Continuum Mechanics - GEO325C/398C, Fall 2025

Class details

Room:	EPS 1.126
Course website:	https://mhesse.github.io/continuum_mechanics/
Class time:	Tu/Th 9:30-11:00am
Unique:	(29800/30160 - undergrad/grad)
Prerequisites:	MATH 427J (ODE's & matrices), MATH 427 L (∇, $\nabla\cdot$, $\nabla\times$)
Description:	Explores modeling and simulation of fluids and solids in geological and geophysical phenomena, such as mantle convection, glaciology, and climate dynamics. Explores basic principles of continuum mechanics and thermodynamics. Covers the fundamental conservation laws and the common constitutive relations for fluids and solids. Emphasis on three dimensional geometries and real-world examples from all areas of the Earth Sciences.

Instructor

Instructor:	Dr. Marc Hesse
Office:	JGB 4.216G
Office hours:	TBD
Email/Website:	mhesse@jsg.utexas.edu and https://www.jsg.utexas.edu/hesse/

Assessment

Undergraduates: 20% Problem Sets + 15% Midterm 1 + 15% Midterm 2 + 30% Final + 20% Attendance
Graduate students: 20% Problem Sets + 15% Midterm 1 + 15% Midterm 2 + 30% Final + 20% Project

A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
>94	90	87	84	80	77	74	70	67	64	60	<60

Collaboration: Students can discuss homeworks, but must write up solutions individually.
Exams: In class, closed book, you can bring a cheat sheet

Course materials

Two books that are useful but not required are:
Continuum Mechanics in the Earth Sciences, by Newman
A first course in continuum mechanics, by Gonzalez and Stuart

Syllabus

lecture	date	topics	problem sets
Topic I: Force and Torque			
1	Aug 25	Vector review and index notation	-
2	Aug 27	Body and surface forces, isostacy	PS 1: Vectors
3	Sep 1	Rotation, torque, moment, topling	-
Topic II: Tensor Algebra and Stress			
4	Sep 3	Tensor algebra	PS 2: Force
5	Sep 8	Cauchy stress	-
6	Sep 10	Principal stresses and Andersonian faulting	PS 3: Tensors
7	Sep 15	3D Rotations	-
8	Sep 17	Change of basis	PS 4: Rotations
9	Sep 22	Mohr circle and failure	-
Topic III: Tensor Calculus			
10	Sep 24	Tensor calculus	PS 5: Fault stress
11	Sep 29	Integral theorems	
12	Oct 1	Equilibrium equations	**Pick grad project!**
	Oct 6	**Midterm Exam 1: Topics I and II**	-
Topic IV: Kinematics and Strain			
13	Oct 8	Deformation map and gradient	PS 6: Div, Grad, Curl
14	Oct 13	Cauchy-Green strain tensor	
15	Oct 15	Interpretation of strain tensor	PS 7: Deformation map
16	Oct 20	Infinitesimal strain tensor	-
17	Oct 22	Motions and rates	PS 8: Material derivative
18	Oct 27	Reynolds transport theorem	-
Topic V: Balance and Constitutive Laws			
19	Oct 29	Mass and momentum balance	-
20	Nov 3	Energy conservation - heating	PS 9: Mass and Momentum
21	Nov 5	Energy conservation - working	-
22	Nov 10	Constitutive laws	PS 10: Energy
	Nov 12	**Midterm Exam 2: Topics III and IV**	
Topic VI: Applications			
23	Nov 17	Fluids I: Navier Stokes Equation	
24	Nov 19	Fluids II: Boundary layers and energy dissipation	
Nov 23-27: Thanksgiving break			
25	Dec 1	Solids I: Static problems	
26	Dec 3	Solids II: Elastic waves	
	Dec 10-14	**Final Exam (Comprehensive)**	**Grad Project due**

Academic accommodations from Disability and Access (D&A)

Please let me know if you are a student with a disability and deliver your Accommodation Letter to me as early as possible in the semester. See here for the UT standard statement.

For general University Policies and Resources follow this link.

Learning Outcomes

- Apply tensor analysis: Students will utilize vector index notation, tensor algebra, and integral theorems to evaluate three-dimensional physical fields such as stress and strain.
- Analyze stress states: Students will calculate principal stresses, rotations, and maximum shear stress using Cauchy tensors and Mohr circle constructions.
- Quantify material deformation: Students will formulate and interpret kinematic deformation maps, Cauchy-Green strains, and infinitesimal strain tensors.
- Formulate conservation laws: Students will evaluate fundamental Eulerian balance laws for the conservation of mass, momentum, and thermal energy.
- Model geophysical applications: Students will apply continuum mechanical principles to simulate phenomena like mantle convection, glaciology, and seismic waves.