Rotational Dynamics: Day 1

AT Rotational Dynamics A (16)

Directions: Answer/ Solve the problems. Each is worth 5 points.

1) Two identical bicycle frames are fitted with different wheel sets. Both sets are 700c (700 mm diameter) wheels with the same tire. Wheel set A essentially has all of the mass at the outer edge of the wheel and has a mass of 250g. Wheel set B is a solid disc, but has a mass of 350 g. Which wheel should you ride if speed is the name of the game? Justify your answer with math and words

Total Energy @ Speed v of Wheel Set A $m = .25kg$

2 wheels; Each w/ Translational & Rotational Energy

$2[RKE + TKE]$ (2 wheels)

$2[(\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2)]$

$2[\frac{1}{2}(mr^2)(\frac{v^2}{r^2}) + (\frac{1}{2}mv^2)]$

$2[\frac{1}{2}mv^2 + \frac{1}{2}mv^2]$

$2[\frac{1}{2}(.25kg)v^2 + \frac{1}{2}(.25kg)v^2]$

$.25kg\, v^2$

Wheel Set B $m = .35kg$

$2[RKE + TKE]$

$2[\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2]$

$2[\frac{1}{2}(\frac{1}{2}mr^2)(\frac{v^2}{r^2}) + \frac{1}{2}mv^2]$

$2[\frac{1}{4}mv^2 + \frac{1}{2}mv^2]$

$2[\frac{1}{4}(.35kg)v^2 + \frac{1}{2}(.35kg)v^2]$

$2[.0875kg\, v^2 + .175kg\, v^2]$

$2[.2625kg\, v^2]$

$.525v^2$

wheel B is Solid

The Solid Wheel Requires more energy for Any Speed v

2) A 0.12 Nm torque is applied to a wheel that is made up of a solid cylinder of radius 6 cm and a mass of 0.4 kg and a heavy thin outer ring around the outside of mass 2 kg. The thin outer ring is attached to the wheel for the purpose of increasing the rotational inertia of the wheel; this is a flywheel. Determine the linear speed of the outer edge of the wheel after a time of 3 seconds. (Assume the thickness of the out ring is insignificant)

$\omega = \omega_0 + \alpha t$

$\omega_0 = \text{zero}$

$\omega = \alpha t$

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

$\tau = I\alpha$

$\frac{\tau}{I} = \alpha$

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

Ring $m_R = 2kg$ — Solid part $m_S = .4kg$

$r_{Both} = 6cm = .06m$

$\omega = \frac{\tau t}{(m_R r^2 + \frac{1}{2} m_S r^2)}$

$\omega = \frac{\tau t}{r^2(m_R + \frac{1}{2} m_S)}$

$v = \omega r$

$\frac{v}{r} = \omega$

$\frac{v}{r} = \frac{\tau t}{r^2(m_R + \frac{1}{2} m_S)}$

$v = \frac{\tau t}{r(m_R + \frac{1}{2} m_S)}$

$v = \frac{(.12Nm)(3s)}{(.06m)(2kg + (\frac{1}{2})(.4kg))}$

$v = 2.73 \, m/s$

key Level I Physics pd:1

Solid wheel

3) A wheel of mass 12 kg is rolling along at 3 m/s. Determine the work that is needed to stop the wheel.

$W = KE$

$W = rKE + tKE$

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

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

$W = \frac{1}{4}(12\,kg)(3\,m/s)^2 + \frac{1}{2}(12\,kg)(3\,m/s)^2$

$W = 27\,kg\,m^2/s^2 + 54\,kg\,m^2/s^2$

$W = 81\,kg\,m^2/s^2 = 81\,J$

4) A diver of mass 68kg begins rotating at 0.32 rotations per second. They tuck resulting in a rotation of 4 rotations/sec. Determine the ratio of their final rotational inertia to their initial inertia

$$L_0 = L$$

$$I_0 \omega_0 = I \omega$$

$$\frac{\omega_0}{\omega} = \frac{I}{I_0} = \text{Ratio of Final To Initial}$$

$$\frac{2\pi f_0}{2\pi f} = \frac{I}{I_0}$$

$$\frac{f_0}{f} = \frac{I}{I_0}$$

$$\frac{.32 \text{ Rot/s}}{4 \text{ Rot/s}} = \frac{I}{I_0} = .08$$

key Level I Physics pd:1

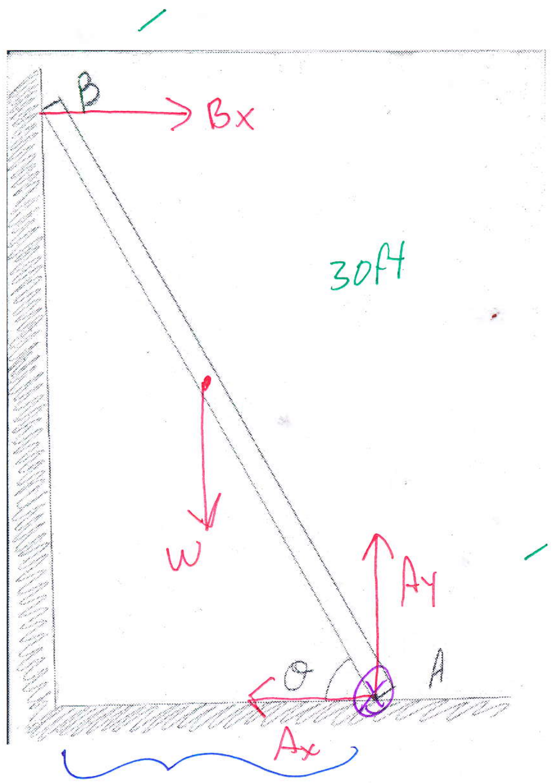
key Level I Physics pd:1

Rotational Dynamics: Day 2

AT Rotational Dynamics A (16)

Directions: Answer/ Solve the problems. Each is worth 5 points.

5) A ladder leans against a wall. The wall-ladder (point B) interaction point is frictionless. The ladder-ground (point A) interaction has a coefficient of friction of 0.6. Determine greatest distance the ladder can have with the wall without sliding. The ladder is 30 feet long. You may report your response in feet.



$x = 30ft \cos\theta$

$x = (30ft)\cos(39.8)$

$x \cong 23 ft$

$\Sigma F_x = B_x - A_x = 0$

$B_x = A_x$

$\Sigma F_y = A_y - W = 0$

$A_y = W$

$\Sigma \tau_A = \tau_{Bx} - \tau_W = 0$

$\tau_{Bx} = \tau_W$

$(B_x)(30ft \sin\theta) = W(15ft)\cos\theta$

$B_x = A_x$

$B_x = \mu A_y$

$B_x = \mu W$

$\frac{\mu W(30ft)\sin\theta}{W(15ft)\cos\theta} = \frac{W(15ft)\cos\theta}{W(15ft)\cos\theta}$

$\mu 2 \tan\theta = 1$

$\tan\theta = \frac{1}{2\mu}$

$\theta = \tan^{-1}\frac{1}{(2\mu)} = \tan^{-1}\left(\frac{1}{2(.6)}\right)$

$\theta = 40^0$ 39.8^0

key Level I Physics pd:1

Is this Question Fair? 3D...

6) Solve the textbook problem below:

4.66 A small winch is used to raise a 120-lb load. Find (*a*) the magnitude of the vertical force **P** which should be applied at *C* to maintain equilibrium in the position shown, (*b*) the reactions at *A* and *B*, assuming that the bearing at *B* does not exert any axial thrust.

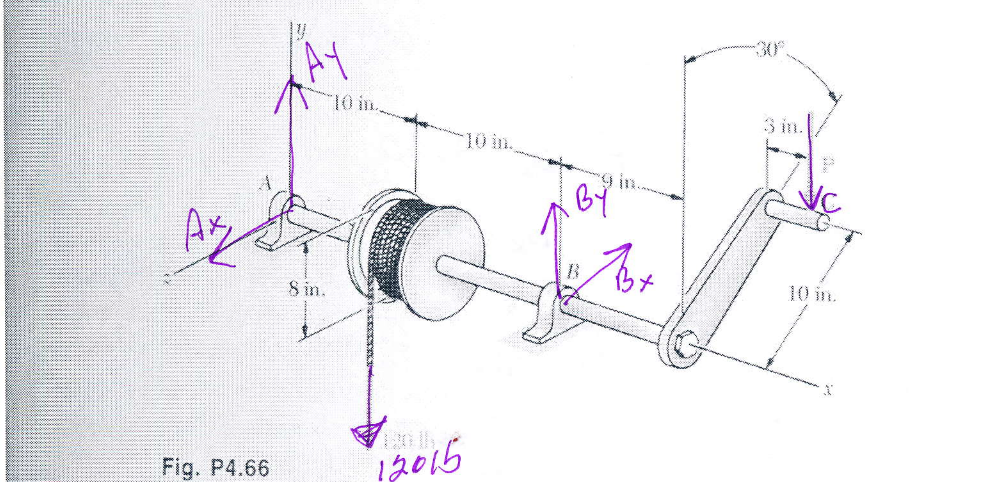
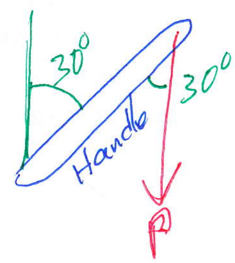


Fig. P4.66



$\Sigma T_{Axel\ A-B} = T_W - T_P = 0$

$(120lb)(4in) = P(10in)\sin 30°$

$\frac{(120lb)(4in)}{(10in)(\sin 30°)} = P$

$96 lb = P$

$\Sigma T_A = T_{By} - T_P = 0$

$(B_y)(20in) = P(32in)$

$B_y = \frac{(96lb)(32in)}{(20in)}$

$B_y = 153.6 lb$

$\Sigma F_y = A_y + B_y - P - W$

$A_y = P + W - B_y$

$A_y = (96lb) + (120lb) - 153.6lb$

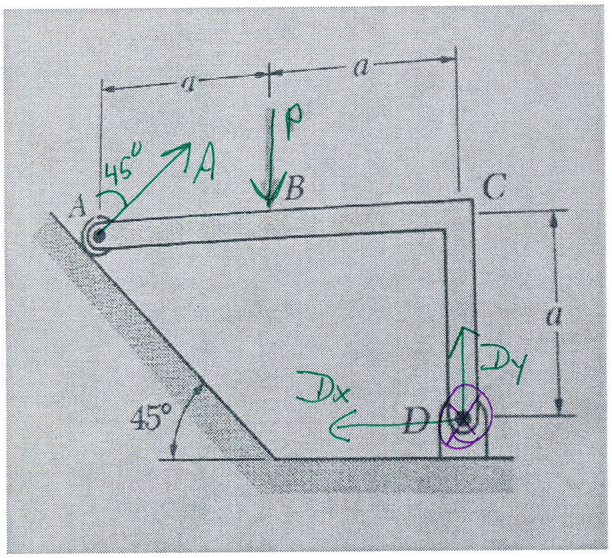
$A_y = 62.4 lb$

key Level I Physics pd:1

7) Solve for the reaction at A & D knowing P=100N. Distance a=20cm. Assume the structure has an insignificant mass.

$\Sigma F_y = A_y + D_y - P = 0$ $\quad \Sigma F_x = A_x - D_x = 0$

$A_x = D_x$



$\Sigma \tau_D = \tau_P - \tau_{A_x} - \tau_{A_y} = 0$

$P(.2m) - A_y(.4m) - A_x(.2m) = 0$

$P(.2m) - A\cos(45^0)(.4m) - A\sin 45(.2m) = 0$

$P(.2m) = A[\cos 45(.4m) + \sin 45(.2m)]$

$$\frac{(100N)(.2m)}{[(\cos 45)(.4m) + (\sin 45)(.2m)]} = A$$

~~471N~~ $= A$

47.1N

$A_y + D_y - P = 0$

$D_y = -A_y + P$

$D_y = -A\cos 45^0 + P$

$D_y = -(47.1N)(\cos 45^0) + (100N)$

$D_y =$ ~~133N~~

66.7N

$\Sigma F_x = A_x = D_x$

$A\cos\theta = D_x$

$(47.1N)(\cos(45^0)) = D_x$

$33.3N = D_x$