial component. Computer exercises using matlab will run each day from 13:00 – 17:00 in ES 924.

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

Course Site:

D2L: GOPH 667 L01-(Spring 2018)-Intro to Microseismic Methods

Department of Geoscience:

Office: ES 118

Phone: 403 220-5841

Email: geoscience@ucalgary.ca

Note:

Students must use their U of C account for all course correspondence.

2. **Requisites:**

See section [3.5.C](#) in the Faculty of Science section of the online Calendar.

Prerequisite(s): Consent of the Department.

Permission of the Department is required to take this course. Please contact Dr. David Eaton (eatond@ucalgary.ca).

3. **Grading:**

The University policy on grading and related matters is described in [F.1](#) and [F.2](#) of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Component(s)	Weighting %
Course Project	100

Each of the above components will be given a letter grade using the official university grading system. The final grade will be calculated using the grade point equivalents weighted by the percentages given above and then converted to a final letter grade using the official university grade point equivalents.

Project rubric is posted on D2L. There is both a written and an oral component.

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/themselves with these regulations. See also [Section E.3](#) of the University Calendar.

5. **Scheduled out-of-class activities:**

There are no scheduled out of class activities for this course.

6. **Course Materials:**

Required Textbook(s):

David W. Eaton, *Passive Seismic Monitoring of Induced Seismicity: Fundamental Principles and Application to Energy Technologies*: Cambridge University Press (2018) .

7. **Examination Policy:**

No aids are allowed on tests or examinations.

Students should also read the Calendar, [Section G](#), on Examinations.

8. **Approved Mandatory and Optional Course Supplemental Fees:**

There are no mandatory or optional course supplemental fees for this course.

9. **Writing across the Curriculum Statement:**

For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also [Section E.2](#) of the University Calendar.

10. **Human studies statement:**

Students will not participate as subjects or researchers in human studies.

See also [Section E.5](#) of the University Calendar.

11. **Reappraisal of Grades:**

A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the grade

being reappraised may be raised, lowered or remain the same. See [Section I.3](#) of the University Calendar.

1. **Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within **15 days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall immediately submit the Reappraisal of Graded Term work form to the department in which the course is offered. The department will arrange for a re-assessment of the work if, and only if, the student has sufficient academic grounds. See sections [I.1](#) and [I.2](#) of the University Calendar
2. **Final Exam:** The student shall submit the request to Enrolment Services. See [Section I.3](#) of the University Calendar.

12. 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. Examples of academic misconduct may include: submitting or presenting work as if it were the student's own work when it is not; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; collaborating in whole or in part without prior agreement of the instructor; borrowing experimental values from others without the instructor's approval; falsification/fabrication of experimental values in a report. **These are only examples.**

- b. **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on [assembly points](#).

- c. **Academic Accommodation Policy:** 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 [procedure-for-accommodations-for-students-with-disabilities.pdf](#).

Students needing an accommodation in relation to their coursework or to fulfill requirements for a graduate degree, based on a protected ground other than disability, should communicate this need, preferably in writing, to the Sr. Instructor of the Department of Geoscience, Dr. Rudi Meyer by email rmeyer@ucalgary.ca or phone 403-210-7848. Religious accommodation requests relating to class, test or exam scheduling or absences must be submitted no later than **14 days** prior to the date in question. See [Section E.4](#) of the University Calendar.

- d. **Safewalk:** Campus Security will escort individuals day or night (See the [Campus Safewalk](#) website). Call [403-220-5333](#) 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). 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 [Legal Services](#) website.

- f. **Student Union Information:** [VP Academic](#), Phone: [403-220-3911](#) Email: suvpaca@ucalgary.ca. SU Faculty Rep., Phone: [403-220-3913](#) Email: sciencerep@su.ucalgary.ca. Student Ombudsman, Email: suvpaca@ucalgary.ca.

- g. **Internet and Electronic Device Information:** Unless instructed otherwise, cell phones should be turned off during class. All communication with other individuals via laptop, tablet, smart phone or other device is prohibited during class unless specifically permitted by the instructor. Students that violate this policy may be asked to leave the classroom. Repeated violations may result in a charge of misconduct.

- h. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction ([USRI](#)) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.

- i. **SU Wellness Center:** The Students Union Wellness Centre provides health and wellness support for students including information and counselling on physical health, mental health and nutrition. For more information, see www.ucalgary.ca/wellnesscentre or call [403-210-9355](#).

Department Approval:

Electronically Approved

Date: 2018-04-10 11:12