Friction

Friction

- F_f is a force which always opposes the velocity or the attempted motion.
- <u>The magnitude of friction from a surface is:</u>

1. Independent of the speed of the object or the area of contact.
2. Proportional to the normal force, F_N. If we push the two objects together harder, F_N increases and thus F_f increases.
3. Proportional to the coefficient of friction, μ. μ depends upon:
   a) Type of motion: stationary, sliding, rolling
   b) Type of materials
   c) Lubrication

Types of Friction: Kinetic

1. Kinetic Friction: This applies to sliding or skidding motion. There is relative motion between the object and the surface.

$$F_f = \mu_k F_N$$ [N] = [No Units][N]

μ is a decimal number which indicates the stickiness of the surface.

If the surface is sticky, μ is large.

Ex: Melissa's 1500 kg BMW is zooming at 30 m/s. She hits the brakes and skids to a stop. The coefficient of friction between the tires and the road is 0.2. Find the distance to stop.

Types of Friction: Static

2. Static Friction: This applies to a stationary object or to a vehicle rolling to a stop on the verge of skidding. There is not relative motion between the object and the road.

$$F_f = \mu_S F_N$$ For rolling to a stop on the verge of skidding. The wheel generates as much friction as possible.

$$F_f \leq \mu_S F_N$$ For a stationary object. The friction is very wise and adjusts itself to exactly match the pushing force. Therefore, F_f will cancel F_{PUSH} and the object will remain stationary.

To explain the ≤ sign for…

Given: $\mu_S = .8$ m = 5 kg

1

2

3

4

Static Friction

- As soon as the mass begins to move, the force of friction will become less than 40 N since the "fingernails of friction" have been broken. At that time we must use $F_f=\mu_k F_N$ since it is now sliding.

- $\mu_S > \mu_k$ always, because when the object is stationary, the fingernails of friction are intact and have a good grip.

- μ_s applies to rolling to a stop on the verge of skidding because there is no relative motion between the tire and the road. The tire peels onto and off of the road, leaving the fingernails intact.

Example: A 15 kg pumpkin is stationary on a frozen field where $\mu_s = 0.8$ and $\mu_k = 0.2$.

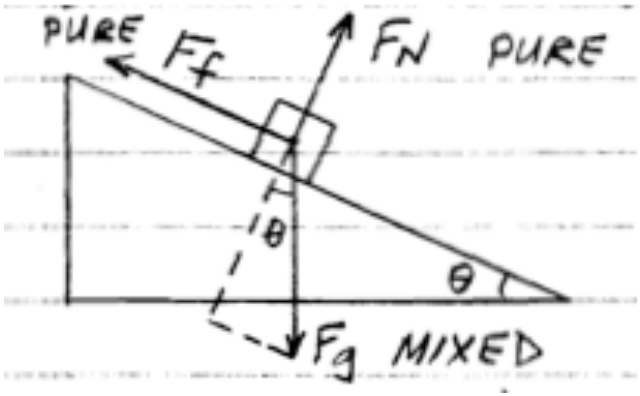
Find the force required to just start the squash moving.

Find the force required to accelerate it at 4 m/s^2.

The pumpkin is moving at -34 m/s when we stop pushing. Find the distance for it to slide to a stop.

Inclined Planes with Friction

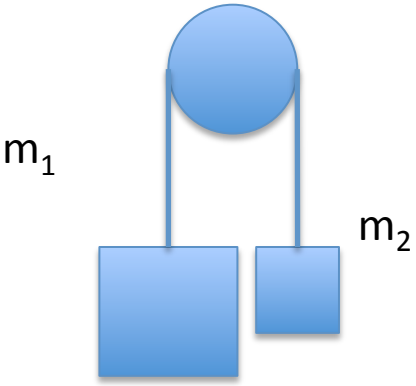
Ex: Find a formula for the acceleration down the incline. Use a tilted coordinate axis.



Alphabet Soup

- Objective: To make a general formula as a solution to a problem.

Ex: Given Find formulas for the acceleration and the tension.



Ex: Given: Find a formula for the distance required to stop the car.