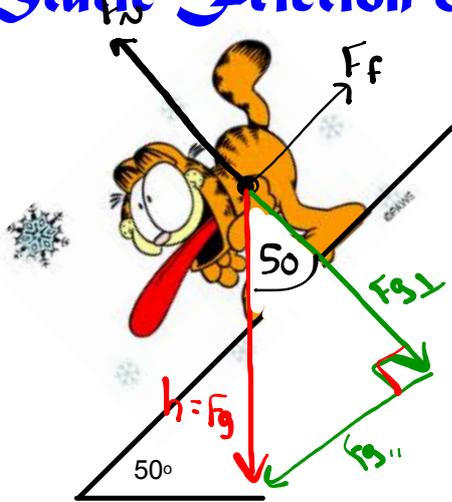


L05 - Friction in 2-Dimensions

Agenda:

- Attendance
- Review: Static and Kinetic Friction
 - *What's the difference?*
- Static Friction on a Slope
 - *Modified Free-Body Diagrams*
 - *Breaking Gravity into Parallel and Perpendicular Components*
- Kinetic Friction on a Slope
 - *Modified Free-Body Diagrams*
 - *Breaking Gravity into Parallel and Perpendicular Components*
 - *Net Force in the Perpendicular? Zero!*
 - *Net Force in the Parallel? Non-Zero implies Acceleration.*
- Practice
 - *Pg 175 #1-2*
 - *Pg 179 #2*

Static Friction on a Slope

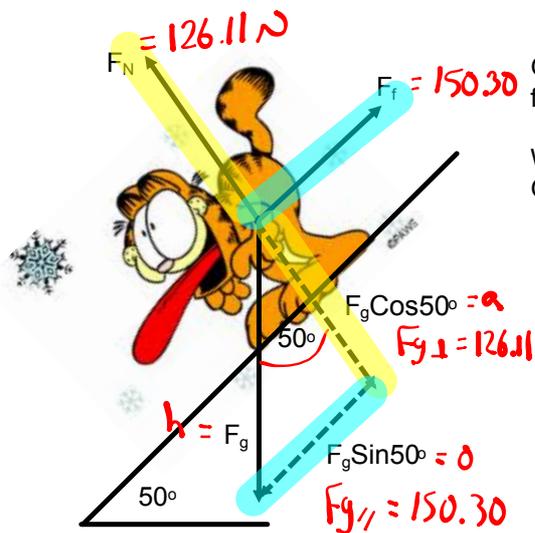


Garfield has a mass of 20kg, and is barely able to keep from slipping down the slope.

What is the Coefficient of Static Friction between Garfield's clawed feet and the snow?

Parallel (||)
Perpendicular (⊥)

Static Friction on a Slope



Garfield has a mass of 20kg, and is barely able to keep from slipping down the slope.

What is the Coefficient of Static Friction between Garfield's clawed feet and the snow?

$$\sin \theta = \frac{o}{h}$$

$$\sin 50 = \frac{F_{g\parallel}}{F_g}$$

$$F_{g\parallel} = F_g \sin 50$$

$$= (mg) \sin 50$$

$$= (20)(9.8) \sin 50$$

$$= 150.30 \text{ N}$$

$$\cos \theta = \frac{a}{h}$$

$$\cos 50 = \frac{F_{g\perp}}{F_g}$$

$$F_{g\perp} = F_g \cos 50$$

$$= (20)(9.8) \cos 50$$

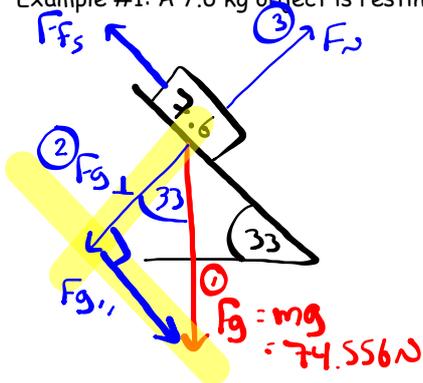
$$= 126.11 \text{ N}$$

$$F_{f_s \max} = \mu_s F_N$$

$$150.30 = \mu_s (126.11)$$

$$\mu_s = 1.19$$

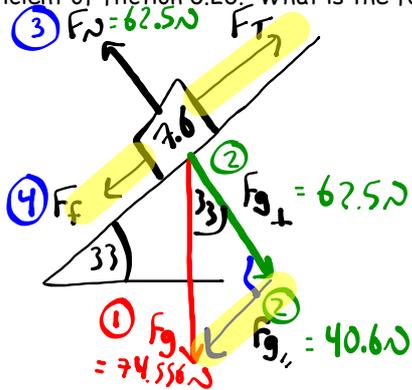
Example #1: A 7.6 kg object is resting on a incline of 33 degrees. What is the normal force acting on the object?



$$\begin{aligned} \textcircled{2} F_{g\perp} &= F_g \cos \theta \\ &= (74.556)(\cos 33) \\ &= 62.5 \text{ N} \end{aligned}$$

$$\textcircled{3} F_N = 62.5 \text{ N}$$

Example #2A 7.6 kg object is pulled with a constant speed up an incline plane with an angle of 33 degrees and a coefficient of friction 0.20. What is the force of friction?

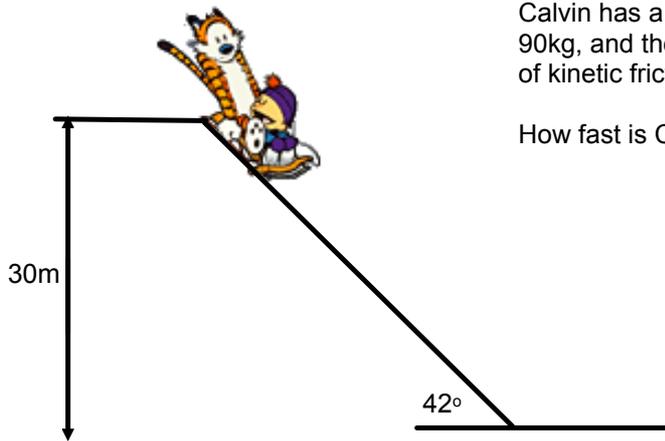


$$\begin{aligned} a &= 0 \\ F_{\text{net}} &= 0 \end{aligned}$$

$$\begin{aligned} \textcircled{4} F_{f_k} &= \mu_k F_N \\ &= (0.20)(62.5) \\ &= 12.5 \text{ N} \end{aligned}$$

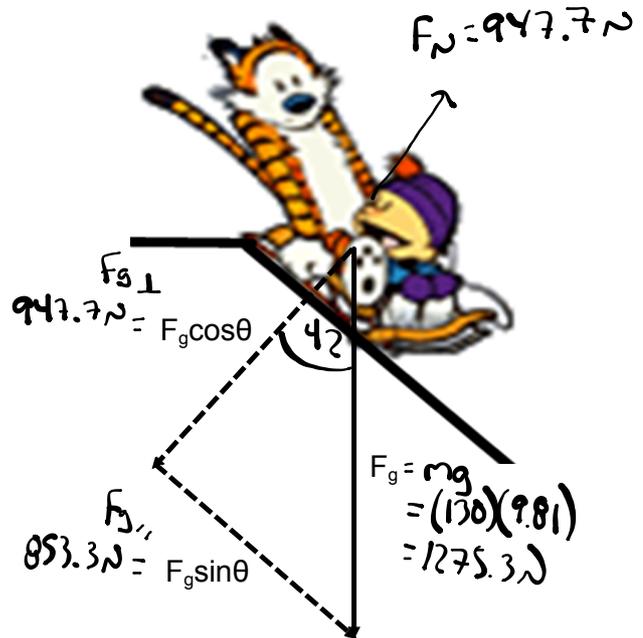
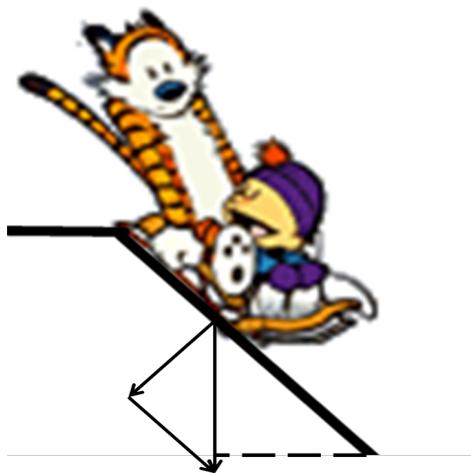
$$\begin{aligned} \textcircled{5} \quad & F_{\text{net}} = F_T + F_{g\parallel} + F_f \\ 0 &= F_T + (-40.6) + (-12.5) \\ & \boxed{F_T = 53.1 \text{ N}} \end{aligned}$$

Kinetic Friction on a Slope

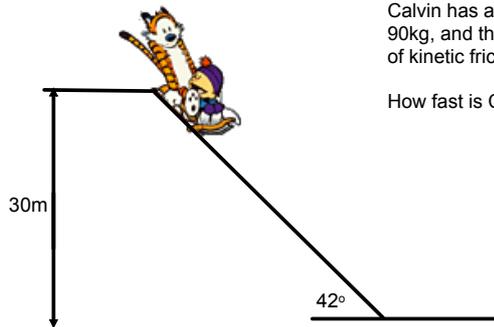


Calvin has a mass of 30kg, Hobbes has a mass of 90kg, and the sled has a mass of 10kg. The coefficient of kinetic friction of the sled on the snow is 0.4.

How fast is Calvin going at the bottom of the slope?



Kinetic Friction on a Slope



Calvin has a mass of 30kg, Hobbes has a mass of 90kg, and the sled has a mass of 10kg. The coefficient of kinetic friction of the sled on the snow is 0.4.

How fast is Calvin going at the bottom of the slope?

Step-by-Step:

✓ Draw a Free-Body Diagram

✓ What is the Force of Gravity acting on the combined mass of the sled and occupants?

✓ What is the Normal Force acting on the sled and occupants?

d) How much Kinetic Friction does the sled experience?

$$F_{fk} = \mu_k F_N$$

$$= (0.4)(947.7)$$

$$= 379.1 \text{ N}$$

e) What is the Net Force of the sled down the hill?

$$F_{net} = F_{g_{\parallel}} + F_{fk}$$

$$= (+853.3) + (-379.1)$$

$$= 474.2 \text{ N}$$

f) What is the acceleration of the sled down the hill?

$$a = \frac{F_{net}}{m} = \frac{474.2}{130} = 3.65 \text{ m/s}^2 \text{ (downhill)}$$

g) What diagonal distance will the sled cover?

$$44.8 \text{ m}$$

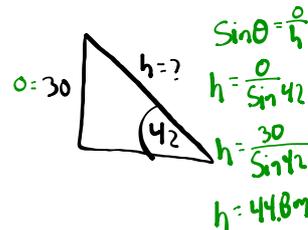
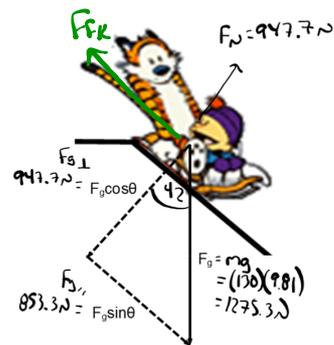
h) For your Kinematics Equations, what variables do you know?

i) Pick your equation and solve for v_f

$$v_f^2 = v_i^2 + 2ad$$

$$v_f^2 = 0^2 + 2(3.65)(44.8)$$

$$v_f = 18.1 \text{ m/s} \approx 65 \text{ kph}$$



$$a = \frac{v_f - v_i}{t}$$

$$d = \left(\frac{v_f + v_i}{2} \right) t$$

$$d = v_i t + \frac{1}{2} a t^2$$

$$v_f^2 = v_i^2 + 2ad$$

$$d = v_f t - \frac{1}{2} a t^2$$

Practice

- Pg 175 #1-2

- Pg 179 #2