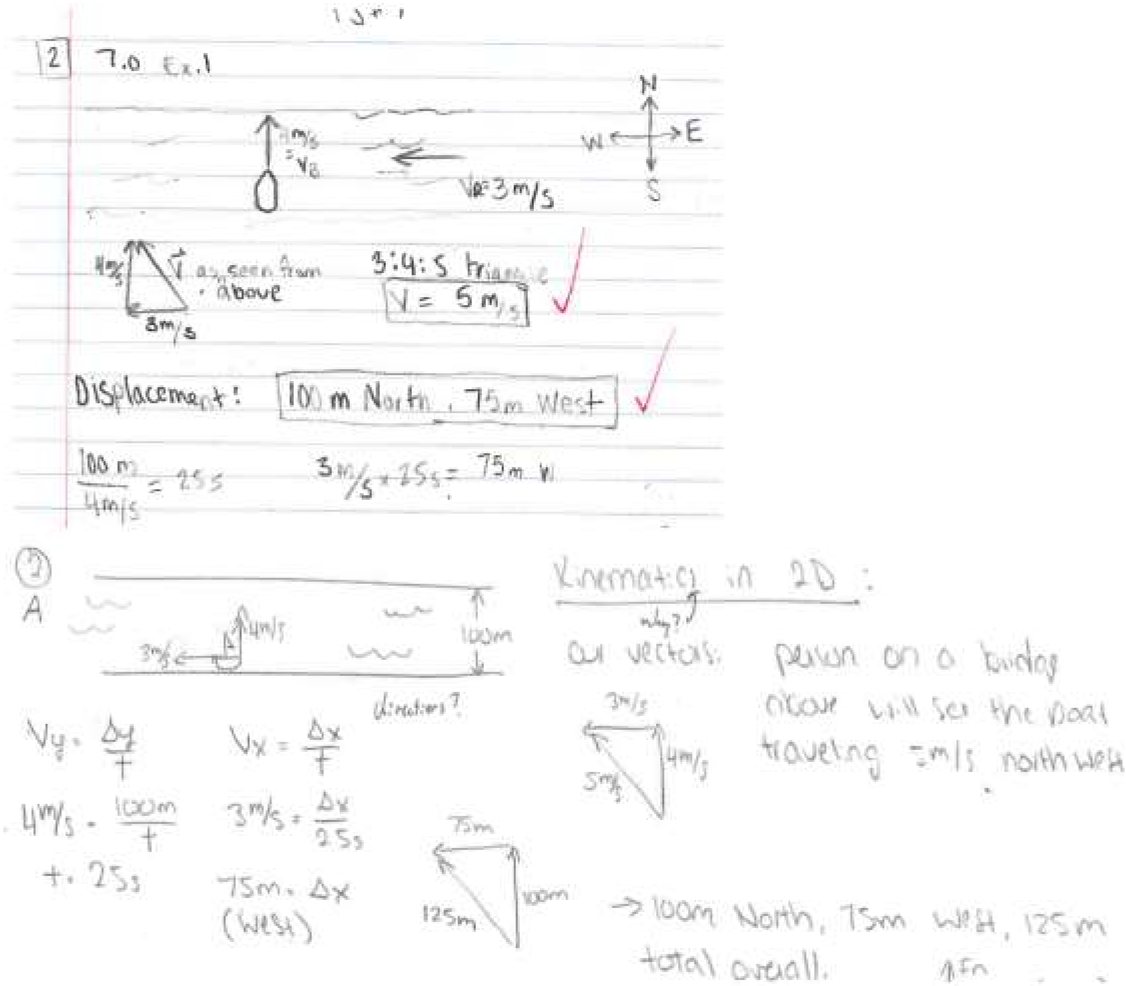
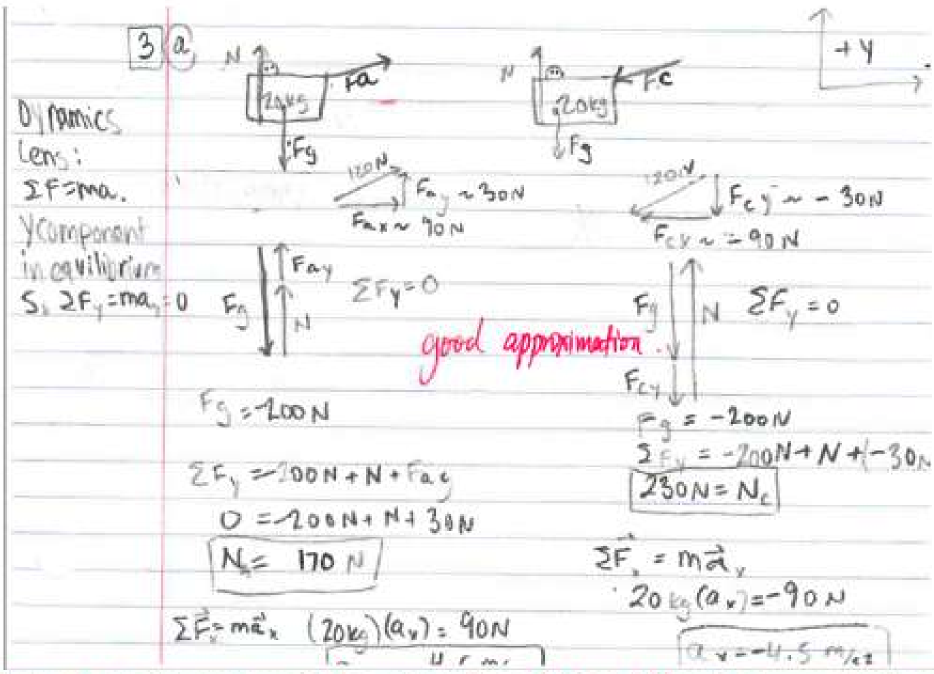
PS#8 Due in Class Monday, March 2 Please pay good attention to describe the lens you are using and explain your method.

**** Make sure to consider the direction of acceleration to inform your choice of axis. Do you remember how to pick a good axis?

1. 7.0 Exercise 1

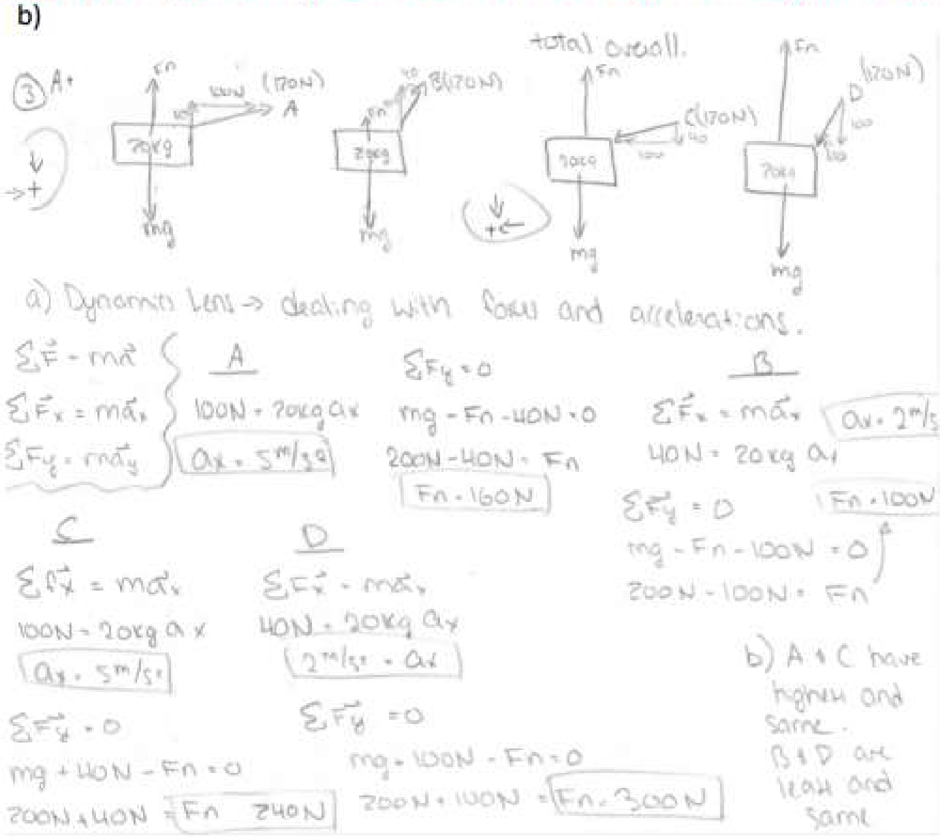


2. 7.0 Exercise 2, pushing my daughter on a sled

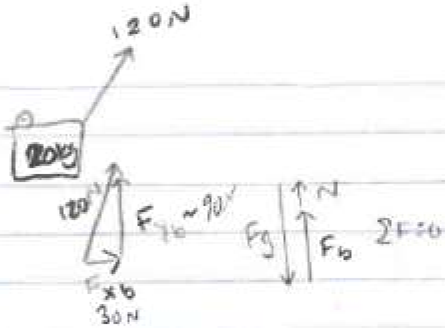


Both a) and c) scenarios yield accelerations of 4.5 m/s^2 for the approximations made by this student.

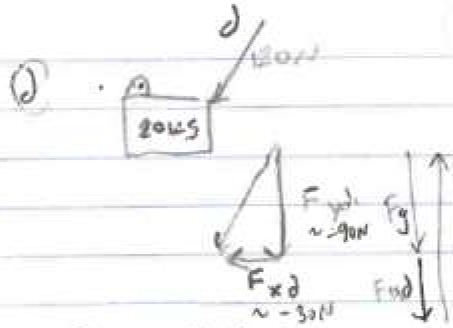
b)



b.



(d)



$\Sigma F_y = 0 = N + G + F_{yB}$

$200 + (-90N) = N$

$\boxed{N_B = \sim 110N}$

$\Sigma F_y = 0 = N + F_g + F_{yD}$

$200 + 90N = N$

$\boxed{N_D = \sim 290N}$

$\Sigma F_x = ma_x = F_{xb}$

$a_x = 30N/20kg$

$\boxed{a_x = 1.5 m/s^2}$

$F_x = ma_x = F_{xd}$

$a_x = -30N/20kg$

$\boxed{a_x = 1.5 m/s^2}$

(b) $\boxed{(\vec{a}_A = \vec{a}_C) > (\vec{a}_B = \vec{a}_D)}$ ✓

(c) This changes things since a greater upward component of force will decrease normal force ∴ decrease frictional force in the x direction. ✓

$\boxed{\vec{a}_B > \vec{a}_A > \vec{a}_C > \vec{a}_D}$ ✗ Draw FBDs.

(d) Flip the lawn mower around and pull like scenario A and B. This pull has an upward y-component, decreasing N and decreasing Ffriction since $F_f = \mu N$. ✓

c) If the coefficient of kinetic friction is 0.2 then
$F_{fr} = (0.2)(F_n)$

A

$F_{fr} = (0.2)(160N) = 32N$
$\Sigma F_{\vec{x}} = m\vec{a}_x$
$100N - 32N = 20kg\, a_x$
$68N = 20kg\, a_x$ $\boxed{a_x = 3.4 m/s^2}$

B

$F_{fr} = (0.2)(100N) = 20N$
$\Sigma F_{\vec{x}} = m\vec{a}$
$40N - 20N = (20kg)\, a_x$
$20N = 20kg\, a_x$ $\boxed{a_x = 1 m/s^2}$

C

$F_{fr} = (0.2)(240N) = 48N$
$\Sigma F_{\vec{x}} = m\vec{a}_x$
$100N - 48N = (20kg)\vec{a}_x$
$52N = (20kg)\, a_x$ $\boxed{a_x = 2.6 m/s^2}$

D

$F_{fr} = (0.2)(300N) = 60N$
$\Sigma F_{\vec{x}} = m\vec{a}_x$
$40N - 60N = (20kg)\, a_x$
$-20N = (20kg)\, a_x$ $\boxed{a_x = -1 m/s^2}$

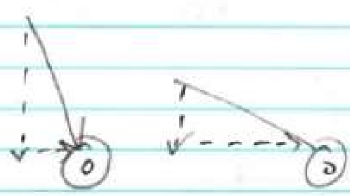
Friction is resistive so it can't accelerate the object backwards

e) Have you ever pushed a lawn mower (or watched someone do it)… you are using force scenario d, pushing along the handle. When you run into some thick grass the "coefficient of friction" might be high enough to stop you cold. What scenario can you change to, and why does this work?

d) You can change to scenario C because you are applying less downward force and therefore there is a smaller Normal force and thus a smaller friction too which increases the ΣF_x.

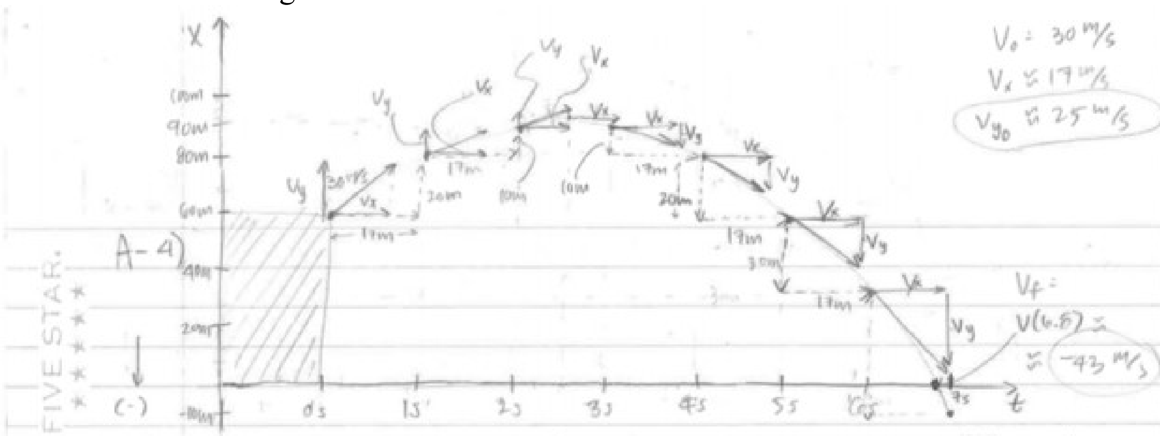
Yes, that idea is the first thing you will do… lower the handle to reduce the downward component of the pushing force…. but my guess is you have never mowed a thick lawn in Buffalo N.Y. when it's been raining a lot. Scenario "C" is not enough. Eventually, you would turn the lawn mower around and pull it in scenario "A".

When pushing a lawn mower, it can be beneficial to lower the handle on the rougher patches.
The amount of downward force decreases, which lowers the normal force acting on the mower and allows you to push it easier!



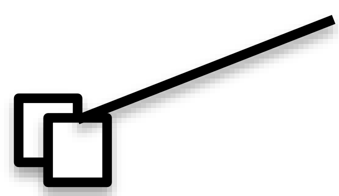
**** Make sure to consider the direction of acceleration to inform your choice of axis. Do you remember how to pick a good axis?

3. 7.0 Exercise 3. Throwing a rock off a cliff



$V_f = V_0 + gt$	$V_{avg} = (V_i + V_f)\frac{1}{2}$	$\Delta x = (V_{avg})(t)$
1 s : V_y = 25 m/s + (-10 m/s²)(1 s) = 15 m/s	½(25 m/s + 15 m/s) = 20 m/s	(20 m/s)(1 s) = 20 m
2 s : V_y = 25 m/s + (-10 m/s²)(2 s) = 5 m/s	½(15 m/s + 5 m/s) = 10 m/s	(10 m/s)(1 s) = 10 m
2.5 s : V_y = 25 m/s + (-10 m/s²)(2.5 s) = 0 m/s	½(5 m/s + 0 m/s) = 2.5 m/s	(2.5 m/s)(1 s) = 2.5 m
3 s : V_y = 25 m/s + (-10 m/s²)(3 s) = -5 m/s	½(0 m/s - 5 m/s) = -2.5 m/s	(-2.5 m/s)(1 s) = -2.5 m
4 s : V_y = 25 m/s + (-10 m/s²)(4 s) = -15 m/s	½(-5 m/s - 15 m/s) = -10 m/s	(-10 m/s)(1 s) = -10 m
5 s : V_y = 25 m/s + (-10 m/s²)(5 s) = -25 m/s	½(-15 m/s - 25 m/s) = -20 m/s	(-20 m/s)(1 s) = -20 m
6 s : V_y = 25 m/s + (-10 m/s²)(6 s) = -35 m/s	½(-25 m/s - 35 m/s) = -30 m/s	(-30 m/s)(1 s) = -30 m
7 s : V_y = 25 m/s + (-10 m/s²)(7 s) = -45 m/s	½(-35 m/s - 45 m/s) = -40 m/s	(-40 m/s)(1 s) = -40 m

4. You are watching the fuzzy dice from the rearview mirror. As you take off on level ground, it makes an angle as shown at right.
   a) **** state how you will inform your choice of axis.
   b) Estimate the acceleration of the car.
   c) What must be the coefficient of friction of your tires for this to happen?
   d) Is this realistic?
   e) If the mass of the dice is 100 g, what is the tension in the string?



5. 7.1 Exercise 1 Pushing sled using energy

We will use an energy lens because the work I do will be transferred to kinetic and thermal energy. We recognize that work is the parallel component of the force times the distance. It looks as though the 40 N tension on the rope provides a little less than 30 N forward and a little more than 30 N upward, Let's say 28 N forward, and 32 N upward. Thus, the 10 kg sled is in equilibrium in the vertical direction with 100 N of gravitational force downward, 32 N of vertical tension upward, and 68 N of normal force (upward). The work done is ~ 280 J

a) Without friction, this would yield 280 J of E_K, corresponding to a final speed of 7.5 m/s.

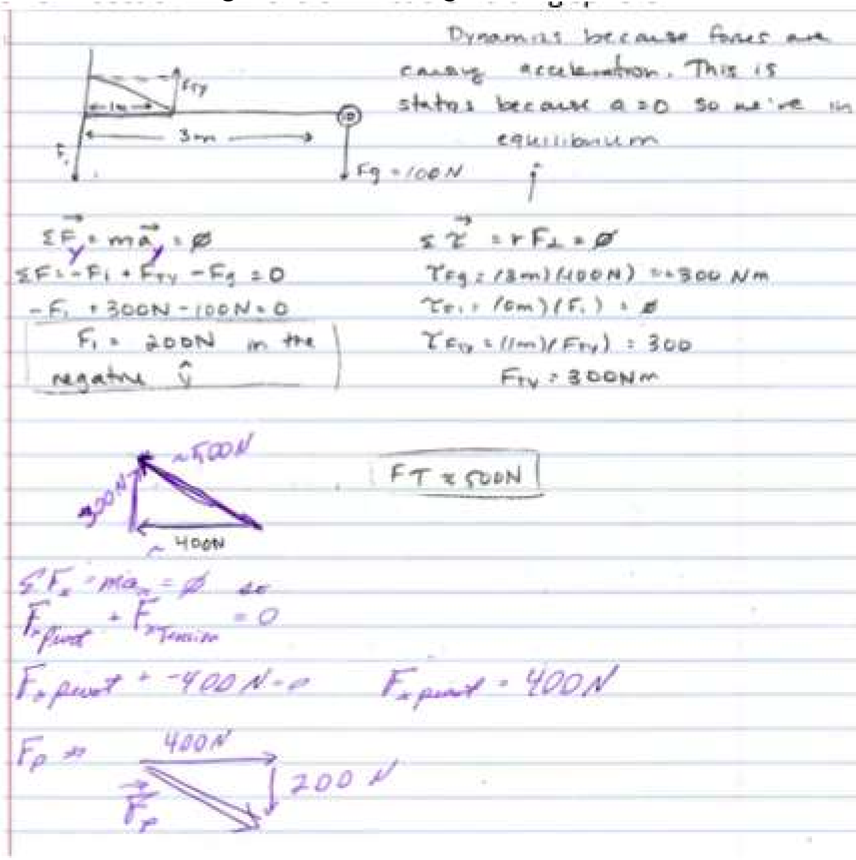
b) The force of friction with a coefficient of friction of 0.15 is about 10 N, yielding 100 Joules of heat (work of friction), leaving only ~180 J of E_K corresponding to a final speed of 6.0 m/s.

6. 7.1 Exercise 2 finding torque

Most of the “mistakes” for this were estimating or just getting the numbers wrong. For starters, a diameter of 1 m means a *radius* of 0.5 m. Then we can see that d) probably has a perpendicular force of only 10 m and c) has a perpendicular force of about 25 N.

a) $\vec{\tau} = 5Nm\otimes$
b) $\vec{\tau} = 0$
c) $\vec{\tau} = 12.5Nm\odot$
d) $\vec{\tau} = 10Nm\otimes$

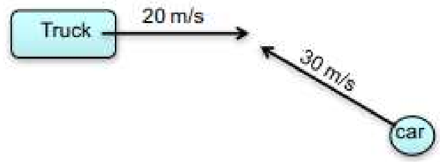
7. 7.1 Exercise 3 Finding tension on string



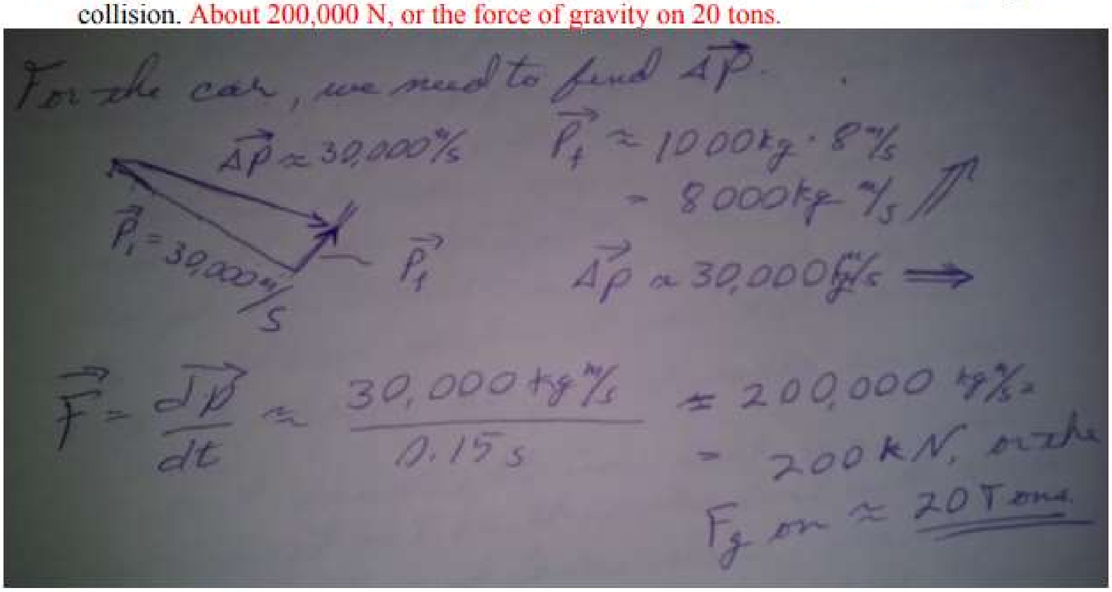
8. 7.1 Exercise 4 Collision on ice

7. Please do Exercise #4 in section 7.1: Collision on ice

On a very slippery road, a 1000 kg car and a 2000 kg truck have a collision and stick to each other as shown at right

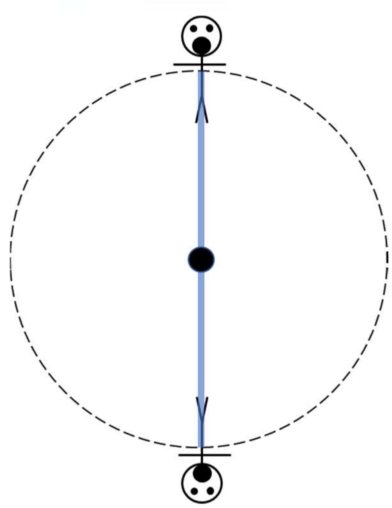


- Could the wreckage have gone off in this direction? How do you know? We are going to conserve momentum here because there are negligible outside forces. Neither of the vehicles have a velocity component in the negative y direction, so this could not be the correct direction.
- Estimate the general direction that the wreckage went after collision. Because we need to conserve momentum, we need to turn this diagram from velocity to momentum. The truck has momentum of 40,000 kg m/s, and the car has 30,000 kg m/s. and ***NO***, this doesn't mean the total momentum is 70,000 kg m/s. If we draw this picture correctly and add the momenta correctly, we should end up with a total momentum of about 25,000 kg m/s in about this direction: Corresponding to a final velocity of about 8 m/s in the same direction.
- Find the impulse that the car received during the collision. Making a good momentum diagram, we can see the change in momentum of the car is about 30,000 kg m/s
- If the collision lasted 1/15 of a second, estimate the average force on the car during the collision. About 200,000 N, or the force of gravity on 20 tons.



9. *Please see Solutions to Assessment #8 for these.*

Your 50 kg friend is considering a new ride at the amusement park, kind of like a Ferris wheel that takes you in a circular path high in the sky except in *this* ride, you are tied at your waist onto a rotating bar and are inverted at the bottom as shown. The bar can either pull or push on your body. The ride is 10 m across and maintains a constant speed of 10 m/s where the people are.



i. At which position (top or bottom) would the force the bar puts on your friend's body be the greatest or is this force always the same? Please fully explain your reasoning.

ii. Find the force the bar puts on your friend in the position it pushes/pulls the hardest

10. *Please see Solutions to Assessment #8 for these.*

Two identical masses, A and B, hang from strings wrapped around the outer edge and inner pulley of a freely rotating flywheel as show. The pulley is connected to the flywheel and they rotate as a single body. The flywheel/pulley is released from rest. Which string A or B has a greater tension, or are they the same tension? Please fully explain your answer.