

**Common exam #2:** 8:30-9:45am tomorrow!  
at 205 Kupfrian Hall  
(arrive by 8:15am)

All of Chapters 4 and 5. Bring scientific calculators

Due for HW#6 : delayed to March 9<sup>th</sup> (Friday)

<http://geocities.com/kenahn7>

## **Ch. 6, Force and Motion-II**

Frictional Force

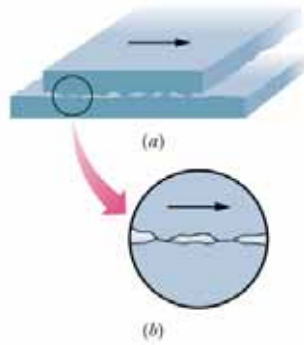
More applications of Newton's Laws

Uniform Circular motion → Next Thursday

## Friction

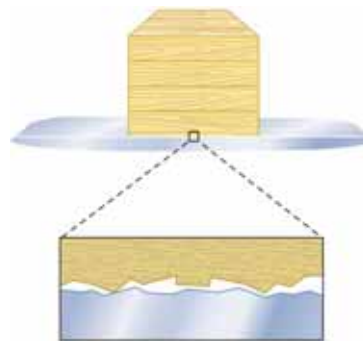
Frictional forces are unavoidable

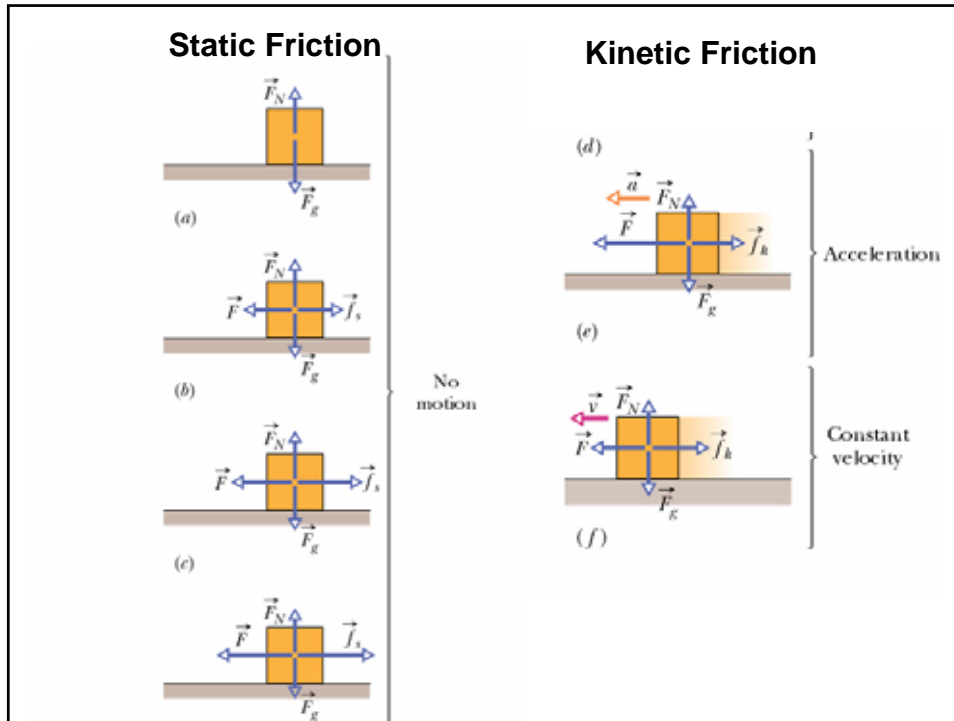
~20% of gasoline in automobile is used to counteract friction in the engine and drive train.



## Frictional Forces: Observations

- Frictional forces are contact forces
- No surface is smooth
- Extremely smooth surfaces stick as well
- Whatever you have you will always have some friction
- Frictional forces depend on many things, we will explore it in detail...





## Static and Kinetic Friction

Static friction :  $f_S$

Direction: opposite to sum of all other forces

Magnitude: variable, till reach a maximum

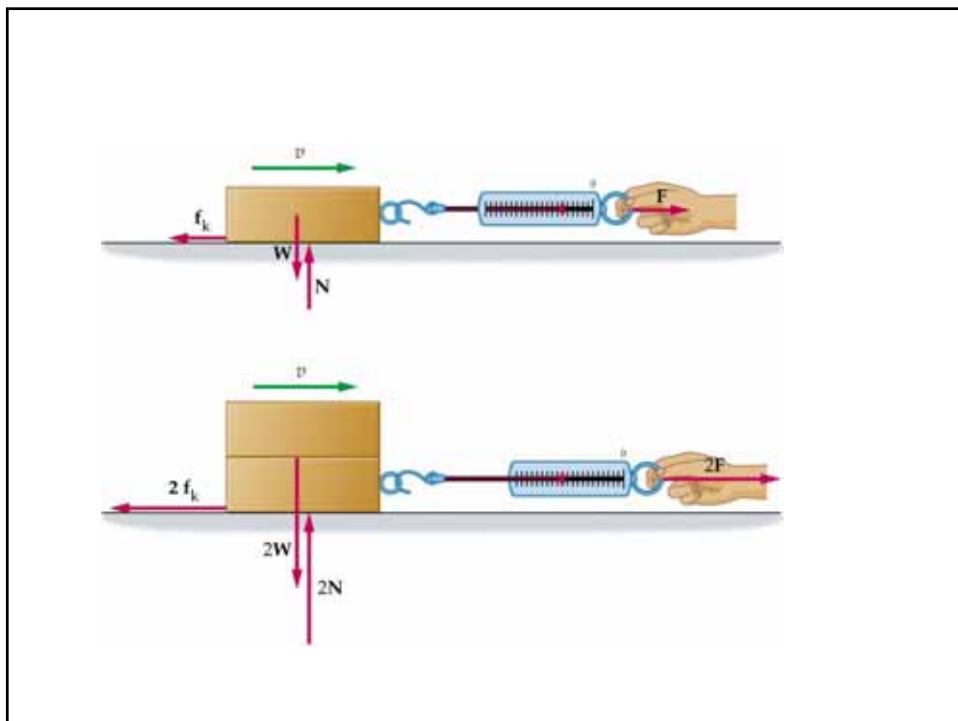
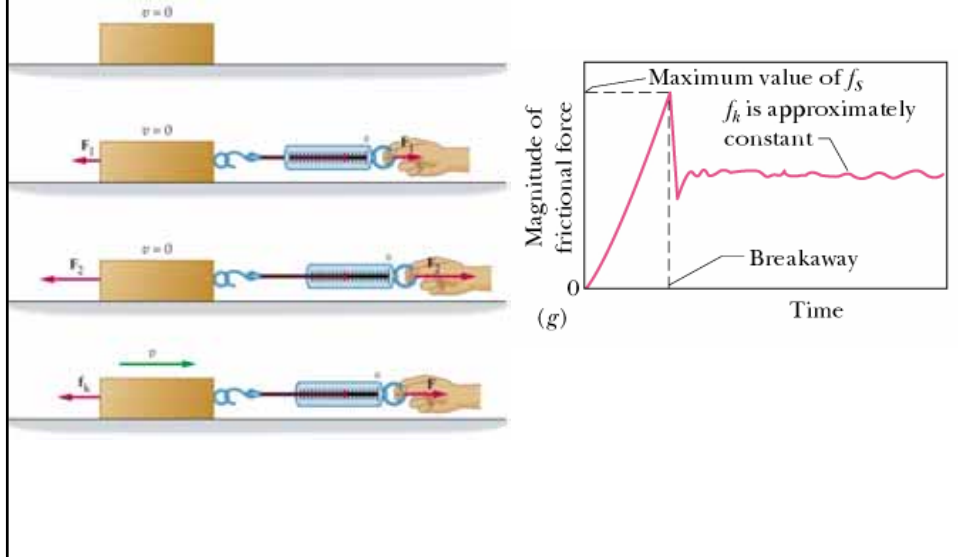
Kinetic friction:  $f_K$

Direction: opposite to the velocity

Magnitude: constant, approximately

**Static ( $v = 0$ ) and kinetic friction (non zero  $v$ ) are two related but different types of friction!**

# Static and Kinetic Friction



### Object Moving

$$\text{Kinetic friction : } f_k = \mu_k F_N$$

$$F_N = (\text{normal force})$$

$$\mu_k = (\text{coefficient of kinetic friction})$$

### Object Not Moving

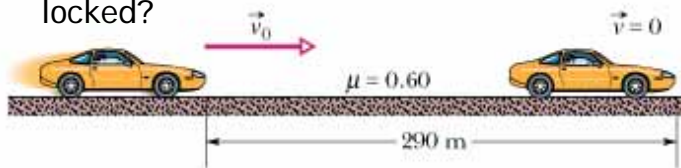
$$\text{Maximum static friction : } f_S^{Max} = \mu_S F_N$$

$$F_N = (\text{normal force})$$

$$\mu_S = (\text{coefficient of static friction})$$

## Sample Problem 6-1

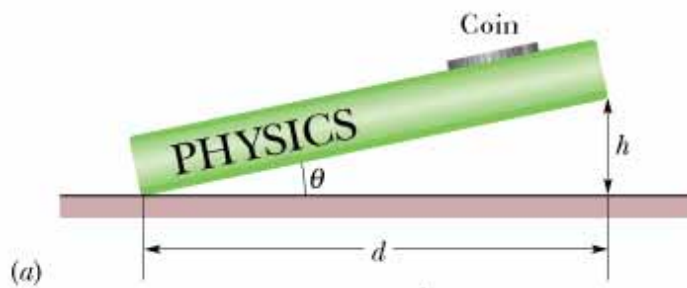
If a car's wheels are "locked" (kept from rolling) during emergency braking, the car slides along the road. Ripped-off bits of tire and small melted sections of road form the "skid marks" that reveal that cold-welding occurred during the slide. The record for the longest skid marks on a public road was reportedly set in 1960 by a Jaguar on the M1 highway in England—the marks were 290 m long! Assuming that  $\mu_k = 0.60$  and the car's acceleration was constant during the braking, how fast was the car going when the wheels became locked?



(a)

### Sample Problem 6-3

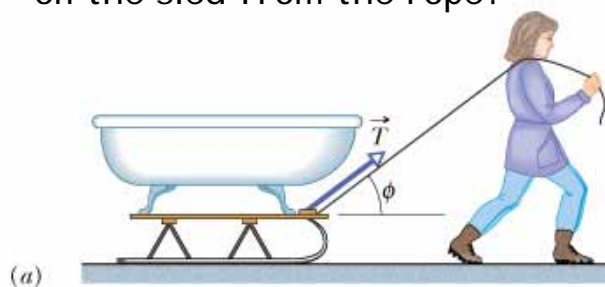
Figure shows a coin of mass  $m$  at rest on a book that has been tilted at an angle with the horizontal. By experimenting, you find that when is increased to  $13^\circ$ , the coin is on the *verge* of sliding down the book, which means that even a slight increase beyond  $13^\circ$  produces sliding. What is the coefficient of static friction  $\mu_s$  between the coin and the book?



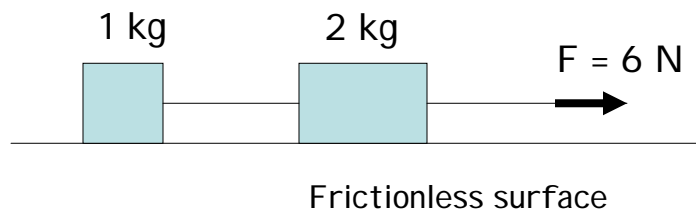
### Sample Problem 6-2

In Figure, a woman pulls a loaded sled of mass  $m = 75 \text{ kg}$  along a horizontal surface at constant velocity. The coefficient of  $\mu_k$  kinetic friction between the runners and the snow is 0.10, and the angle is  $42^\circ$ .

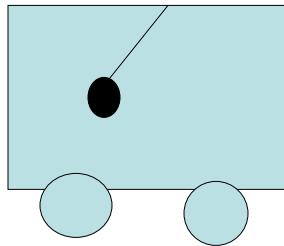
(a) What is the magnitude of the force  $T$  on the sled from the rope?



More applications of Newton's Laws



What is the tension in the rope between two objects?



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