

Silly Putty Opening Question

- Does it behave like an elastic solid or a viscous fluid?
What was your prediction?

- It actually has viscoelastic behavior! It has properties of an elastic solid and a viscous fluid.

Viscoelastic Materials

Viscoelasticity

- Materials that exhibit both viscous and elastic characteristics when undergoing deformation
 - Results in time-dependent behavior: The rate that a force/displacement is applied matters as well as how long the force/displacement is applied
- What type of materials are viscoelastic?
 - polymers
 - biological materials

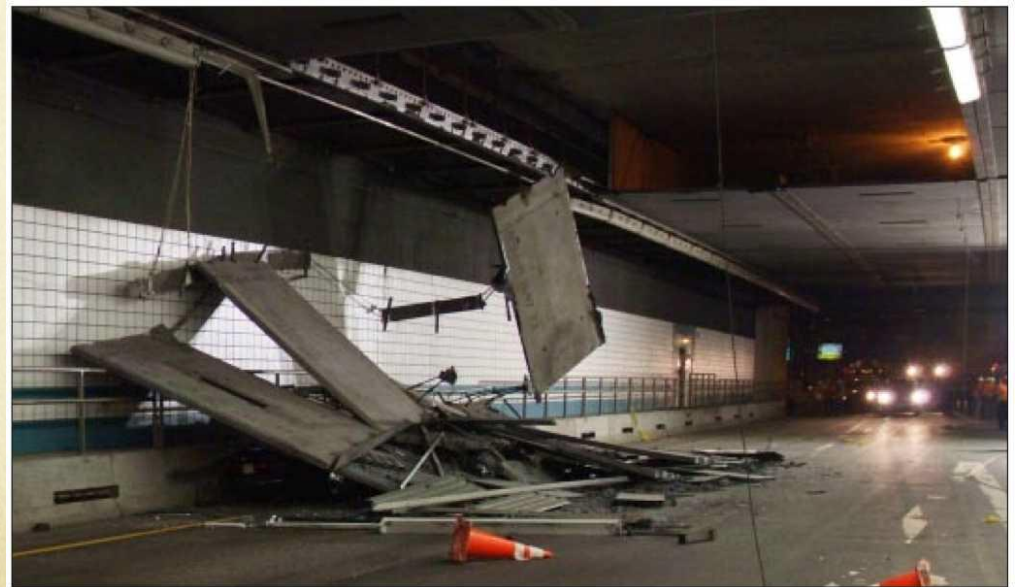
Viscoelasticity

- Why is it important to understand viscoelasticity?
 - If using a viscoelastic material in your device/structure design
 - If your device must operate in an environment that contains viscoelastic materials
 - Real-life example: Fort Point Channel Tunnel in Boston

■ Ceiling panels secured with bolts embedded in epoxy (a polymer)

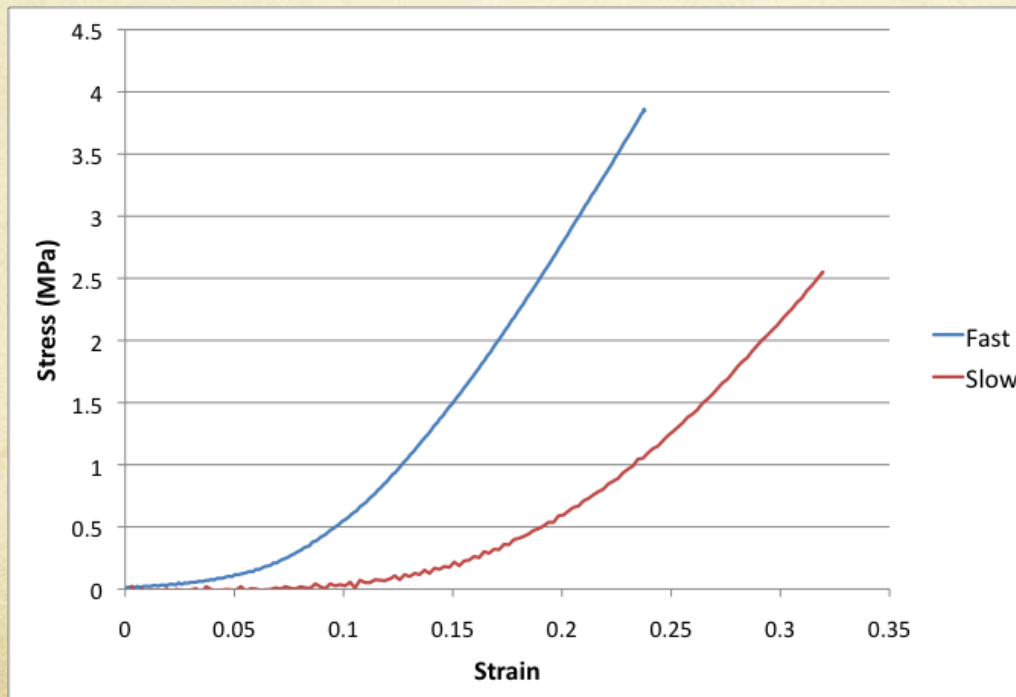
■ 12 tons of concrete fell

■ 242 unsafe bolts found



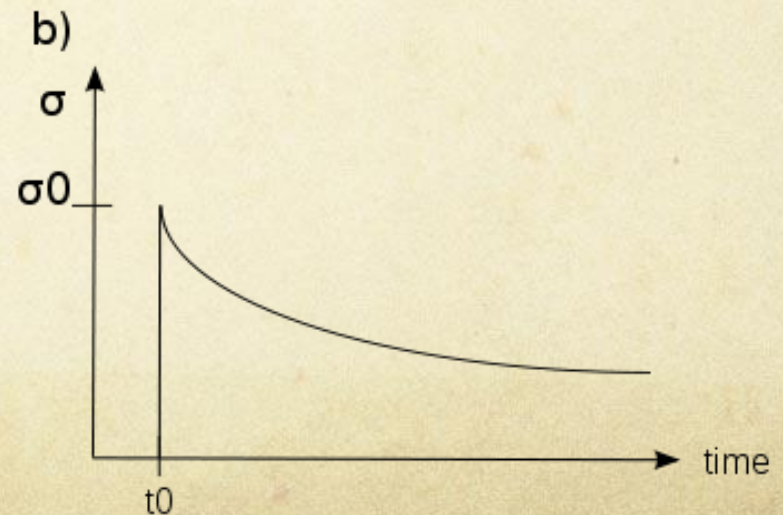
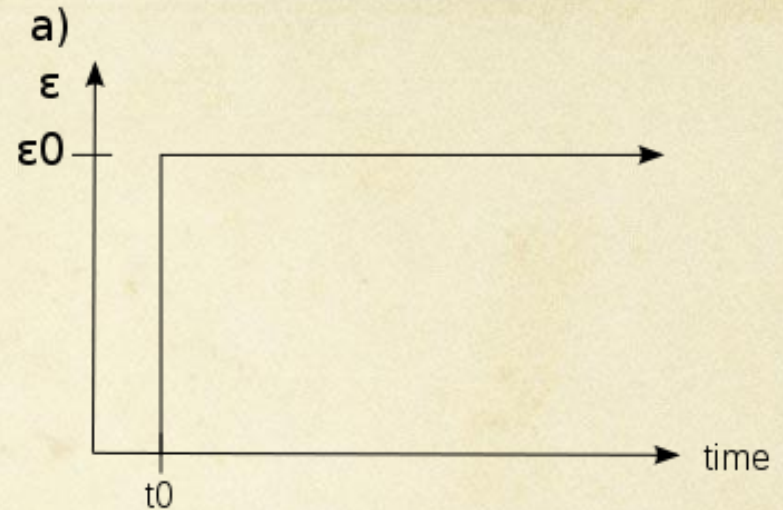
Strain Rate Dependence

- The faster the loading rate:
 - The more elastic the response
 - The smaller the curvature
 - The stiffer the material response



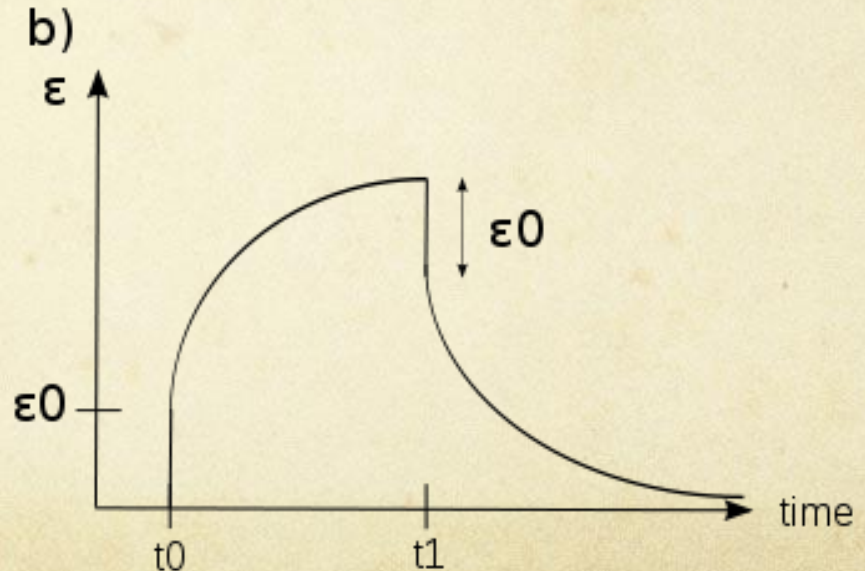
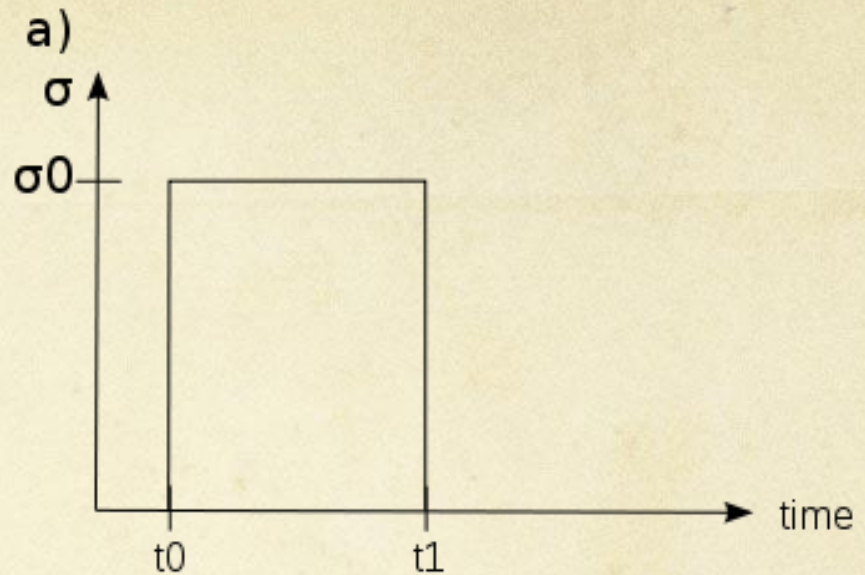
Stress Relaxation

- If you apply a constant displacement then the force decreases as a function of time.
- Example:
 - A rubber band around a newspaper for a long period of time will decrease the force that it applies



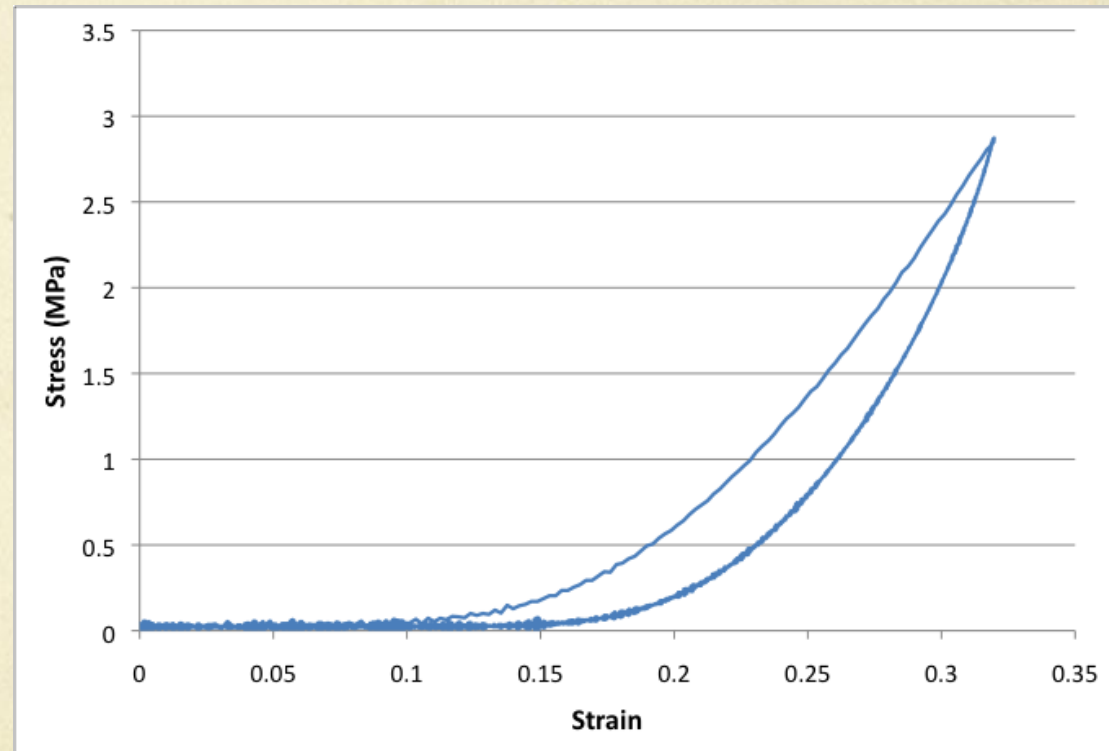
Creep

- If you apply a constant force then the displacement will increase as a function of time.
- Example:
 - Hang a bike from a bungee cord and the bungee cord will lengthen over time



Hysteresis

- Takes more energy to load the material than to unload. This energy is lost during the loading phase.
- The area between the load and unloading curve represents the energy lost.

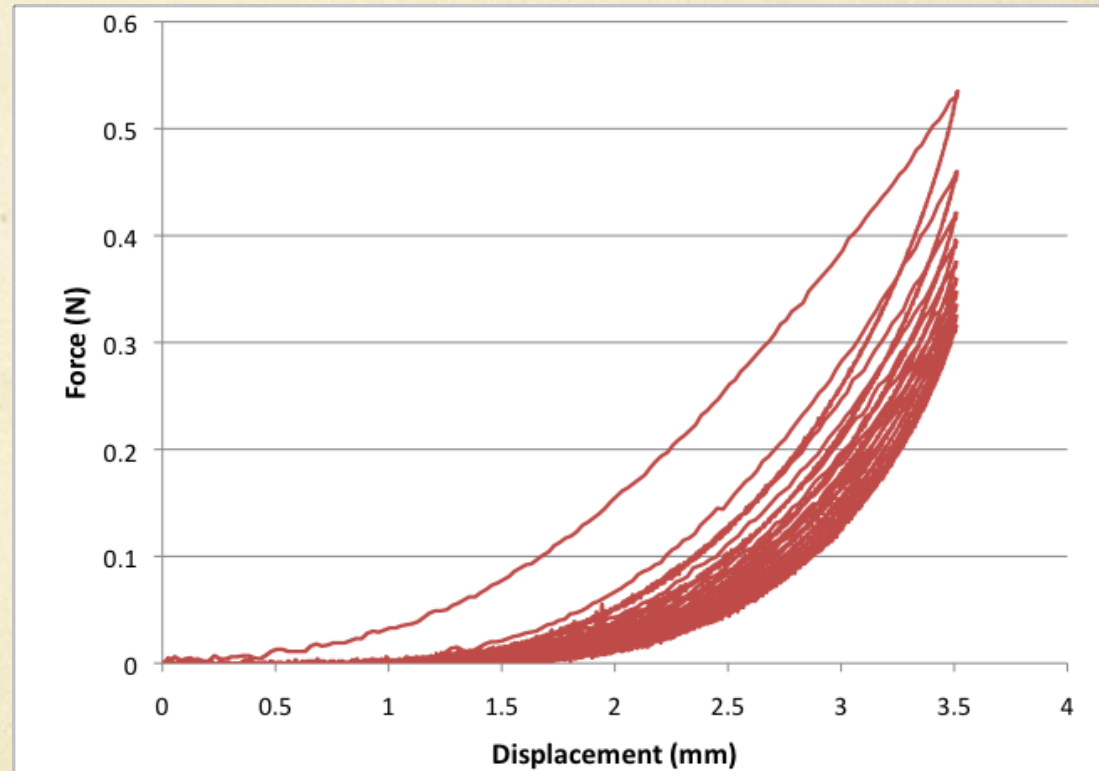


Preconditioning

○ As you continue to cycle the material, the amount of energy loss decreases until it reaches an equilibrium close to zero.

The amount of force it takes to displace the material decreases with more cycles. Eventually, equilibrium is reached.

Example: Stretching balloon material to make them easier to blow up/stretch.



Silly Putty Experimentation

- Let's demonstrate some of these properties with silly putty
 - strain rate dependence
 - creep
- In your lab notebook, describe the differences that you observed in behavior between springs and silly putty.