GEOL 510: Kinematic and Thermal Modeling Fall 2020 Syllabus
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Introduction/Contact

Course name:	Kinematic and Thermal Modeling
Times:	M, W 1:30-2.45 pm
Instructor:	Brandon Lutz, blutz@nmsu.edu; zoom meetings by appointment

- PhD candidate at NMT
- Tectonic reconstruction, fault mechanics, thermal modeling, geochronology
- Excited to learn about NMSU grads

Course Description

This course is designed to introduce students to the principles and practices of geological modeling, specifically structural, kinematic, stress, and thermal modeling. By the end of the course, students will:

1. Grasp standard philosophy, uses, techniques of structural, kinematic, and thermal modeling
2. Generate 2D and 3D geometric and kinematic models of deformation at many scales
3. Learn how heat is transported through the lithosphere, and what factors control surface heat flow
4. Create numerical simulations of advective and conductive heat transport
5. Use thermo-chronometric data to validate kinematic models of faulting
6. Fit 3D fault planes to various data
7. Model stress on a 3D fault network to understand slip tendency; fracture stability

Grading

Modeling exercises	50%
Exams (2x)	30%
Participation	10%
Final project	10%

Course Structure

Mondays:

- lecture and discussions on reading assignments
- introduce concepts, methods, and techniques for the week's modeling exercises
- discuss uses, implications, and approaches to kinematic and thermal modeling
- most exam material comes from Mondays, but also includes application of modeling methods

Wednesdays (mask and distance):

- in class exercises using kinematic and thermal modeling software programs
- skills developed in exercises will be both tested and applied during final project and exams
- completion of deliverables for exercises will be used in final project

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Weekly Readings

Read the assigned material prior to Monday's class. This will take <1 hour. I will give small quizzes (extra credit; very simple) to make sure people are at least skimming those readings. The lectures will be much more engaging if everyone read the material. I will go over main concepts from the readings during the lectures.

Modeling Exercises and Software

Exercises are designed to develop skills in geometric, kinematic, and thermal modeling for geological purposes, but students will also learn generic practices and principles of modeling (e.g. data, assumptions, sensitivity). There are 9 exercises scheduled. Some exercises may be eliminated due to time restrictions. Most exercises require just minor (<1-2 hours) time-commitments outside of the Wednesday class period.

Exercises require access to the following software programs:

- **MOVE** (Petroleum Experts, ltd)
    - structural modeling software
    - 10 NMSU licenses
    - maintaining social distancing.
    - you may need to schedule time to use the labs outside the Wednesday class period.
- **GPLATES** (EarthByte)
    - plate-kinematic reconstruction tool
    - open source
    - GPLATES.org to download
    - install on your personal computer, or find a machine on campus for which you have admin capacity to install the software.
- **Fetkinprep & Fetkin** (Ecopetrol & Rich Ketcham @ UT, Austin)
    - numerical, finite-element thermo-kinematic modeling software package
    - transform Move reconstructions into velocity models
    - simulate heat flow in a 2D numerical grid
    - track the thermal histories of chosen points in the model
    - calculate modeled cooling ages.
    - will install this on Move PC's when the time comes

Deliverables:

- .mve file(s) with your current working model(s) (this is the file extension for Move)
- .gproj , .gpml , .rot , and .png (snapshots) files of your working model (this is GPLATES)
- Both input and output directories for Fetkin thermal modeling projects (we'll discuss later)
- Visualizations of you model (snapshots or screenshots cropped or treated properly to be neat)
- Brief summary of the exercise that should contain these sections:
    - Introduction: purpose of the exercise; uses of the technique applied
    - Method: summarize (probably with figures) the methods/techniques
    - Data: what data were used; could be a table; or in writing
    - Results: summary (possibly with figure) of results of method applied
    - Discussion: any points you'd' like to make; this will be more important in later exer.
    - References: any literature you needed to cite

- Writeup notes

- The write-up will become easy and quick once you get into a rhythm.
- Exercises compound on one another each week
- Some write-up material may be “recycled”
- Write ups will become longer with depth into the series per program.

If there is an exercise that students are struggling with, we can allocate a Monday class period to work together through these problems so that everyone is keeping pace with the course load.

Exams

The exams will focus on:

- the lecture material **(emphasis)**
- out of class readings
- skills learned from the modeling exercises

In lecture and via little quizzes (extra credit), I make it very clear what will be tested, so if students are engaged during the lectures (and reading), they should know precisely what to study.

Exams format:

- make and/or describe conceptual sketches and diagrams
- describe and apply modeling techniques
- utilize mathematical formulae (minimal)
- name and describe geologic structures and the processes that form them
- define the most important terminology

Final Project

To be determined. May be whole class, in small groups, or with partners. If the final project yields interesting results, then it may be incorporated into some sort of publication in the future, with you students as co-authors. We will talk more about the final project toward the middle/end of the semester.

Late Policy

Please do not fall behind in this class. I have designed it so that skills learned from one exercise are applied to the next. Models that you initiate in week 1 will be added to and used in weeks 2-5. So, if you fall behind, you will not be able to complete the next exercise.

Late deliverables will receive partial credit at my discretion. If you have a real, documented excuse, then we can talk about a solution.

If you’re required to work on an exercise from the week before, you will lose half (5% of total grade) of your participation grade for the class. If it happens twice, you lose the other 5% of your participation points.

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Weekly Plan (subject to change)

Week	Lecture Topics (Monday)	Exercise/Lecture (Wednesday)	Deliverables	Reading (prior to week)
8/19	No Class	Course Introduction	none	Make sure you're set up to work on a MOVE PC
8/24 8/26	Modeling intro Structural geology review Data types	Data Types; (1) importing and creating data (MOVE)	none	fault geometries cross-section basics Groshong (1994)
8/31 9/2	Faults & shear zones Cross-section basics	(2) projecting data to 2D cross-section and building subsurface geometries (MOVE)	Exercise (1) (MOVE) (Tuesday 11:59 pm)	Reconstruction methods Extensional systems
9/7 9/9	No Class Labor Day	(3) reconstructing 2D cross-sections (MOVE)	Exercise (2) (MOVE) (Tuesday 11:59 pm)	Shear zones
9/14 9/16	Faults & shear zones Reconstruction methods	(3) reconstructing 2D cross-sections (MOVE)		Wernicke and Axen (1988); Buck (1988); Wernicke (1981)
9/21 9/23	Detachment faults\footwall rebound	(4) forward modeling and cross-section validation (MOVE)	Exercise (3) (MOVE) (Tuesday 11:59 pm)	Isostasy; flexure; elastic thickness
9/28 9/30	thrust faults\flexural loading	(4) forward modeling and cross-section validation (MOVE)	Exercise (4) (MOVE) **(Friday 11:59 pm)**	
10/5 10/7	Review for exam 1	Exam 1	none	Mueller (2019); Install GPLATES Seton et al. (2012) McQuarrie and Wernicke (2005)
10/12 10/14	Plate tectonics Map-view kinematics Large-magnitude extension Strike-slip faulting	(5) Introduction to GPLATES, Euler Pole rotations, and 2D map-view kinematic modeling (GPLATES)	none	Burchfiel and Stewart (1966) GPS modeling paper Bahadori et al (2018)
10/19 10/21	Fault growth patterns (all fault types) Map-view strain: from GPS observations and	(6) Line topology: creating a transfer fault; topological networks: modeling dilations, strain and crustal stretching (GPLATES)	Exercise (5) (GPLATES) (Tuesday 11:59 pm)	Clerc et al (2015) Naliboff et al. (2020) Brune et al. (2017) Huismans and Beaumont (2014)

	kinematic modeling			Petrunin and Sobelev (2008)
10/26 10/28	Crustal thickness reconstructions Continental rifting & rifted margins Thermo-mechanical modeling	1D and 2D heat flow crustal heat flow introduction to Fetkin & Fetkinprep	Exercise (6) (GPLATES) (Tuesday 11:59 pm)	Almendral et al. (2015)
11/2 11/4	Thermo-chronology Finite-element numerical modeling	(7) Converting your MOVE reconstructions to Fetkin velocities (FetkinPrep)	Exercise (7) (Fetkinprep) (**Friday 11:59 pm)**	Ricketts et al. (2015)
11/9 11/11	(8) 2D numerical simulations of heat flow; parameter testing; tracking thermal evolutions	(8) 2D numerical simulations of heat flow; matching thermal evolutions	Exercise (8) (Fetkinprep & Fetkin) (**Friday 11:59 pm)**	
11/16 11/18	Fault mechanics	(9) 3D stress modeling (MOVE)		
11/23 11/25	Happy Thanksgiving	Happy Thanksgiving	Happy Thanksgiving	Happy Thanksgiving
11/30 12/2	Exam 2	Group Project discussion: planning	Exercise (9) (Monday 11:59 pm)	Do your part of group project
12/7 12/9	Work on Group Project	Work on Group Project		Do your part of group project
12/14 12/16	finals week; Group Project	finals week; Group Project	Submit your group project deliverables	