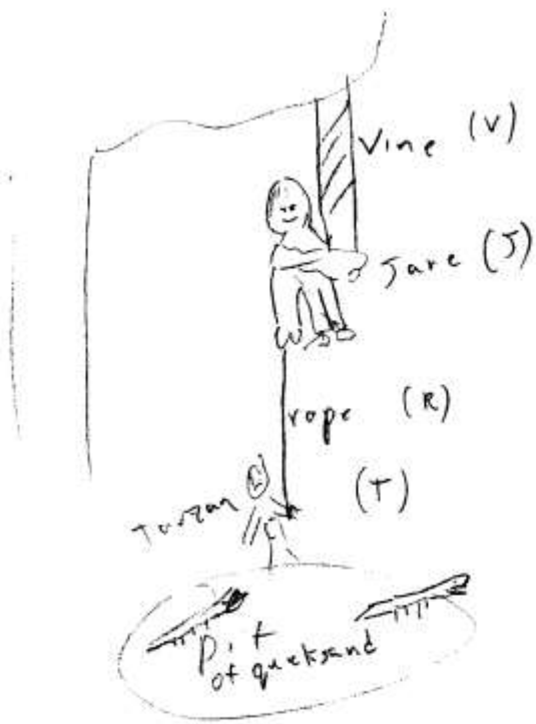
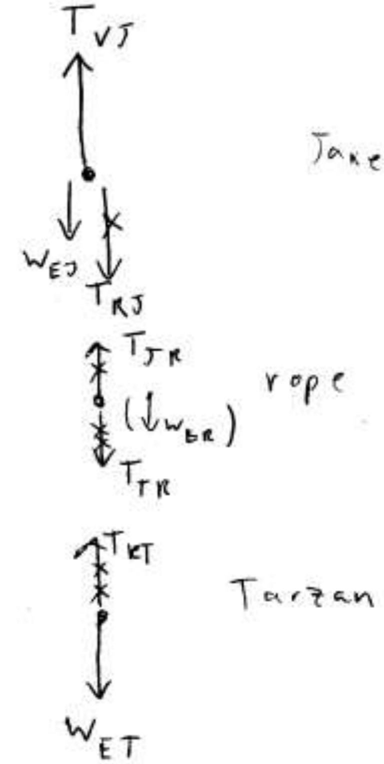
Name Solution

1. Jane clings to a vine hanging from a tree with one hand. With her other hand she clings to a rope. On the other end of the rope dangles Tarzan, mere centimeters from a crocodile-filled pit of quicksand (10 points).





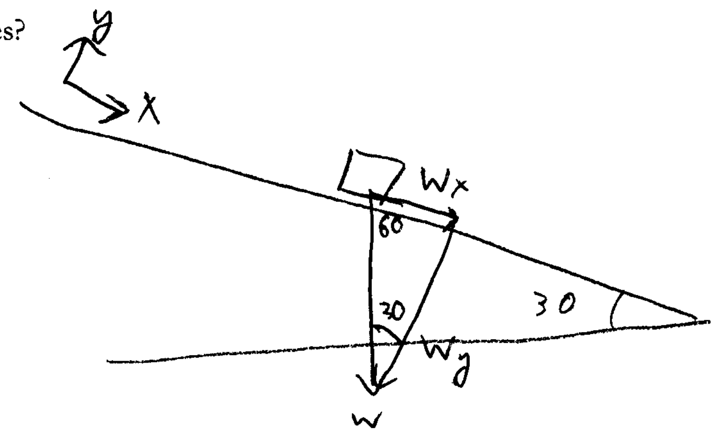
Draw the force diagrams for Jane, the rope, and Tarzan.

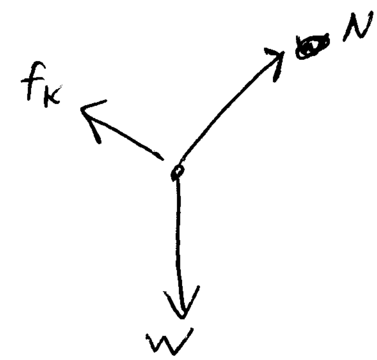
1) All forces should be labeled as weights (W), normal forces (N), frictional forces (f), or tension forces (T).
2) Use the subscript notation to indicate the object being affected by and causing the force. For example W_{GE} might be the weight of a giraffe caused by the earth. Use the following subscripts: V=vine, J=Jane, R=rope, T=Trazan, E=Earth.
3) Label any action reaction pairs that are in the diagrams by drawing an X through the arrows representing the forces. If there is more than one pair, the second pair should be labeled XX, the third labeled XXX, etc.

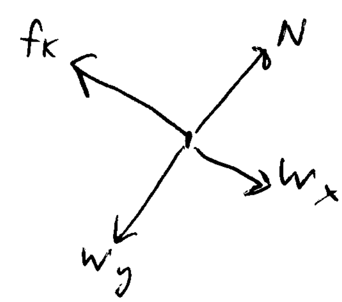
2. A karate master strikes a board with her hand and the board shatters. What was greater: the force of her hand on the board, the force of the board on her hand, or neither. Explain your answer using Newton's Laws (3 points).

The magnitudes of the forces are equal: the forces are 3rd Law action - reaction pairs.

3. A block slides down a slope that makes and angle of 30 degrees with the horizontal. If the coefficient of kinetic friction between the block and the block is 0.3, what is the acceleration of the block as it slides?







$W_x = W \sin 30$

$W_y = w \cos 30$

N's second:

$-f_K + W_x = ma_x$ } from $F_{net,x} = m a_x$

$N - W_y = ma_y = 0$ } from $F_{net,y} = m a_y$

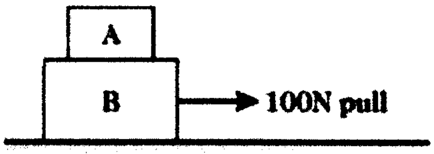
so $N = W_y = W \cos 30 = mg \cos 30$

$f_K = \mu_K N$. so, plugging this in to the equation for the x-direction gives

$-\mu_K mg \cos 30 + mg \sin 30 = m a_x$

$\Rightarrow a_x = g(\sin 30 - \mu_K \cos 30) = 2.35 \, m/s^2$

3) Two blocks, A and B, are being pulled to the right with **constant velocity** along a horizontal surface by a horizontal 100 N pull from a rope, as shown in the figure. Box A has a mass of 10 kg and box B has a mass of 20 kg. Do not assume friction is negligible between the various surfaces (although it might be zero in some situations).



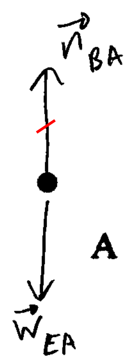
a) According to Newton's first law, what is the net force on block A? What about block B? Think carefully! This is the key to the whole problem! (1 point).

The blocks are moving with constant velocity. So $F_{net} = 0$ for both!

b) Draw free body diagrams for boxes A and B in the space provided below. Label all forces with subscripts. Note any action-reaction pairs with slashes. **Check that your diagrams are consistent with your answer to part A!** (2 points)

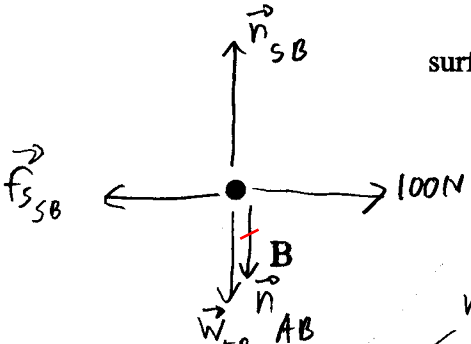
c) What is the magnitude of the force of friction of the surface acting on box B? **Check that your answer is consistent with your answer to part A!** (1 point)

Since $F_{net} = 0$ $f_{s_{SB}}$ must be 100N to counteract the 100N pull



d) What is the magnitude of the force of friction of box B acting on box A? **Check that your answer is consistent with your answer to part A!** (1 point)

Zero! There is no friction needed to keep A moving @ constant velocity.



e) What is the coefficient of kinetic friction between the surface and block B? (2 points).

$f_{s_{SB}} = \mu_s n_{SB}$.

Looking at the vertical forces

$n_{SB} - W_{EB} - n_{AB} = m_B a_{By} = 0$

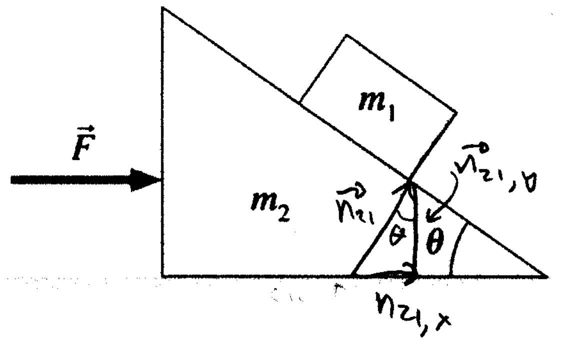
and

$n_{BA} - W_{EA} = m_A a_{Ay} = 0$

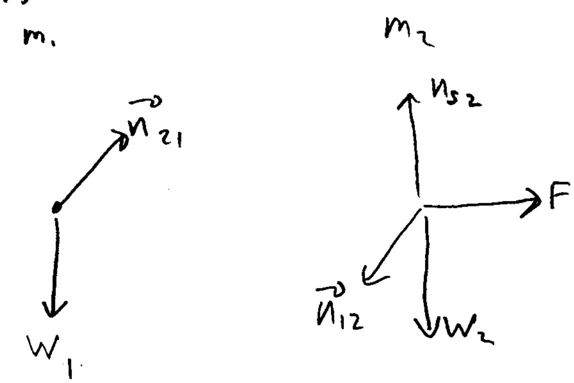
So $n_{BA} = W_{EA} = m_A g$ and $n_{SB} = W_{EB} + n_{AB} = m_B g + m_A g$

$\rightarrow$ so $\mu_s = \frac{f_{s_{SB}}}{n_{SB}} = \frac{f_{s_{SB}}}{m_B g + m_A g} = \frac{100\,N}{(30kg)\,9.8\,m/s^2} = 0.34$

5. **Find an expression for the magnitude of the horizontal force F in the figure below for which m_1 does not slip either up or down along the wedge. All surfaces are frictionless. Your answer may contain the constants m_1, m_2, θ, and g, although it does not necessarily need to include all of these constants.**



FBDs:

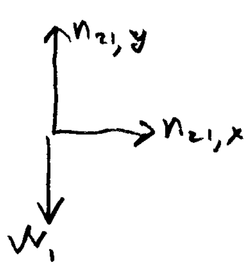


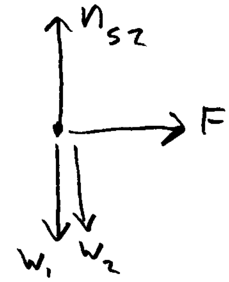
I'll use a standard $\uparrow\!\!\rightarrow x$ coord system since, to stay "stuck" on ~~the~~ the block m_2, block 1 is going to have to have the same a_x and $a_y = 0$ as block 2.

Components of $\vec{n}_{21}$: see above for diagram:

$n_{21,x} = n_{21}\sin\theta \qquad n_{21,y} = n_{21}\cos\theta$

New FBD for m_1: Let us also consider the system $m_1 + m_2$:





N's 2nd ~~give~~ on m_1 and the system gives

$\Sigma F_{1,y} = n_{21,y} - W_1 = m_1 a_{1,y} = 0 \Rightarrow n_{21,y} = W_1 = m_1 g = n_{21}\cos\theta$

$\Rightarrow n_{21} = m_1 g/\cos\theta$

sub in

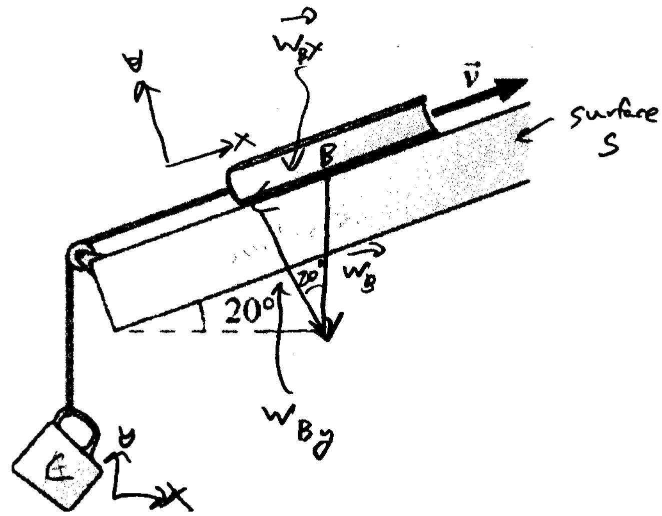
$\Sigma F_{1,x} = n_{21,x} = n_{21}\sin\theta = m_1 a_x \Rightarrow a_x = \dfrac{n_{21}\sin\theta}{m_1} = \dfrac{m_1 g \frac{\sin\theta}{\cos\theta}}{m_1} = g\tan\theta$

sub in

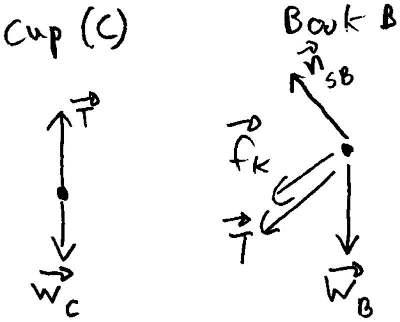
$\Sigma F_{sys,x} = F = M_{sys}\, a_x = M_{sys}\, g\tan\theta$

$$\boxed{F = (m_1 + m_2) g \tan\theta}$$

6. The 1.0 kg physics book in figure is connected by a string to a 500 g coffee cup. The book is given a push up the slope and released with a speed of 3.0 m/s. The coefficients of friction are $\mu_s = 0.50$ and $\mu_s = 0.20$.



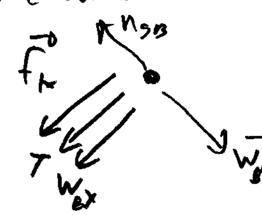
a) How far does the book slide?



We'll use tilted co-ords for the book but regular co-ords for the cup

we see from the figure $W_{Bx} = W_B \sin 20$. $W_{By} = W_B \cos 20$

so the books FBD is



N's 2nd: (1) $F_{net,c,y} = T - W_c = m_c a_{cy}$

(2) $F_{net,B,x} = -f_K - T - W_{Bx} = m_B a_{Bx}$

(3) $F_{net,B,y} = n_{SB} - W_{By} = m_c a_{cy} = 0$ b/c the book will stay on ramp.

also $f_K = \mu_K n_{SB}$ and $a_{cy} = a_{Bx}$ b/c they are attached and when C moves in the +y direction, B will move in the +x direction also

Find frictional force: From (3), $n_{SB} = W_{By} = W_B \cos 20 = m_B g \cos 20$

so $f_K = \mu_K n_{SB} = \mu_K m_B g \cos 20$

Now solve (1) for T: $T = m_c a_{cy} + W_c = m_c a_{cy} + m_c g = m_c a_{Bx} + m_c g$

sub into (2): $-f_K - (m_c a_{Bx} + m_c g) - W_{Bx} = m_B a_{Bx}$

$\Rightarrow -\mu_K m_B g \cos 20 - m_c a_{Bx} - m_c g - m_B g \sin 20 = m_B a_{Bx}$

$\Rightarrow -m_B g(\mu_K \cos 20 + \sin 20) - m_c g = (m_B + m_c) a_{Bx}$

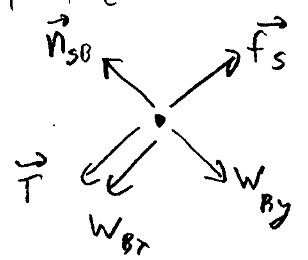
$$\Rightarrow a_{Bx} = \frac{-(m_B g(\mu_K \cos 20 + \sin 20) + m_c g)}{m_B + m_c} = -6.73 \text{ m/s}^2$$

Now use the kinematic eqn $\cancel{V_D^2}^{\,0} = V_A^2 + 2 a_x \Delta x$

This problem is continued on the next page $\Rightarrow \Delta x = \frac{-V_A^2}{2a_x} = 0.669$ m

b) At the highest point, does the book stick to the slope, or does it slide back down? Explain your reasoning.

At the highest point, $\vec{V} = 0$, so the static friction has a "chance" to stop the book. At this moment the FBD of the book is:



The question is, is it possible for $a_{Bx} = 0$ if $f_s \le \mu_s n_{SB}$?

Let's assume $a_{Bx} = 0$ and see what the friction force needs to be:

Cup: (FBD is the same) $\quad T - w_c = m_c a_{cy} = m_c a_{Bx} = 0 \quad \Rightarrow T = w_c = m_c g.$

$$\Sigma F_{z,x} = f_s - T - w_{Bx} = m_B a_{Bx} = 0$$

$$\Rightarrow f_s = T + w_{Bx} = m_c g + m_B g \sin 20$$

$$= 8.75 N.$$

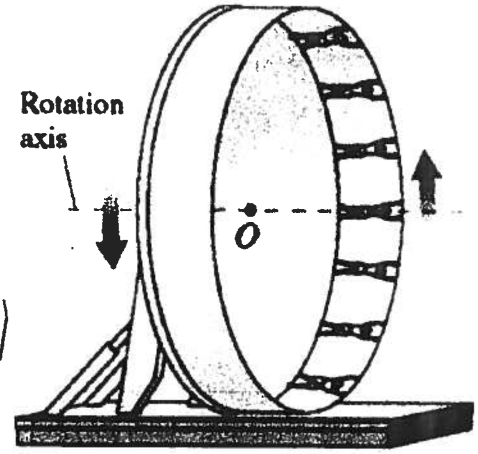
what is $f_{s,max}$? $\quad f_{s,max} = \mu_s n_{SB} = \mu_s m_B g \cos 20$

$$= 4.60 N$$

this is insufficient static friction to prevent acceleration of the book, so the book will not stop, and will slide back down.

We'll need the person's speed. The person covers a distance of $\pi(16\text{m}) = 16\pi$ meters in 4.5 s so $v = \frac{dist}{\Delta t} = 11,17\ \text{m/s}$

7. In an amusement park ride called The Roundup, passengers stand inside a 16-m diameter ring. After the ring has acquired sufficient speed, it tilts into a vertical plane as shown in the figure. Suppose the ring rotates once every 4.5 s.



a) If a rider's mass is 55 kg, with how much force does the ring push on her i) at the top of the ride and ii) at the bottom?

At the top:

$\vec{w}$ $\vec{n}$

N's second says

$|F_{net,y}| = |-w-n| = |ma_y|$

$\Rightarrow w + n = m|a_y|$

and $|a_y| = v^2/r$ if we are in uniform circular motion, so $w + n = mv^2/r$

so $n = mv^2/r - w = mv^2/r - mg = 318.8\ N$

At the bottom $\vec{n}$ $\vec{w}$ so $|F_{net,y}| = |n - w| = |ma_y|$

$\Rightarrow n - w = ma_y$

$\Rightarrow n = ma_y + w = m\frac{v^2}{r} + mg = 1396.8\ N$

(n must be largest here b/c it has to provide cent. force and counteract weight)

b) What is the longest rotation period of the wheel that will prevent the riders from falling off at the top?

If the person barely doesn't fall off, then $\vec{w}$ ~~just~~ provides ~~the~~ just enough force to provide the centripetal force $\frac{mv^2}{r}$. $\vec{n}$ will be zero. so $w = mg = \frac{mv^2}{r} \Rightarrow v = \sqrt{gr} = 8,85\ \text{m/s}$

At that speed, it will take for ~~the~~ a revolution

$T = \frac{\pi d}{v} = 5,68\ s$