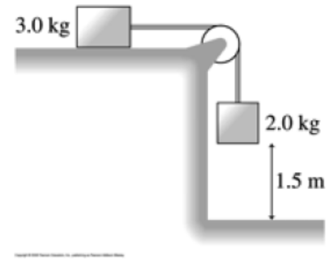
You will be graded on your *COMMUNICATION* of physics understanding

For a full "A", please estimate numerical answers in decimal form



#1 Two objects, one with a mass of 3 kg and the other with a mass of 2 kg, are connected by a light string over a low mass pulley, as shown in the figure at right. A coefficient of friction of 0.20 exists between the horizontal surface and the 3 kg mass. If the system starts at rest, Many people wrote, "conserve energy because there are no outside forces…" but is this true? What about the force of gravity? No outside forces usually means that momentum is conserved. However, energy is conserved even if you have an outside force – you just have to account for where that energy came from. For instance, for the barbell in space pulling the spinning masses closer together, there is no outside force, but the motor connected to the strings provides work with an internal force between the masses. So here you can change the energy of system without even having an outside force… Energy is conserved all the time, but you have to account for where it came from and where it goes. In short: when is energy conserved?: always!

a) Please calculate the speed of the hanging mass when it hits the floor. Answer is about 2.9 m/s

b) Let's say your friend calculates the tension in the string and asks you if you think the answer is correct. You might compare it to some other forces in the problem above. What other force(s) would you compare it to and how should the tension compare?

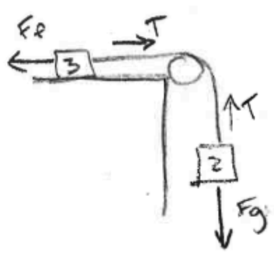
I will be using an energy lens, as the provided coefficient of friction allows us to calculate the thermal energy lost & thus the energy flow from Gravitational potential to kinetic.

a) $E_{TOTAL} = E_P = E_T + E_K$

THERMAL $= N\mu \cdot d = 30N(.2)\cdot 1.5m$

$= 9J$

$= 2.0kg \cdot 10 m/s^2 \cdot 1.5m = \boxed{30J}$



$30J = 9J + E_K$

mass of system

$21J = E_K = \frac{1}{2} m v^2$

$42J = 5.0kg\, v^2 = \frac{42 m^2}{5 s^2}$

$\boxed{v = \sqrt{\frac{42}{5}}\ m/s}$

≈? please estimate answer in decimal

A-

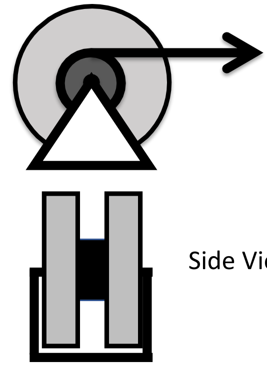
b) Using a dynamics lens because there are forces ~~present~~. ⇒ $\vec{a}$

- The tension must be less than the force of gravity on the 2 kg block as the sum of the forces is downwards ∴ $F_T < 20N$
- The tension must be greater than the force of friction on the 3kg block as the block accelerates in the direction of tension ∴ $F_T > 6N$

good....

#2 A yo-yo device is mounted on a stand and I pull on a long string wrapped around the center with a force of 8 N. The yo-yo starts from rest, has a mass of 2 kg, and center shaft and body radii of 20 cm and 40 cm, respectively. The word "train wreck" comes to mind… Where to start… concepts! Lots of metric system mistakes. There are 100 cm in a meter.

I never should have had it be a 2m string… I didn't *mean* that I pulled it 2m… You were supposed to ignore that. Full disclosure: if you work it out correctly finding the correct angular acceleration, you will find that you need to pull 4 m of string! If you made this false assumption and did everything right, you received a good grade, but please do the problem again and understand how to do this stuff for the final exam. We need to review some basic stuff as many students are mixing up angular acceleration, angular velocity, linear velocity, linear acceleration… these all have different units, they are different things.



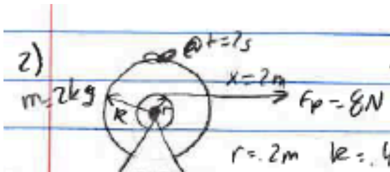
Side View

a) After I pull for 2 seconds, find the wheel's angular velocity. This is going to be a rotational dynamics lens because the torque I'm providing by pulling the string causes angular acceleration of the wheel (which we want). Many people wrote "no outside torques"… but I'm pulling on the string. Isn't this an outside torque?

b) If a bug is on the top of the wheel at that moment (2 seconds), find the bug's acceleration, indicating the correct x and y directions. No one got this completely right. There are two kinds of linear acceleration for the bug. Is it accelerating in the + x direction? Why? How about the -y direction? This is all just kinematics, because we have the equations of motion already.

c) Find the power I am putting into the yo-yo at t = 2 s. Careful how you do this because we can talk about power as the rate of change of energy. You could use the work you put in divided by 2 s, but that would be the *average* power. Is the power constant? How do you find instantaneous power?

2)



t=2s

r=.2m R=.4m

a) lens: dynamics, torque causes angular acceleration

$\Sigma\tau = Fr$ $\quad\quad$ $I = \frac{1}{2}mr^2$

$\tau = 8N(.2m)$ $\quad\quad$ $I = \frac{1}{2}(2kg)(.4m)^2$

$\tau = 1.6 N{\cdot}m$ $\quad\quad$ $I = 0.16\,kg\,m^2$

$\tau = I\cdot\alpha$

$1.6 N.m = 0.16\,kg\,m^2\cdot\alpha$

$\alpha = 10/s^2$

$\alpha = \frac{\Delta w}{\Delta t}$

$10/s^2 = \frac{\Delta w}{2s}$ $\quad$ $\boxed{\Delta w = 20/s}$

b) lens: kinematics, motion as an explicit function of time

$a_t = r\alpha$ $\quad\quad$ $a_c = rw^2$

$a_t = 0.4m(10/s^2)$ $\quad\quad$ $= 0.4m(20/s)^2$

$\boxed{a_t = 4\,m/s^2 \text{ in the x-direction, right}}$ $\quad\quad$ $\boxed{a_c = 160\,m/s^2 \text{ in the y-direction downward}}$

c) lens: energy, there is a transformation of energy, energy is conserved

$Power_{ave} = \frac{work}{time} = \frac{F\cdot dx}{t} = \frac{8N(2m)}{2s} = 8\text{ watts}$

$Power_{(inst)} = \vec{\tau}\cdot\vec{w} = 1.6 N{\cdot}m(20/s) = \boxed{32\text{ watts}}$

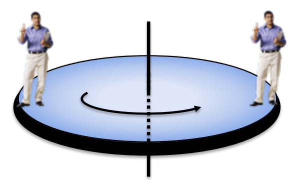
#3 A satellite in a circular orbit around a planet is moved to a lower orbit, half as far from the planet's center: $R \Rightarrow \frac{1}{2} R_o$ *Clearly Explain Both Answers Below.*

a) By what factor did the gravitational attraction to the planet change: $F \Rightarrow$ ___F_o

b) By what factor did the satellite's speed change: $v \Rightarrow$ ___v_o

This would require a dynamics lens because the force of gravity causes centripetal acceleration. Using the inverse square relation, the gravitational pull of the planet would increase by a factor of 4. Then equating this to centripetal acceleration v^2/r… but remember that r has also decreased by a factor of 2. The resulting speed would then increase by a factor of $\sqrt{2}$.

#4 A playground carousel is an 80 kg uniform flat disk (r = 2 m) on a freely rotating axis. Two kids, each of mass 20 kg are standing on the top opposite edges of the carousel and are rotating with the carousel as shown.



a) Both kids decide that they don't want to be rotating anymore, so they begin running in the opposite direction of the carousel's rotation such that they are no longer moving with respect to the ground. When they start running, does the rotational speed of the carousel change? If not, how do you know? If so, does it increase or decrease and by about what factor? You could use a rotational dynamics lens (because the torque between the kids and carousel causes angular acceleration.) or angular momentum because there are no outside torques, so….? In the end, in order to get a ratio, you will see that you need to use the angular momentum lens.

b) Was kinetic energy conserved in this transition? If so, how do you know? If not, did it increase or decrease and by about what factor – and where did the kinetic energy go or come from? You could just go calculate the energies… but it's easier if you use ratios… first of all, do the kids do positive work or negative work as they push themselves around? Think about what goes on between their feet and the carousel. But in the end figure out by what factor the rotational velocities and moment of inertias change.
… it might be good to see the ratio between the moment of inertias of the kids and the moment of inertia of the carousel.

A) Angular momentum lense because outside torques are neglesible
The angular speed of the carosel would increase becase both the kids and the cerosel had angular momentum but when the kids started running they lost their angular moment and it was transfered into the carousel.

4

$L = I\omega$

The rotation speed of the carousel would increase by a factor of two since the moment of Inertia was decreased by a factor of 1/2

$I = mr^2$ $\quad I = \frac{1}{2}mr^2$

$I = 2(20kg)(2^2 m)$ $\quad I = \frac{1}{2}(80kg)(8m^2)$

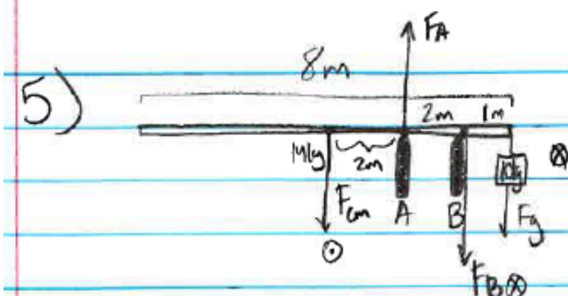
$I_{kids} = 160\ kgm^2$ $\quad I_{carosel} = 160$

Rotational Energy lense $K_I + W_J \Rightarrow K_f$

B) Kinetic energy was not conserved because moment of Inertia of the system was decreased by a factor of 1/2 and angular velocity increased by a factor of 2 so the kinetic energy would increase by a factor of 2. The energy came from the work the children do on the disk by running

#5 A uniform plank ***has a mass of 14 kg***, is 8 m long, and is supporting a 10 kg hanging mass as shown. The supporting structures (A and B) are bolted onto the plank and are located 1 m and 2 m from the right edge where the 10 kg mass is attached. Find the forces (*and include direction*) that each support supplies. The most common mistake was that in addressing the torques due to the force of gravity on the 10 kg mass and the mass of the board. Yes, both of these forces are downward and in the same direction. However, if you pick the pivot at A or B, are the torques from these forces in the same direction? Notice how the person's work below identified the direction of the torques in the diagram, recognizing that the force of B must be downward.

5)



this is a statics promblem

Using angular dynamics and dynamics I know that $a=0, \alpha=0$ and since $F \Rightarrow a$ + $\tau \Rightarrow \alpha$, $\Sigma\tau=0$ + $\Sigma F=0$. Therefore,

$\Sigma F = 0 = F_A - F_{cm} - F_B - F_g$

$0 = F_A - 140N - 80N - 100N$

$0 = F_A - 320N$

$F_A = 320N$

$$\boxed{\begin{aligned} F_A &= 320\text{ N upword} \\ F_B &= 80\text{ N downword} \end{aligned}}$$

pivot point r=0

$\Sigma\tau = \cancel{\tau_A} - \tau_B + \tau_{cm} - \tau_g$

$0 = -F_B r + F_{cm} r - F_g r$

$0 = -F_B(1m) + (14kg)(10m/s^2)(2m) - (10kg)(10m/s^2)(2m)$

$0 = -F_B(1m) + 280\,Nm - 200\,Nm$

$0 = -F_B(1m) + 80\,Nm$

$-80\,Nm \quad -80\,Nm$

$\dfrac{-80Nm}{-1m} = \dfrac{-F_B(1m)}{-1m}$

$F_B = 80\,N$ ← magnitude