Geol 4610
Structural Geology

Taught in even years (2008, 2010 etc.) by Prof. Barbara John
Taught in odd years (2009,2011 etc.) by Prof. Art Snoke

The following pages contain the syllabi
For both Professors

Fall 2008 **Geology 4610** **John**

Structural Geology and Tectonics

The purpose of this course is to improve your understanding of deformation of the Earth's lithosphere. This introductory course in structural geology will focus on the three-dimensional nature of structural features, how they relate to tectonic associations and processes, and their basic mechanical development. We will begin the class by taking a series of four daylong field trips to see geologic structures in the field first hand. During those trips you are expected to observe and take careful notes that will be turned in at the end of the day. By the end of the course I hope you will be able to think in three-dimensions, feel comfortable in gathering and working with structural data, and will start to appreciate how basic physical processes influence the primary structure of the Earth's lithosphere.

Pre-requisites:

It is assumed that you have a basic understanding of physical and historical geology, including rock classification, geologic time, and stratigraphy. A working knowledge of trigonometry is essential. Some knowledge of basic mechanics, as developed in the first semester, general physics course is also helpful.

Text:

The required texts are:

Davis, G. H., and Reynolds, S.J., 1996
'Structural Geology of Rocks and Regions'

Marshak, S., and Mitra, G., 1988
'Basic Methods of Structural Geology'

Note There are many structural geology texts available including those authored by Twiss and Moores; Hobbs, Means and Williams; van der Pluijm, and Yeats to name a few. If you are having trouble with a particular topic, check out another from the library, and read through the relevant section(s). They are there for you to use.

Lectures: (MWF 10-10:50 am), Room 209

The lecture material represents the core of the course. It is therefore important to attend all lectures. I'll try to show slides and overhead projections of geologic structures, maps, cross-sections, etc. to supplement the lecture and text. Questions from the class are welcome at any time. There will be a few homework assignments associated with the lecture material. The computer classroom in the department may be used for some lectures.

Labs: (Tuesday 1:10-3:00 pm or Wednesday 2:10-4:00 pm), Room 318

The lab is the 'hands-on' part of the course. We will begin lab with 3 field trips to local areas on **Saturday Sept. 6, 20, and 27, 2008.** If the weather is poor on Friday, we may try to go on Sunday instead, or cancel and have the final field trip Saturday October 4. You will be responsible to attend each of the field trips, observe structures in the field, and submit your field notebook, and maps at the end of the day for comments.

Some lecture time will be devoted to discussion of the lab work, so that maximum time in the lab is spent working on exercises. **Assignments outside those done in the field are due at the start of lab.** Some lab exercises will require graphical or analytical solutions of simple geometric problems. Other labs will emphasize the study and interpretation of geologic maps, cross-sections, or hand samples of rocks, as these provide the best alternative to visiting structures in the field. Structures and problems studied in the lab will parallel closely material covered in lecture. Note that materials in the lab, must stay there. **Please** do not take any materials from the lab.

Each student should bring the following to lab, starred items on the field trips:

lab manual (Marshak and Mitra)	stereonet
*pencils (hard lead)	*colored pencils
*eraser	*ruler
graph paper	*protractor
*field notebook	*compass
tracing paper (tablet)	calculator

A *very-fine felt or rapidograph-type pen will be necessary for inking cross-sections.

Office Hours:

John: ESB Room 3010
Tu/Th 9:30-11
or by appointment (bjohn@uwyo.edu; ph. 766-4232)

Goyette:
TBA (or by appointment jgoyette@uwyo.edu)

Field Trips:

The three field trips are scheduled for weekend days at the start of the semester (subject to weather). We will leave the parking lot behind the department at

8:00 AM, and return by 6 PM. The purpose of each exercise is to allow you to see basic structural features in the field, map them, collect your own structural data, plot them up and make your own interpretation. Each field trip will build on the previous one, and will last most of the day. You will be required to attend the trip, carry out the basic exercise, and submit your field notebook at the end of each day, for comments and evaluation.

Examinations:

There will be two lecture mid-term exams, and a comprehensive final. Each of the midterms (2) will last one hour, and will be worth 100 points; the final will be worth 100 points. Lab exercises will be handed in and graded (200 points total). The total possible points for the course is 500.

1st mid-term: Wednesday, October 15

2nd mid-term: Wednesday, November 12

Final: week of December 8-12

If you have a physical, learning, or psychological disability and require accommodations, please let me know as soon as possible. You will need to register with, and provide documentation of your disability to, University Disability Support Services (UDSS) in SEO, room 330 Knight Hall, 766-6189, TTY: 766-3073.

Note: Lab is an integral part of the course. You must pass the lab (C or better grade) to pass the course. Exams given during lecture as well as the final exam will include problems similar to those worked for the lab up to that time.

General outline 4610

I. Introduction to structure and tectonics: formation and structure of the Earth
(D+R, p. 2-37, 564-596)

II. Introduction to geologic maps, cross-sections, and basic structural field methods
(D+R, p. 626-656; 662-676; M/M, Chapters 1 and 9).

III. Primary and non-tectonic structures (sedimentary and igneous)
(D+R, p. 656-662)

IV. Stereographic projections
(D+R, p. 691-717; M/M, p. 105-110)

V. Force and Stress
(D+R, p.98-122)

VI. Deformation and strain
(D+R, p. 38-85; Yeats, 122-130)

VII. Brittle behavior
(D+R, p. 131-149, 226-256; Yeats 17-41)

VIII. Origin of joints and veins
(D+R, p. 204-225; M/M, Chapter 11)

IX. Faults and faulting- nomenclature and description
(D+R, p. 161-193, 199-202, 269-318, 336-337)

X. Fault rocks, fault zone models and kinematic analysis
(D+R, p. 45-50; Yeats, p. 49-58)

XI. Tectonic settings of fault systems:
thrust and reverse faults (D + R, p. 319-336; Yeats, p. 301-368)

normal faults (D + R, p. 340-357; Yeats, p. 249-300)

strike-slip faults (D + R, p. 357-371; Yeats, p. 167-244)

XII. Theories and paradoxes of faulting
(D +R, 336-339)

XIII. Folds and mechanisms of folding
(D+R, p. 372-410, 413-423; M/M, p. 213-226)

XIV. Penetrative rock fabrics
(D+ R, p. 424-479; M/M Chapter 11 - p. 223-246

Fall 2007 **GEOL 4610** **Instructor: A.W. Snoke**
Teaching Assistant: Dan Jones

Structural Geology and Tectonics

The prime purpose of this course is to improve your understanding of the deformation of the Earth's crust. I believe that a first course in structural geology should focus on the three-dimensional nature of structural features, how these features fit into tectonic associations, and the basic mechanical development of such features. I will attempt to develop such integration throughout this course. I certainly want you to begin to think "structurally" (i.e., in a three-dimensional framework); and I want you to appreciate how basic physical processes influence the primary structure of the Earth's crust.

PREREQUISITES: I assume a basic understanding of physical and historical geology, including elementary nomenclature for such topics as rock classification, geologic time, and stratigraphy. A working knowledge of trigonometry is essential. Some knowledge of basic mechanics, as developed in a first-semester general physics course, would be helpful but it is not mandatory.

TEXTS: Required text: Davis, G. H., and Reynolds, S. J., 1996, *Structural Geology of Rocks and Regions*: John Wiley & Sons, Inc.
Highly recommended laboratory manual: Marshak, S., and Mitra, G., 1988, *Basic Methods of Structural Geology*, Prentice Hall.

LECTURES: I consider that these meetings and the material discussed represent the core of the course. It is, therefore, important to attend all lectures. Furthermore, commonly I use overhead projections or occasionally PowerPoint presentations of geologic features, maps, cross-sections, etc. to supplement the discussion in the text or to enhance my verbal presentations. **Questions from the audience are always encouraged.**

LABS: The laboratory is the essential "hands-on" experience of the course (*see laboratory schedule on page 4*). Some lecture time will be devoted to "lab lectures," so that maximum time is spent working on the exercises. Some exercises involve graphical and analytical solutions of simple geometric problems. Some labs will emphasize the study and interpretation of geologic maps, since maps offer the best alternative to visiting structures in the field. Some materials will be available in the lab ***or*** on reserve in the Brinkerhoff Earth Resources Information Center, if you wish to work at times other than the scheduled lab periods. Out of courtesy to others, PLEASE do not remove any materials from the laboratory room (Rm. 318). **Each student should bring his or her own pencils, erasers, notebook paper, colored pencils, inexpensive protractor, straight-edge, and compass to lab. A ballpoint, fine felt-tipped, or radiograph-type**

pen is essential for inking cross-sections. Structures and problems studied in lab will parallel those covered in concurrent lectures as closely as possible, but don't expect a perfect overlap.

FIELD TRIPS: There are *four* **required** one-day field trips on the following consecutive Saturdays: **September 8th, 15th, 22nd, and 29th**. **There will be no make-up field trips. There is no such thing as an "excused absence" in regard to the field trips. Please be there.** If you miss a field trip (regardless of the reason), you will be given a zero for that week ***until*** you complete an assigned cross-section project (about 10 hours of work, i.e., equivalent to the time in the field). These assigned cross-section projects are due the last day of class (December 7th). For ***every*** field trip missed, you will assigned a cross-section project as your "make-up" for the missed field trip. *Thus, I strongly suggest that you do not miss any of the field trips.* Also, I will collect your field notebooks after each trip, and they will be graded and returned to you before the next trip. Furthermore, there will be specific exercises for you to do in the field. ***You will learn structural geology by seeing and doing it***. We will leave from the Department of Geology and Geophysics at 8:00 AM sharp and will return to campus at approximately 6:00 PM. **You should bring a lunch, water, a notebook and pencil, and a hand lens and wear clothing appropriate for hiking in the mountains.** The weather could be beautiful ***or*** cold and wet. More later … .

EXAMINATIONS: There will be **two** lecture exams during the semester and a **comprehensive** final examination (**Wednesday, December 12th, 10:15–12:15 PM**). Each hour exam will be worth 100 points, the final exam will be worth 150 points, and laboratory exercises (including field-related work) will equal 150 points. Therefore, the total possible points for the course = 500. Please note: Exams given during lecture as well as the final exam will (or at least could) include laboratory material (i.e., problems) covered up to that point in time.

GENERAL LECTURE OUTLINE FOR GEOLOGY 4610:
Note: The lecture class is cancelled for Friday, **August 31st**, because of the annual departmental Rocky Mountain field trip (GEOL 4060). The lecture class is also cancelled on **October 29th and 31st** because of the Geological Society of America meeting that will be held in Denver, Colorado, this year.

I. Introduction to structural geology and tectonics (Davis and Reynolds [subsequently referred to as D & R], Preface [vii-ix] and Chapter 1 [p. 2–37]).

II. An introduction to geologic maps, cross sections, and basic structural field measurements (D & R, p. 626–644, 662–669 (*please read before first field trip*); Marshak and Mitra, Chapter 1; also see Chapter 9 by Lucian B. Platt in Marshak and Mitra for a more advanced treatment).

III. Geologic contacts (D & R, p. 645–656) and primary sedimentary and igneous structures (D & R, p. 656–662).

IV. An introduction to stereographic projections (Marshak and Mitra, Chapters 5 and 6, p. 105–110; D & R, p. 691–704; for advanced techniques see p. 708–720).

V. Faults—descriptive and nomenclature (D & R, p. 38–50, 269–279, 292–303).

VI. Fault rocks (D & R, p. 280–286; Marshak and Mitra, Chapter 11, p. 226–238).

VII. Tectonic settings of fault systems: thrust and reverse-slip faults (D & R, p. 319–331), normal faults (D & R, p. 340–357), and strike-slip faults (D & R, p. 357–371). Also read "Structural Styles, Their Plate-Tectonic Habitats, and Hydrocarbon Traps in Petroleum Provinces" by T. P. Harding and James D. Lowell that appeared in *The American Association of Petroleum Geologists Bulletin*, v. 63, no. 7 (July 1979), p. 1016–1058.

VIII. Preparing subsurface contour maps (D & R, p. 679–683; also see p. 27–31 in Marshak and Mitra).

IX. Folds—descriptive; classification of folds (D & R, Chapter 7, p. 372–397; Marshak and Mitra, Chapter 11, p. 213–226; F. A. Donath and R. B. Parker, 1964, Folds and Folding: *Geological Society of America Bulletin*, v. 75, p. 45–62).

X. Penetrative fabric elements: cleavage, foliation, and lineation (D & R, p. 424–477; Marshak and Mitra, Chapter 11, p. 238–247).

XI. Preparing geologic cross-sections (D & R, p. 669–679; for advanced techniques see Chapter 14 by Stephen Marshak and Nicholas Woodward in Marshak and Mitra).

XII. Stress analysis and Mohr stress circle (D & R, p. 98–122; M. K. Hubbert, 1951, Mechanical basis for certain familiar geologic structures: *Geological Society of America Bulletin*, v. 62, p. 355–372).

XIII. Mohr-Coulomb law of failure (Suppe, 1985, p. 149–167, D & R, p. 226–245, 252–256, 304–317).

XIV. Anderson's theory of faulting.

XV. Origin of joints (D & R, Chapter 5, p. 204–226, 261–268); role of fluids in the fracture of rocks (D. T. Secor, Jr., 1965, Role of fluid pressure in jointing: *American Journal of Science*, v. 263, p. 633–646 ; D & R, p. 245–251).

XVI. Mechanics of folding (D & R, Chapter 7, p. 397–423).

XVII. How is strain measured? (D & R, p. 51–66, 482–485).

XVIII. Finite strain ellipse and ellipsoid and applications (D & R, p. 66–83, 477–482). Coaxial deformation versus noncoaxial deformation (D & R, p. 83–85).

XIX. Shear zones and progressive deformation (D & R, Chapter 9, p. 493–551).

GENERAL LABORATORY OUTLINE FOR GEOLOGY 4610:

Note: **In-door laboratory sessions begin on Tuesday, October 2nd.** No lab is scheduled for the week of the Geological Society of America Annual Meeting in Denver, Colorado (i.e., October 30th and 31st). There will be no scheduled lab the week of November 20th and 21sr (Thanksgiving week), although the lecture class will meet on Monday, November 19th. Lab #7 will be handed out on November 13th or 14th; it is a cross-section exercise (please see below). Lab #8 will be handed out on November 27th or 28th. Lab #9 will be done the last week of school (December 4th or 5th) and can *virtually* be completed and discussed *during* the laboratory period and is due the last day of the class on December 7th.

Laboratory 1. Planes and topography (Marshak and Mitra, Chapters 2, p. 19–27 & 3, p. 50–56).

Laboratory 2. Stereonet problems (Marshak and Mitra, Chapters 5 & 6, p. 87–110; also see D & R, p. 691–704).

Laboratory 3 & 4. Geologic maps of faulted terranes and some fault rocks (Marshak and Mitra, Chapter 11, p. 226–232).

Laboratory 5. Three-point problems (Marshak and Mitra, Chapter 3, p. 49–50; also see D & R, p. 690–691).

Laboratory 6. Structural contours, vertical cross-sections, etc. (Marshak and Mitra, Chapter 2, p. 27–31; Chapter 4, p. 67–70, 73–78; also see D & R, p. 685–687).

Laboratory 7 & 8. Cross-section construction exercise. See D & R, p. 669–679.

Laboratory 9. Structural interpretation of seismic-reflection section.