Friction

Objectives

- Define and identify frictional forces.
- Explain the factors that determine the amount of friction between two surfaces
- Determine the frictional force and coefficient of friction between two surfaces.

Friction

- Friction opposes motion
  - Kinetic friction opposes motion for an object sliding along another surface.
  - Static friction acts on an object that isn't sliding.
- Magnitude of frictional force determined by
  - Nature of surfaces in contact (μ) = coefficient
  - Normal force acting on the object (F_N)

Coefficient of Friction

$$\mu = \frac{F_f}{F_n}$$

- Ratio of the frictional force and normal force provides the coefficient of friction.

COEFFICIENTS OF FRICTION (APPROXIMATE VALUES)					
	μ_s	μ_k		μ_s	μ_k
steel on steel	0.74	0.57	waxed wood on wet snow	0.14	0.1
aluminum on steel	0.61	0.47	waxed wood on dry snow	–	0.04
rubber on dry concrete	1.0	0.8	metal on metal (lubricated)	0.15	0.06
rubber on wet concrete	–	0.5	ice on ice	0.1	0.03
wood on wood	0.4	0.2	Teflon on Teflon	0.04	0.04
glass on glass	0.9	0.4	synovial joints in humans	0.01	0.003

Sample Problem 1

- A car's performance is tested on various horizontal road surfaces. The brakes are applied, causing the rubber tires of the car to slide along the road without rolling. The tires encounter the greatest force of friction to stop the car on

A. Dry concrete
B. Dry asphalt
C. Wet concrete
D. Wet asphalt

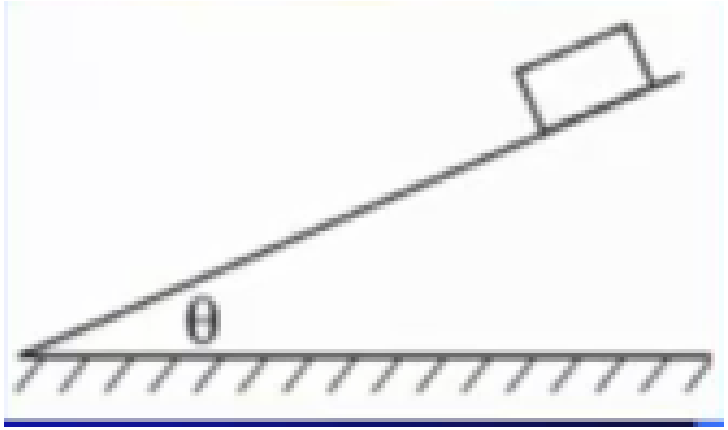
Approximate Coefficients of Friction

	Kinetic	Static
Rubber on concrete (dry)	0.68	0.90
Rubber on concrete (wet)	0.58	
Rubber on asphalt (dry)	0.67	0.85
Rubber on asphalt (wet)	0.53	
Rubber on ice	0.15	
Waxed ski on snow	0.05	0.14
Wood on wood	0.30	0.42
Steel on steel	0.57	0.74
Copper on steel	0.36	0.53
Teflon on Teflon	0.04	

Sample Problem 2

- The diagram shows a block sliding down a plane inclined at angle θ with the horizontal. As angle θ is increased, the coefficient of kinetic between the bottom surface of the block and the surface of the incline will

A. Decrease
B. Increase
C. Remain the same



Coefficient of Friction

- The coefficient of friction is a ratio between the force of friction and the normal force between two surfaces.
  - The *coefficient of kinetic friction* is the ratio kinetic friction to the normal force.

$$\mu_k = \frac{F_k}{F_n}$$

  - The *coefficient of static friction* is the ratio of the maximum value of static friction to the normal force.

$$\mu_s = \frac{F_s, \mathrm{max}}{F_n}$$

Calculating the Force of Friction

- The force of friction depends inly upon the nature of the surfaces in contact (μ) and the magnitude of the normal force (F_N).

$$F_f = \mu F_N$$

- Combine with Newton's 2nd Law and FBDs to solve more involved problems.

Sample Problem 3

- A 24 kg crate is initially at rest on a horizontal floor requires a 75 N horizontal force to set it in motion. Find the coefficient of static friction, between the crate and the floor.

Sample Problem 4

- Once the same crate in problem 3 is in motion, a horizontal force of 53 N keeps the crate moving with a constant velocity. Find μ_k, the coefficient of kinetic friction, between the crate and the floor.

Sample Problem 5

- A 25 kg chair initially at rest on a horizontal floor requires a 365 N horizontal force to set it in motion. Once the chair is in motion, a 327 N horizontal force keeps it moving at a constant velocity. Solve for the static friction and kinetic friction between the chair and the floor.

Sample Problem 6

- A museum curator moves artifacts into place on many different display surfaces. Use the values in Table 4-2 on page 144 to find F_s, max and F_k for the following situations.

a) Moving a 145 kg aluminum sculpture across a horizontal steel platform

b) Pulling a 15 kg steel sword across a horizontal steel shield

c) Pushing a 250 kg wood bed on a wood floor

d) Sliding a 0.55 kg glass amulet on a glass display case.