

Friction

- What causes Friction?
- Static, Kinetic and Rolling
- Newton's 2nd Law with Friction

Quick Quiz:

The pilot of the helicopter that you are in has fallen asleep, and the helicopter is now in freefall. Can you run to the cockpit and save the day?

A) Yes

B) No

Static Friction

$$\vec{f}_s \leq \mu_s N \quad [\text{in the direction that prevents slippage}]$$

- This is the friction that keeps things from starting to move
- Notice that this is an **inequality!**

Kinetic Friction

$$\vec{f}_k = \mu_k N \quad [\text{in the direction that reduces the relative motion between the two surfaces}]$$

- This is the friction that you get when the two surfaces are already moving relative to each other
- This one is an equality

Quick Quiz:

A horizontal force of 150 N is applied to a 50 kg box on a level floor. The coefficient of static friction between the box and the floor is 0.5. The magnitude of the frictional force on the box is:

- (A) 150 N
- (B) 250 N
- (C) 500 N
- (D) 3750 N
- (E) 15000 N

Rolling Friction

$$\vec{f}_r \leq \mu_r \mathcal{N} \quad [\text{in the direction opposite the motion}]$$

- The coefficient of rolling friction is much smaller than the coefficient of kinetic friction.
- Dragging a bicycle with its brakes on is much harder than rolling it along

Quick Quiz:

What is the point of an anti-lock braking system?

- (A) It increases rolling friction
- (B) It increases the coefficient of static friction
- (C) It makes sure you never have kinetic friction
- (D) It makes sure you never have static friction

Example:

You are pulling a sled across a level, snowy field. There is a package on the sled, which you do not want to have slip off. The coefficient of static friction between the package and the sled is 0.5.

What is the maximum acceleration of the sled for which the package does not slip?

Quick Quiz:

If the coefficient of static friction for rubber on pavement is about 1, which of the following best represent the maximum acceleration that a car can have on level ground?

(A) 1 m/s^2

(B) 10 m/s^2

(C) 100 m/s^2

(D) There is no maximum, you just need a faster car

Example:

You are pulling a 10 kg sled at constant velocity across a level, snowy field. The rope that you are using to pull the sled is inclined at 45° to the horizontal. If the coefficient of kinetic friction between the sled and the ground is 0.2, what is the tension in the rope.

Quick Quiz:

A box is sliding down a ramp. The ramp is inclined 30° to the horizontal and the coefficient of kinetic friction between the box and the ramp is μ_k .

Friction stops the box from sliding in distance 'd'. If the mass of the box is doubled, how many times further does it slide before stopping?

- A) It slides twice as far.
- B) It slides four times as far.
- C) It slides half as far.
- D) It slides four times as far.
- E) It slides the same distance.