- **<u>Today's Topics:</u>** Resistive Forces & Friction
- **<u>Cartoon:</u> Bill Watterson**

Calvin & Hobbes

Announcements

- ROOM CHANGE for review session!! C-104
  - tonight 7-8pm
  - bring me questions/problems!
- Extra office hours Thursday 6-7pm
- Some tips about exams:
  - Work in symbols until the very end!
  - If you cross something out on an exam, I won't look at it
  - If you run out of time to do the calculation, write in words what you would have done

Kinds of Forces

- Forces are what objects do to each other when they interact.
- Types of Force
  - Contact: C
    - Normal: N
    - Resistive: f, F^D, F^V
  - Tension: T
  - Gravitational: g or G
- *N*otation convention.

$$\vec{F}_{\text{(object causing force)}\rightarrow\text{(object feeling force)}}^{\text{type of force}}$$

Chapter 5 - Getting Around: Friction and Motion

Reading Questions

I'd like to know more about the necessity of friction for living organisms.

I would like to talk about the role of friction and how it changes based on the angle of the surface the object is against. Also, how adding a pushing force alters the forces experienced on the object.

I know that as the force of the pull increases the friction force would decrease, but I also know that in order to calculate the force needed to pull the sled you need to know the force of friction. I guess I just don't know where to start.

What is friction good for?

The purpose of eyelashes and eyebrows is to provide a defense against particles getting into the eye. If friction did not exist, the eyelashes or eyebrows wouldn't be able to stop particles, they would just slip past.

A cheetah is able to make quick turns thanks to the friction between its paws and the ground which allow for the cheetah to not go sliding when it wants to make a sharp turn.

With friction we are able to do things like cooking (where you have a lot of ingredients and items that have to be picked up and set down) without having to worry that the spoon that you briefly set down will start sliding away on the counter.

Friction prevents living organisms from sliding downhill. Friction allows living organisms to climb hills and mountains for shelter or food uses.

Foothold ideas: Resistive forces

- Resistive forces are contact forces acting between two touching surfaces that are parallel to the surface and tend to oppose the surfaces from sliding over each other.
- There are three types:
  - Friction (independent of velocity)
  - Viscosity (proportion to velocity)
  - Drag (proportional to the square of velocity)

Foothold Ideas: Friction

- Friction is our name for the interaction between two touching surfaces that is parallel to the surface.
- It acts to oppose the relative motion of the surfaces. It acts as if the two surfaces stick together a bit.
- Normal forces adjust themselves in response to external forces. So does friction – up to a point.

Static

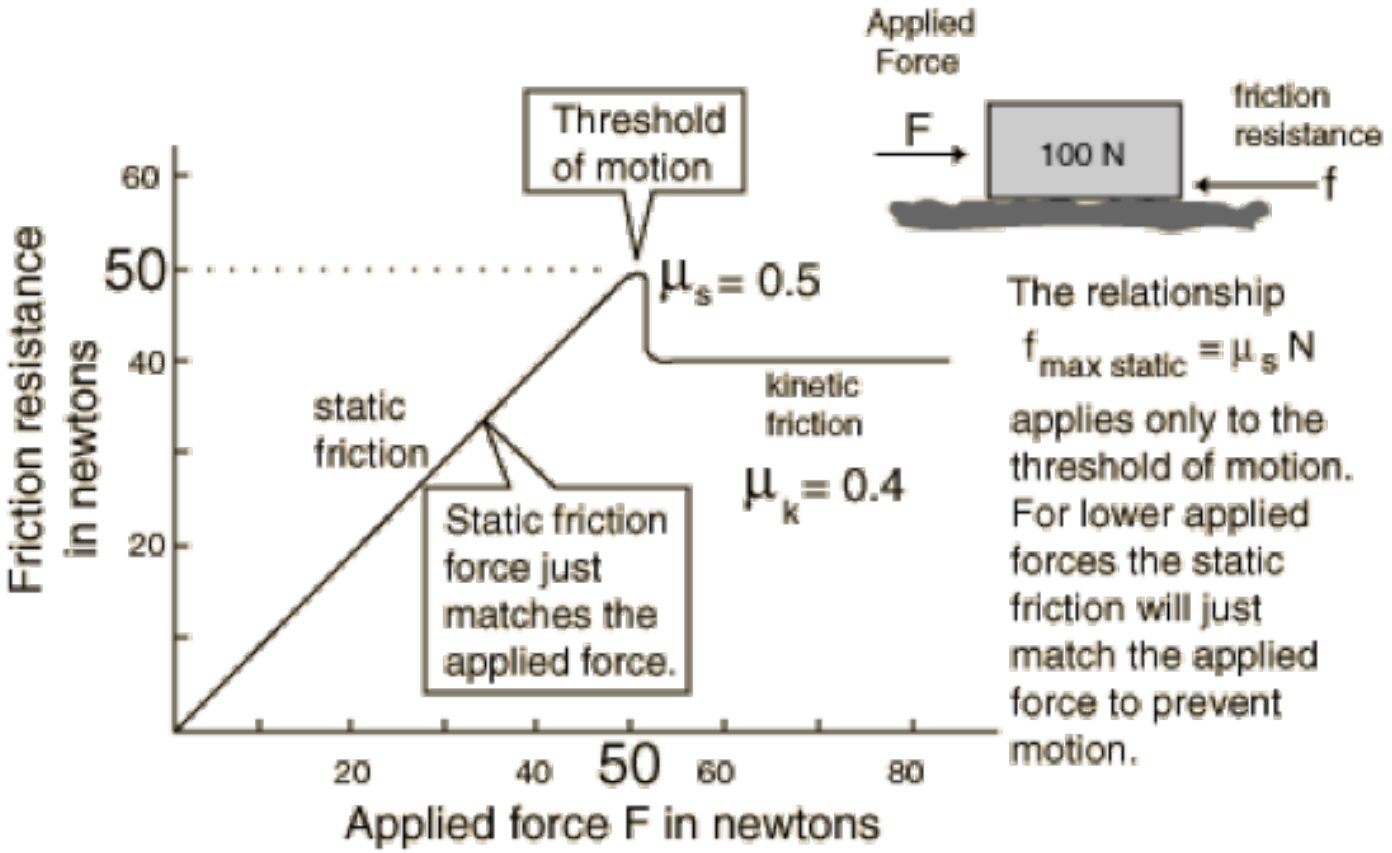
$$f_{A\to B} \le f^{\max}_{A\to B} = \mu^{static}_{AB} N_{A\to B}$$

Sliding/Kinetic

$$f_{A\to B} = \mu^{kinetic}_{AB} N_{A\to B}$$

$$\mu^{kinetic}_{AB} \le \mu^{static}_{AB}$$

Frictional force vs. applied force



Why are the coefficients of static and kinetic friction different if we are dealing with the same objects?

In moving a heavy couch (weight ~ 1960N) in my house, I applied a horizontal force of 500N. The couch didn't move. What can you conclude?

A. To move the couch I need to apply a force at least equal to 1960N.
B. The coefficient of static friction is greater than .255.
C. The coefficient of kinetic friction is greater than .255.
D. None of the above.

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I know here that the couch isn't moving, so I'm in the realm of static friction. I also know that static friction responds to how hard I push. So I can find the magnitude of the frictional force at this point, but I only know the coefficient of static friction is at LEAST that amount.

I go and get the furniture moving discs I have for this problem, and now applying a 500N force the couch slides along at a constant speed. What can you conclude?

A. The moving discs changed the normal force of the floor on the couch.
B. The moving discs changed the coefficient of static friction.
C. The coefficient of static friction is equal to .255.
D. The coefficient of kinetic friction is equal to .255.
E. None of the above.

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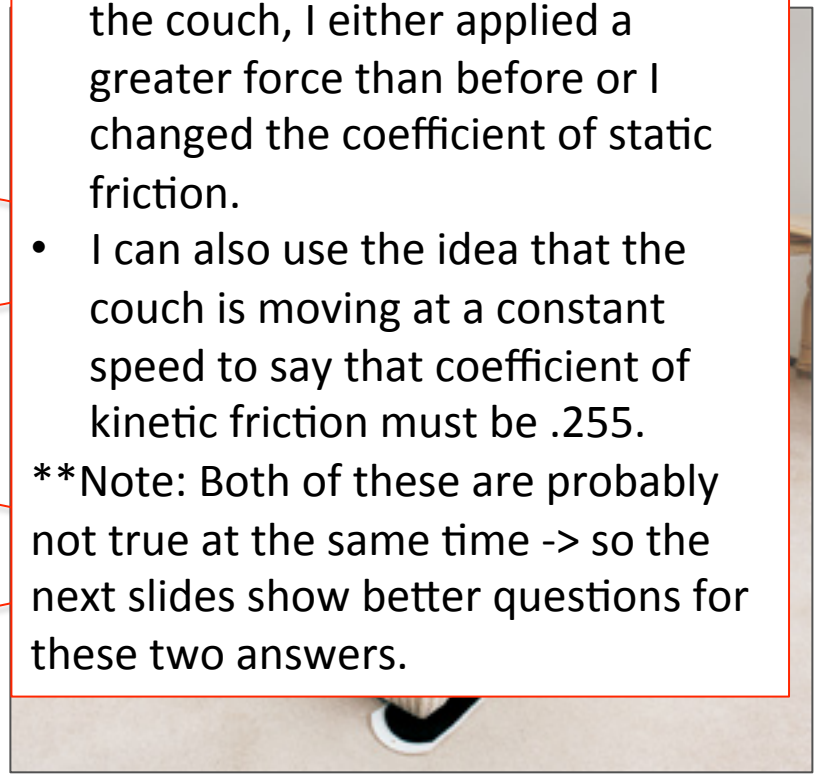
- Because I am now able to move the couch, I either applied a greater force than before or I changed the coefficient of static friction.
- I can also use the idea that the couch is moving at a constant speed to say that coefficient of kinetic friction must be .255.

**Note: Both of these are probably not true at the same time -> so the next slides show better questions for these two answers.



I go and get the furniture moving discs I have for this problem, and now applying a 500N force the couch slides along at an **increasing speed**. What can you conclude?

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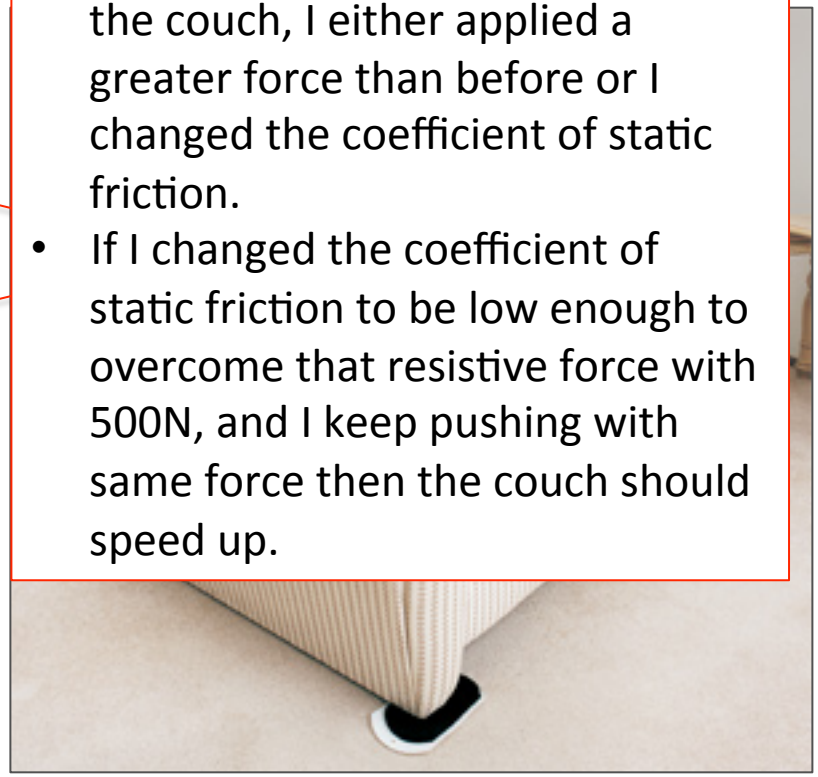
- Because I am now able to move the couch, I either applied a greater force than before or I changed the coefficient of static friction.
- If I changed the coefficient of static friction to be low enough to overcome that resistive force with 500N, and I keep pushing with same force then the couch should speed up.



I go and get the furniture moving discs I have for this problem, and now applying a 500N force the couch slides along at an **constant speed** after I finally get it moving with abig push. What can you conclude?

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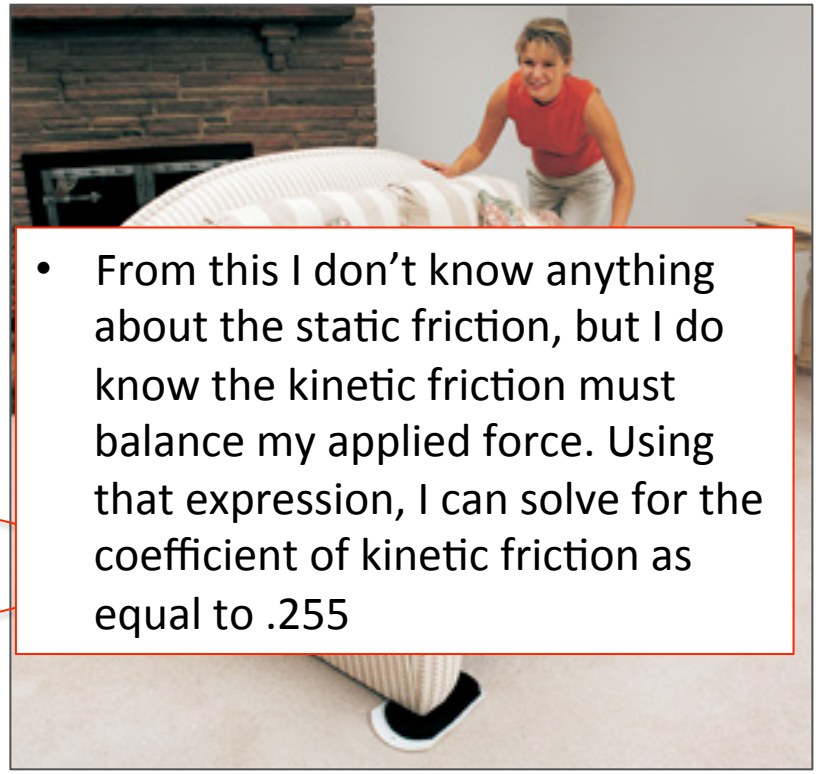
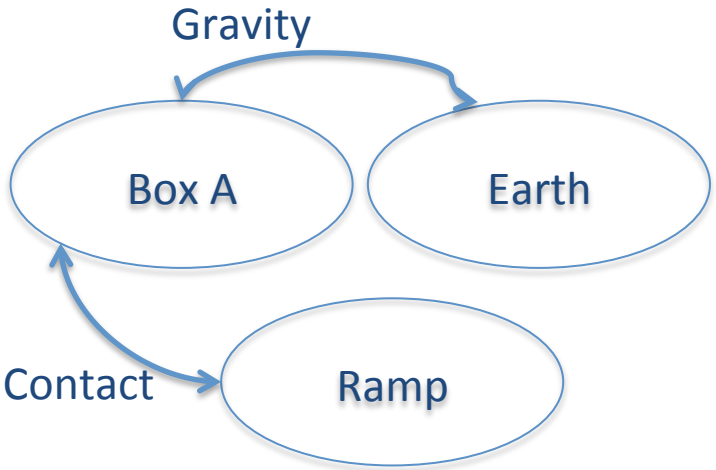
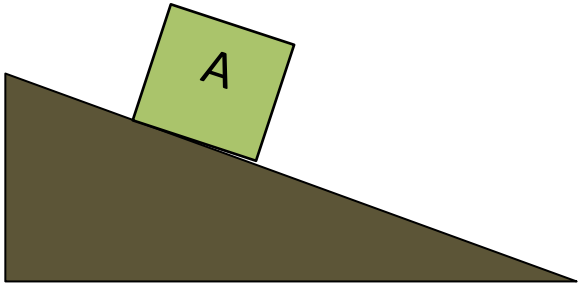


- From this I don't know anything about the static friction, but I do know the kinetic friction must balance my applied force. Using that expression, I can solve for the coefficient of kinetic friction as equal to .255

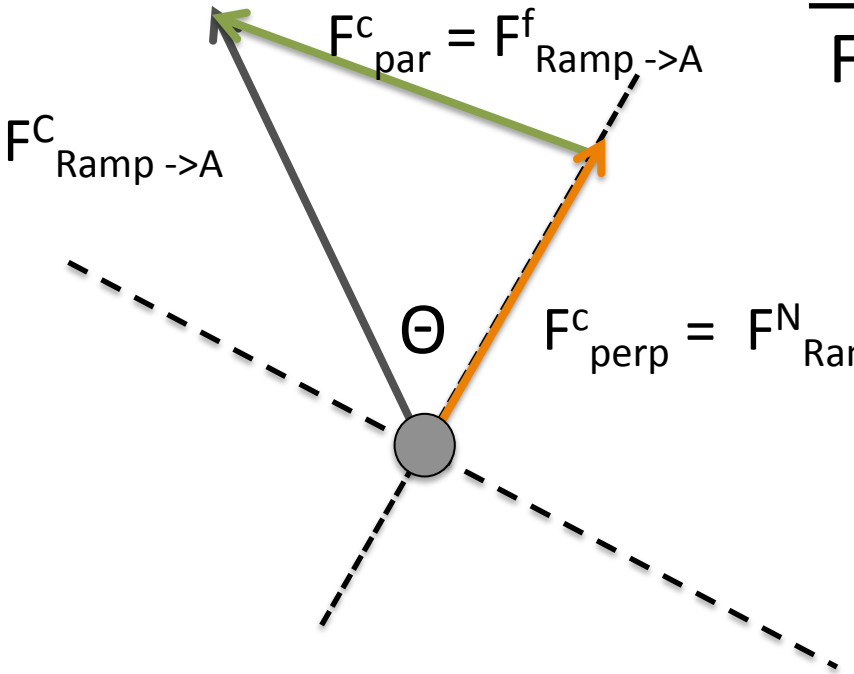
The Relationship Between the Contact, Normal, & Friction Forces





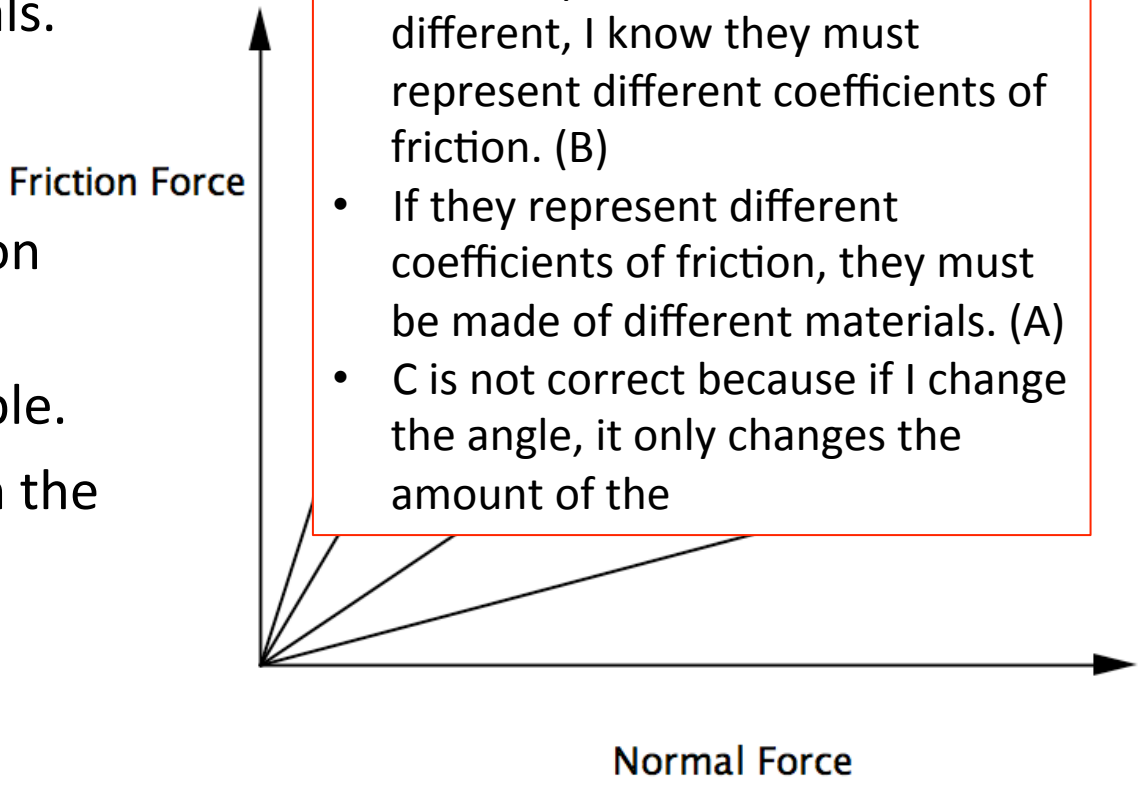
$$F^f_k = \mu_k F^N$$

$$\tan\theta = \frac{F^f_{ramp->} A}{F^N_{ramp ->A}}$$



Consider the various lines in the graph below. What would best describe the difference between these lines?

A. They are different materials.
B. They have different coefficients of friction.
C. They are the same situation with different angle.
D. All of the above are possible.
E. None of the above explain the differences.



- If the slope of the lines are different, I know they must represent different coefficients of friction. (B)
- If they represent different coefficients of friction, they must be made of different materials. (A)
- C is not correct because if I change the angle, it only changes the amount of the

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