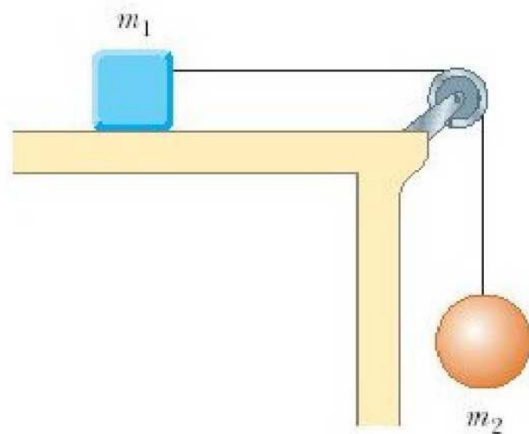




# Good Morning

Do Now:

- Draw the FBD for  $m_1$  &  $m_2$ . Assume that the objects are stationary.

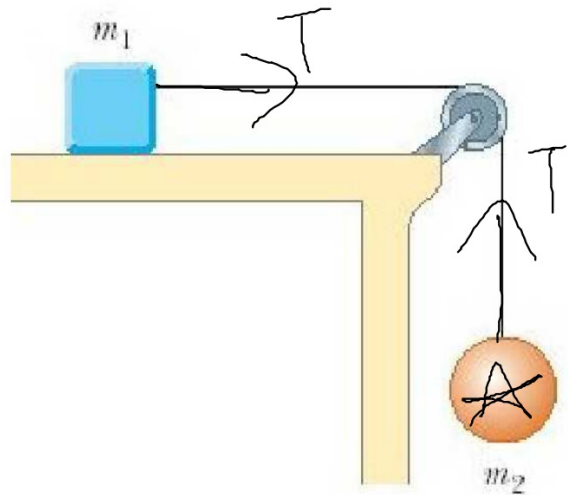


## Problem Solving – A General Approach

1. Read the problem carefully; then read it again.
2. Draw a sketch, and then a free-body diagram.
-  3. Choose a convenient coordinate system.
4. List the known and unknown quantities; find relationships between the knowns and the unknowns.
-  5. Estimate the answer.
6. Solve the problem without putting in any numbers (algebraically); once you are satisfied, put the numbers in.
7. Keep track of dimensions.
8. Make sure your answer is reasonable.

# Solve for $F_f$

- $m_1: 12\text{kg}$
- $m_2: 14\text{kg}$



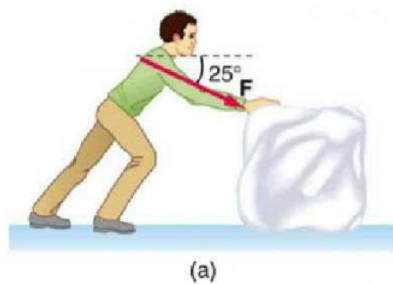
A 5kg desk is pushed at a constant speed. The coefficient of friction between the desk and the floor is 0.2. What is the force of friction? What is the force needed to keep the desk moving?



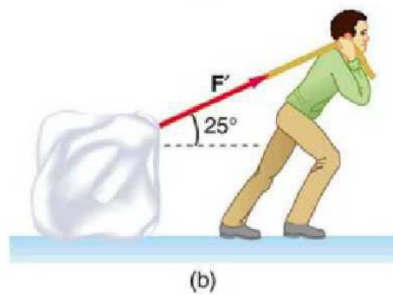
What Forces Are Acting On You?



Which of these requires less effort to push at a constant speed?



2



14

a) The man pushes a 50kg ice block with a force of 100N at an angle of 25 degrees below horizontal. What is the force of friction?  $\mu_k = 0.15$

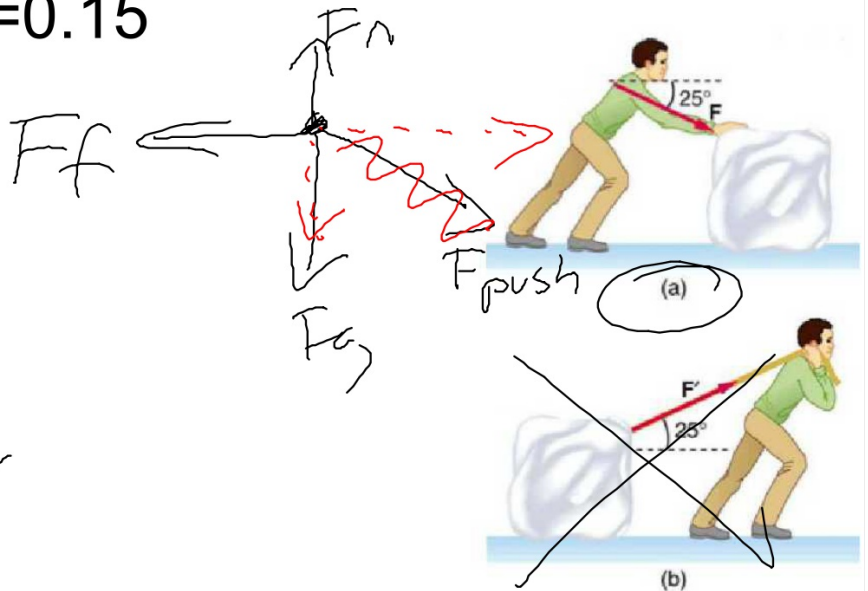
$$F_g = 490 \text{ N}$$

$$F_{p,x} = 90.6 \text{ N}$$

$$F_{p,y} = 42.3 \text{ N}$$

$$F_n = 532.3 \text{ N}$$

$$F_f = 79.8 \text{ N}$$

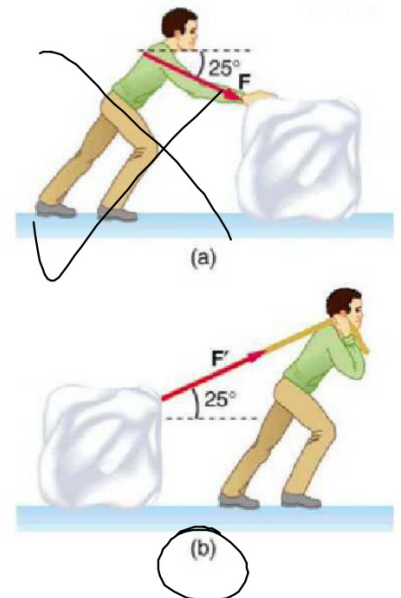


b) The man pulls a 50kg ice block with a force of 100N at an angle of 25 degrees above the horizontal. What is the force of friction?  $\mu_k = 0.15$

$$F_y = 490 \text{ N}$$

$$F_{px} = 90 \text{ N}$$

$$F_{py} = 42.3 \text{ N}$$



# Comparisons

- The force applied in both situations was the same.
- The force of friction was higher when the applied force came from above the horizon.
- What other force was higher in this situation?

# Friction and the Normal Force

- The force of friction is directly proportional to the normal force.
- There is a ratio of the force of friction and the normal force.  $F_n/F_f$ .
- This is the coefficient of friction.

$\mu$



$\mu$ : the coefficient of friction.

# Kinetic and Static Friction

- Both are ratios to the normal force.
- $\mu_s$ : coefficient of static friction.
- $\mu_k$ : coefficient of kinetic friction.
- Static friction  $>$  kinetic friction.

**TABLE 4–2 Coefficients of Friction<sup>†</sup>**

<b>Surfaces</b>	<b>Coefficient of Static Friction, <math>\mu_s</math></b>	<b>Coefficient of Kinetic Friction, <math>\mu_k</math></b>
Wood on wood	0.4	0.2
Ice on ice	0.1	0.03
Metal on metal (lubricated)	0.15	0.07
Steel on steel (unlubricated)	0.7	0.6
Rubber on dry concrete	1.0	0.8
Rubber on wet concrete	0.7	0.5
Rubber on other solid surfaces	1–4	1
Teflon <sup>®</sup> on Teflon in air	0.04	0.04
Teflon on steel in air	0.04	0.04
Lubricated ball bearings	<0.01	<0.01
Synovial joints (in human limbs)	0.01	0.01

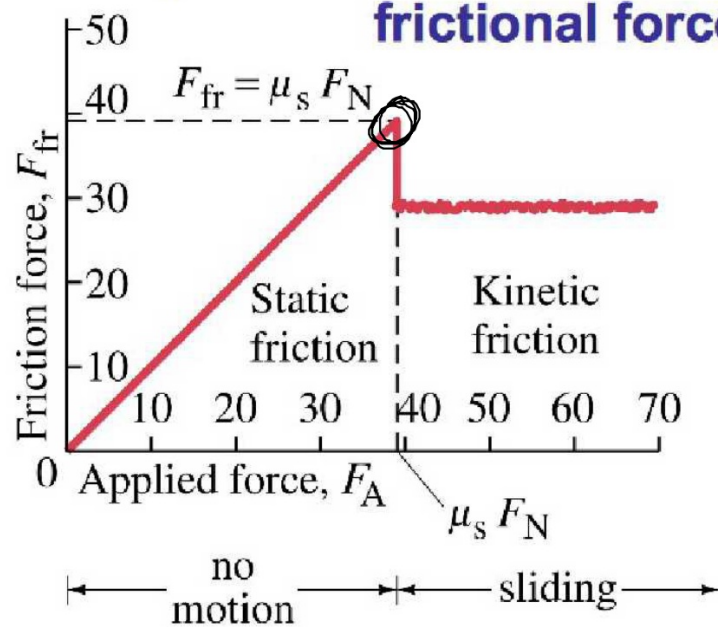
<sup>†</sup> Values are approximate and intended only as a guide.

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# Variable Forces

- $\mu_s$  is determined by the maximum force applied until an objects begins to move.
- $\mu_k$  is constant.

**The static frictional force increases as the applied force increases, until it reaches its maximum. Then the object starts to move, and the kinetic frictional force takes over.**

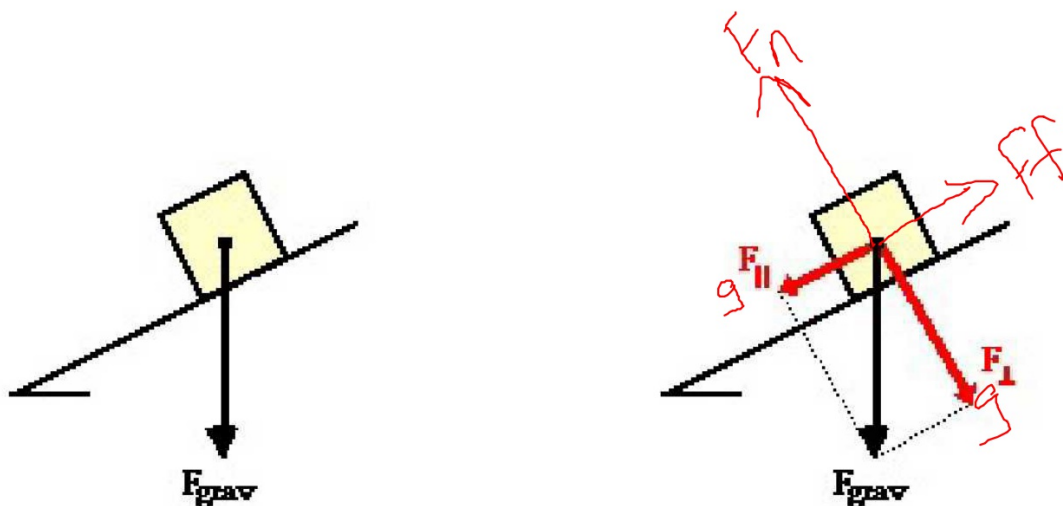




A World Without Friction

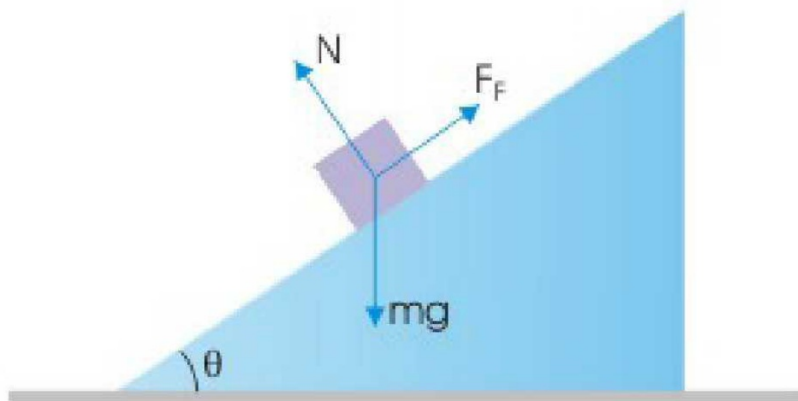


# We Need Friction



The force of gravity can be resolved into two components. Together, these two components replace the affect of the force of gravity.

# Forces on an inclined plane



# Creating new axis

A chicken stands on the ramp to its coop. If the chicken weighs 1.7kg and the angle of the ramp is  $20^\circ$ , what is the force of friction?



A 75kg skier moves at a constant velocity down a  $30^\circ$  slope. What is the force of friction? What is the coefficient of kinetic friction?



55kg Luke Fox feeble grinds a  $40^\circ$  handrail. If Luke is moving at a constant velocity what is the coefficient of friction between the trucks and the handrail?



