UNIVERSITY OF CALGARY
DEPARTMENT OF GEOSCIENCE
COURSE OUTLINE

1. Course: GEOPHYSICS 667 – INTRODUCTION TO MICROSEISMIC METHODS

Lecture Section:	L01	R	16:00-18:50	SS 008	WINTER 2014

Instructor(s):	Dr. D.W. Eaton	ES 214	220-4233	eatond@ucalgary.ca

Geoscience Department ES 118; (403) 220-5841; 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. PREREQUISITE(S): Geophysics 355, 551 and Mathematics 221, or the equivalent. Students should be enrolled in the graduate program in geophysics or receive the consent of the Department

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

3. **GRADING**: The University policy on grading and related matters is described in "Academic Regulations, sections F.1 and F.2" of the online University Calendar (**http://www.ucalgary.ca/pubs/calendar/current/f-1.html** and **http://www.ucalgary.ca/pubs/calendar/current/f-2.html**) In determining the overall grade in the course the following weights will be used:

Assignments (8)	20%
Labs (5)	20%
Course Project	60%

Each piece of work (assignment, laboratory report, midterm test or final examination) submitted by the student will be assigned a percentage score. The student's average percentage score for the various components listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course 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: **http://www.ucalgary.ca/pubs/calendar/current/sc-3-6.html**. It is the student's responsibility to familiarize himself/herself with these regulations. See also **http://www.ucalgary.ca/pubs/calendar/current/e-3.html**.

5. No class exercises will be held outside of the scheduled classes.

Department Approval: ORGINAL SIGNED Date: January 20 2014

6. In this course, the quality of the student's writing in laboratory reports will be a factor in the evaluation of those reports. See also **http://www.ucalgary.ca/pubs/calendar/current/e-2.html**.

7. OTHER IMPORTANT INFORMATION FOR STUDENTS:

(a) 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 K. Student Misconduct (**http://www.ucalgary.ca/pubs/calendar/current/k.html**) 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 at http://www.ucalgary.ca/emergencyplan/assemblypoints.

(c) ACADEMIC ACCOMMODATION POLICY. Students with documentable disabilities are referred to the following links:
Calendar entry on students with disabilities: **http://www.ucalgary.ca/pubs/calendar/current/b-1.html**
Student Accessibility Services: www.ucalgary.ca/access

(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**: 220-3911 **Email**: suvpaca@ucagary.ca.
SU Faculty Rep. **Phone:** 220-3913 **Email:** sciencerep@su.ucalgary.ca Website **http://www.su.ucalgary.ca/home/contact.html**.
Student Ombudsman: www.ucalgary.ca/provost/students/ombuds; ombuds@ucalgary.ca 220-6420

(g) INTERNET and ELECTRONIC COMMUNICATION DEVICE Information. You can assume that in all classes that you attend, **your cell phone should be turned off**. 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.

UNIVERSITY OF CALGARY
DEPARTMENT OF GEOSCIENCE
COURSE OUTLINE

GEOPHYSICS 667
INTRODUCTION TO MICROSEISMIC METHODS

TERM: Winter 2014

PREREQUISITE(S): Geophysics 355, 551 and Mathematics 221, or the equivalent. Students should be enrolled in the graduate program in geophysics or receive the consent of the Department

LECTURER(S):	Dr. D.W. Eaton		ES 214	220-4233	eatond@ucalgary.ca

LECTURE :	L01	R	15:30-18:20	SS 008
LAB(S):	B01	T	14:00-16:50	ES 924

TEXT: All required teaching materials will be posted on Desire to Learn. There is no textbook for this 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 the matlab-based microseismic processing and modeling software developed by the Microseismic Industry Consortium.

MARK DISTRIBUTION:

A. Composition of Final Grade

Assignments	20%
Labs	20%
Course Project	60%

Students who are unable to submit laboratory reports or assignments on time because of illness or other unforeseen circumstances may be granted an excused absence by the Course instructor upon presentation of adequate documentation (a completed Physician/Counsellor Report form <http://www.ucalgary.ca/registrar/PDFs/physcoun.pdf> for illness; equivalent documentation for other circumstances. There will be no "make-up" assignments for excused absences. The weight assigned to the missed components will be transferred to the Course Project.

B. Grading Scheme

A+	95 – 100%
A	86 – 94%
A-	80 – 85%
B+	77 – 79%
B	73 – 76%
B-	70 – 72%
C+	67 – 69%
C	63 – 66%
C-	60 – 62%

D+	55 – 59%
D	50 – 54%
F	<50%

Tentative Lecture Schedule

Weeks 1-2. 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

Weeks 3-4. 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

Weeks 5-8. 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 traveltime (ray tracing, ray bending, eikonal)
- Uncertainty analysis
- Multiplet analysis and double-difference location algorithms
- Ambient-noise recording

Weeks 9-10. Microseismic interpretation

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

Some sections will be taught by invited presenters.

Weeks 11-12. Project presentations