Answer Key Pd 1

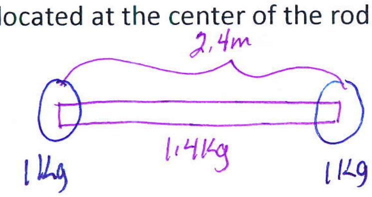
Rotational Dynamics; Day 1

AT Rotational dynamics (17)

Directions: Solve the following problem. Show all work. Be neat. Your solution should mathematically read like an essay.

1) A small cylindrical rod of diameter 0.4 cm and length 2.4 m has a mass of 1.4 kg. There is a large spherical mass of radius 4 cm at each end of the rod such that the center of the sphere is at the end of the rod. Determine the rotational inertia of the assembly rotating on an axis that is perpendicular to the rod, located at the center of the rod.

Sphere mass 1 kg



$I_{Total} = I_{mass} + I_{Rod}$

$I_{Total} = 2(mr^2)$

$I_{Total} = 2((1\,kg)(1.2\,m)^2) + (\frac{1}{12})(1.4\,kg)(2.4\,m)^2$

$I_{Total} = 2.88\,kg\,m^2 + .672\,kg\,m^2$

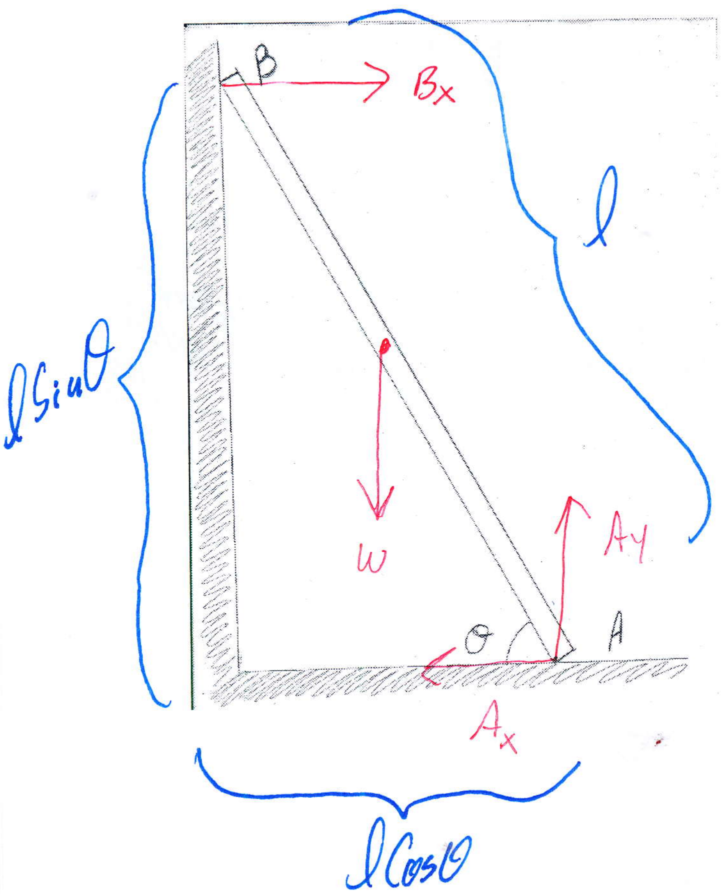
$I_{Total} = 3.6\,kg\,m^2$

Answer Key Pd 1

Rotational Inertia

Particle $I=mr^2$
Solid cylinder $I=(1/2)mr^2$
Stick about end $I=(1/3)mr^2$
Solid Sphere $I=(2/5)mr^2$
Stick about middle $I=(1/12)mr^2$

2) Determine the greatest angle theta for the rod below if point B is frictionless and point A has a coefficient of friction of 0.6.



$$\Sigma \tau_A = \tau_{B_x} - \tau_w = 0$$

$$\tau_{B_x} = \tau_w$$

$$B_x l \sin\theta = \frac{w\, l \cos\theta}{2}$$

$$B_x \sin\theta = \frac{w \cos\theta}{2}$$

$$\frac{\sin\theta}{\cos\theta} = \frac{w}{2B_x}$$

$$\tan\theta = \frac{w}{2B_x}$$

$$\Sigma F_x = B_x - A_x = 0 \qquad \Sigma F_y = A_y - W = 0$$

$$B_x = A_x \qquad A_y = W$$

$A_y \Rightarrow$ normal

$A_x \Rightarrow$ Friction

$$F_f = \mu N$$

$$A_x = \mu A_y$$

$$\tan\theta = \frac{w}{2A_x}$$

$$\tan\theta = \frac{w}{2\mu A_y}$$

$$\tan\theta = \frac{w}{2\mu W}$$

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

$$\theta = \tan^{-1}\left[\frac{1}{2(.6)}\right] = 40^\circ$$

Answer Key Pd 1

Rotational Inertia

Particle $I=mr^2$

Solid cylinder $I=(1/2)mr^2$

Stick about end $I=(1/3)mr^2$

Solid Sphere $I=(2/5)mr^2$

Stick about middle $I=(1/12)mr^2$

3) A wheel has a rotational inertia of 12 kgm^2. Determine the torque required for the wheel to obtain a frequency of 3 rev/s.

$I = 12\,kg\,m^2$

$\tau = ?$

$f = 3\,Rev/s$

$\omega_0 = zero$

$t = 3s$

$v = v_0 + at$

$\omega = \omega_0 + \alpha t$

$\omega = \alpha t$

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

$2\pi f = \frac{\tau t}{I}$

$\frac{2\pi f I}{t} = \tau$

$\frac{(2\pi)(3\,Rev/s)(12\,kg\,m^2)}{3s} = 75.4\,Nm$

$F = ma$

$\tau = I\alpha$

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

Answer Key Pd 1

Rotational Inertia

Particle I=mr^2

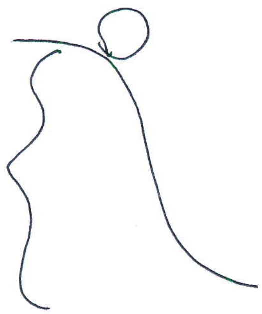
Solid cylinder I=(1/2)mr^2

Stick about end I=(1/3)mr^2

Solid Sphere I=(2/5)mr^2

Stick about middle I=(1/12)mr^2

4) A hoop rolls down a hill without slipping. The hill is 4 m high. Determine the linear speed of the hoop at the bottom of the hill.



$PE = KE + rKE$

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

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\,mr^2\frac{v^2}{r^2}$

$gh = \frac{1}{2}v^2 + \frac{1}{4}v^2$

$gh = .75\,v^2$

$\sqrt{\frac{gh}{.75}} = v = \sqrt{\frac{(9.8\,m/s^2)(4\,m)}{.75}} = 7.2\ m/s$

6.3

Answer Key Pd 1

Rotational Inertia

Particle $I=mr^2$

Solid cylinder $I=(1/2)mr^2$

Stick about end $I=(1/3)mr^2$

Solid Sphere $I=(2/5)mr^2$

Stick about middle $I=(1/12)mr^2$

Rotational Dynamics; Day 2

AT Rotational dynamics (17)

5) A whistle is attached to a 3 foot long string. The whistle is traveling in a circular path at 2 rev/s when the string is allowed to wrap around a finger. Determine the frequency of the whistle when it is only 3 inches from the finger.

$L_0 = L$

$I_0 \omega_0 = I\omega$

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

$r_0^2 f_0 = r^2 f$

$\frac{(3ft)^2 2\frac{Rev}{s}}{(.25)^2} = 288 \frac{Rev}{s}$

«First_Name» «Last_Name» Pd «Period»

Rotational Inertia

Particle I=mr^2

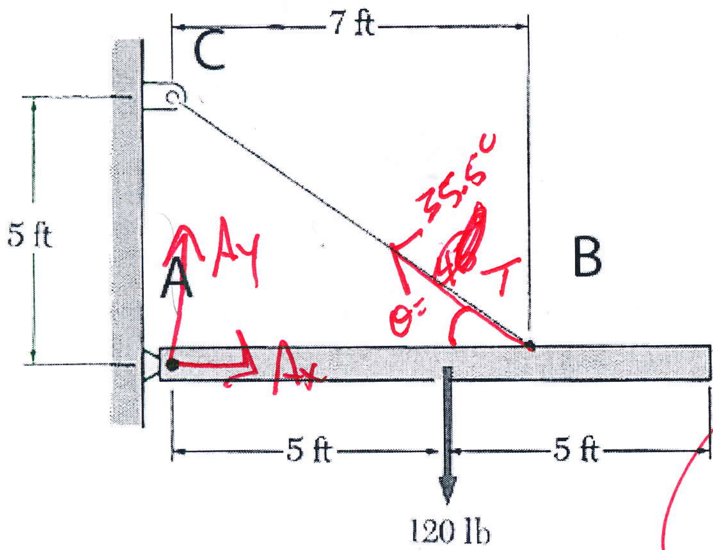
Solid cylinder I=(1/2)mr^2

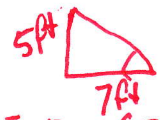
Stick about end I=(1/3)mL^2

Solid Sphere I=(2/5)mr^2

Stick about middle I=(1/12)mL^2

6) Given the 120 pound force as given in the diagram, determine the reaction at "A" and the tension in the cable CB.





$\theta = Tan^{-1}(5/7)$

$\theta = 35.5°$

$\Sigma F_x = A_x - T\cos 35.5 = 0$

$A_x = T\cos(35.5)$

$\Sigma F_y = A_y + T\sin(35.5) - W = 0$

$\Sigma \tau_A = \tau_B - \tau_W = 0$

$\tau_B = \tau_W$

$(T\sin\theta)(7ft) = (W)(5ft)$

$T = \dfrac{(120lb)(5ft)}{\sin(35.5)(7ft)}$

$T = 147.6\ lb$

$A_x = (147.6lb)(\cos 35.5)$

$A_x = 120.2\ lb$

$A_y = W - T\sin(35.5)$

$A_y = (120lb) - (147.6lb)(\sin 35.5)$

$A_y = 34.3\ lb$

«First_Name» «Last_Name» Pd «Period»

Rotational Inertia

Particle $I=mr^2$

Solid cylinder $I=(1/2)mr^2$

Stick about end $I=(1/3)mL^2$

Solid Sphere $I=(2/5)mr^2$

Stick about middle $I=(1/12)mL^2$

7) A wheel starts at rest. The wheel accelerates at 3 rad/s^2 for a time of 3 seconds. Determine the angular speed of the wheel.

$\omega = \alpha t$

$\omega = (3\ rad/s^2)(3s)$

$\omega = 9\ rad/s$

«First_Name» «Last_Name» Pd «Period»

Rotational Inertia

Particle $I=mr^2$

Solid cylinder $I=(1/2)mr^2$

Stick about end $I=(1/3)mL^2$

Solid Sphere $I=(2/5)mr^2$

Stick about middle $I=(1/12)mL^2$

8) Determine the work that needs to be done to take a stationary object with a rotational inertia of 3 kgm^2 and make it rotate at 22 rad/s

$W = KE$

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

$W = \frac{1}{2}(3\,kgm^2)(22\,rad/s)^2$

$W = 726\,J$

«First_Name» «Last_Name» Pd «Period»

Rotational Inertia

Particle $I=mr^2$
Solid cylinder $I=(1/2)mr^2$
Stick about end $I=(1/3)mL^2$
Solid Sphere $I=(2/5)mr^2$
Stick about middle $I=(1/12)mL^2$