October 4, 2010 Physics 121 Prof. E. F. Redish

- **Theme Music: The Grateful Dead**
  When Push Comes to Shove
- **Cartoon: Bill Amend**
  FoxTrot

10/4/10 Physics 121 **1**

Announcements

- Hour exam on Friday
- No lecture HW this week but there are sample exams posted on our "Old Exams" page.
- Regular office hours will be held this week.
- Tutorial HW due in tutorial.
- Don't forget to read HW solutions!
- Q&A session Wednesday 5-7, place TBA.

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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. That is, it acts as if the two surfaces are sticking together a bit.
- Normal forces adjust themselves in response to external forces. So does friction.

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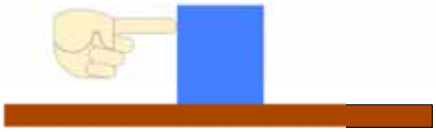
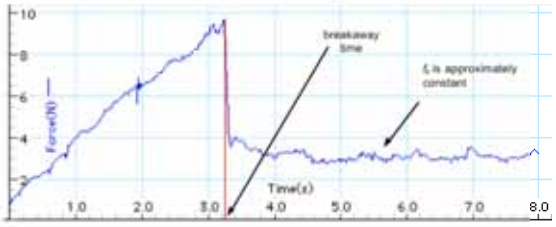
Friction adjusts to oppose relative motion — up to a point

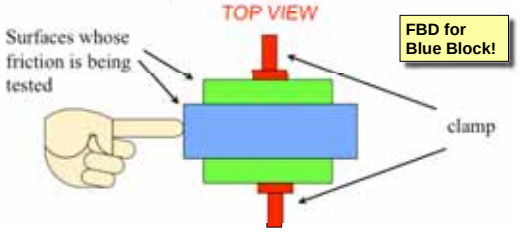


Measuring friction



What does friction depend on?

- The types of material.
- The friction force increases when the two surfaces are pressed together harder.



The friction relation

- When the surfaces are not sliding on each other (but something is trying to make them slide), the friction force may take any value up to a maximum.

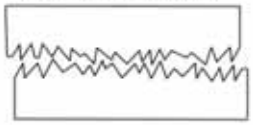
$$f_{A\to B} \le f_{A\to B}^{\max} = \mu_{AB}^{static} N_{A\to B}$$

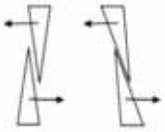
- When the surfaces are sliding on each other, the friction force is a constant value (usually a bit less than the maximum possible).

$$f_{A\to B} = \mu_{AB}^{kinetic} N_{A\to B} \qquad \mu_{AB}^{kinetic} \le \mu_{AB}^{static}$$

Making sense of friction: What's happening?

- Mechanism 1: adhesion / sticking (Johannsen blocks)
- Mechanism 2: "springy" bending

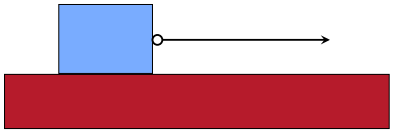




Friction opposes the sliding of two surfaces over each other. (It does NOT opposed *motion!*)

Example

Start from rest
Increase force until box starts moving
Pull so it goes at a constant speed



Graph: position velocity acceleration
net force applied force friction force

What is the role of friction in rolling?

- Is the friction static or kinetic?

If you are driving and hit a patch of ice and begin to skid. This means you are moving (sliding) in a direction that is not the direction your wheels are pointing. In this case you are advised to "steer into the skid", that is, turn your wheels so that they are pointing in the direction you are moving.

Why?

At what angle will the block begin to slide?