**George Mason University**

**Department of Atmospheric, Oceanic, and Earth Sciences**

GEOL 510 ADVANCED STRUCTURAL GEOLOGY – 3 credits

**Course description:** Advanced concepts in structural geology including, stress in the lithosphere, strain analysis, constitutive laws, balanced cross-section construction and restoration, and quantitative analysis of crystal-plastic deformation.

**Learning outcomes Part I, Brittle Structure.**

* Apply principles of geomechanics, the 3D state of stress at depth, and relationships among elastic moduli and seismic wave velocity to analyze stress and pore pressure at depth in sedimentary basins.
* Apply rock failure criterion and fracture scaling relationships to predict the mechanisms of brittle deformation under various geological states of stress.
* Analyze fault-related folding in extensional regimes.
* Analyze fault-related folding in thin- and thick-skinned contractional regimes.
* Apply critical taper theory to predict the mechanical evolution of thrust wedges.

**Learning outcomes Part II, Ductile Structure.**

* Apply techniques of microstructural analysis and the interpretation of deformation textures in thin section, hand samples and the outcrop.
* Apply constitutive equations and plastic flow laws for solid-state deformation of geologic materials to examine the mechanisms and effects of brittle and plastic deformation.
* Recognize and interpret kinematic indicators and perform kinematic analyses of rock fabrics in thin section, hand sample, and outcrop scales.
* Place microstructural observations in the context of local to regional-scale structural observations to interpret a tectonic history.

**Class Times**

Class will meet twice a week. Weekly classes will be divided into a lecture and groupwork on the problem sets. Students will be asked to complete one problem set every one-two weeks, some problem sets will include a geologic report to synthesize observations and results.

## Prior Knowledge

I expect that students have used a petrographic microscope before in at least one prior class. I also expect that students are familiar with, or can catch up on, the basics of mineralogy and crystallography. Students will apply mineral identification skills and basic petrology in class exercises. Recommended prerequisites include courses in structural geology, petrology, field geology, physics, and calculus.

**Grading scheme**

The work for this class consists of weekly readings and 8 graded problem sets. Some problems sets include short (<1000 word) write-ups to synthesize results.

**Final Grade: Problem sets (8, 12.5% ea.)………100%**

**Grade scale:** A+ = 97 - 100%, A = 94 – 97%, A- = 90 – 94%, B+ = 87 – 90%, B = 84 - 87%, B- = 80 - 84%, C+ = 77 - 80%, C = 74 - 77%, C- = 70-74%, D = 60 - 70%, F = 0 - 60%

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| **Week** | **Description** | **Homework** | **Readings** |
| Aug. 23 | **Part I:** Tectonic stress field at depth in sedimentary basins |  | Zoback Ch. 1-5, 9, 11Fossen Ch. 2-6 and anything else. AllmendingerCardozoFisher. Ch. 1-7. |
| Aug. 30  | Strain: progressive deformation and flow.  | Problem set 1: stress and strain |
| Sept. 6 | Constitutive laws and elastic moduli |  |
| Sept. 13 | Faults and fractures at depth, 3D Mohr Diagrams, Failure criterion | Problem set 2: 3D faulting and fractures at depth |
| Sept. 20 | Thrust wedge mechanics, critical taper theory | Problem set 3: critical taper theory | Nemcok et al., Ch. 1-3 |
| Sept. 27 | Thin-skinned thrust-belt structures | Problem set 4: kinematic modeling | Nemcok et al., Ch. 4 |
| Oct. 4 | Thick-skinned thrust-belt structures |  | Nemcok et al., Ch. 5 |
| Oct. 11 | Growth structures | Problem set 5: interpreting slip rates from growth | Nemcok et al., Ch. 6 |
| Oct. 18 | **Part II:** Intro. to microtectonics, flow and deformation | Problem set 6: identifying microstructures | Passchier & Trouw Ch. 1-2 |
| Oct. 25 | Deformation mechanisms |  | Passchier & Trouw Ch. 3 |
| Nov. 1 | Foliations, lineations, lattice preferred orientations | Problem set 7: shear zones and LPO | Passchier & Trouw Ch. 4 |
| Nov. 8 | Shear zones |  | Passchier & Trouw Ch. 5 |
| Nov. 15 | Dilation sites | Problem set 8: veins, fringes, porphyroblasts and reaction rims | Passchier & Trouw Ch. 6 |
| Nov. 22 | Porphyroblasts and reaction rims |  | Passchier & Trouw Ch. 7 |
| Nov. 29 | Special techniques and microgauges | EBSD demonstration (field trip?) | Passchier & Trouw Ch. 9-10 |

**DISABILITIES:**Students with disabilities or medical conditions that affect classroom performance should contact GMU Disability Support Services immediately at 993-2474. NOTE: Students will not receive any disability accommodations unless official GMU paperwork from Disability Resource Office is provided for and signed by Dr. Paul Betka.

**HONOR CODE:** Adherence to the GMU honor code is expected of all students. Class exercises are expected to be individual efforts, unless teams are specifically assigned. Students are encouraged to discuss the concepts and procedures among themselves, but each student is expected to complete the lab assignment individually using their own words.

***To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University Community and with the desire for greater academic and personal achievement, we, the student members of the university community, have set forth this Honor Code: Student Members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work***. [[http://academicintegrity.gmu.edu/honorcode](http://academicintegrity.gmu.edu/honorcode%5D)]