University of Alberta

EAS 421 Structural Geology and Tectonics

Fall 2011

Lecture Room & Time:	**MWF 10-11, Tory Breezeway 2**
Labs:	**MT 2-5, ESB 4-10, with computer work in ESB 1-39**
Instructor:	*John W.F. Waldron*
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Office Hours:	*MWF 2-3*
Teaching assistants*:*	*Hayley Pothier CCIS 3-007* *Shawna White CCIS 3-007*

About the course

Course Description: Geometric, kinematic, and dynamic analysis of structures produced by deformation. Stress and the origin of faults, joints, veins, folds, and tectonites. Brittle and ductile strain in rocks. Extensional, strike-slip, and compressional structural associations. Regional structure, orogens, and crustal tectonics. Lab exercises include structural interpretation for subsurface hydrocarbon and mineral exploration, stereographic techniques for structural analysis, and the study of rock fabrics.

Course Prerequisites: EAS 233 and any 300-level EAS course. Not available to students with credit in EAS 321

EAS 421 is a second course on the structure of the Earth for third and fourth year students in Geology, Geophysics, and related studies. EAS 421 builds upon the basic techniques of structural description learned in EAS 233 - unconformities, fractures, folds, and fabrics - and examines how these structures are formed in the major belts of deformation that affect the Earth's lithosphere - rifts, orogens, and belts of strike-slip deformation.

To understand how the features we see in deformed rocks relate to the movements and forces that have affected the Earth over time, we need to learn some new techniques. For example, sections of the course will be devoted to measuring and understanding stress (the distribution of forces within the Earth) and strain (the changes in shape of rocks). In EAS 421 we introduce those techniques step-by-step, as they are needed to understand different tectonic environments. Thus we will alternate between sections that focus on new techniques for understanding processes at a small scale, and larger-scale examination of major features of the lithosphere.

Course Objectives and Expected Learning Outcomes:

By the end of the course you should have a broad understanding of the major structures produced by deformation of the Earth's lithosphere and how they originate. You should be able to solve problems in the understanding of deformed rocks in three dimensions in hand sample and map scale, and you should be able to explain how these structures were produced by tectonic processes.

- **Geometry**: Learn how to describe the **shapes and three-dimensional orientations** of structures in rifts, orogens, and strike-slip belts.
- **Kinematics**: Learn the methods that can be used to interpret the **movements** that have that have distorted the Earth's lithosphere, over time.
- **Dynamics**: Learn what can (and cannot) be deduced about **forces** involved in the deformation of the Earth's lithosphere.

The emphasis in structural geology is on solving problems, not on learning facts. For these reasons, the laboratory sessions are particularly important.

Classes

Lectures

Lectures take place MWF at 10 am. Please be respectful of your instructor and other students by being on time and by not talking or causing other distractions in class. If you carry a cell phone make sure it is off during lectures. Handouts may be provided at the start of some lectures. If you have to miss a lecture for some medical or other unavoidable reason, try to have a 'lecture buddy' who can make notes for you and collect any handouts. I do not bring copies of previous handouts to subsequent lectures. **Note:** Recording is permitted only with the prior written consent of the professor or if recording is part of an approved accommodation plan.

Labs

You will be registered in either the Monday (D1) or the Tuesday (D2) lab. You must stick to your assigned lab unless you have a particular reason for changing labs in a given week, which must be approved by your TA. Note that there are gaps in the lab schedule for both the Monday and the Tuesday lab to deal with holidays and other special events. Note that different classes deal with the holidays in different ways. Do not assume that your other classes will have the same lab schedule.

For each lab you should have the following available:

- Tracing paper, Graph paper, a ruler at **least 30 cm long** (11.81 inches)
- A calculator with scientific functions
- Lead pencils that are sharp and **can be kept sharp** (old fashioned pencils and a sharpener, or mechanical pencils with 0.5 mm leads).
- A good eraser.
- Some coloured pencils ('pencil crayons'). Please note that these are useful for labelling structures in diagrams but must never be used for accurate constructions!

While working in the lab, please respect the general lab rules. In addition, please adhere to the following special rules:

- **No personal entertainment devices with headphones may be worn.** Often we may offer an explanation that is intended for everyone in the class, or for a group. We should not be competing for your attention.
- **When you are asked to use a computer,** no program may be used in the lab other than those directly related to structural geology. Surfing the web or reading your email while the lab is in session is disrespectful to your instructor and TA, and is not an appropriate use of the resource.

Resources

Required Textbook: *Earth Structure* by Van der Pluijm and Marshak. (*Pluijm* is pronounced, roughly, *Plowm*),

This valuable text allows you to review all the main types of structure found in the Earth's lithosphere, and includes review material for the major topics covered in EAS 233. In addition, it contains a series of synthesis chapters on particular parts of the lithosphere, written by experts on those regions.

Recommended or Optional Learning Resources:

In addition to the text, you may also find that the laboratory manual for EAS 233 contains useful reference material.

Additional references and links will be posted during the course at

http://courses.eas.ualberta.ca/eas421

Note: For students who took EAS 233 in 2008 and earlier, there have been some changes to the content of this prerequisite course. The 2010/2011 course manual for EAS 233 contains summary sections on many of the major structures covered. Copies of this manual will be provided on request if you took EAS 233 in 2008 or before.

Representative Evaluative Material:

Representative sample exam questions will be posted on the class web site during the first three weeks of the class, to indicate the type of question to be asked in the mid-term tests. Sample final exam questions will be posted in October.

Evaluation and grading

Grade Evaluation:

Grade evaluation will be by a combination of relative standing in the class and absolute achievement. This means that grades will be assigned based on the overall quality of the work done so as to be consistent in standard with previous years' grading. No absolute grade distribution ('curve') will be imposed on the grades, but the overall level and range of grades is likely to be similar to other classes at this level at the University of Alberta.

Grades are unofficial until approved by the Department and/or Faculty offering the course.

COMPONENT	WEIGHTING	DATE
Midterm 1	10%	Wednesday Oct 12
Midterm 2	10%	Monday Nov 14
Weekly Lab assignments	40%	
Final Exam*	40%	9 am Dec 19

* WARNING: Students must verify this date on BearTracks when the Final Exam Schedule is posted

Format of Exams:

Exams will combine theoretical and practical aspects of the course, and will include a mixture of short-answer, longer written answer, and practical questions. Questions in the mid-term tests will cover fundamental techniques; you will be asked to answer all the questions. The final exam will contain a mixture of practical and theoretical questions and will include both a compulsory section and a choice of questions.

Requirements for exams: Your student photo I.D. is required at exams to verify your identity. Students will not be allowed to begin an examination after it has been in progress for 30 minutes. Students must remain in the exam room until at least 30 minutes has elapsed. Electronic equipment other than calculators cannot be brought into examination rooms and hats should not be worn.

Bring to the exam room all the materials you normally bring to the labs. Before you enter the exam room, please ensure all textbooks, notes, and review materials are securely stowed inside a bag, and that you have unpacked all the pens, pencils, etc. that you plan to use. You are not permitted to look through your bag during the exam.

Missed Term Exams and Assignments:

A student who cannot write a term examination or complete a term assignment due to incapacitating illness, severe domestic affliction or other compelling reasons can apply for extension of time to complete an assignment or deferral of the midterm weight to the final examination. If you are in this situation at the time of a lab or examination, please be sure to contact your instructor within 48 hours of the missed class. Please note that illness in the days before an exam is not normally considered to be grounds for deferral; don't leave your study to the last minute!

Deferral of term work is a privilege and not a right; there is no guarantee that a deferral will be granted. Misrepresentation of Facts to gain a deferral is a serious breach of the *Code of Student Behaviour*.

Deferred Final Examination:

A student who cannot write the final examination due to incapacitating illness, severe domestic affliction or other compelling reasons can apply for a deferred final examination. Such an application must be made to the student's Faculty office within 48 hours of the missed examination. Deferred examinations are a privilege and not a right; there is no guarantee that a deferred examination will be granted. Misrepresentation of Facts to gain a deferred examination is a serious breach of the *Code of Student Behaviour*.

Reexamination:

A student who writes the final examination and fails the course may apply for a reexamination. Reexaminations are rarely granted in the Faculty of Science. These exams are governed by University (Calendar section 23.5.5) and Faculty of Science Regulations (Calendar section 182.5.9). Misrepresentation of Facts to gain a reexamination is a serious breach of the *Code of Student Behaviour*.

Student Responsibilities:

Academic Integrity: 'The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the *Code of Student Behaviour*, online at

www.ualberta.ca/secretariat/appeals.htm,

and avoid any behaviour which could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.'

All forms of dishonesty are unacceptable at the University. Any offense will be reported to the Senior Associate Dean of Science who will determine the disciplinary action to be taken. Cheating, plagiarism and misrepresentation of facts are serious offenses. Anyone who engages in these practices will receive at minimum a grade of zero for the exam or paper in question and no opportunity will be given to replace the grade or redistribute the weights. As well, in the Faculty of Science the sanction for **cheating** on any examination will include **a disciplinary failing grade** (no exceptions) and senior students should expect a period of suspension or expulsion from the University of Alberta.

EAS 421 is a very practical course in which you may benefit from discussions with your instructor, teaching assistants, and fellow students in devising problem-solving strategies. However, the actual answers you record must be exclusively your own work. This means that:

- observations must be your own;
- written answers must be expressed in sentences and paragraphs ***composed uniquely in your own words;***
- every calculation and construction ***must be carried out by you***.

(In the event that you are explicitly instructed to work in groups on a problem, your answer must contain a written acknowledgement of the other participants.)

Cell phones: Cell phones are to be turned off during lectures, labs and seminars. Cell phones are not to be brought to exams.

Support

Students with disabilities: Students who require accommodation in this course due to a disability are advised to discuss their needs with Specialized Support & Disability Services (2-800 Students' Union Building).

Academic support centre: Students who require additional help in developing strategies for better time management, study skills or examination skills should contact the Academic Support Centre (2-703 Students' Union Building).

Legalities

Disclaimer: Any typographical errors in this Course Outline are subject to change and will be announced in class. The date of the final examination is set by the Registrar and takes precedence over the final examination date reported in this syllabus.

Tentative schedule of lectures and labs

Date	Topic	Lecture	Lab: Mon, Tue
Wed-Sep-07	Introduction	Structural Geology & Tectonics	
Fri-Sep-09	Orientation data	Lines and planes	
Mon-Sep-12		Orientation statistics	
Wed-Sep-14	Global tectonics	Plate boundaries	
Fri-Sep-16		Plate kinematics	
Mon-Sep-19		Measuring plate motion	Orientation data
Wed-Sep-21	Stress	Stress	
Fri-Sep-23		Stress and fracture	
Mon-Sep-26		Measuring the state of stress	Plate kinematics
Wed-Sep-28	Rift tectonics	Rifts	
Fri-Sep-30		Normal fault systems	
Mon-Oct-03		Gravity and salt tectonics	Stress
Wed-Oct-05	Strain in 2D	Strain - longitudinal and shear strain	
Fri-Oct-07		Strain in 2D	
Mon-Oct-10			
Wed-Oct-12		Test 1	
Fri-Oct-14		Measuring strain	
Mon-Oct-17	Orogens	Introduction to Orogens	Rifts
Wed-Oct-19	Subductio, Accretion, Mélange	Subduction	
Fri-Oct-21		Mélange	
Mon-Oct-24	Foreland thrust belts	Foreland fold & thrust belts	Strain 1
Wed-Oct-26		Thrust kinematics	
Fri-Oct-28		Section balancing	
Mon-Oct-31		Thrust dynamics	Strain 2
Wed-Nov-02	Slate belts	Slate belts	
Fri-Nov-04	Polyphase metamorphic belts	Polyphase metamorphic belts	
Mon-Nov-07		Pressure-temperature-time	Thrust belts 1
Wed-Nov-09	Rheology	Rheology	
Fri-Nov-11			
Mon-Nov-14		Test 2	Thrust belts 2
Wed-Nov-16		Crystal defects and deformation	
Fri-Nov-18		Deformation mechanisms	
Mon-Nov-21	Shear zones	Shear zones	Polyphase deformation
Wed-Nov-23		Shear zone fabrics	
Fri-Nov-25	Strain in 3D	Strain in 3D	
Mon-Nov-28		Progressive strain in 3D	Case studies
Wed-Nov-30	Strike-slip tectonics	Strike-slip	
Fri-Dec-02		Transpression	
Mon-Dec-05		Transtension	Strike slip, transpression, transtension
Wed-Dec-07		Review	