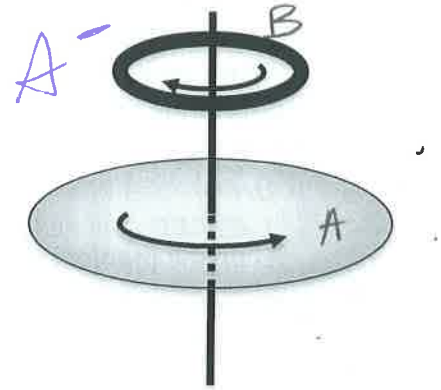
#3 There is a solid, uniform disk ("B" for "bottom") rotating at ω_o on a low friction bearing. I drop a ring ("T" for "top") on it that is rotating in the opposite direction at the same angular velocity. The ring stays centered on the rotating axis. The ring and the disk have the same mass, but the ring has ½ the diameter of the disk. After a while, the ring is connected to the disk and still centered about the axis of rotation. I want to know if they're still turning:



a) Please set this problem up.
b) Are they still turning? If not, how do you know? If so, please find the final rotational velocity and direction.
c) Is any heat given off in the process? Please prove why this should be so.

a. I used a rotational momentum lens because ^A momentum is conserved. why?

$\Sigma \vec{\tau} = 0$ outside

no outside torque because of low friction bearing.

$W_A = -W_B$

$m_A = m_B$

$l_{B_0} + l_{A_0} = l_{A_f} + l_{B_f}$

final

$l_{A_0} = I\vec{\omega} = \frac{1}{2} m_A (2r)^2 \omega_A$

$l_{B_0} = I\vec{\omega} = m_A (r^2)(-W_A)$

$2 m_A r^2 W_A - m_A r^2 W_A = l_{A_f} + l_{B_f}$

$I_A = \frac{1}{2}(2r)^2 m_A \qquad l_{A_f} = 2r^2 m_A W_f$

$I_B = r^2 m_A \qquad l_{B_f} = r^2 m_A W_f$

$m_A r^2 W_A = l_{A_f} + l_{B_f}$

$\cancel{m_A} \cancel{r^2} W_A = \cancel{r^2} \cancel{m_A} W_f (2+1)$

$W_A = 3W_f$

b. yes; using the rotational momentum lens we find the final angular velocity is $\frac{1}{3}$ the initial ω $\quad W_A = 3W_f$ or $\frac{1}{3} W_A = W_f$

c. I used an energy lens because $KE_A + KE_B = KE_{A+B} + E_T$

$KE_i - KE_f = E_T$

initial $KE_{ROT_{total}} = KE_{ROT_A} + KE_{ROT_B}$

oops! can $E_K < 0$

$= \frac{1}{4} m_A (2r)^2 (W_A) - \frac{1}{2} m_A (r^2)(W_A)$

$= m_A r^2 \omega_A - \frac{1}{2} m_A r^2 \omega_A$

$= \frac{1}{2} m_A r^2 W_A$

$E_T = \frac{1}{3} m_A r^2 W_A$

$= \frac{2}{3} E_{K_0}$

$KE_{ROT_f} = \frac{1}{2}(2r^2 m_A)(\frac{1}{3} W_A) - \frac{1}{2} m_A r^2 (\frac{1}{3} W_A)$

$= \frac{1}{6} m_A r^2 W_A$

we lost $\frac{2}{3}$ of the original $E_{K(rot)}$

There is a solid, uniform disk ("B" for "bottom") rotating at ω_o on a low friction bearing. I drop a ring ("T" for "top") on it that is rotating in the opposite direction at the same angular velocity. The ring stays centered on the rotating axis. The ring and the disk have the same mass, but the ring has ½ the diameter of the disk. After a while, the ring is connected to the disk and still centered about the axis of rotation. I want to know if they're still turning:

a) Please set this problem up.
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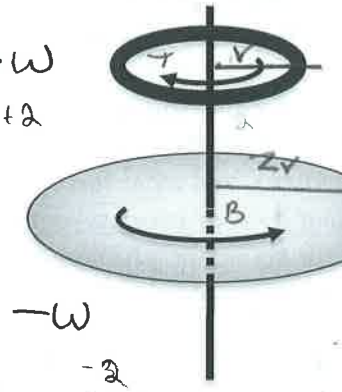
$+\omega$ $+2$



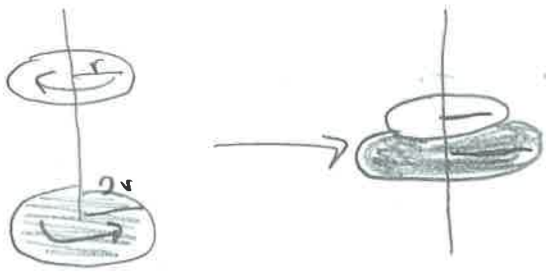
$-\omega$ -2

a) angular Momentum of the system is conserved! b/c freely rotating

$\vec{\tau}_{outside} = ?$ why ?

same masses! different radii!

A



$l = I\omega$

$I_{ring} = mr^2$

$I_r = mr^2$

$I_{disk} = \frac{1}{2}mr^2_{\leftarrow 2r}$

$= \frac{1}{2}m(4r^2)$

$I_d = 2mr^2$

angular Momentum is conserved!

$l_{ring} + l_{disk} = l_{ring + disk}$

$I_r\omega + I_d\omega = I_{r+d}(\omega_f)$

$mr^2(+\omega) + 2mr^2(-\omega) = \underbrace{3mr^2}_{\text{same mass}}(\omega_f)$

$+2 \quad -2 = 3\omega_f$

$\cancel{mr^2}(\omega - 2\omega) = \cancel{mr^2}(3\omega_f)$

$-\omega_i = 3\omega_F$

$-\frac{1}{3}\omega_i = \omega_F$ moving $\boxed{1/3 \text{ times}}$ the speed(ω) in the $\boxed{\text{negative}}$ direction Of direction of the disk initially.

b) yes they are still turning b/c angular momentum is conserved $\boxed{\omega \neq 0}$

c) yes heat would be given off! Energy lens b/c $\rightarrow$ $PE_r + KE_{rot(ring)} + KE_{rot(disk)} + KE_{L(ring)} = KE_{rot(r+d)} + E_{thermal}$

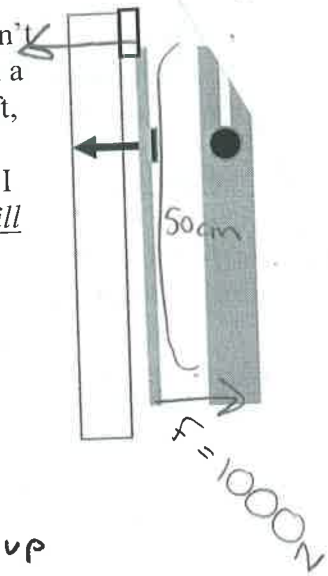
converted to

due to friction

#4 I have a nail stuck in a vertical wall. I need to pull it with 1000 N to get it to come out but I can't pull 1000 N. I get a 50 cm slotted pry bar and slide the nail all the way down the 10 cm slot. I put a small white block under the slotted end of the pry bar. I've included two depictions of this. At left, you are looking at the arrangement from the side. At right, you see it as if you are looking at the wall. To pull out the nail, find the force I have to put on the pry bar (include direction and where I put the force), and what force does the white block put on the pry bar (include direction). *You will be graded by your process and explanation. The correct answer helps.*

a) Please set up the problem with good reasoning.

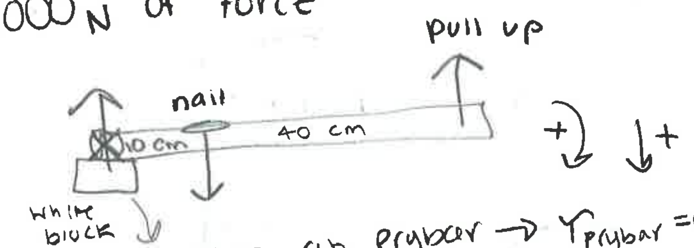
b) Please solve the problem.



Dynamics + rotational dynamics lenses b/c forces + torques.

Goal: maximize torque to get 1000 N of force

Statics b/c no movement yet forces + torques



Fulcrum at prybar → $\tau_{prybar} = 0$

$\Sigma F = ma = 1000\,N$

$\Sigma \tau = 0$

$0 = \underbrace{F_{nail}}_{1000\,N}(0.10m) - F_{hand}(0.5m)$

A

$0 = 100 - F_{hand}(0.5m)$

$\boxed{F_{hand} = 200\,N}$ upward

Force of block: Fulcrum at pull up

$\Sigma \tau = 0$

$0 = F_{nail}(0.4) - F_{block}(0.5)$

$0 = 1000\,N(0.4) - F_{block}(0.5)$

$\boxed{F_{block} = 800\,N}$ upward

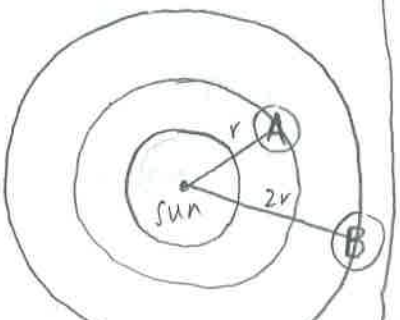
$\Sigma F = 1000\,N = 800\,N + 200\,N$

Name Isabella Ribble

#2 Two identical planets, planet A and planet B orbit the same sun. The mass of the planets is much less than the mass of the sun: $m_A = m_B << m_S$. However, planet B is twice as far from the sun as planet A. ***You must explain your answers to receive credit.***

A

a) How do the planets' attractions to the sun compare? $F_B = \frac{1}{4} F_A$.
b) How do the accelerations of two planets compare? $a_B = \frac{1}{4} a_A$.
c) How do the speeds of the two planets compare? $v_B = \frac{1}{\sqrt{2}} v_A$.
d) What difference (if any) would there be if the masses of the planets were not the same? Explain.
e) Would it be different if the mass of the planets were *not* much less than that of the sun? Explain.



a. I am using the dynamics lens because I am dealing with forces.

$\vec{F} = m\vec{a}_c$

m stays same for both but a_c differs for the planets so $\boxed{F_B = \frac{1}{4} F_A}$

b. Dynamics lens because I am dealing with acceleration. I use the centripetal acceleration formula:

$a_c = \frac{v^2}{r}$. I am using the answer I got from part c.

$\boxed{a_B = \frac{(\sqrt{\frac{1}{2}})^2}{2} = \frac{1}{4} a_A}$

c. I don't know which lens this is, but I am using the satellite equation to figure out v. This is probably the dynamics lens because of G.

① $\frac{m_m m_e}{r^2} G = m_m \frac{v^2}{r}$ => ② $\frac{m_e}{r^2} G = \frac{v^2}{r}$

③ => $\frac{m \cdot G}{r} = v^2$ => ④ $v = \sqrt{\frac{mG}{r}}$

Since m & G is the same for both planets and the only thing changing is planet B's radius, which is 2r, $\boxed{v_B = \sqrt{\frac{1}{2}} v_A}$

d. I am using the dynamies lens because there's forces/acceleration. Everything? would be different if the masses were not the same because all the formulas I used depend on the fact that mass is the same, and that I can disregard mass. If $m_B > m_A$, then F_B becomes bigger and vice versa.

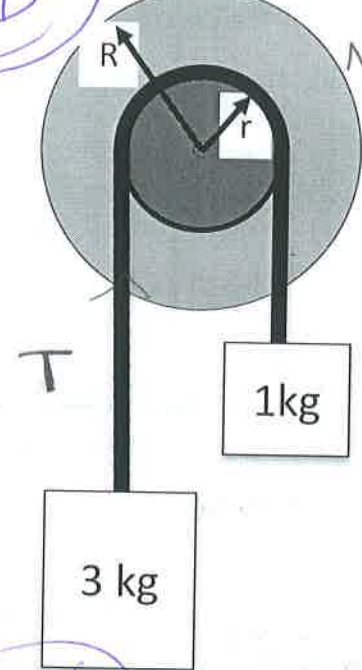
e. Same lens & motivation as part d. It would not be different because even if the masses were not much less, there would still be the same gravitational force between the sun and planets.

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

14

B+

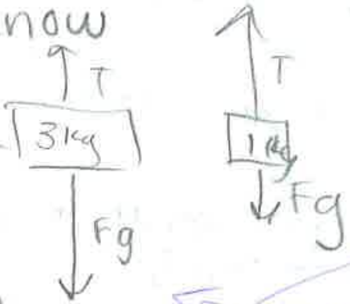
#1 The two masses at right are connected by a thin string over a light plastic pulley of radius r. The pulley is connected to a concrete flywheel of radius R and mass M. The pulley/flywheel is free to turn on a smooth axel and moves along with the string. I would like to know the tension in the string connected to the 3 kg mass as I release it from rest.



a) What do you expect to see when the system is released from rest?
b) Can you tell me anything about the tension in the string? How does it compare to 30 N? 10 N? to the tension in the string above the 1 kg mass? Please explain why.
c) Please conceptually describe a plan to find the acceleration of this system by any means you like. But carefully explain your lens(es) and method.
d) Clarify your method above with the necessary equations.

B+

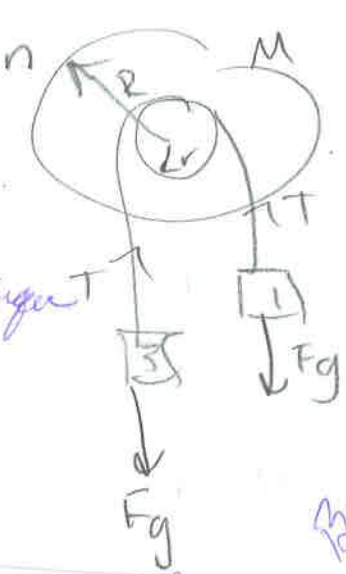
a) with a dynamics lens, I know $\Sigma \vec{F} = m\vec{a}$ & I know that F_g of m_3 is much greater than m_1 so the torque will be ⊙ & the 3kg mass will accelerate down & the other up.



great!

b) The tension in the string on the left side is less than 30 N b/c the 3kg block is accelerating down, but the tension in the string on the right side is greater than 10 N b/c the 1kg block is accelerating up.
However the tension on the 3kg block side is greater than the other b/c it also has to accelerate the pulley, and the string isn't on the outside of the pulley so there is more mass it will have to accelerate.

c) dynamics lens b/c I'm looking for acceleration and I will use torque and add the torques/forces vectors



Beautifully articulated!

$I_{wheel} = \frac{1}{2}MR^2$

$\alpha = \frac{\tau}{I}$ $\quad \tau = I\alpha \quad \tau = rF\perp$

not a torque

$\Sigma\tau = (3kg(10 m/s^2)r) - (1kg(10 m/s^2)r) - (\frac{1}{2}MR^2\alpha)$ (30 N − 10 N)

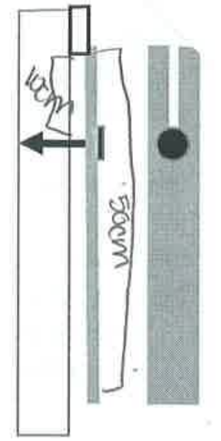
$T_3 r$

$20N \cdot r - \frac{1}{2}MR^2\alpha$

$T_3 \neq 30N$ you just said!

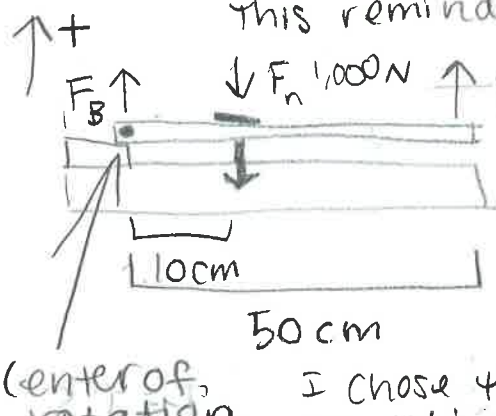
$\boxed{\Sigma\tau = I\alpha}$

#4 I have a nail stuck in a vertical wall. I need to pull it with 1000 N to get it to come out but I can't pull 1000 N. I get a 50 cm slotted pry bar and slide the nail all the way down the 10 cm slot. I put a small white block under the slotted end of the pry bar. I've included two depictions of this. At left, you are looking at the arrangement from the side. At right, you see it as if you are looking at the wall. To pull out the nail, find the force I have to put on the pry bar (include direction and where I put the force), and what force does the white block put on the pry bar (include direction). <u>*You will be graded by your process and explanation. The correct answer helps.*</u>



a) Please set up the problem with good reasoning.

b) Please solve the problem.



This reminds me of the diving board prob, so I am looking at torques so this is a rotational dynamics problem. It is going to move, so it's not a statics problem, ↳ but $a, \alpha \approx 0$

I chose the force of the block as my center of rotation to solve the force Pete needs to apply on the pry bar. He needs to apply a perpendicular force to the bar to give it torque, and $\tau = r F_\perp$,

To find the force the board is applying, I do the same thing but use pete as the center of rotation.

$\vec{F_P}(0m) = -F_n(.4m) + F_B(.5m)$

$(0m)F_B = -F_{nail}(.1m) + F_{pete}(.5m)$

b) $0 = (-1000N)(.1m) + F_P(.5m)$

$.5F_P - 100Nm$

$\dfrac{100Nm = .5m \cdot F_P}{.5}$

$\boxed{F_P \leq 200 \text{ newtons}}$

$F_P(0m) = (-1000N)(.40m) + F_B(.5m)$

$0 = F_B(.5) - 400Nm$

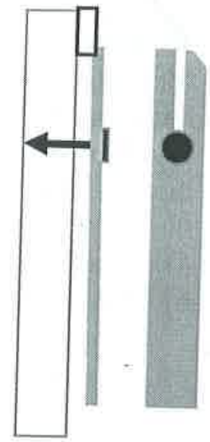
$\dfrac{400Nm = F_B(.5)}{.5}$

$\boxed{F_B \leq 800N}$

A

Name Emma Salam

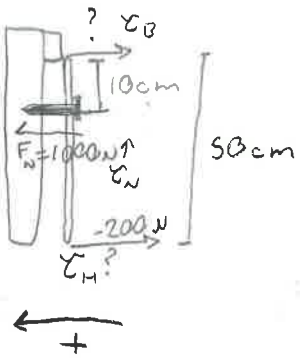
#4 I have a nail stuck in a vertical wall. I need to pull it with 1000 N to get it to come out but I can't pull 1000 N. I get a 50 cm slotted pry bar and slide the nail all the way down the 10 cm slot. I put a small white block under the slotted end of the pry bar. I've included two depictions of this. At left, you are looking at the arrangement from the side. At right, you see it as if you are looking at the wall. To pull out the nail, find the force I have to put on the pry bar (include direction and where I put the force), and what force does the white block put on the pry bar (include direction). *You will be graded by your process and explanation. The correct answer helps.*



a) Please set up the problem with good reasoning.

b) Please solve the problem.

a)



Static

Dynamics (Nothing moving until nail dislodged, forces)

$\sum \vec{F} = m\vec{a} = 0$ $\quad \sum \vec{\tau} = I\vec{\alpha} = 0$

$F_B + F_H + F_N = 0$ $\quad \tau_N + \tau_H + \tau_B = 0$

b) Use τ_B as reference (cancel to 0)

$\tau_N + \tau_H + 0 = 0$

$1000N \cdot 10cm + \tau_H = 0$

$\tau_H = -10000 N \cdot cm$

$0 + F_H + F_N = 0$

$F_H \cdot 50cm = -10000 N \cdot cm$

$F_H = -200N = \boxed{200N = F_B}$

$F_B + 200N - 1000N = 0$

$\boxed{F_B = 800N}$

A

Name Cameron Starton

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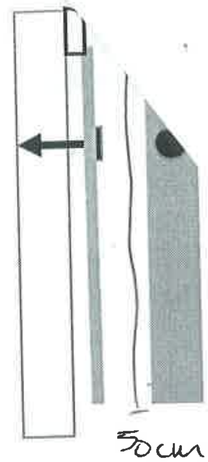
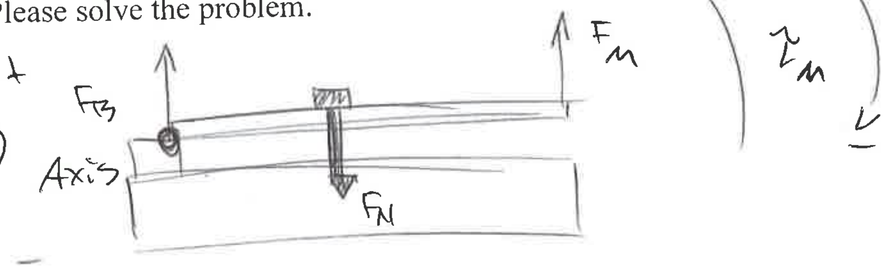


a.)



A

Lever & Dynamics — This is a statics problem! Right now the forces and torques are in equilibrium. $\Sigma \vec{F} = 0$ and $\Sigma \tau = 0$. To find out how hard to push/pull and where, we want to know how much force we need to overcome the equilibrium.

Establish

$$\Sigma \tau = \cancel{\tau_B}^{\,0} + \tau_N + \tau_M = 0$$

$$\Sigma \vec{F} = F_B + F_M - F_N = 0$$

b.)

$$\tau_M = r_M F = r_N F = \tau_N \Rightarrow (0.05\,m)F_M = (0.01\,m)(1000\,N)$$

$$F_M = \frac{10\,N \cdot m}{0.05\,m} = 200\,N$$

$$F_B = F_N - F_M = (1000 - 200)\,N = 800\,N.$$

The block will apply 800 N to the right of the picture. In equilibrium, the nail will not move if the force you apply is between 0 and 200 N. To remove the nail and overcome the minimal force, apply a force greater than 200 N to the right.

Name William McTaggart