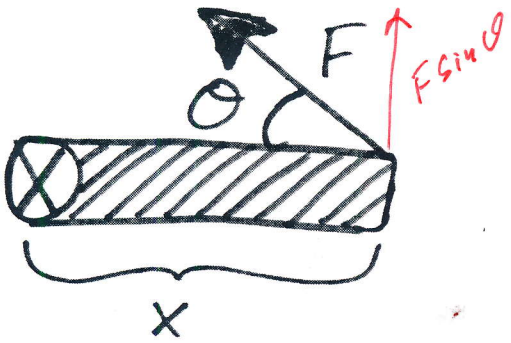
Level I Key Pd 1

# Rotational Dynamics

AT rotational dynamics (13)

Directions: Solve the following problems. Each is worth 5 points. Show all work and circle your answer. Rotational Inertias are on the back of the test.

1) Determine the torque that is applied utilizing the diagram below. The lever has a mass of 12 kg and the length (the distance "x") of 28 cm. The angle shown is 23 degrees and the force applied is 120 N. The axis is represented with the circle and the "X."

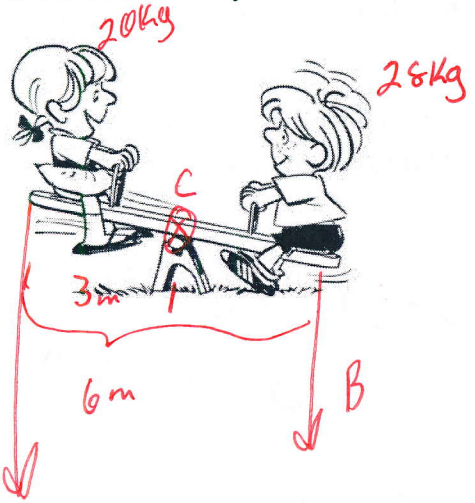



$\tau = F_{\perp} r = F(\sin\theta) r$

$(120\,N)\sin(23^\circ)(.28\,m)$

$\tau = 13.1\ Nm$

2) Use the diagram below as a guide, determine the angular acceleration of the see saw with the following situation: The boy and the girl are each sitting at the end of the see saw. The board has a total length of 6 m, and is pivoted at the center. The board has a mass of 12 kg and is uniformly constructed. The boy has a mass of 28 kg and the girl has a mass of 20 kg. Assume the board starts level, with both children having their feet on the ground. Determine the angular acceleration of the board if they both lift their feet at the same time.




$$\Sigma \tau_C = \tau_B - \tau_G = I\alpha$$

$$\frac{\tau_B - \tau_G}{I} = \alpha$$

$$\frac{(28\text{kg})(9.8\text{m/s}^2)(3\text{m}) - (20\text{kg})(9.8\text{m/s}^2)(3\text{m})}{\left[\left(\frac{1}{12}\right)(12\text{kg})(6\text{m})^2 + (20\text{kg})(3\text{m})^2 + (28\text{kg})(3\text{m})^2\right]} = \alpha = .5\ \text{rad/s}^2$$

(Board) (Girl) Boy

823.2 Nm
235.2

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$\Sigma \tau_A = \tau_C - \tau_{T_x} - \tau_{T_y} = 0$

$(200N)(.3m) - T\cos 23°(.45m) - T\sin 23(.6m) = 0$

$(200N)(.3m) = T\left[(\cos 23)(.45m) + \sin(23)(.6m)\right]$

$$\frac{(200N)(.3m)}{\left[(\cos 23°)(.45m) + \sin(23)(.6m)\right]} = T$$

$92.5N = T$

$\Sigma F_y = T_y + A_y - 200N = 0$

$T\sin(23°) + A_y = 200N$

$A_y = (200N) - T\sin 23$

$A_y = 164N$

$\Sigma F_x = A_x - T_x = 0$

$A_x = T_x$

$A_x = T\cos\theta$

$A_x = (92.5N)(\cos 23°)$

$A_x = 85N$

3) Solve the problem below:

**4.48** One end of rod $AB$ rests in the corner $A$ and the other is attached to cord $BD$. If the rod supports at 200-N load at its midpoint $C$, find the reaction at $A$ and the tension in the cord.

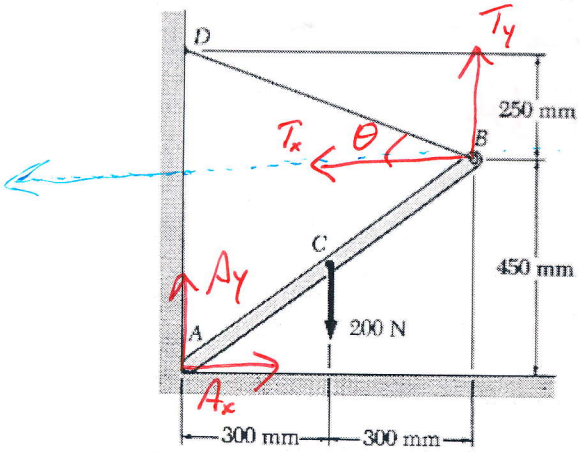



Fig. P4.48

$\Sigma J_A = J_B - J_C = 0$

$(T_x)(.45m) - (C)(.3m) = 0$

$T_x = \frac{(C)(.3m)}{.45m}$

$T_x = \frac{(200N)(.3m)}{(.45m)} = 133N$

$\Sigma F_x = A_x - T_x = 0$

$A_x = T_x = 133N$

$A_x = 133N$

$\tan\theta = \frac{opp}{Adj} = \frac{.25m}{.6m}$

$\theta = 23°$

$T_x = T\cos\theta$

$\frac{T_x}{\cos(23°)} = T$

$144N = T$

$\Sigma F_y = T_y + A_y - 200N = 0$

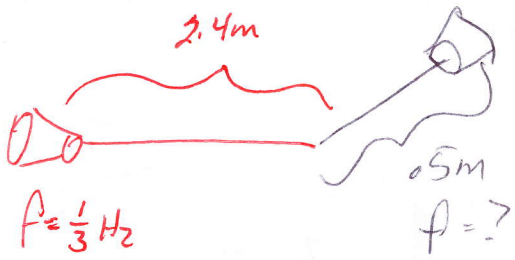
$T\sin\theta + A_y - 200N = 0$

$A_y = 200N - T\sin\theta$

$A_y = 200N - (144N)\sin 23°$

$A_y = 144N$

4) A stopper is spun at the end of a 2.4 m long string in such a manner that it makes 2 revs every 6 seconds. Determine the frequency if the radius is shortened to 0.5 m. No torque acts on the stopper.




$f = \frac{1}{3}$ Hz

$L_0 = L$

$I_0 \omega_0 = I \omega$

$m r_0^2 2\pi f_0 = m r^2 2\pi f$

$r_0^2 f_0 = r^2 f$

$$\frac{(2.4\text{m})^2 (.33\text{Hz})}{(.5\text{m})^2} = 7.6\text{Hz}$$

5) A wheel with a radius of 25 cm and a rotational inertia of 45 kgm$^2$ starts at rest. A torque of 225 Nm is applied to the wheel. Determine the final angular speed of the wheel after 15 seconds.

$\omega_0$

$\tau = 225\,N$

$I = 45\,kgm^2$

$\omega = ?$

$t = 15\,s$

$\omega = \omega_0 + \alpha t$

$\omega = \alpha t$

$\omega = \frac{\tau t}{I}$

$\tau = I\alpha$

$\omega = \frac{(225\,Nm)(15\,s)}{45\,kgm^2}$

$\omega = 75\,rad/s$

6) A bowling ball (Bowling balls are solid...) is rolled down a hill that is 1.4 m high with an angle of declination of 12 degrees. Determine the speed of the ball at the bottom of the hill.

$PE = KE + RKE$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$mgh = \frac{1}{2}mv^2 + \left(\frac{1}{2}\right)\left(\frac{2}{5}\right)mr^2\frac{v^2}{r^2}$

$gh = \frac{1}{2}v^2 + \frac{1}{5}v^2$

$gh = \frac{7}{10}v^2$

$\sqrt{\frac{(10)(9.8\ m/s^2)(1.4\ m)}{7}} = 4.4\ m/s$