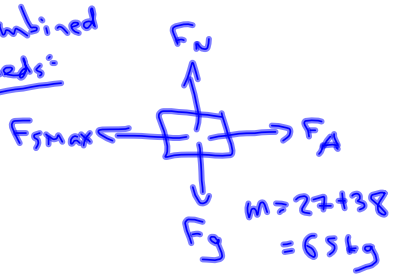
SPH3U 4.3 Solving Friction Problems

1. Static friction acting on several objects

Two sleds are tied together with a rope. The coefficient of static friction between each sled and the snow is 0.22. A small child is sitting on sled 1 (total mass of 27 kg) and a larger child sits on sled 2 (total mass of 38 kg). An adult pulls on the sleds.

a. What is the greatest horizontal force that the adult can exert on sled 1 without moving either sled?

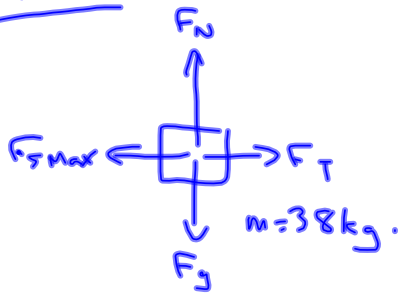
Combined sleds:



$F_A = F_{Smax}$
$= \mu_s F_N$
$= \mu_s mg$
$= 0.22(65)(9.8)$
$= 140\,N.$

b. Calculate the magnitude of the tension in the rope between sleds 1 and 2 when the adult exerts this greatest horizontal force.

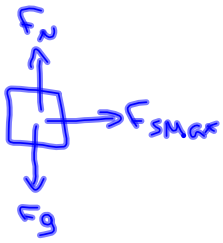
Sled 2:



$F_T = F_{Smax}$
$= \mu_s mg$
$= 0.22(38)(9.8)$
$= 82\,N.$

2. Static friction can cause motion

The coefficient of static friction between a person's shoe and the ground is 0.70. Determine the maximum magnitude of acceleration of the 62 kg person, if he starts running on a horizontal surface from rest.



$F_{Net} = ma \qquad a = \frac{F_{Net}}{m}$

$F_{Net} = F_{SMax}$

$= \mu_s F_N$

$= \mu_s mg = 0.70(62)(9.8)$

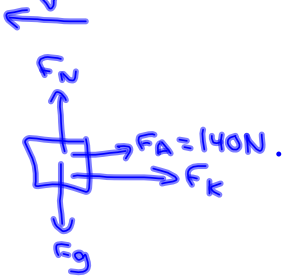
$= 425.3\,N.$

$a = \frac{F_{Net}}{m} = \frac{425.3}{62} = 6.9\ m/s^2.$

3. Stopping a sliding box

A 250 kg box slides down a ramp and then across a level floor. The coefficient of kinetic friction along the floor is 0.20. A person sees the box moving at 1.0 m/s [left] and pushes on it with a horizontal force of 140 N [right].

a. How far does the box travel before coming to rest?



$F_{Net} = ma \qquad a = \frac{F_{Net}}{m}$

$F_{Net} = F_A + F_K = F_A + \mu_K mg.$

$= 140\,N + 0.20(250)(9.8)$

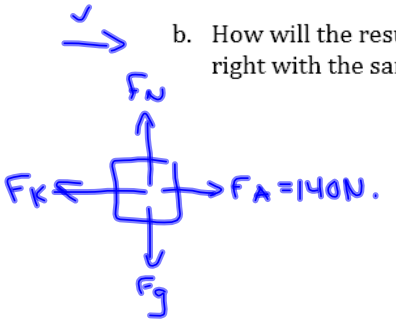
$= 630\,N.$

$a = \frac{F_{Net}}{m} = \frac{630}{250} = 2.52\ m/s^2.$

$v_f^2 = v_i^2 + 2a\Delta d$

$\Delta d = \frac{v_f^2 - v_i^2}{2a} = \frac{0 - (-1.0)^2}{2(2.52)} = -0.20\ m$

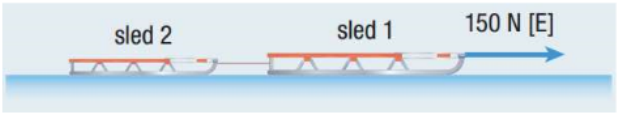
b. How will the results change if the box is moving right and the person still pushes right with the same force?



The person is fighting friction instead of helping it. ∴ the box will move further.

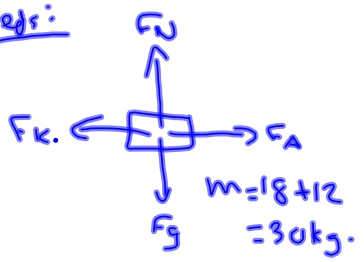
4. Kinetic friction and tension

Two sleds tied together are pulled across an icy surface with an applied force of 150 N [E]. The mass of sled 1 is 18.0 kg and the mass of sled 2 is 12.0 kg. The coefficient of kinetic friction for each sled is 0.20.



a. Calculate the acceleration of the sleds.

Combined Sleds:



$\vec{a} = \frac{F_{Net}}{m}$

$F_{Net} = F_A - F_K$

$= F_A - \mu_K F_N$

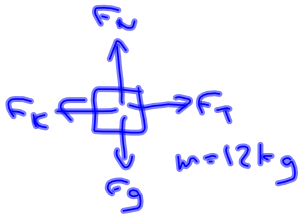
$= 150 - 0.20(30)(9.8)$

$= 91.2\,N$

$\vec{a} = \frac{F_{Net}}{m} = \frac{91.2}{30} = 3.0\,m/s^2\,[E]$

b. Determine the magnitude of the tension in the rope between the sleds.

Sled 2:



$F_{Net} = ma$

$F_{Net} = F_T - F_K$

$F_T = F_{Net} + \mu_K mg$

$= ma + \mu_K mg$

$= (12)(3.0) + 0.20(12)(9.8)$

$= 60\,N$

Homework: page 178: #1, 3, 7, 8