ESS 411/511 Geophysical Continuum Mechanics Class #2

Highlights from Class #1 – Jason Ott
Today's highlights on Monday? – Jensen DeGrande

Warm-up question (break-out with 1 or 2 partners, 4 minutes)
You are a DOT traffic engineer, and you want to treat traffic on Interstate 5 as a continuum problem

- suggest a value for averaging length *r*
- Why?

Your Class-prep answers for today (break-out groups, 6 minutes)

Read Raymond Notes Ch 1 (class web site, https://courses.washington.edu/ess511/NOTES/notes.shtml (Links to an external site.)),
Read Mase, Smelser and Mase, Ch 1
Read Raymond Notes Ch 2, (2.1 and 2.2, also on class web site).
Then
In a prose sentence for each, discuss what you see as the key feature of a spring, and of a dash pot.
and
In a prose sentence for each, discuss what you consider to be the essential nature of each of stress, strain, and elastic behavior.

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For Monday Oct 4, Class_03

Please read Raymond Chapter 2 through Section 2.9.

(Focus on the 1-D model descriptions, not the Earth properties yet)

It's time to start Homework Problem Set No.1 under the **HOMEWORK** tab.

https://courses.washington.edu/ess511/ASSIGNMENTS/assignments.shtml (Links to an external site.)

It’s a good idea to have some initial ideas formed so that you can contribute to discussions in Problem Lab on Thursday.

This week, also check out “EDW_notes_about_1-D_models” under the **READING & NOTES** tab

https://courses.washington.edu/ess511/NOTES/notes.shtml (Links to an external site.)

Class-prep writing assignment Class_03, due in Canvas before class on Monday:

Viscoelasticity

You are working in a mechanics lab, and your lab boss has asked you to perform a creep test on a rock sample. In general terms, what are you going to do?

The lab boss has now asked you to perform a relaxation test on an identical rock sample. In general terms, what will you do differently this time?

I would expect you can answer each question in a few sentences for each, for something like half a page total.

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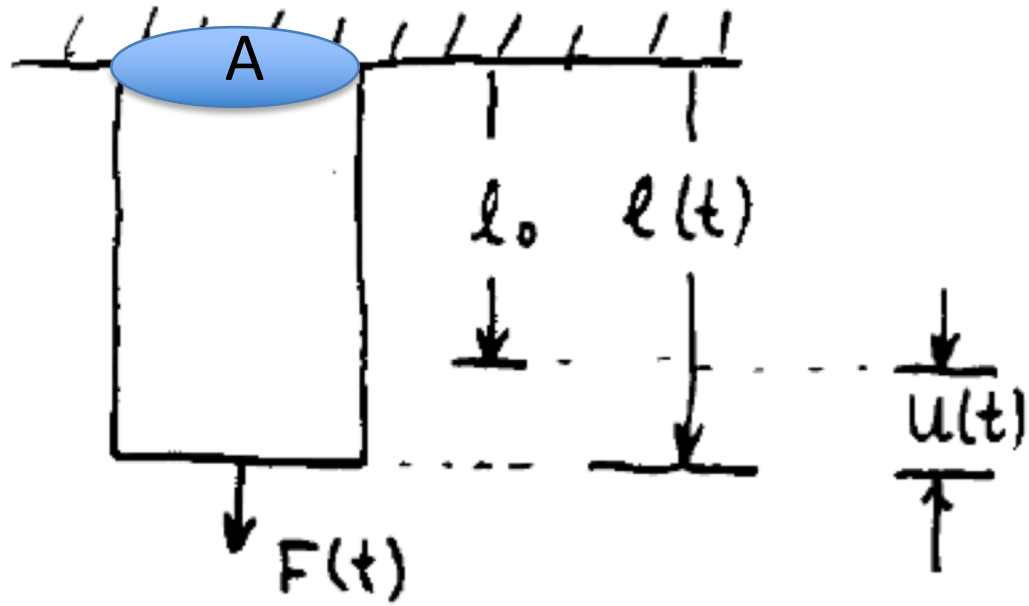
Dealing with a continuum

Environment	**The continuum**	**How it responds**
• Temperature T	Material properties	Constitutive properties
• Pressure *P*	• density ρ	• thermal conductivity
• Force ***F***	• charge state E	• electrical conductivity
• Electromagnetic ***H,B,E***	• magnetization state	• elastic constants
		• Viscosity
		• magnetic permeability

Force *vs* stress in 1-D

- $F(t)$ applied force
- l_0 initial length
- $l(t)$ deformed length
- $u(t)$ elongation

- A cross-sectional area



We want to discover a relationship between force and response (shape change) independent of the geometry.

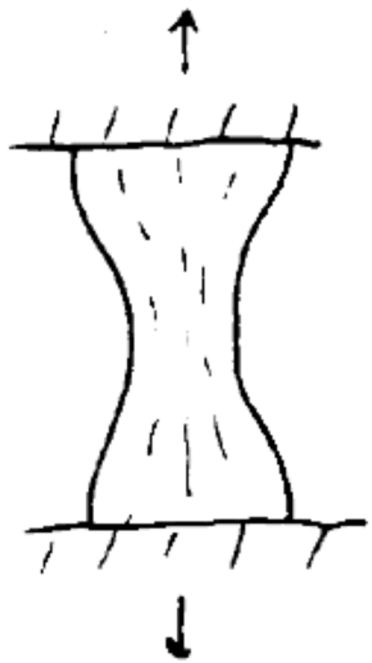
- **Stress** is force per unit area $\sigma(t) = \mathbf{F}/A$
- **Strain** is *fractional* elongation $e(t) = u(t)/l_0$

- Goal is to relate σ and e ***independent of geometry***

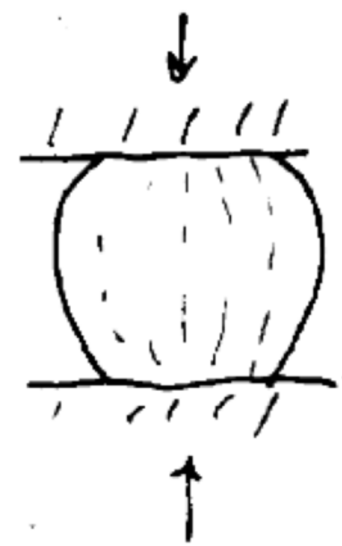
Issues

- Large strains – necking (no, not that necking)
- Silly-putty demo
- What happens to total force in the neck?
- What happens to stress in the neck?

Necking instability

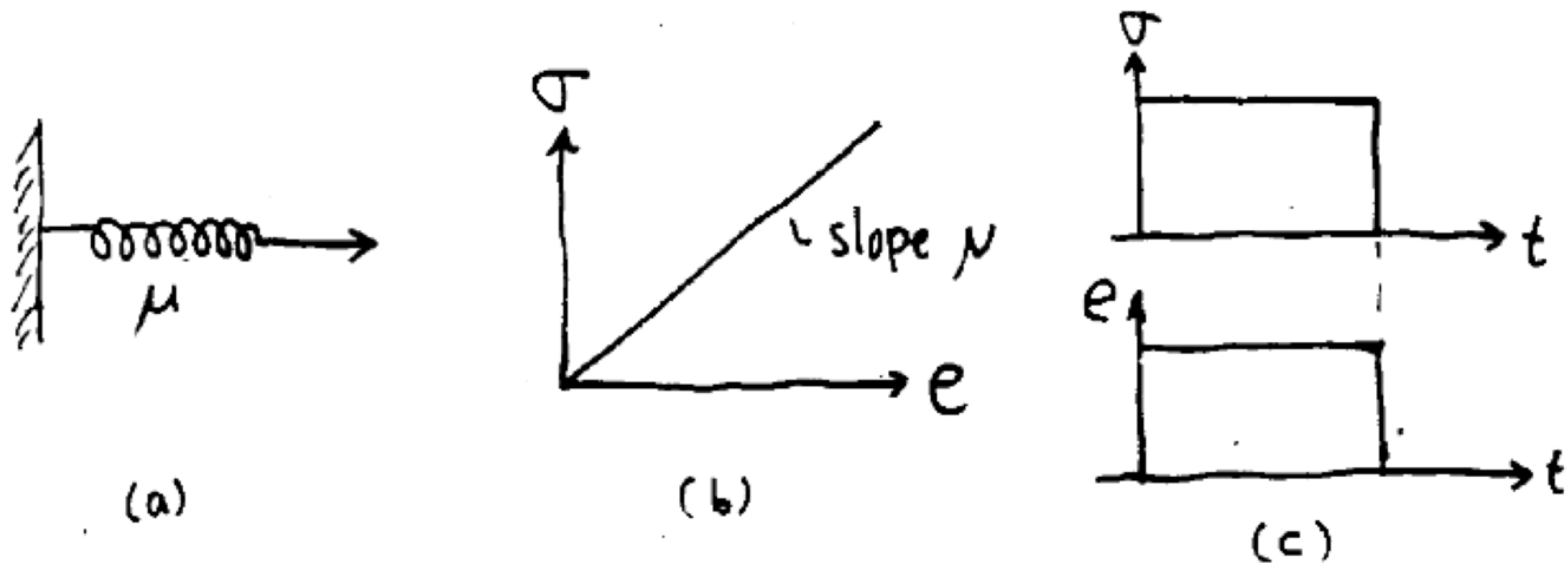


Barrel instability



Linear Elastic Behavior – Hookean solid (an idealization)

$$\sigma(t) = \mu\, e(t)$$



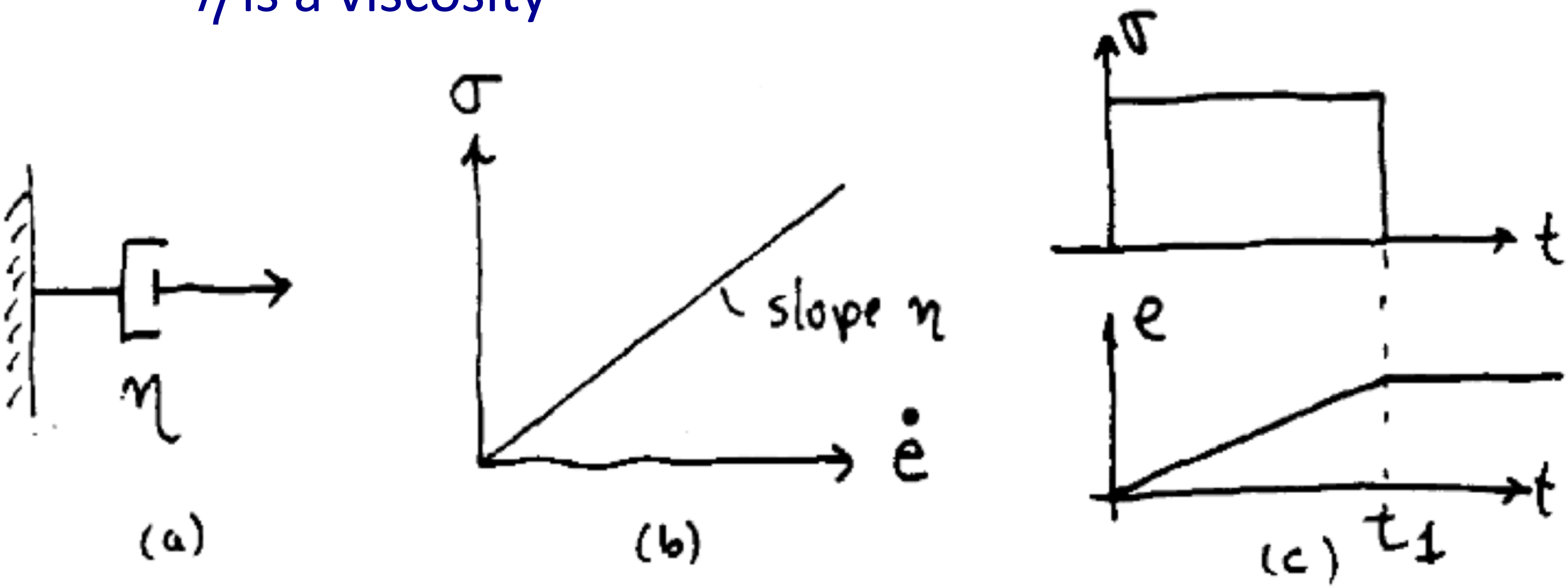
Linear viscous Behavior – Newtonian fluid (an idealization)

$$\sigma(t) = \eta \, \dot{e}(t)$$

The dot indicates a time derivative

$\dot{e}$ is a strain *rate*

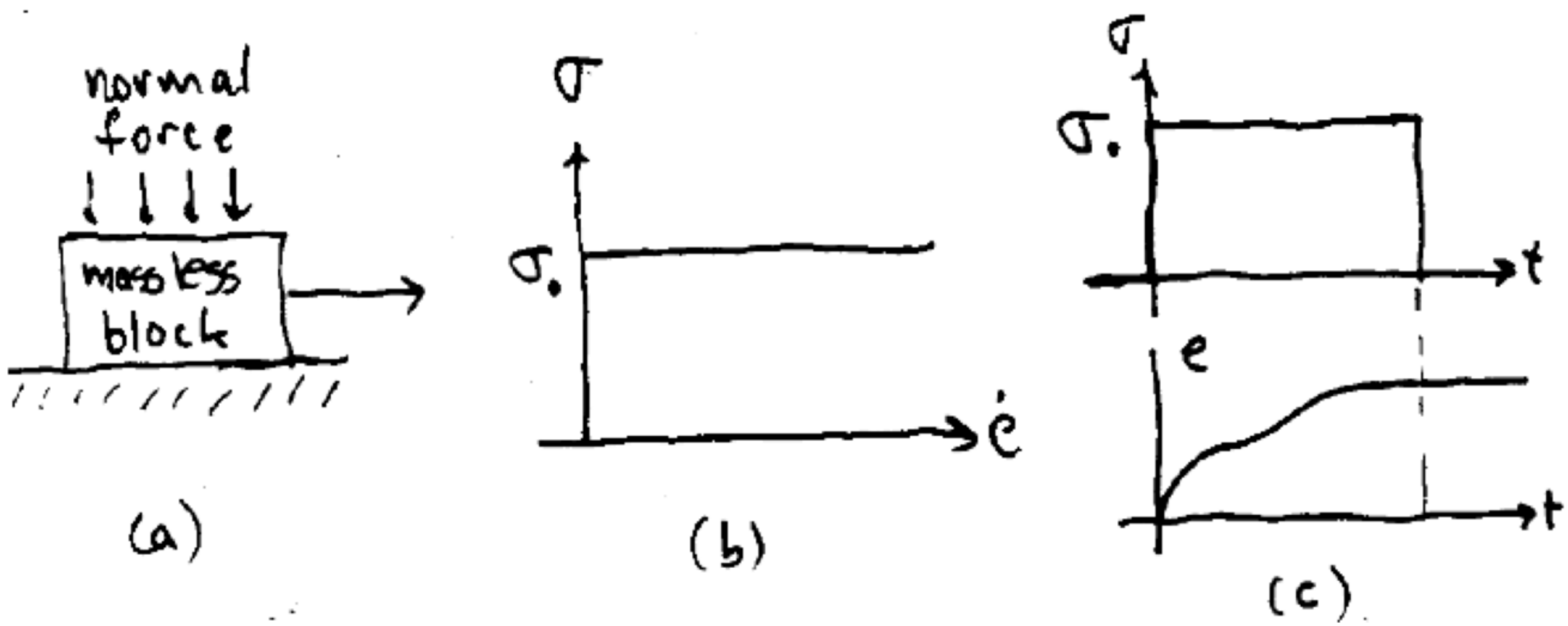
η is a viscosity



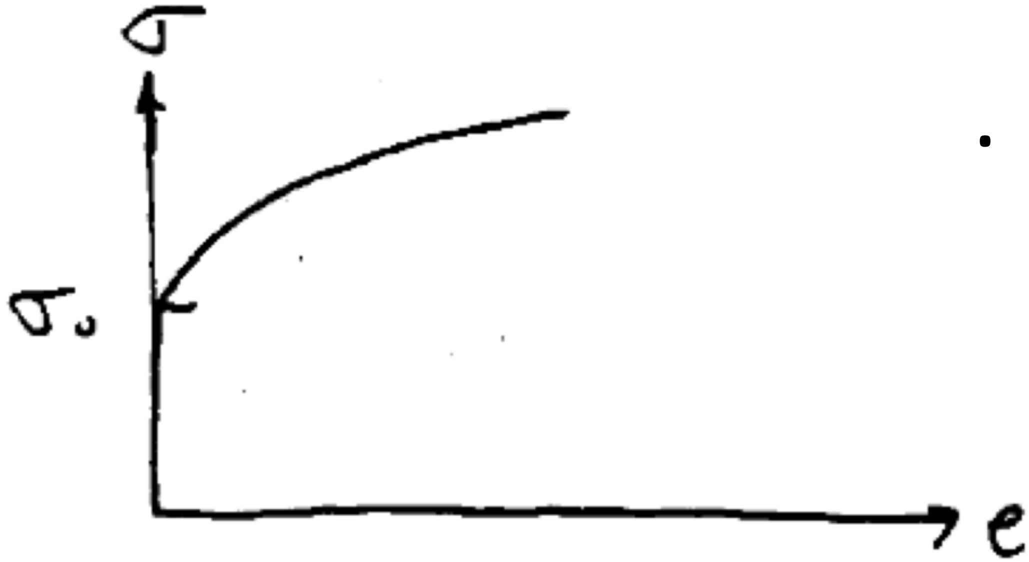
Failure (an idealization)

There is a critical stress σ_0 called the yield stress

- Below σ_0 there is no deformation
- At σ_0 the deformation can be anything
- Can be brittle failure, or perfect plasticity, or work hardening



Failure – A work-hardening plastic material



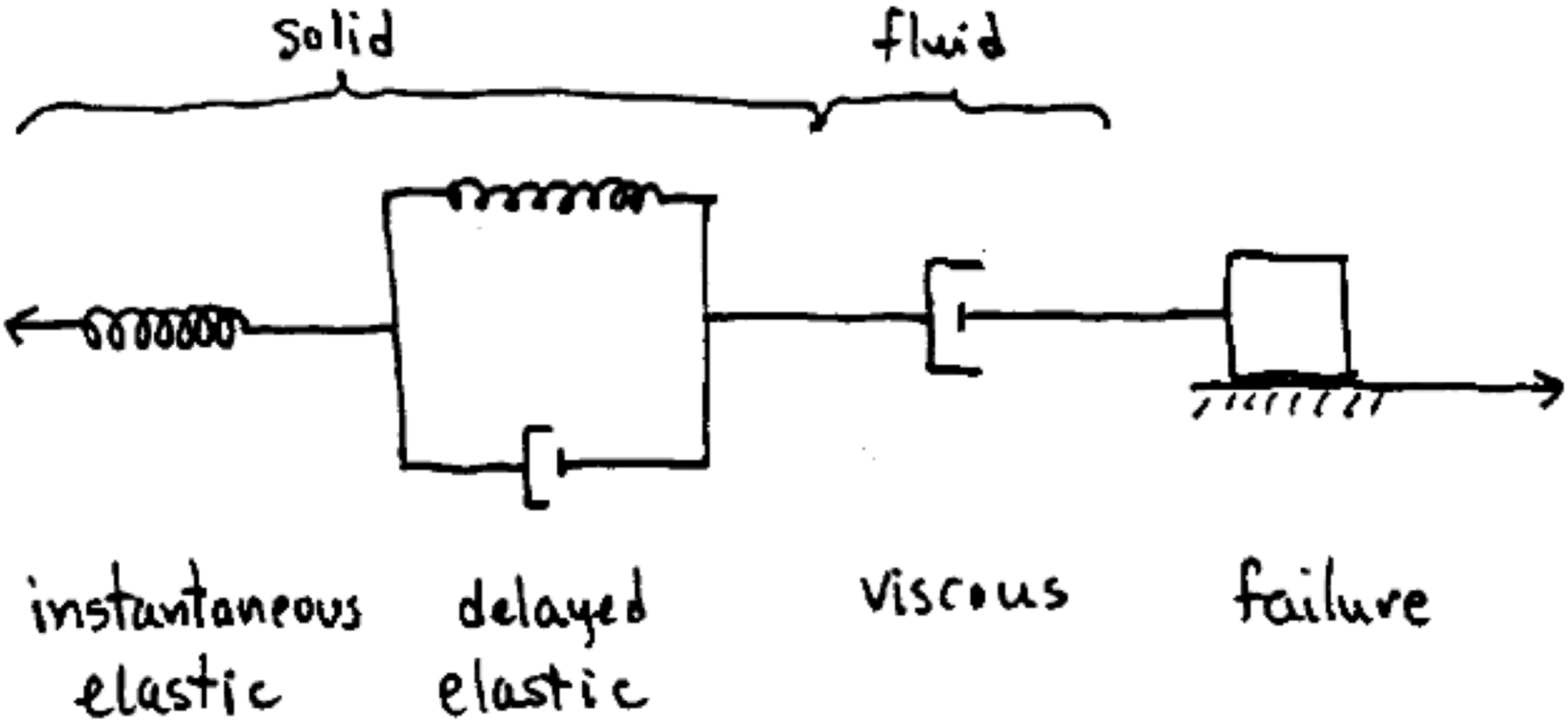
- No strain until stress reaches σ_0.
- For straining to continue, applied stress must continue to rise.
- The more strain that has occurred, the greater the stress must be to cause further strain.

Brittle vs ductile behavior

The difference is rate of loss of strength

- Brittle material loses strength immediately
- Ductile material loses strength slowly as strain increases

A more realistic model for real materials



The importance of each element depends on time scale, pressure, temperature, and state of stress