Quiz 13 Review topics

Quiz 13 will include:

Stress/Strain (2 Problems)

1. Using a graph to find average or instantaneous velocity, speed or acceleration
2. Something where a FBD would help
3. Rolling and/or sliding on an incline

Optional Extra Credit (Wed., April 27)

Group Project: 1-4 people (can do alone if you want but graded by the same rubric, incentive to have to work on your groupwork skills)

Graded based upon in-class presentation (see syllabus for detailed rubric)

You are to pick some movie scene where you question whether the scene could physically happen. You should do calculations based on what we learned in class to analyze if the movie did it correctly.

Worth **up to** 5 quiz points on a quiz

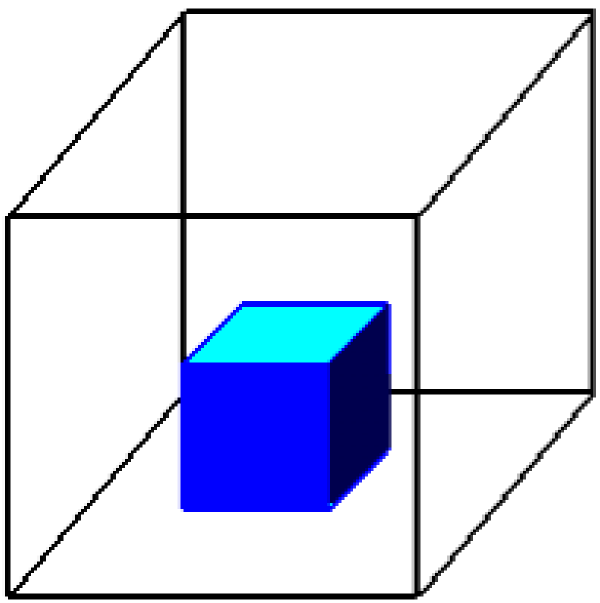
Section 9.10

What does it take to change the shape or volume of a solid?

An external force

Like a spring, the shape of an object will return if a small force is applied.

Large forces might break/deform object



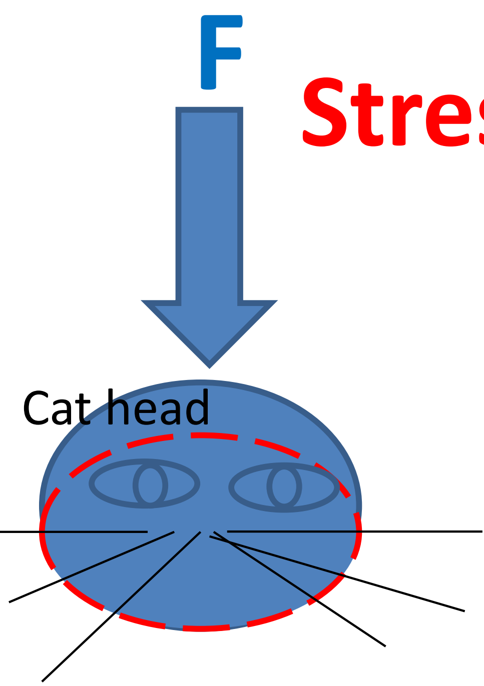
Solid

Holds Shape

Fixed Volume

Solids

Like a spring, the shape of an object will return if a small force is applied.



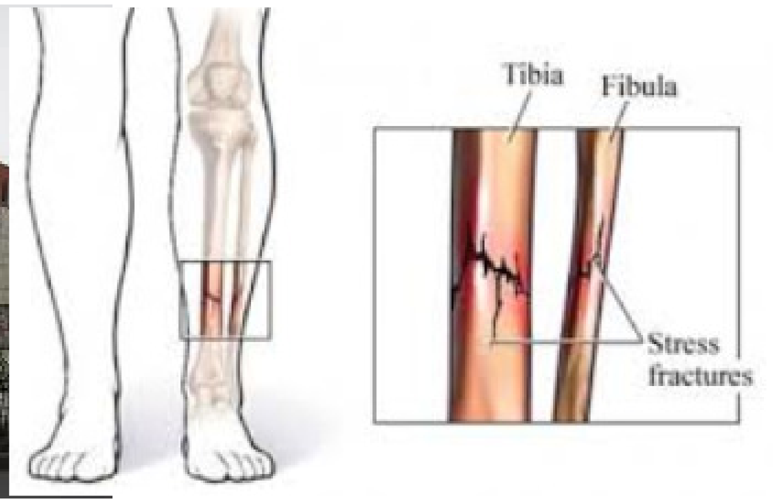
Stress is force per unit area causing a deformation (change in length/shape/volume).

Stress = Force / Contact Area

Strain is a measure of the amount it's deformed when a force is applied.

Why We Care About Strain

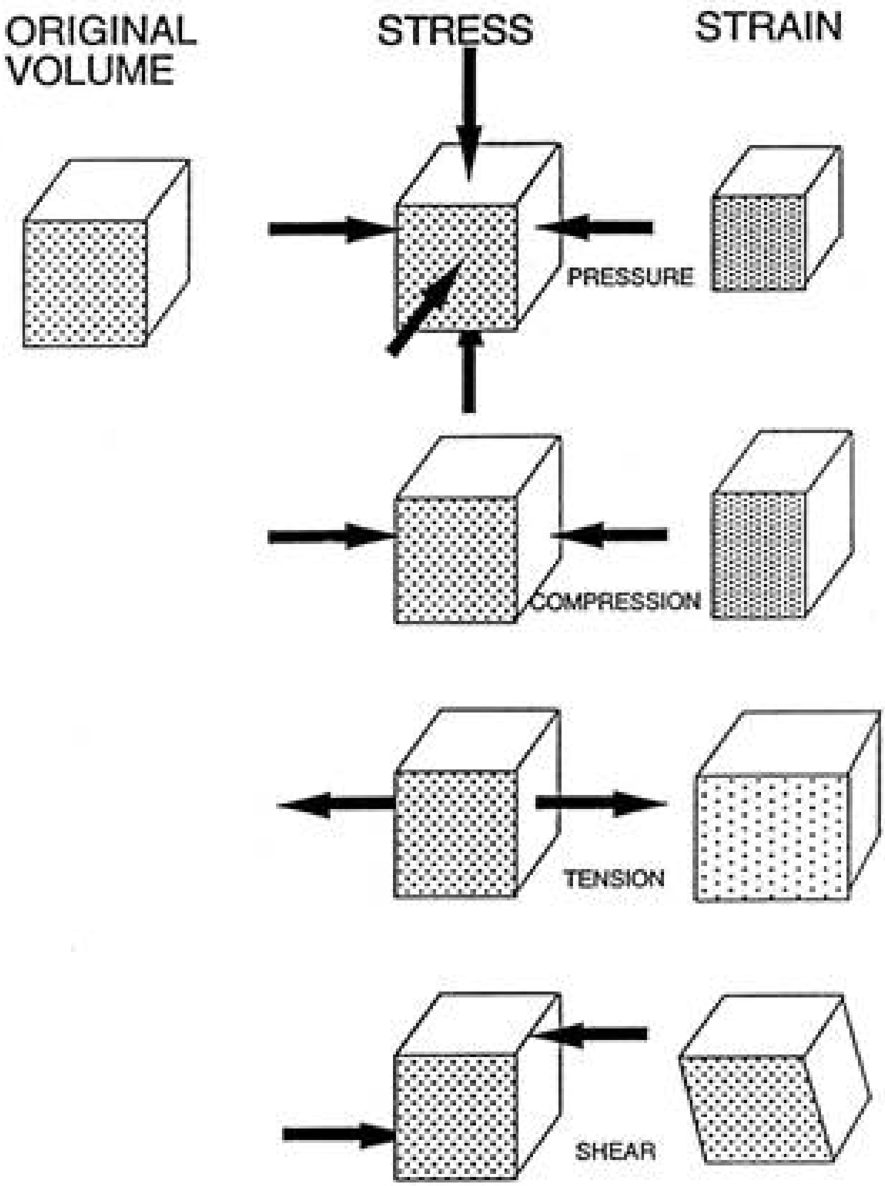
Ex: roads, airplane wings, medical inserts, building materials, etc.

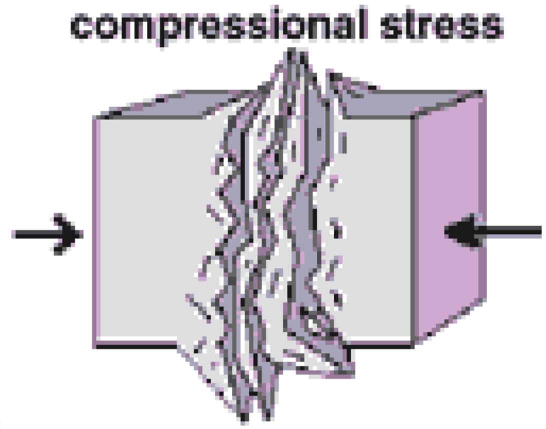


Performance for the controversial metal-on-metal (MoM) hip replacement devices continues to create cause for concern, particularly in women, according to this year's National Joint Registry (NJR) Annual Report, UK.

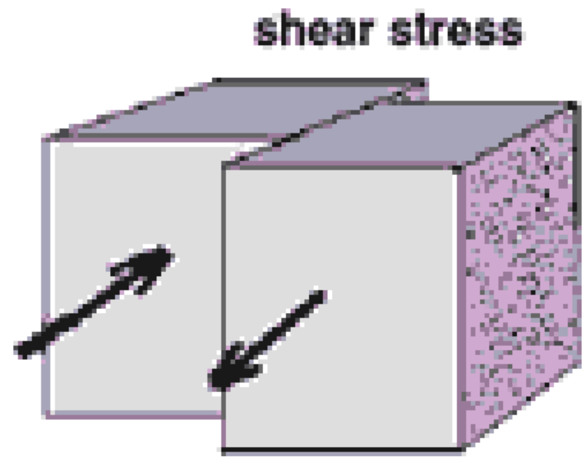
Revision rates (how likely it is that a patient will need an operation to remove and usually replace a prosthesis) for the

What can happen to the dimensions of an object when you put stress on it?





Change in Length



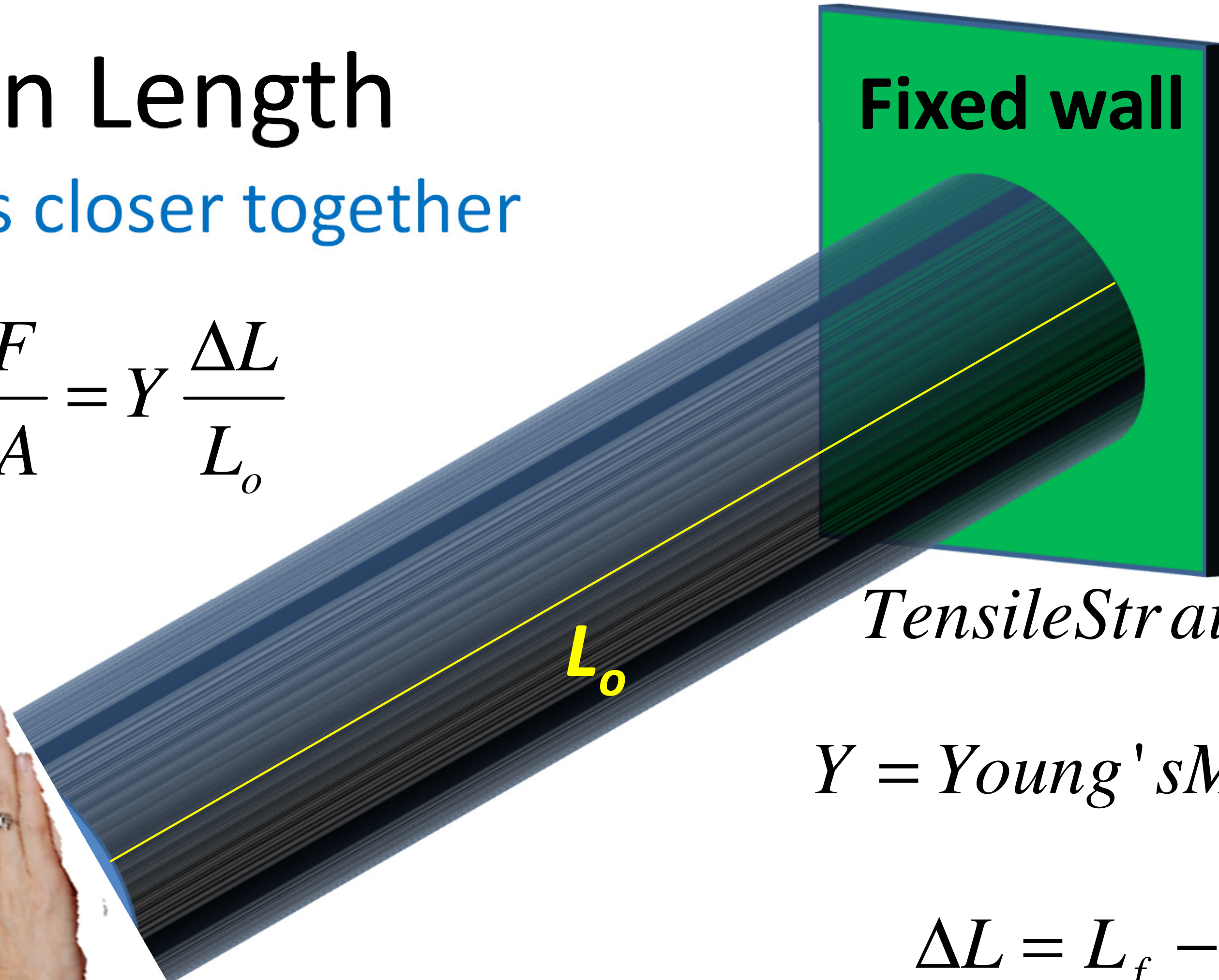
Change in Shape and/or broken bonds

Elasticity in Length

Pushing atoms closer together

$$TensileStress = \frac{F}{A} = Y\frac{\Delta L}{L_o}$$

$$1Pa = 1N/m^2$$



$$TensileStrain = \frac{\Delta L}{L_o}$$

$$Y = Young's Modulus$$

$$\Delta L = L_f - L_0$$

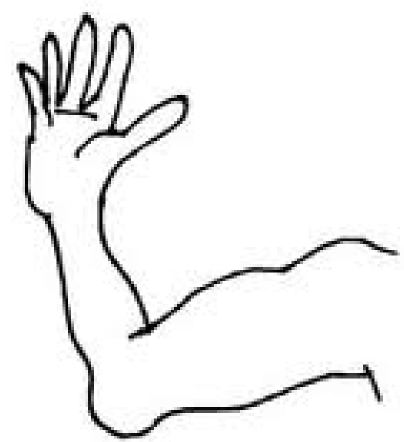
A material with a large Y is difficult to stretch or compress.

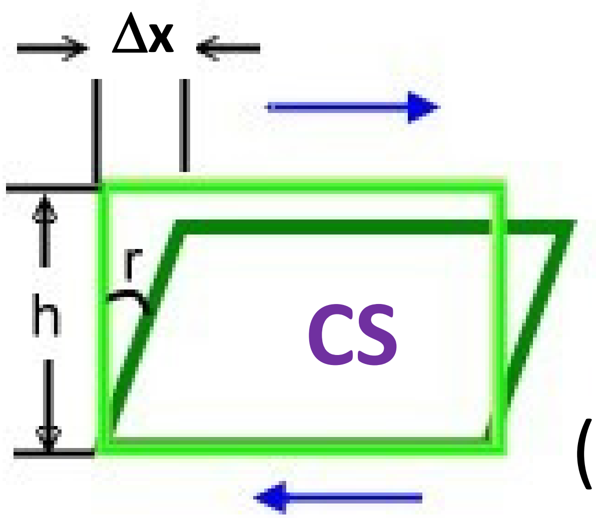
What must be the units of Y?

Example Problem

The total cross-sectional area of the calcified portion of the two forearm bones is approximately 2.4 cm^2. During a car crash, the forearm is slammed against the dashboard. The arm comes to rest from an initial speed of 80 km/h in 5.0 ms. If the arm has an effective mass of 3.0 kg, what is the compressional stress that the arm withstands during the crash?

$$a = \frac{\Delta v}{\Delta t} \qquad Stress = \frac{F}{A} = \frac{ma}{A}$$





Elasticity in Shape

Bending or breaking bonds

The **volume stays the same** in this type of stress.

(e.g., punching out a hole in paper or wall)

In shear stress, the applied force is parallel to the cross-sectional area. (In tensile stress, the force is ⊥ to **CS** area.)

What is the **shear** cross-sectional area of the missing paper?

A. πr^2 B. $\pi r^2 t$

C. $2\pi r$ D. $2\pi rt$

$$ShearStress = \frac{F}{A_{CS}} = S\frac{\Delta x}{h}$$

Q117

$$ShearStrain = \frac{\Delta x}{h}$$

A material with a large shear modulus *S* is difficult to bend.

ickness

Volume Elasticity

The shape stays the same.

The bulk modulus characterizes how easy it is to uniformly squeeze a material in all directions. (For example, if you put the material deep in the ocean.)

$$VolumeStrain = \frac{\Delta V}{V_o}$$

$$VolumeStress = \Delta P = -B\frac{\Delta V}{V_o}$$

$$B = BulkModulus$$

Notice the negative sign. Makes sense: Increasing the pressure on an object, decreases it volume and vice versa.

Strain in Computers

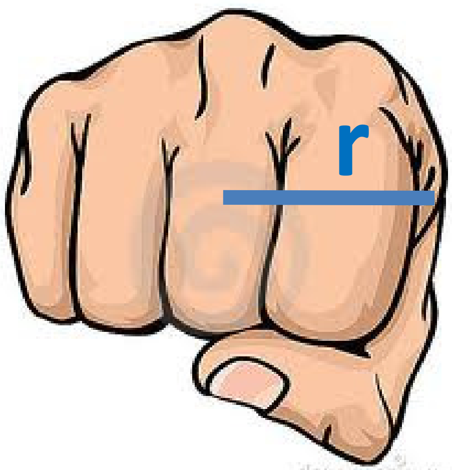
Industry found that it could improve electron travel in transistors by straining (essentially squeezing) silicon.

Strain can allow quicker, more efficient transfer of electrons.

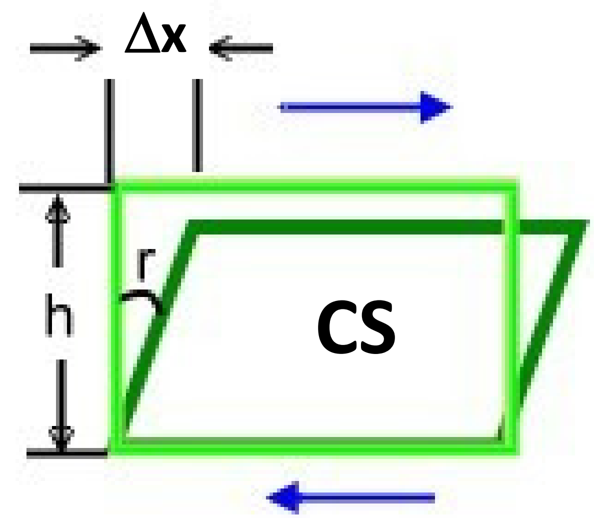
This is just a quick taste of Materials Science, the field where scientists learn how to make stronger armor, faster computers, more energy-efficient batteries, flexible solar cells, crash-safe vehicles, space stations that can withstand cosmic rays, and much more!

Superhero Punching

(Tricky. I won't be this mean on a quiz.)



Cross section ~ 100 cm²



Superheroes sometimes punch holes through steel walls. If the ultimate shear strength of steel is 2.50×10^8 Pa, what force is required to punch through a steel plate 2.0 cm thick (t)? Assume the superhero's fist has a cross-sectional area of 100 cm^2 and is approximately circular.

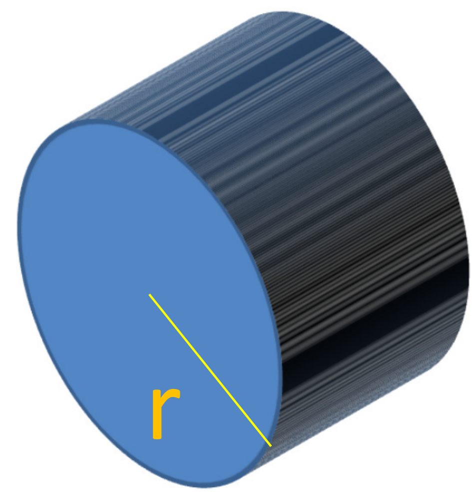
What is the **shear** cross-sectional area of the missing steel?

A. πr^2

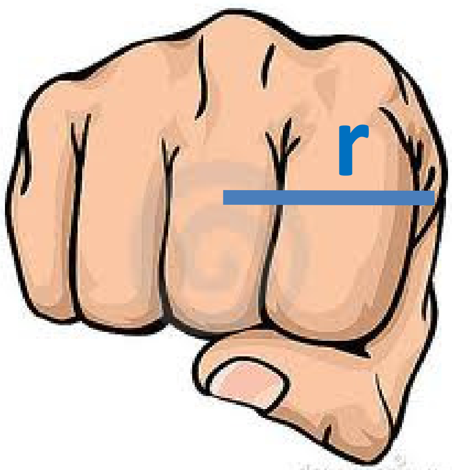
B. $2\pi r^2$

C. $2\pi r$

D. $2\pi rt$

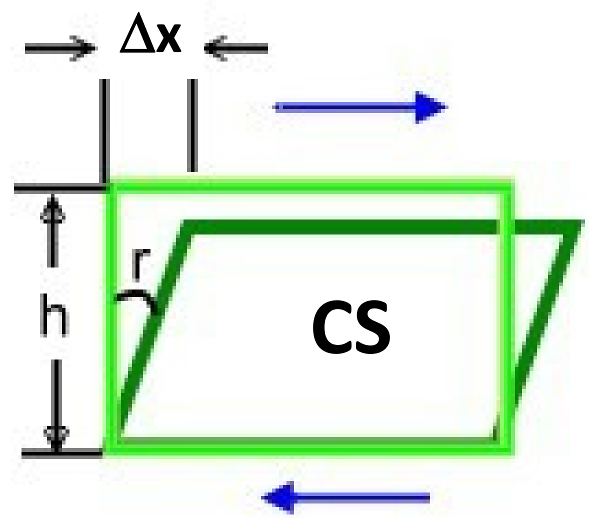


Q129



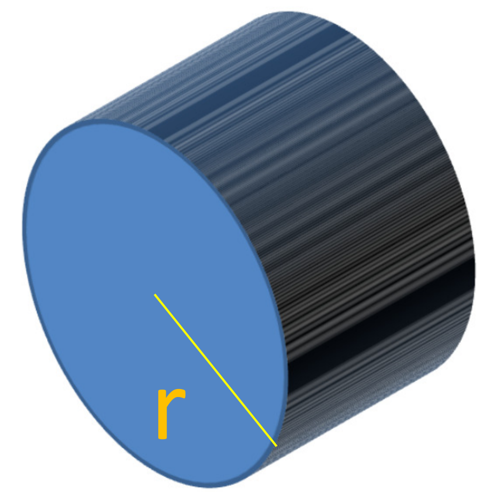
Cross section ~ 100 cm^2

Superhero Punching



Superheroes sometimes punch holes through steel walls. If the ultimate shear strength of steel is 2.50 x 10^8 Pa, what force is required to punch through a steel plate 2.0 cm thick (t)? Assume the superhero's fist has a cross-sectional area of 100 cm^2 and is approximately circular.

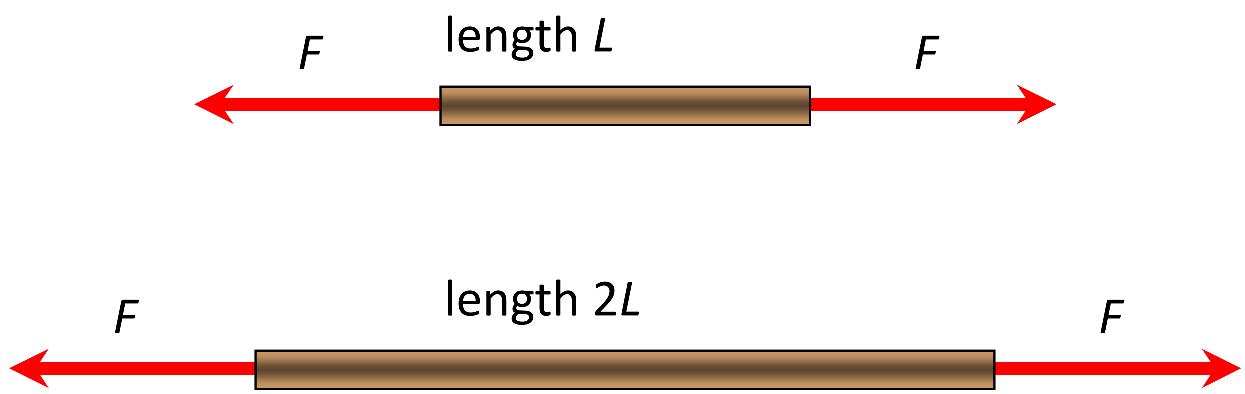
Qualitatively, what would happen to the superhero on delivery of the punch? What physical law applies?



Limits of the Human Body

Bone has a Young's modulus of 1.8×10^{10} Pa. Under compression, it can withstand a stress of about 1.6×10^{8} Pa before breaking. Assume that a femur (thigh bone) is 0.5 m long and calculate the amount of compression this bone can withstand before breaking.

Two rods are made of the same kind of steel and have the same diameter.



A force of magnitude *F* is applied to the end of each rod. Compared to the rod of length *L*, the rod of length 2*L* has

A. more stress and more strain.

B. the same stress and more strain.

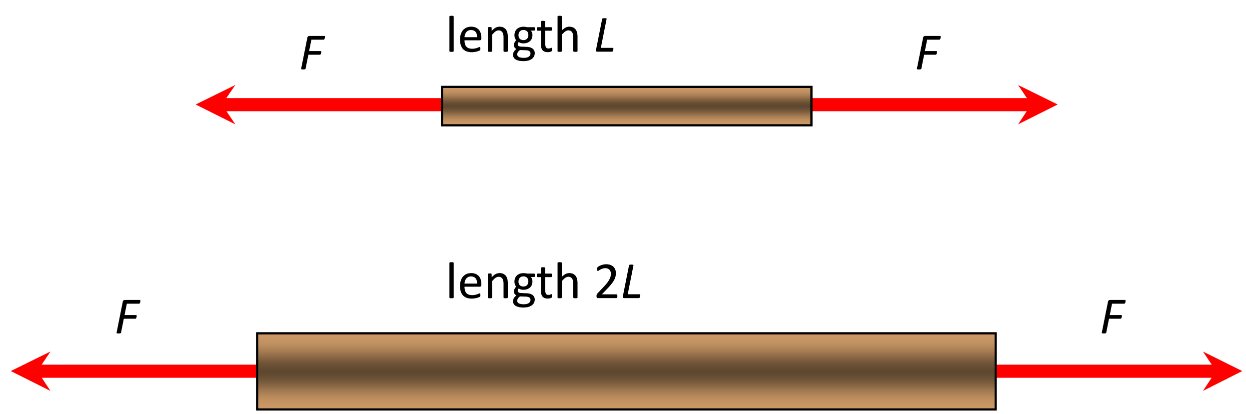
C. the same stress and less strain.

D. less stress and less strain.

E. the same stress and the same strain.

Q121

Two rods are made of the same kind of steel. The longer rod has a greater diameter.



A force of magnitude *F* is applied to the end of each rod. Compared to the rod of length *L*, the rod of length 2*L* has

A. more stress and more strain.

B. the same stress and more strain.

C. the same stress and less strain.

D. less stress and less strain.

E. the same stress and the same strain.

Q122

Main Ideas in Class Today

After today, you should be able to:

- Determine the Stress and Strain a material can withstand
- Understand how to apply to breaking things

Extra Practice: 9.65, 9.67, 9.69, 9.71

Clicker Answers

117=D, 121=E, 122=D, 129=D (tricky, think about what bonds are breaking)