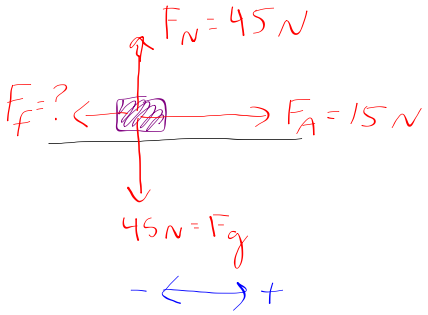
7. A 45 newton sled rests on a frozen pond. A child pulls the sled with a horizontal force of 15.0 newtons and causes it to accelerate at a rate of 1.50 m/s^2.

a) Determine the force of friction.



$\Sigma \vec{F} = m\vec{a}$

$\vec{F}_A + \vec{F}_f = m\vec{a}$

$\vec{F}_f = m\vec{a} - \vec{F}_A$

$= 4.5\,kg \cdot 1.5\,m/s^2 - 15\,N$

$\sim \boxed{-8.3\,N}$

$g \sim 10\,m/s^2$

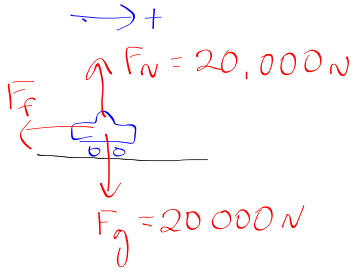
$m = 4.5\,kg$

b) Determine the coefficient of friction.

$F_{fK} = \mu_K F_N$ $\quad \mu_K = \frac{F_f}{F_N} = \frac{8.3\,N}{45\,N} = \boxed{.18}$

8. A driver slams on the brakes and her 2.0 x 10^3 kg car skids to a stop on a dry asphalt highway.

a) What is the force of friction stopping the car?



$F_{fK} = \mu_K \cdot F_N$

$= (.8)(20,000\,N)$

$= 16\,000\,N$

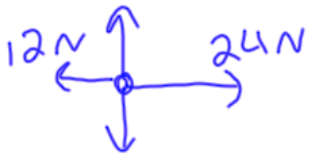
b) What is the acceleration of the car while it is stopping?

$\Sigma \vec{F} = m\vec{a}$ $\quad a = \frac{F}{m} = \frac{16000\,N}{2000\,kg} = 8\,m/s^2$

X

d) How much force is needed to move the box with a constant velocity?

e) If the student kept pushing with this amount of force in (c), what would happen to the box? *(i.e. solve for the acceleration)*

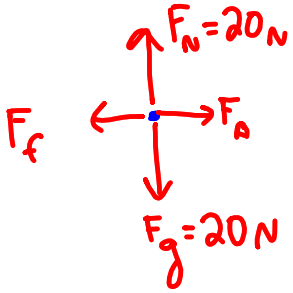


$F_{fs}^{max} = \mu_s F_N$

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

2. In lab, the coefficient of kinetic friction for dragging a brick across a tabletop is found from experiment to be 0.23.

a) How much force would you need to drag a 2.0 kg brick across the tabletop at a constant speed?

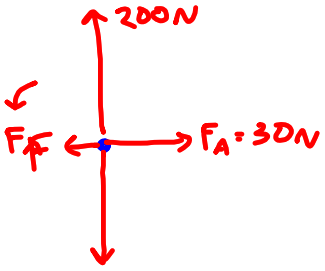


b) If that brick is replaced with one that has a mass of 4.0 kg, which of the following will change? If so, how much?

Weight ✓ Normal force ✓ Force of Friction ✓ Coefficient of friction

3. A 20-kg sled rests on a bed of ice. A pulling force of 30 N is applied to the sled and it is found to accelerate at a rate of 0.5 m/s^2.

a) Draw a free body diagram of the sled.



b) Determine the force of friction.

$\Sigma \vec{F} = m\vec{a}$ $\quad \vec{F}_f = m\vec{a} - \vec{F}_A$

$\vec{F}_A + \vec{F}_f = m\vec{a}$ $\quad 20kg \cdot .5\frac{m}{s^2} - 30N$

c) Determine the coefficient of friction.

$F_{fK} = \mu_K F_N$

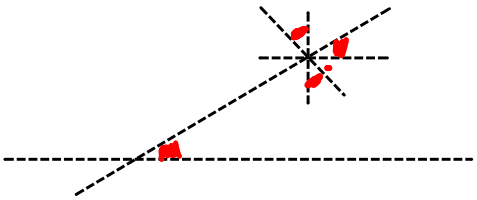
Tension

Assumptions

a. Ropes have no mass

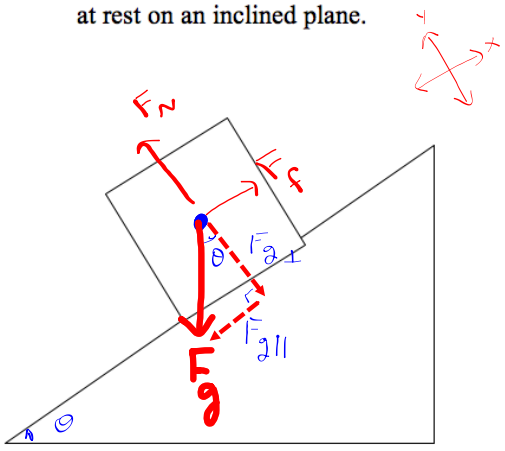
b. The force is transmitted instantly

c. Ropes do not stretch at all



The Inclined Plane

Draw a free-body diagram for this box at rest on an inclined plane.



Resolving F_g into components that are parallel and perpendicular to the surface of the inclined plane:

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

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

If the box is in equilibrium, then . . .

$F_N = F_{g\perp} = mg\cos\theta$

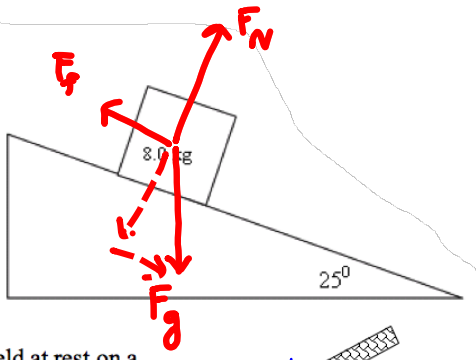
$F_f = F_{g\parallel} = mg\sin\theta$

1. Draw and calculate the magnitude of all the forces acting on this box sliding down a hill at a constant speed of 12 m/s.

$F_g = mg = 8\text{kg} \cdot 10\text{m/s}^2 = 80\text{N}$

$F_N = F_{g\perp} = F_g\cos\theta = 80\text{N}\cdot\cos 25^\circ = 73\text{N}$

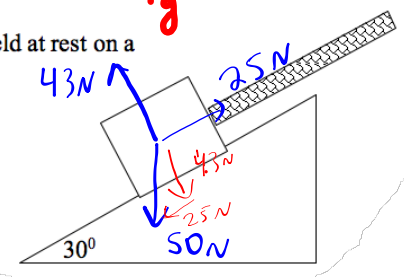
$F_f = F_{g\parallel} = F_g\sin\theta = 80\text{N}\cdot\sin 25^\circ = 34\text{N}$



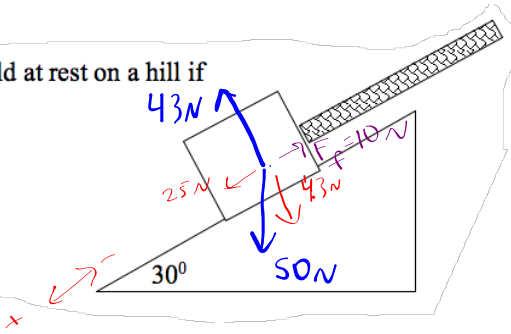
2. Calculate the force of tension in the rope holding this 50. N box held at rest on a frictionless hill.

$F_T = F_{g\parallel} = 25\text{N}$

$F_N = F_{g\perp} = 43\text{N}$



3. Calculate the tension in the rope holding this 50. N box held at rest on a hill if there is a 10. N force of friction.

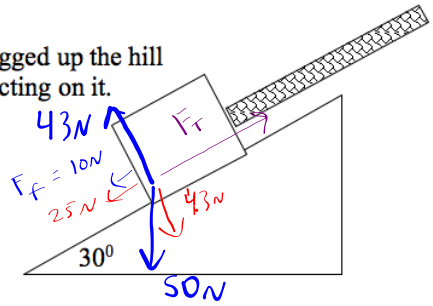


$\Sigma F_{\parallel} = ma$

$F_{g\parallel} + F_f + F_T = 0$

$(25N) + (-10N) + (\ \ ) = 0$

4. Calculate the tension in the rope when this 50. N box is being dragged up the hill at a constant speed of 5.0 m/s if there is a 10. N frictional force acting on it.



$\Sigma F_{\parallel} = ma$

$F_{g\parallel} + F_f + F_T = 0$

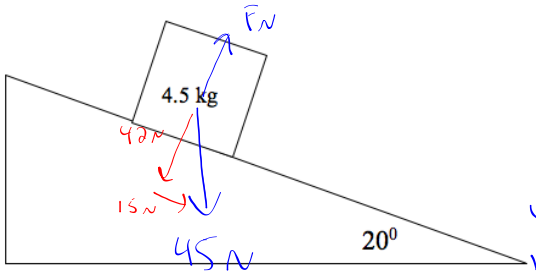
$(25N) + (10N) + (\ \ ) = 0$

$F_T = 35N$

b. What is the coefficient of friction between these surfaces? $F_{fK} = \mu_K \cdot F_N$

$\mu_K = \frac{10N}{43N} = .23$

5. Calculate how fast this box will accelerate down the hill if the hill is frictionless.



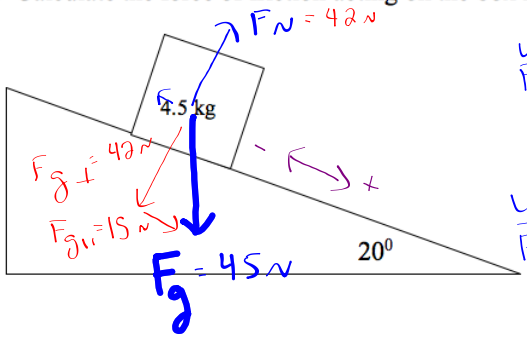
$a_g = g\sin\theta$

$\Sigma F_{\parallel} = ma_{\parallel}$

$mg\sin\theta = ma_{\parallel}$

$a \sim 3.4\ m/s^2$

6. Calculate the force of friction acting on the box if it now accelerates down the incline at a rate of 0.67 m/s^2.



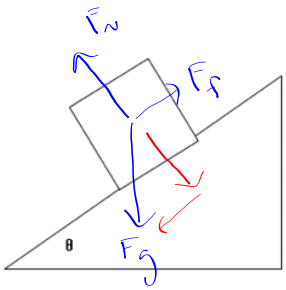
$\Sigma F_{\perp} = ma_{\perp}$

$F_{g\perp} + F_N = 0$

$\Sigma F_{\parallel} = ma_{\parallel}$

$F_K + F_{g\parallel} = ma_{\parallel}$

$F_f = ma_{\parallel} - F_{g\parallel} = 4.5\text{kg} \cdot .67\ m/s^2 - 15\text{N} = -12\text{N}$



7. As the angle θ increases, what happens to the . . .

weight?

normal force? ↓

force of friction? ↑

coefficient of friction?

14

'crit' angle move if:

$F_{g_{\parallel}} > F_{f_s}^{max}$

$mg\sin\theta > \mu_s \cdot F_N$

$mg\sin\theta > \mu\, mg\cos\theta$

$\frac{mg\sin\theta}{\cos\theta} > \mu\, mg\frac{\cos\theta}{\cos\theta}$

if $\tan\theta > \mu_s$

Newton's Third Law