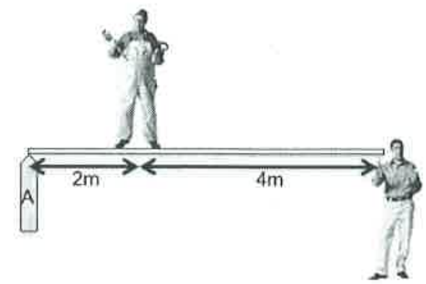
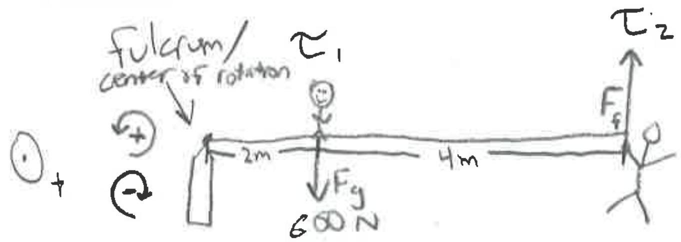
A

Big Exam! #3

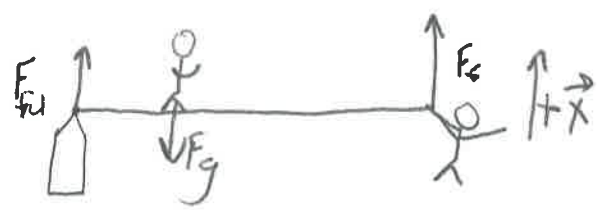
#1 I am helping a *60 kg* friend do some construction work by supporting one side of a (very light) plank for him to stand on. How much force do I need to support with my finger so that he doesn't fall?
Please set this up in fine form. Did you define a lens? Did you make a FBD? Did you write out the equations and calculate all the forces and torques? Did you define a direction (rotational *and* linear)… a center of rotation?

"no mass"





$\uparrow + \vec{x}$



Identify that this is a dynamics problem because of the presence of forces, torques, & acceleration, both linearly and rotationally, even though both are 0.

$\alpha = 0\ /s^2$

F_f = force of finger

$\Sigma \tau = I\alpha$

$\tau_2 - \tau_1 = I(0\ /s^2)$

$F_f(6m) - (600\ N)(2m) = 0$

$F_f(6m) = 1200\ N\cdot m$

$\boxed{F_f = 200\ N}$

You must use a force of 200 N to support your 60 kg friend.

$a = 0\ m/s^2$

F_{ful} = force of fulcrum.

$\Sigma F = ma$

$F_f - F_g + F_{ful} = ma$

$200\ N - 600\ N + F_{ful} = m(0\ m/s^2)$

$F_{ful} = 400\ N$

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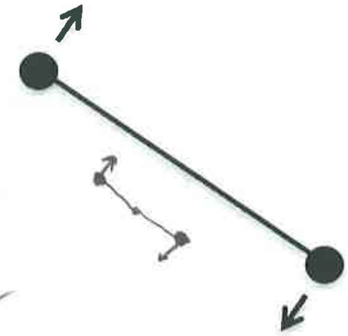
#2 You see two equal masses tied together with a string spinning in outer space at ω_o when a motor at the center pulls them both inward such that the final diameter of their paths is 1/3 the original diameter, or, $d \Rightarrow \underline{1/3}\ d_O$.



Provide reasons and show work please.

a) When you look at this system, what do you know won't change? What is conserved, and why do you know it's conserved?

You know that angular momentum is conserved using an angular momentum lens, because no outside torque was applied to the system to change its angular momentum.

b) By what factor does the momentum of inertia change?, $I \Rightarrow \underline{\frac{1}{9}}\ I_O$,

Since diameter decreases by a factor of 3, radius also decreases by a factor of 3. Since $I = mr^2$, and $r = \frac{1}{3} r_o$,

because it's a point mass. $mr^2 \Rightarrow m\left(\frac{1}{3}r_o\right)^2 \Rightarrow \frac{1}{9} m r_o^2$

c) By what factor does the angular momentum change? $\vec{l} \Rightarrow \underline{1}\ \vec{l}_o$

Since angular momentum is conserved, $\vec{l} \Rightarrow 1 \vec{l}_o$, and does not change.

d) By what factor does the angular velocity change? $\vec{\omega} \Rightarrow \underline{9}\ \vec{\omega}_o$

Because $I = \frac{1}{9} I_o$, and angular momentum is conserved,

$\vec{l} = \vec{l}_o$,

$\vec{I}\vec{\omega} = \left(\frac{1}{9}\vec{I}_o\right)\left(9\vec{\omega}_o\right)$

so, $\vec{\omega} \Rightarrow 9\vec{\omega}_o$

e) By what factor does the kinetic energy change? $E_K \Rightarrow \underline{9}\ E_{Ko}$

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Unlike momentum, kinetic energy is not conserved and work done by the motor transfers to kinetic energy of the system, looking at this through an energy lens.

$E_k = E_{k_o} + W_m$

$E_k \Rightarrow E_{ko}$

$\frac{1}{2}\vec{I}\vec{\omega} \Rightarrow \frac{1}{2}\left(\frac{1}{9}\vec{I}_o\right)\left(9\vec{\omega}_o\right)^2 \Rightarrow \frac{1}{2}(9)\vec{I}_o\vec{\omega}_o$

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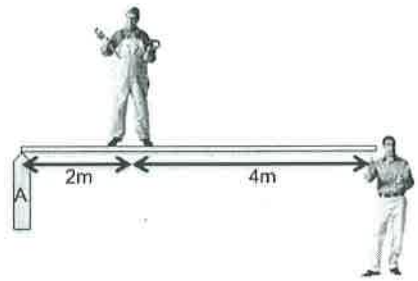
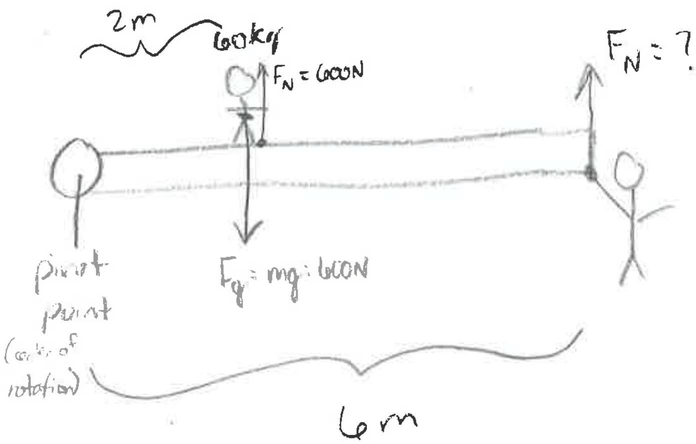
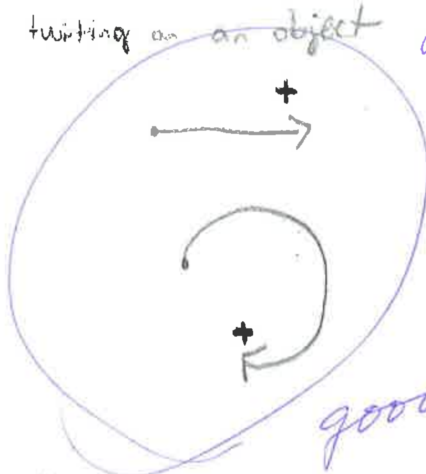


Rotational Dynamics Problem, multiple forces twisting ~~on~~ ~~an object~~ $\alpha = 0$





good!

$\sum \tau = 0$ (board is in equilibrium so friend doesn't fall)

$= \tau_1 + \tau_2 = 0 \quad \tau_1 = -\tau_2$

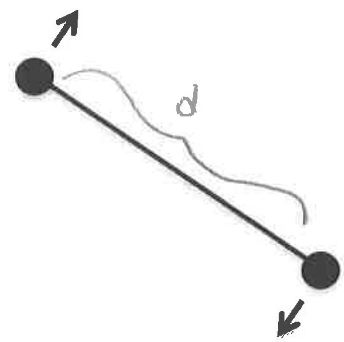
$\tau_1 = F_1 \cdot d_1 = F_{N_{friend}} \cdot d_1 = (600N)(2m) = 1200\ Nm$

$\tau_2 = F_2 \cdot d_2 = F_{N_{lift}} \cdot d_2 = (F_{N_{lift}})(6m) = -1200\ Nm$

$\boxed{F_{N_{lift}} = 200\ N}$

A

#2 You see two equal masses tied together with a string spinning in outer space at ω_o when a motor at the center pulls them both inward such that the final diameter of their paths is 1/3 the original diameter, or, $d \Rightarrow \underline{1/3}\, d_O$.



Provide reasons and show work please.

a) When you look at this system, what do you know won't change? What is conserved, and why do you know it's conserved?

Angular momentum must be conserved because no torque acted on the system

b) By what factor does the momentum of inertia change?, $I_f \Rightarrow \underline{1/9}\ I_O$.

$I_0 = mr^2$ (point mass) m = total mass of system

$I_f = m\left(\frac{1}{3}r\right)^2 = m\left(\frac{1}{9}\right)r^2$

c) By what factor does the angular momentum change? $\vec{l}_f \Rightarrow \underline{1}\ \vec{l}_o$

angular momentum lens

angular momentum is conserved

d) By what factor does the angular velocity change? $\vec{\omega}_f \Rightarrow \underline{9}\ \vec{\omega}_o$

angular momentum lens

$l_0 = I\omega$

$l_f = I_f \omega_f = \frac{1}{9} I \omega_f = l = I\omega$

$\omega_f = 9\omega$

e) By what factor does the kinetic energy change? $E_{K_f} \Rightarrow \underline{9}\ E_{Ko}$

energy lens

$RKE_0 = \frac{1}{2} I \omega^2$

$RKE_f = \frac{1}{2}\left(\frac{1}{9} I\right)(9\omega)^2 = \frac{1}{2} I \omega^2 \left(\frac{1}{9}\right)(81) = \frac{1}{2} I \omega^2 (9) = 9\ RKE_0$

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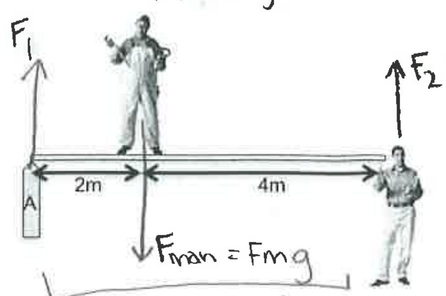
← ⊙ out of board

Big Exam! #3

$m = 60kg$



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This is a statics problem! [Forces lense because of mass and acceleration]

We know $\Sigma \vec{F} = m\vec{a} = 0$ since the plank isn't moving

$\tau = I\alpha$ ← centripital acceleration; $m(r^2)$

If we lable $\uparrow +y$, then we know

$F_1 - F_{man} + F_2 = 0$

$\tau_{F_1} = 0 \cdot F_1 = 0$

$\tau_{F_2} = 6F_2$

$\tau_{mg} = 2mg$

Identify Torques

From our Torque equations, we can say that $(\Sigma \vec{F} = m\vec{a})$

$\tau_{F_2} - \tau_{mg} = 0 \Rightarrow 2F_2 - 2mg = 0$

$F_2 = +\frac{1}{3}mg = +\frac{1}{3}(60kg)(10 m/s^2) = +200N$

$\boxed{F_2 = 200N}$

Coming back to our original equation, we can plug our now known F_2 force back into equation and solve:

$F_1 - \frac{1}{2}mg + F_2 = 0$

$F_1 = \frac{1}{2}mg - F_2$

$F_1 = \frac{1}{2}(60kg)(10 m/s^2) - 200N$

$F_1 = 300N - 200N = 100N$

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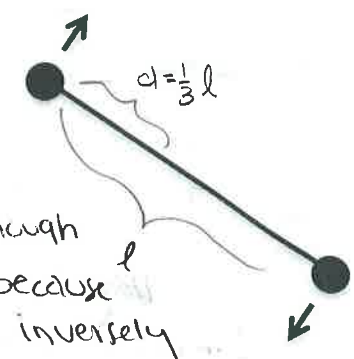
Provide reasons and show work please.



a) When you look at this system, what do you know won't change? What is conserved, and why do you know it's conserved?

We know that angular momentum is conserved so even though the masses are closer together, their ang momentum will not change because angular velocity and moment of inertia are always inversely proportional $l = I\omega$

why?

b) By what factor does the momentum of inertia change?, $I \Rightarrow \underline{9}\, I_O$.

We know That $I = mr^2$ and if d is reduced by a factor of $\frac{1}{3}$, ~~r must be reduced by a factor of~~ $\frac{1}{3}$

Thus $I_f = \left(\frac{1}{3}\right)^2 m = \frac{1}{36m}$ which would imply I_o has a factor of $\boxed{9}$

c) By what factor does the angular momentum change? $\vec{l} \Rightarrow \underline{1}\, \vec{l}_o$

We know $l = I\omega$ and angular momentum is conserved st as $I\uparrow, \omega\downarrow$

Thus we know $\vec{l}_F = \vec{l}_0$ so it does not change

d) By what factor does the angular velocity change? $\vec{\omega} \Rightarrow \underline{\frac{1}{9}}\, \vec{\omega}_o$

As stated above, we know I and ω are inversely proportional as $I\uparrow\omega\downarrow$ so if I_0 changes by a factor of 36, we know $\vec{\omega}_0$ changes by a factor of $\boxed{\frac{1}{36}}$

A

e) By what factor does the kinetic energy change? $E_K \Rightarrow \underline{9}\, E_{Ko}$

We see that our $KE = \frac{1}{2}mv^2$ and since above we have found that

$\vec{\omega}_f$ is $36x\ \vec{\omega}_0$, we know $E_{K0} = \left(\frac{1}{9}\right)^2 \frac{1}{2} m = \boxed{\frac{1}{9}} \left(\frac{9}{7}\right)^2 mv^2$

$\frac{1}{2} I\omega^2$

Name___ ______________________________