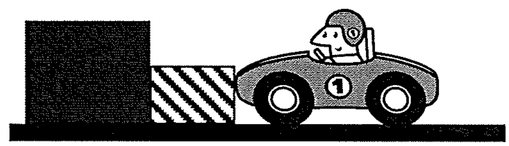
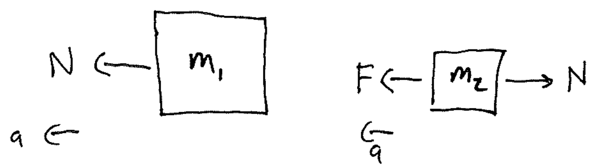
Discussion 5b : Newton's Laws of Motion and Forces

Name: Fun E. Guy

Goal: To be able to apply Newton's laws of motion and to understand forces and rotation with forces.

A) A car is applying a leftward horizontal force of 60 N to a block that has a mass of 2.0 kg. To the left of the small block is a larger block of mass 4.0 kg. The two blocks move together. Gravity acts along the vertical at 10 m/s^2 and there is no friction between the blocks or between the floor and the blocks. What is the force magnitude and direction of the left block on the right block?





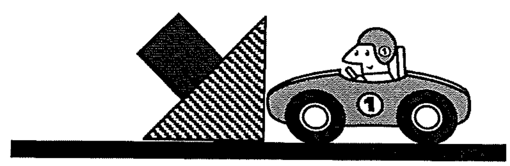
The smaller block would have zoomed ahead, but the larger block gets in its way (remember Normal forces are those that stop objects from moving through other object

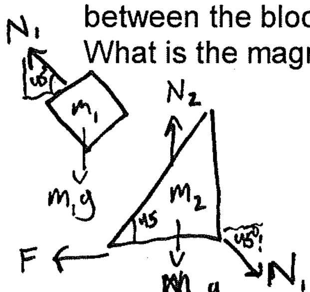
$N = m_1 a \Rightarrow a = \frac{N}{m_1}$ so

$F - N = m_2 a$

$F = N + m_2 a = N + \frac{m_2}{m_1} N = N\left(1 + \frac{m_2}{m_1}\right)$ so $N = \frac{F}{1 + \frac{m_2}{m_1}} = \frac{60}{1 + \frac{2}{4}} = \frac{60}{3/2}$ $\boxed{= 40\,N}$

B) A car is applying an unknown leftward horizontal force to a triangular block that has a mass of 2.0 kg. To the left of this block is a 2nd block of mass 4.0 kg. The 1st block has the shape of a right triangle with two 45° angles. These two blocks move together (i.e., the 2nd block does not move relative to the 1st block). Gravity acts along the vertical at 10 m/s^2 and there is no friction between the blocks or between the floor and the blocks. What is the magnitude of the force by the car on the triangular block?





We break forces into x, y for both blocks, but we want them to both accelerate in the −x direction with the same a so

m_1 | x: $N_1 \cos 45° = m_1 a$
y: $N_1 \sin 45° = m_1 g$

m_2 | x: $F - N_1 \cos 45° = m_2 a$
y: $N_2 = N_1 \sin 45 + m_2 g$ ⇐ not usefull

so combining ⇒ ~~(crossed out)~~ $N_1 \cos 45° = N_1 \sin 45°$ so

$m_1 a = m_1 g$ or $a = 10\,m/s^2 \Rightarrow F - m_1 a = m_2 a \Rightarrow F = (m_1 + m_2) a = (6\,kg)\,10\,m/s^2$

$= 60\,N$

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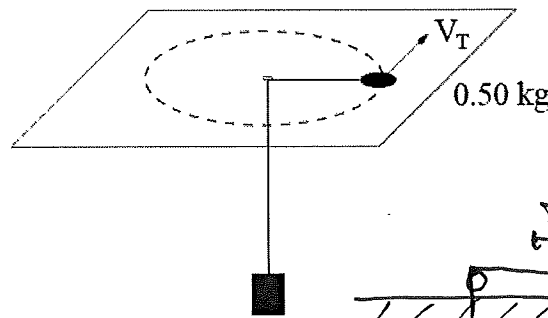
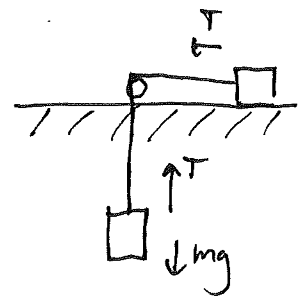
C) In the figure is an assembly consisting of two small masses connected by a massless inflexible string passing through a small hole in a horizontal frictionless table. The string is 1.00 m long. The hanging mass is stationary while the other mass, 0.50 kg, is undergoing uniform circular motion at a speed of 2.0 m/s and a distance 0.10 meters away from the hole. Gravity acts along the vertical and assume that little g is 10 m/s^2





1. What is the magnitude of the centripetal acceleration?

$a_c = \frac{v^2}{r} = \frac{2^2}{0.1} = \boxed{40\, m/s^2}$

2. What is the magnitude of the centripetal force F_c?

$F_c = m a_c = 0.5 \cdot 40 = \boxed{20N}$

3. How does the tension in the string T compare to F_c (which is larger or are they equal)? Explain your reasoning.

The string is massless and inflexible so the tension is the same throughout the string (Think tension as equal + opposite force through the whole thing) so $T = F_c$ since the hanging mass doesn't move ($\Sigma F = 0$)

4. What is the mass of the hanging mass?

$T = mg = 20N$ so $\boxed{m = 2kg}$

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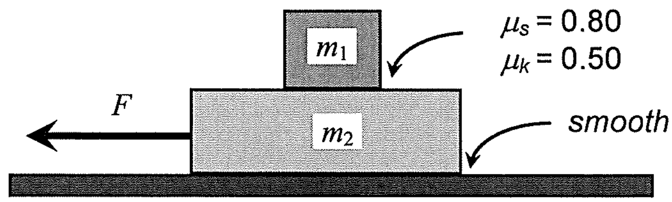
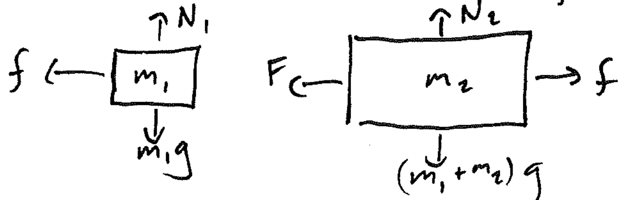
D) A box of mass $m_1 = 1.0$ kg is atop a 2nd box of mass $m_2 = 2.0$ kg. Both are initially at rest. The bottom block is being pulled horizontally to the left with a force *F*. There is a friction between the two masses (with $\mu_s = 0.80$ & $\mu_k = 0.50$) but none elsewhere. Let g =10 m/s^2



1. At what minimum F will the top box just begin to slip?



The minimum happens when static friction is maximum, or $f = \mu_s N_1 = 0.8 \cdot 1 \cdot 10 = 8N$ so

$8 = m_1 a$

$F - 8 = m_2 a \Rightarrow F = (m_1+m_2)a$ but $a = \frac{8}{m_1} = 8\,m/s^2$ so $F = 3 \cdot 8 = \boxed{24N}$

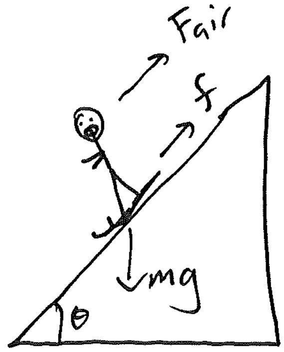
2. What will be the resulting acceleration of the bottom block using F of question 1 above (i.e., when the top block slips)?

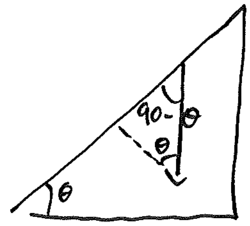
Let the block slip, or $f_s \to f_K$ $\quad a \to a_1, a_2$ so

$F - f_K = m_2 a_2 \Rightarrow a_2 = \frac{F - \mu_K m_1 g}{m_2} = \frac{24 - 0.5 \cdot 1 \cdot 10}{2} = \frac{19}{2} = \boxed{9.5\,m/s^2}$

E) (OPTIONAL) A skier, up on a high mountain, is skiing directly down a uniform 30° slope with a coefficient of sliding (kinetic) friction μ_K=0.10. Their cross-sectional area is 1.0 m^2, the density of air at this altitude is 1.0 kg/m^3 and the skier's coefficient of drag is 0.50. An observer, at rest on the hill, observes a constant 8.8 m/s breeze which is blowing directly up the slope. Under these conditions what will be the terminal speed of the skier?

On back $\quad$ Use $\boxed{m = 50\text{ kg}}$





so in plane

$N = mg\cos\theta$ so

$$mg\sin\theta - F_{air} - \mu_k N = ma$$

$$mg(\sin\theta - \mu_k\cos\theta) - \frac{1}{2}\rho C_v A v^2 = ma$$

For terminal velocity, $a=0$ (velocity constant!)

so

$$v^2 = \frac{2mg(\sin\theta - \mu_K\cos\theta)}{\rho C_v A}$$

$$= \frac{2\cdot 50\cdot 10(\sin 30^\circ - 0.1\cos 30^\circ)}{1\cdot 0.5\cdot 1}$$

$$= 826.8\,(m/s)^2 \Rightarrow v = 28.8\ m/s$$

But, the wind is blowing at the shier, so tle wind seems 8.8 m/s fast than in still air so te shier has an actual terminal velocity of $v_{term} = v - 8.8 = \boxed{20\ m/s}$