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

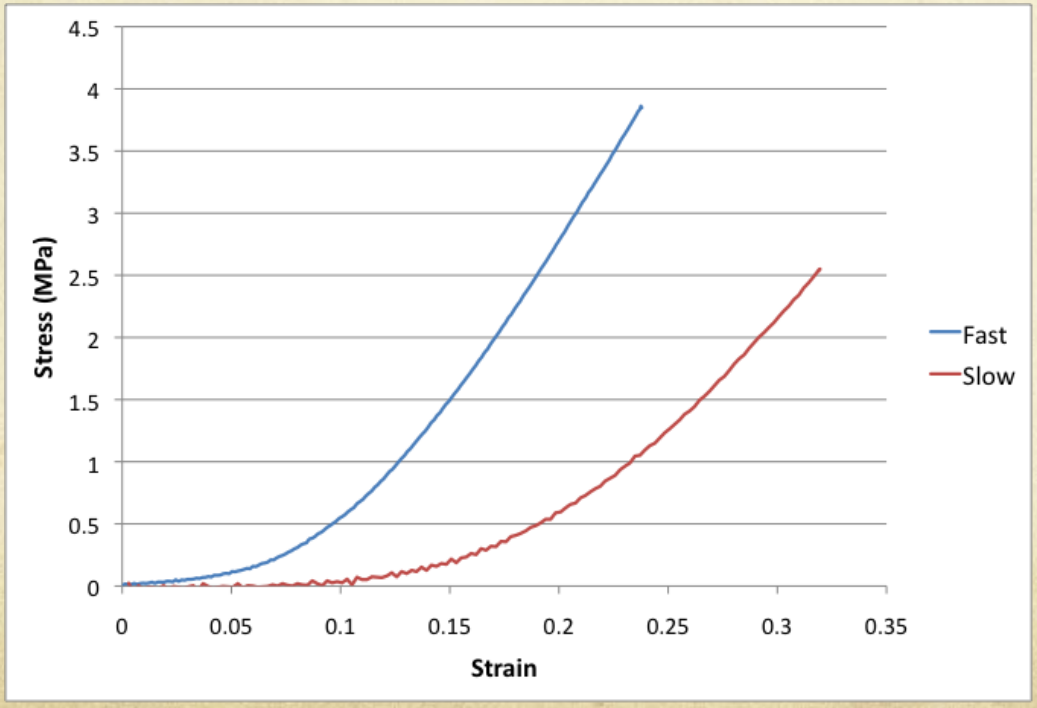
Viscoelasticity

- 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

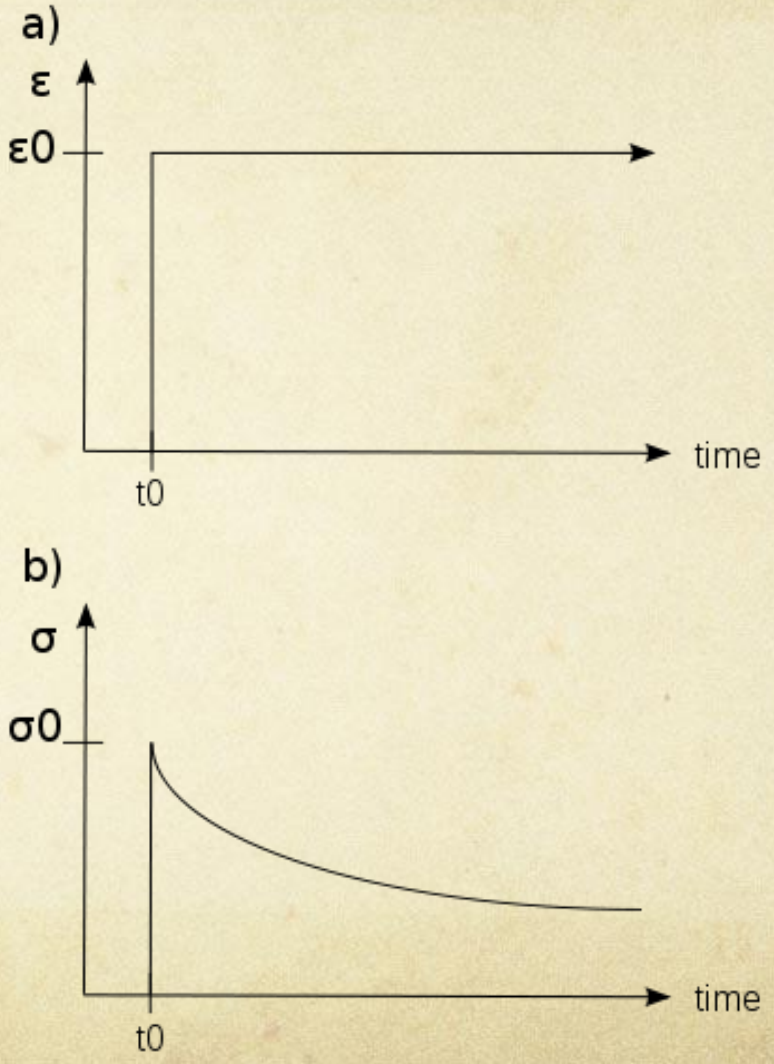
Strain Rate Dependence

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



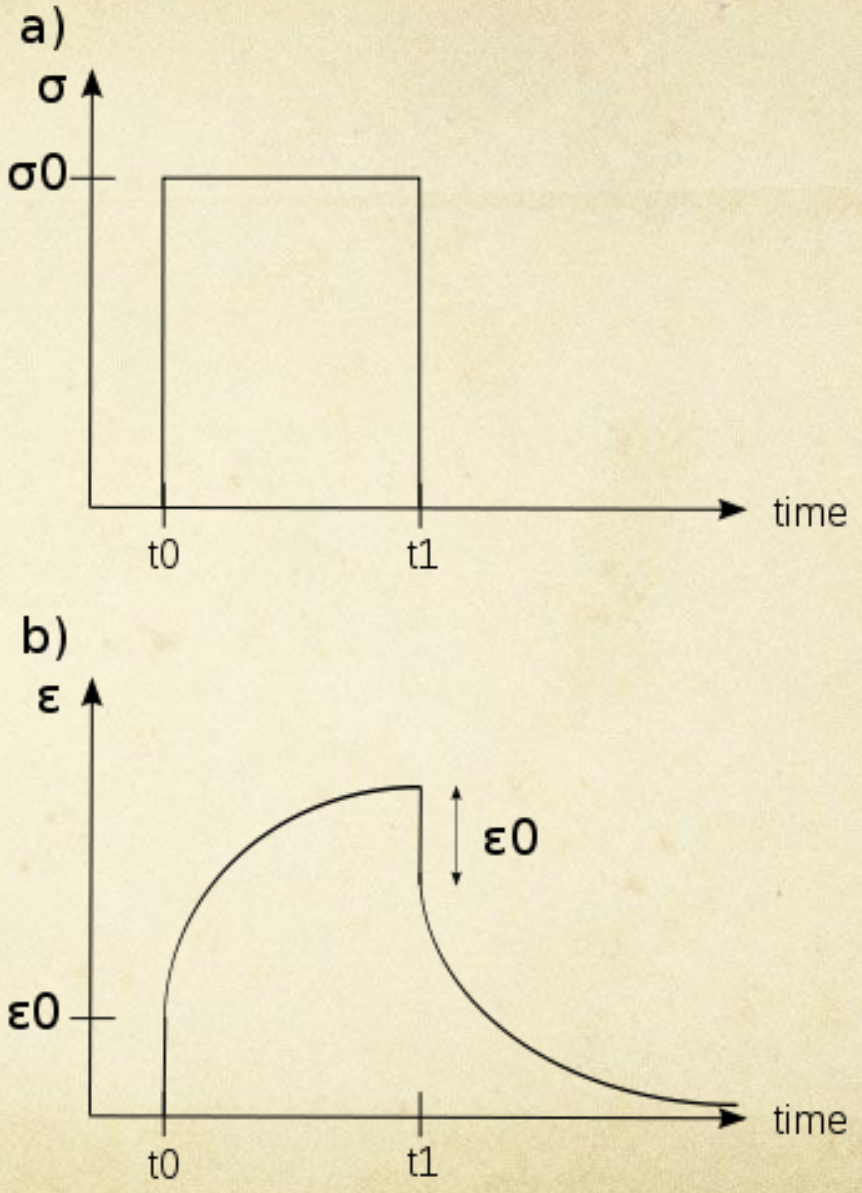
Stress Relaxation

- 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



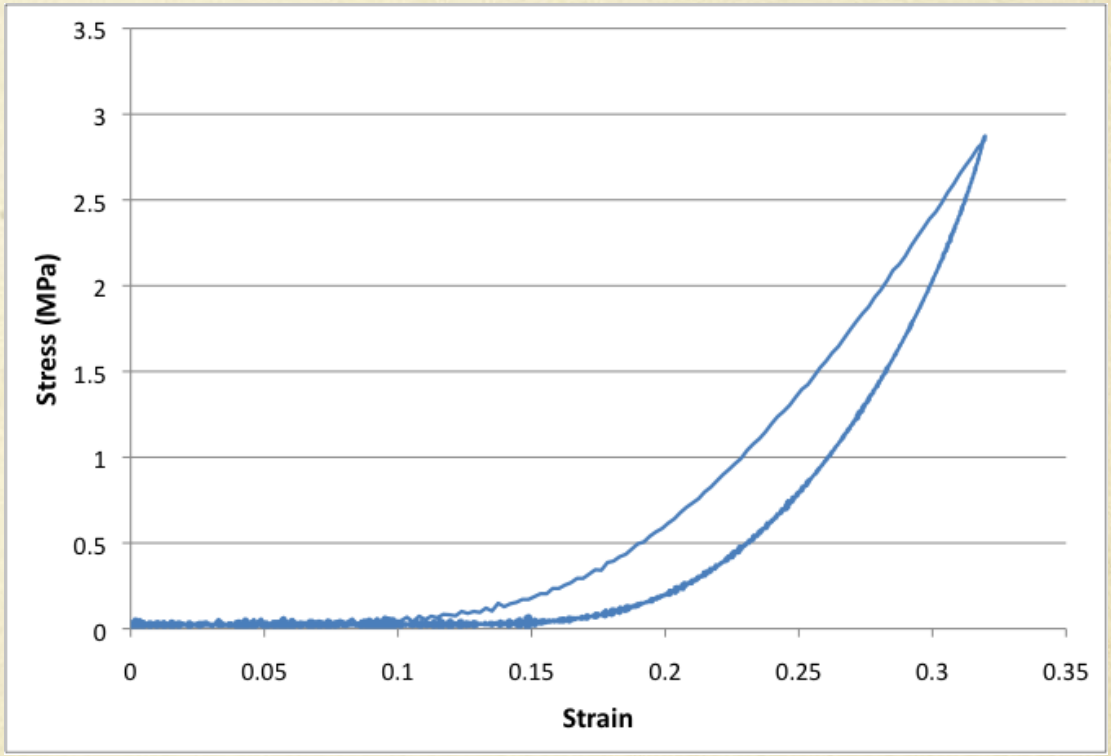
Creep

- 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



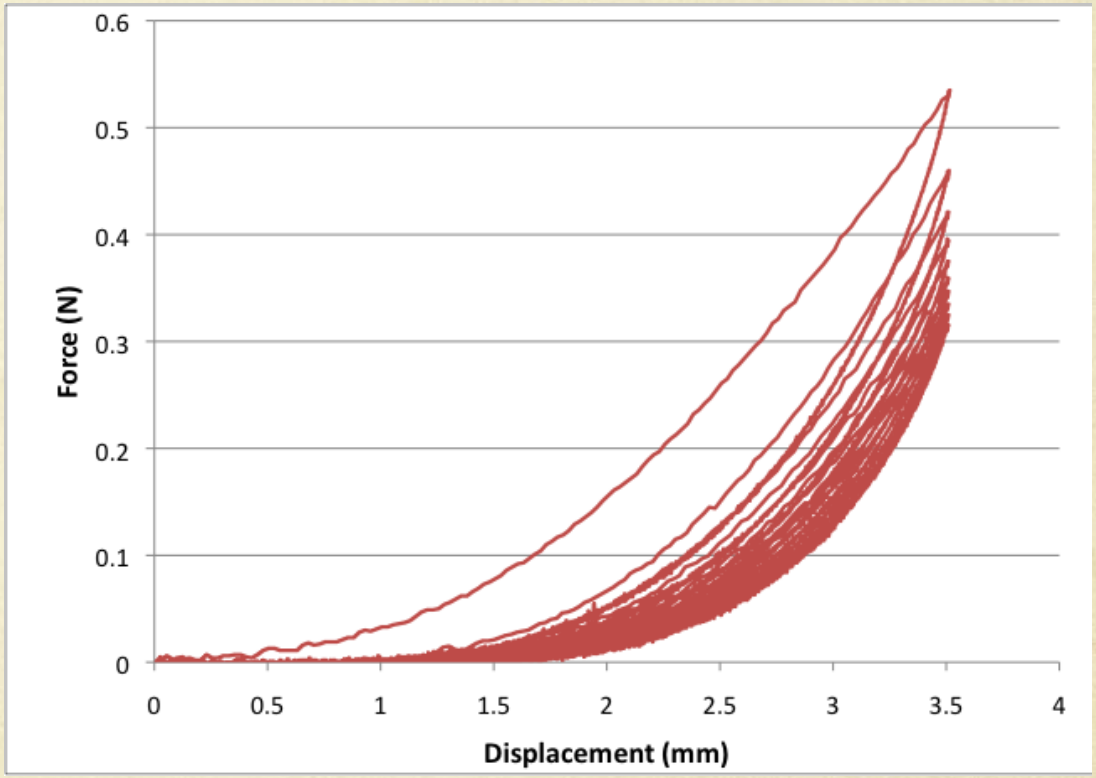
Hysteresis

- 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.