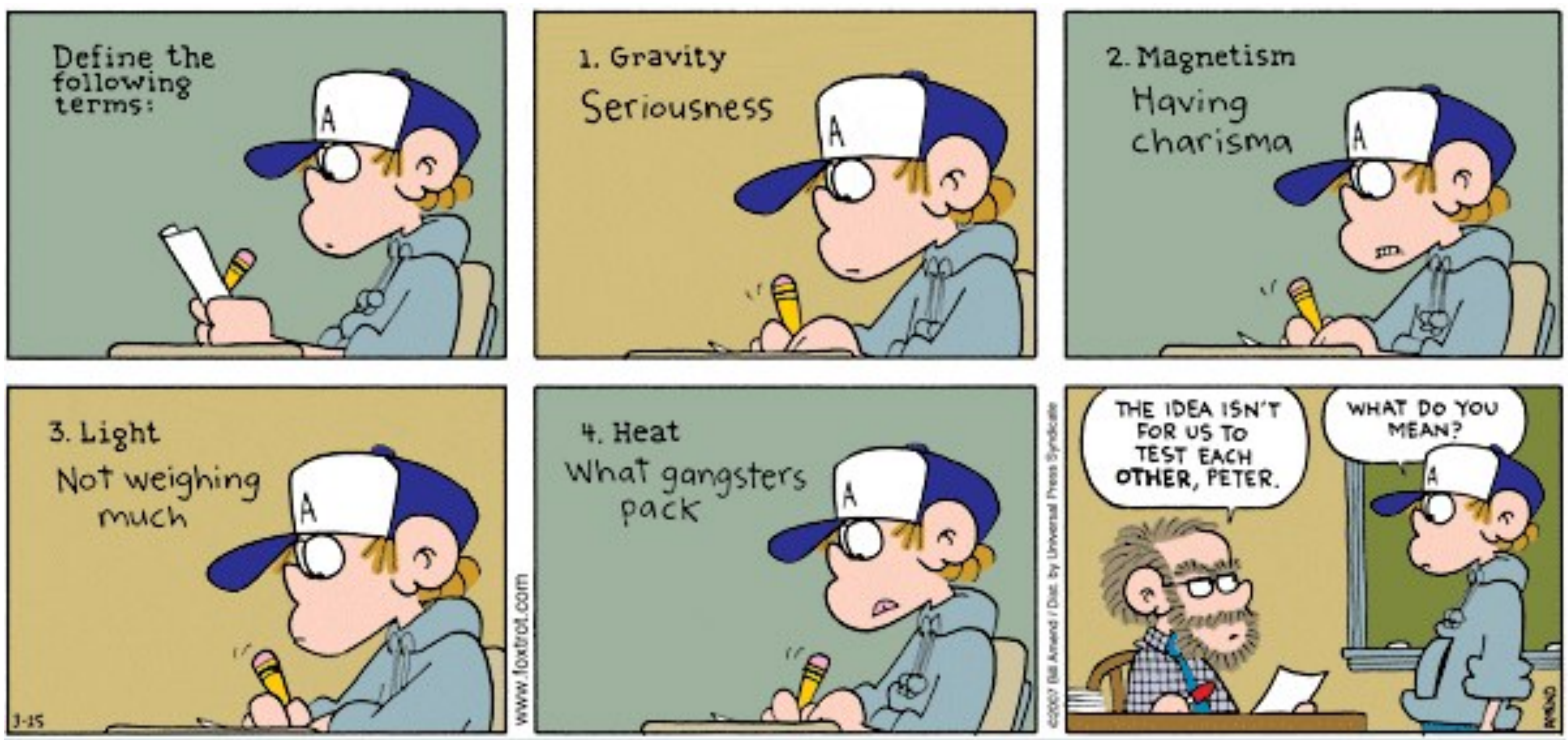
- **<u>Today's Topics:</u>** Stress & Strain, Friction
- **<u>Cartoon:</u> Bill Amend, *Fox Trot***



A student chooses a tilted coordinate system as shown, and then proceeds to write down Newton's 2nd Law in the form $\Sigma F_x = ma_x$ and $\Sigma f_y = ma_y$. What is the correct equation for the y-direction?

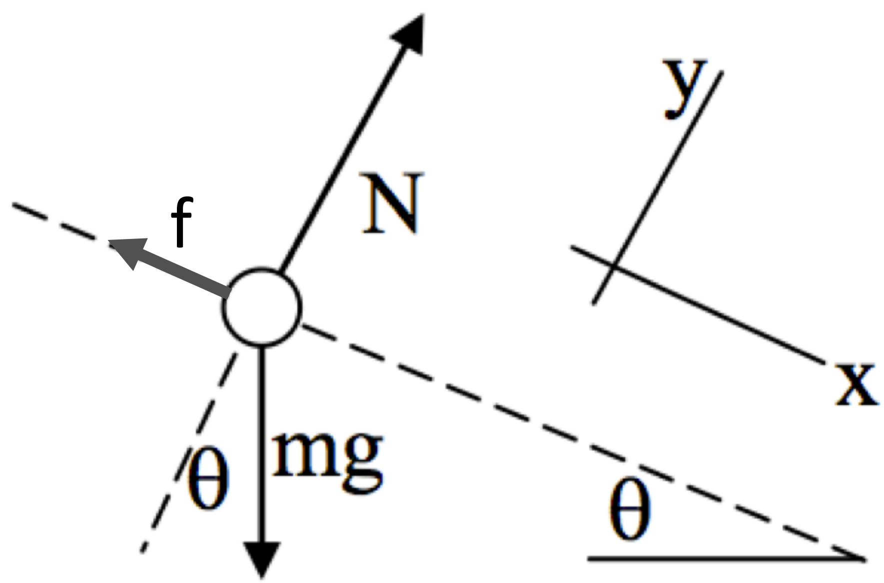
A. N-mgsinΘ = ma

B. N-mgcosΘ = ma

C. MgsinΘ = ma

D. N – mgcosΘ = 0

E. N + mg = ma



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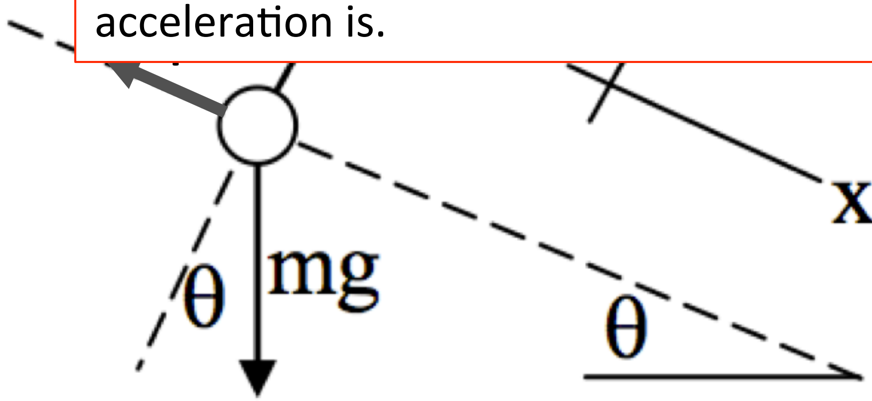
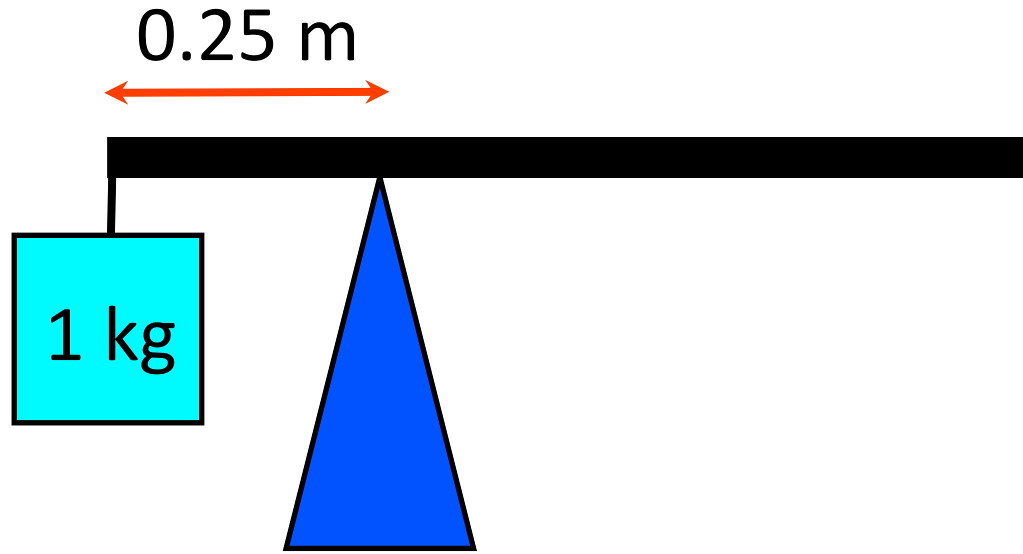
The side of the triangle we want is the one that is in the y direction. This side is the adjacent angle, so we choose cosine. We don't set the right hand side to 0 because we don't know what the acceleration is.



Announcements

- Reminder exam next Monday 9/29
- Extra office hours Thursday 6-7pm
- I've moved the homework due dates around – none due the Friday after the exam

A uniform, massive beam with a length of 1 meter and mass of 1 kg is placed across a fulcrum and has a 1 kg mass attached to it, as shown. When released, will it rotate?



A. Yes, counterclockwise - the 1kg weight exerts a force perpendicular to the lever arm with the net torque pointing out of the screen.
B. Yes, clockwise, because the 1kg weight exerts a force perpendicular to the lever arm with the torque pointing into the screen.
C. Yes, counterclockwise, because the torque from the 1kg weight is greater than the torque from the mass of the beam.
D. No it will not rotate, because the force of gravity on the beam balances the force of the 1kg weight on the beam.
E. Not enough information to determine

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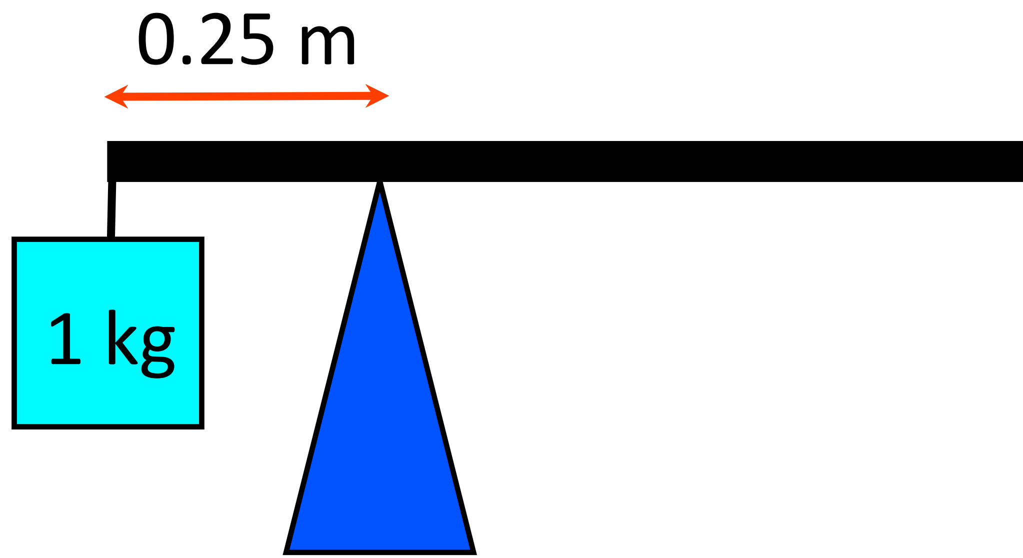


A. Yes, counterclockwise - th ar to the lever arm with the

B. Yes, clockwise, because th ar to the lever arm with the

The force of the 1kg weight is at a distance of .25m. The center of mass of the whole beam is at .5m, which is .25m from the pivot point. So the two torques on the right hand side and left hand side of the beam balance each other.

C. Yes, counterclockwise, because the torque from the 1kg weight is greater than the torque from the mass of the beam.

D. No it will not rotate, because the force of gravity on the beam balances the force of the 1kg weight on the beam.

E. Not enough information to determine

Reading Questions

Can we do some numerical examples of stress and strain in class?

Hooke's law is applied when?

Can we clarify Hooke's Law a bit?

I'd definitely like more clarification on the equilibrium and Strain/Stress components of this lecture.

Foothold Principles of Springs & Stretchy Stuff

- N3: When I pull a spring, it pulls back on me.
- A spring changes its length in response to pulls (or pushes) in the opposite direction
- How hard it pulls depends on the spring (which depends on what it's made of)

$$F^{s}_{spring \rightarrow hand} = -k\Delta x$$

How much you stretched it.

Foothold Principles of Springs & Stretchy Stuff

- We can also think of this in the reverse way (which is more applicable to the stress/strain analogy).
  - How the spring stretches is a result of how much force you put on it
  - And what the material is made of

$$\Delta x = \frac{F^{s}_{hand \rightarrow spring}}{k}$$

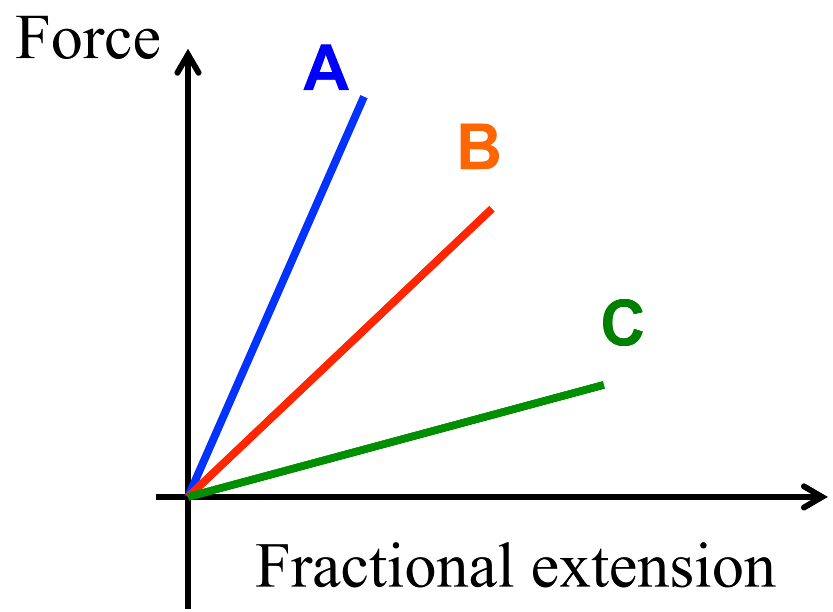
Three springs are well approximated by Hooke's law for extensions (but not compressions) up to ¾ of its resting length. Which one has the largest spring constant (k)? The force needed for a stretch is plotted as a function of the spring's fractional extension, $\Delta L/L_0$.

A. A

B. B

C. C

D. You can't tell from the information given.



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A. A

B. B

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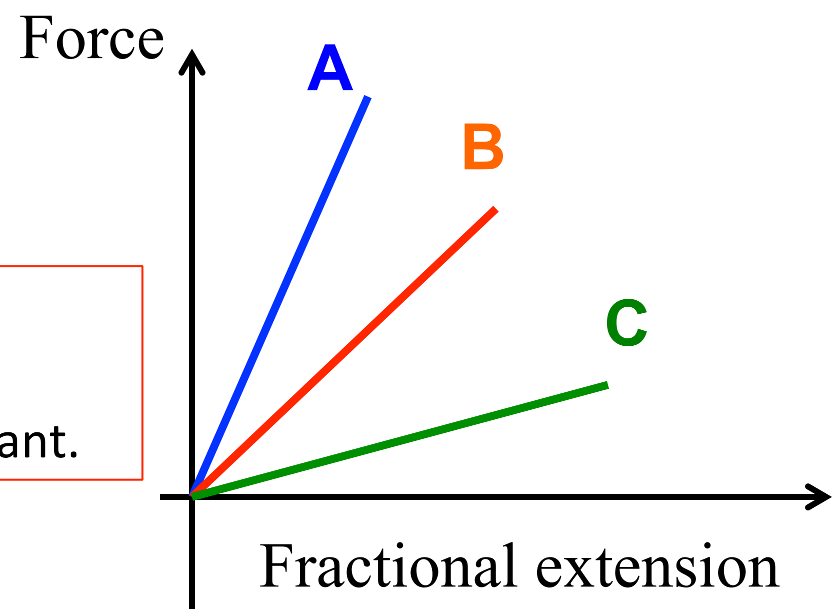
A has the largest slope, and the spring constant (k) is proportional to the force exerted, so A has the largest spring constant.



A 0.5 kg mass is hung from a spring, which is stretched from its resting length by 10 cm. What is Hooke's constant for this spring? (Assume g = 10 m/s^2 to simplify your math)

A. 0.5 N/m
B. 50 N/m
C. 500 N/m
D. Other

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D. Other

The force from gravity balances the force of the spring, so we plug the numbers into the expression for Force of spring and solve for k.

Consider the situation described in the last problem. If I put two identical springs side-by-side (both with the same K as in the last problem) and attached the same single weight to both of them, how would that affect the distance the springs are stretched?

A. They would stretch 1/2 the distance
B. They would stretch double the distance
C. They would stretch the same distance
D. None of the answers above is correct

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above is correct

The gravity force downward is balanced by 2 forces upward by the springs (which are equal since they are identical). So that means the stretch is half the original stretch.

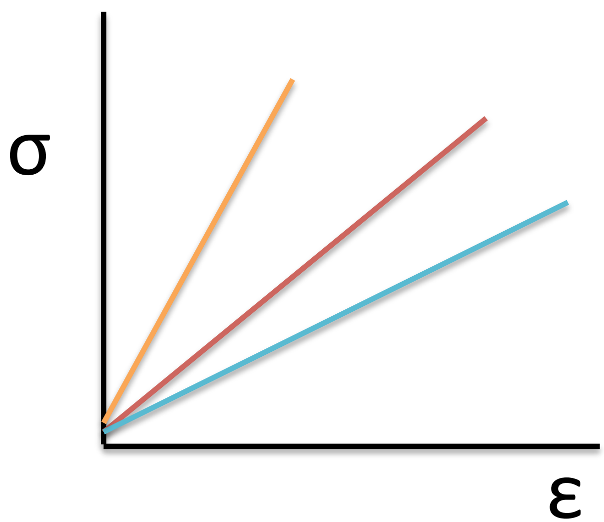
Foothold Principles of Springs & Stretchy Stuff

- Stress is a measure of how many springs you have – or the force per unit area.

$$\sigma = \frac{F}{A}$$

- Strain is a measure of how much the material stretched due to the stress

$$\varepsilon = \frac{\Delta L}{L}$$

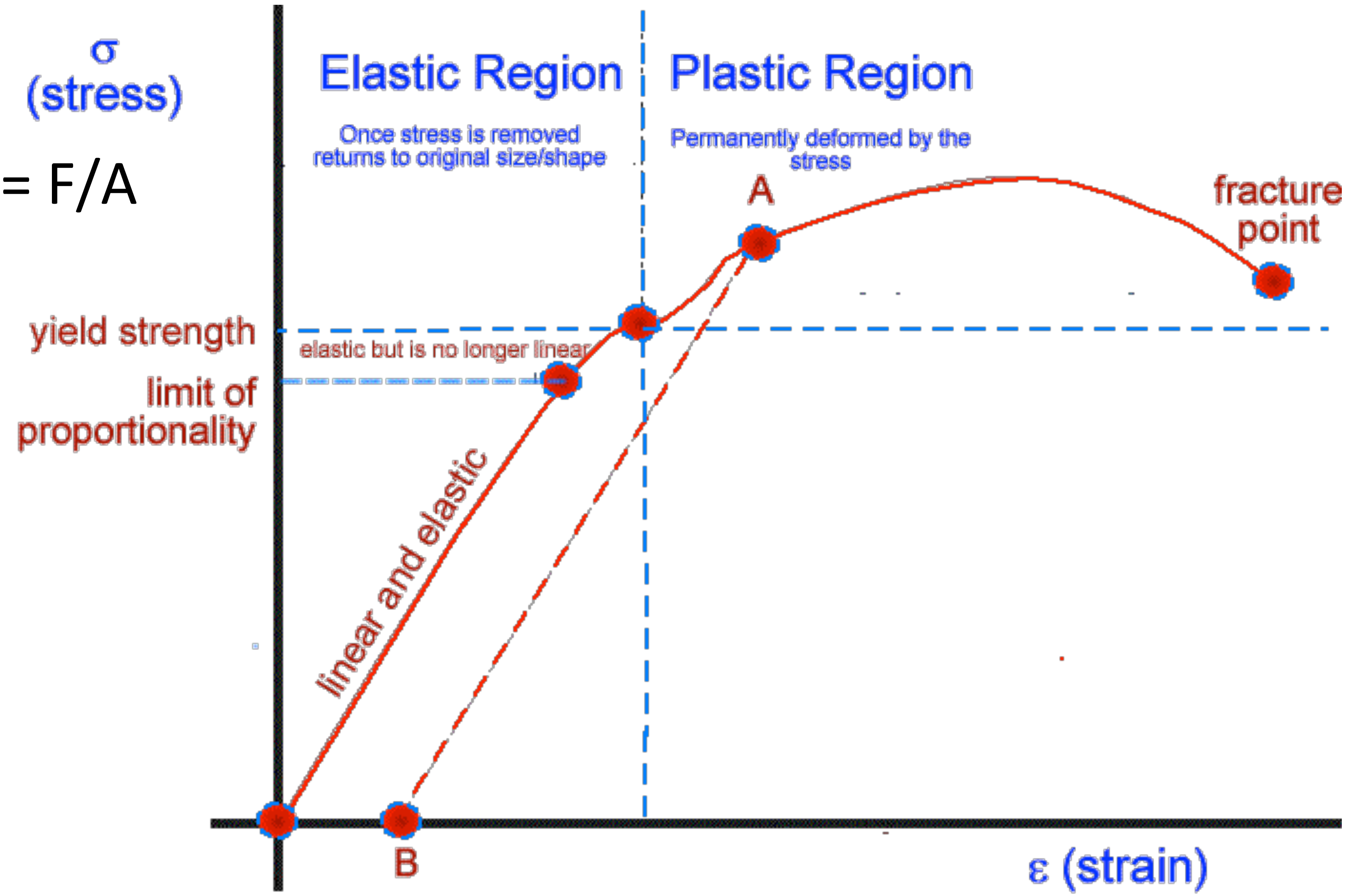


This slope is called the "modulus", and it depends on the material

The average adult human female femur is 45 cm in length, 3 cm in diameter, and has a Young's Modulus of 18 Gpa. When running, the femur experiences the full weight of the body on every stride. Assuming the average female weighs 55 kg and her entire weight is concentrated on the femur at each step, by approximately how much is the femur shortened when you land on it?

A. 0.2 cm
B. 0.002 cm
C. 2.0×10^{-5} cm
D. 2.0×10^{-7} cm
E. 2.0×10^{-9} cm

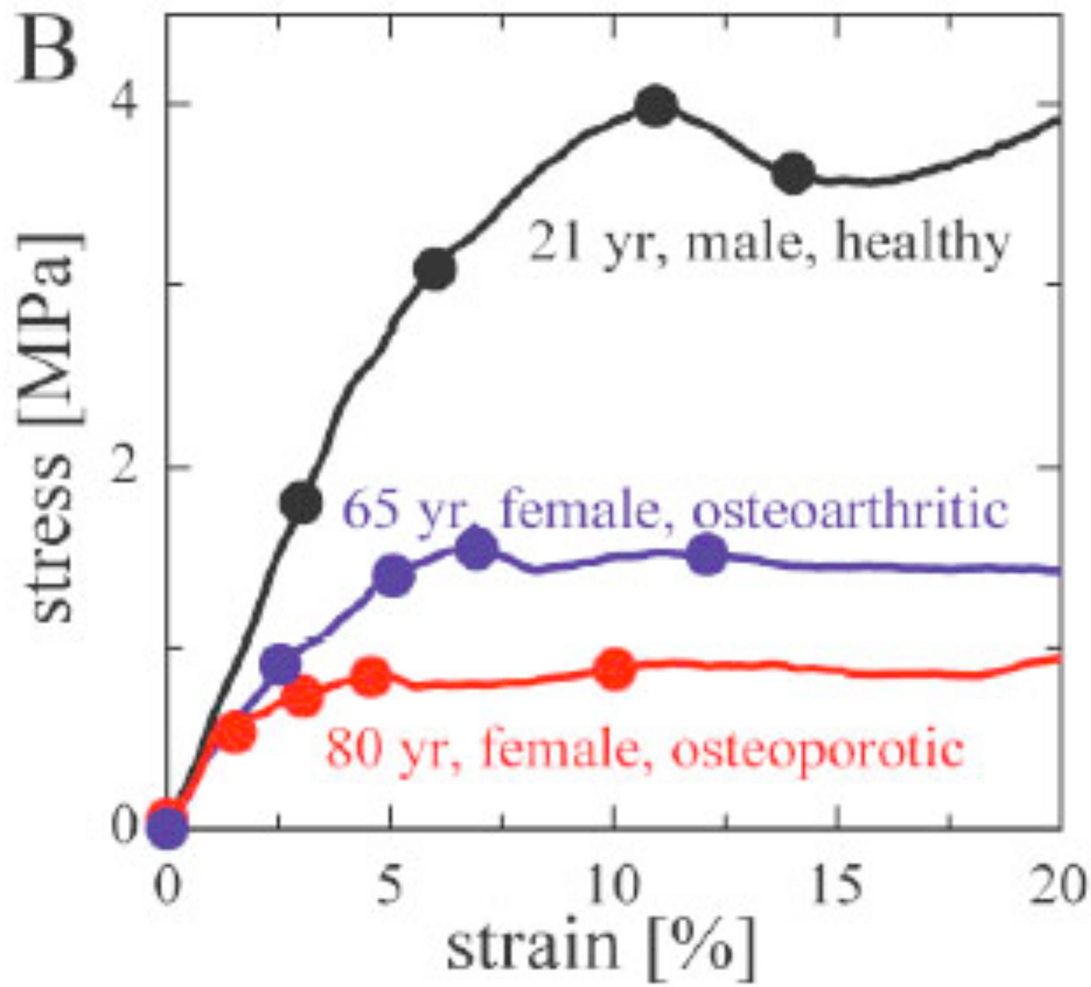
Why is Hooke's law a law if it has so many limitations???????


σ
(stress)
Elastic Region
Plastic Region
Once stress is removed
returns to original size/shape
Permanently deformed by the
stress
A
fracture
point
yield strength
elastic but is no longer linear
limit of
proportionality
linear and elastic
B
ε (strain)

= F/A

= ΔL/L

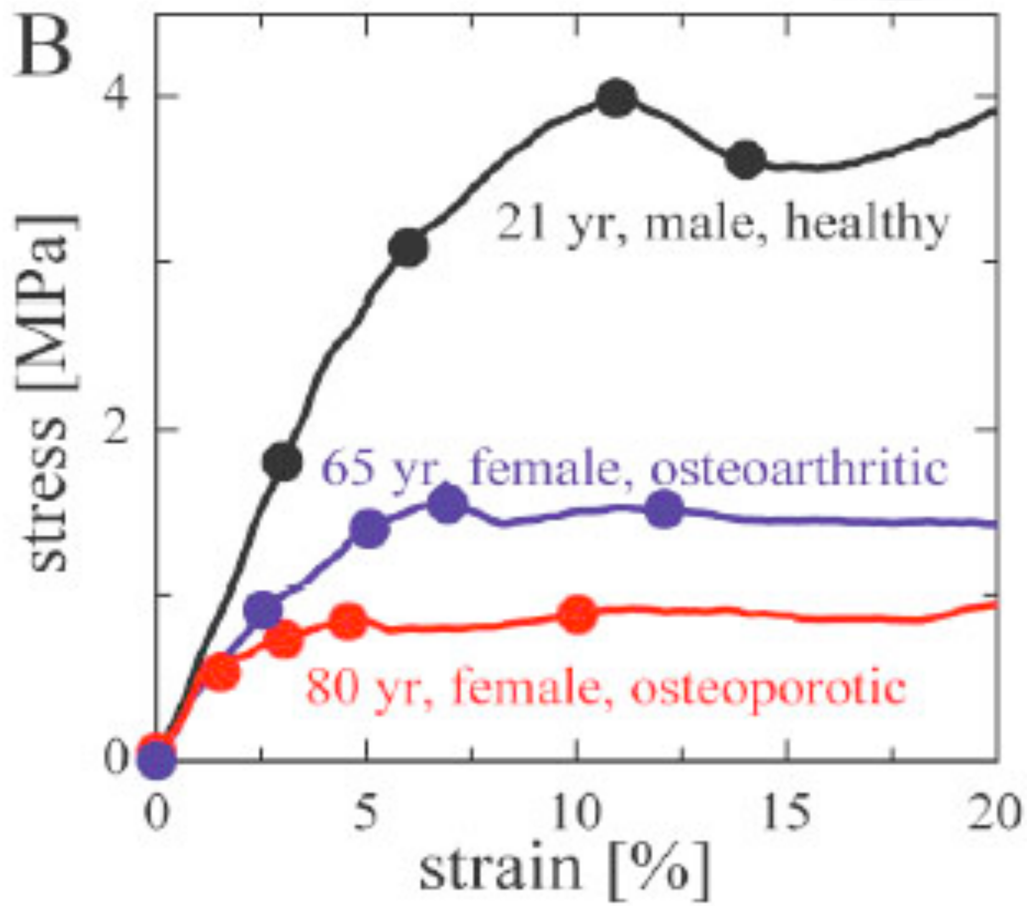
Stress-strain curve for human bone



Thurner et al. 2005, Mat. Res. Soc. Symp. Proc. vol 874

Which curve has a higher Young's Modulus?

A. 21 yr, because it has the largest stress value.
B. 21 yr, because it has the largest slope
C. 80 yr, because it has the lowest slope
D. 80 yr, because it goes flat the fastest
E. Something else



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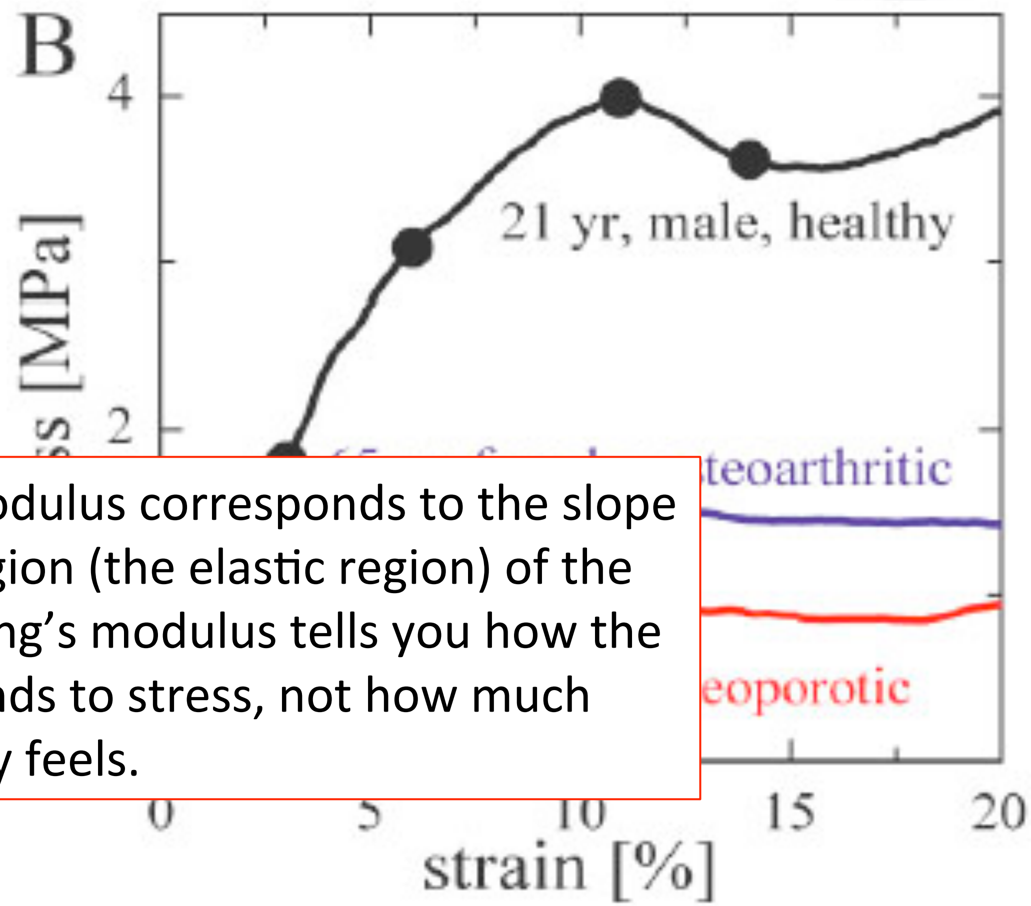

The Young's modulus corresponds to the slope in the linear region (the elastic region) of the graph. The Young's modulus tells you how the material responds to stress, not how much stress it actually feels.