Assignment #1

Physics 2 Spring 2020
Instructor: Prof. Dirk Bouwmeester
Due: 04/05/20 5pm PST

Comments: Each problem is worth three points. If the problem has multiple parts the points breakdown is delineated in the problem.

1 Torque about Square Metal Plate

A square metal plate 2.5m on each side is pivoted about an axis though point O at its center and perpendicular to the plate. Calculate the net torque due to the three forces if the magnitudes of the forces are $F_1 = 18N$, $F_2 = 20N$, and $F_3 = 11N$.

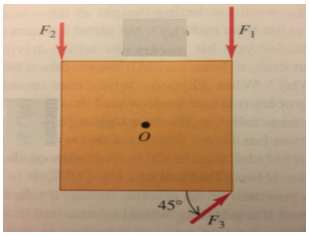


Figure 1: Torque about Square Metal Plate

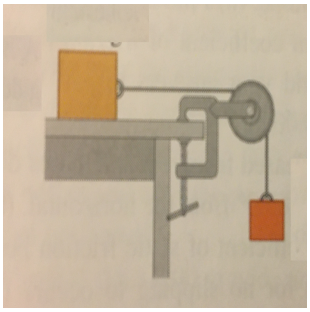


Figure 2: Box on Table with Pulley

2 Box on Table with Pulley

A 14kg Box rests on a frictionless surface. It is attached to a 8kg weight by a thin wire that passes over a frictionless pulley. The pulley is a uniform solid disk of mass 3kg and diameter 1m. After the box is released find (a) the tension in the wire on both sides of the pulley, (b) the acceleration of the box, and (c) the horizontal and vertical components of the force of the axle on the pulley. **Each part is 1 point.**

3 String around Hoop

A string is wrapped several times around the rim of a small hoop with radius 7cm and mass 2kg. The free end of the string is held in place and the hoop is released from rest. After the hoop has descended 80cm calculate (a) the angular speed of the hoop and (b) the speed of its center. **(a) is 1 point (b) is 2 points.**

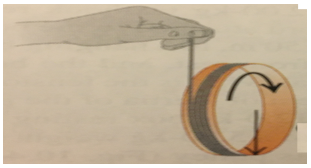


Figure 3: String around Hoop

4 The Spinning Figure Skater

The outstretched hands of a figure skater preparing for a spin can be considered a slender rod pivoting about an axis through its center. When the skater's hands and arms are brought in and wrapped around his body to execute the spin, the hands and arms can be considered a thin-walled hollow cylinder. The skater's hands and arms have a combined mass of 9kg. When outstretched they span 2m, when wrapped they form a cylinder of radius 25cm. The moment of inertia about the rotation axis of the reminder of the skater's body is constant and given as 0.5kg$\cdot m^2$. If the skater's initial angular speed is 0.4 rev/s what is their final angular speed?

5 Uniform Hollow Disk with Wire

A uniform hollow disk with inner radius 30cm and outer radius 60cm has two pieces of thin wire wrapped around its outer rim and is supported from the ceiling. Suddenly one of the wires breaks and the remaining wire does not slip as the disk rolls down. Use conservation of energy to find the speed of the center of this disk after it has fallen a distance of 2m.

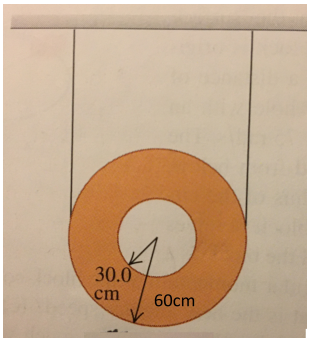


Figure 4: Uniform Hollow Disk with Wire

6 Block on Inclined Surface

A block of mass 5kg slides down a surface inclined at 30 degrees to the horizontal. The coefficent of kinetic friction is 0.3. A string attached to the block is wrapped around a flywheel on a fixed axis at O. The flywheel has a mass 30kg and a moment of inertia 0.25kg$\cdot m^2$ with respect to the axis of rotation. The string pulls without slipping at a perpendicular distance of 0.4m from the axis. (a) What is the acceleration of the block down the plant? (b) What is the tension in the string? **(a) is 2 points (b) is 1 point.**

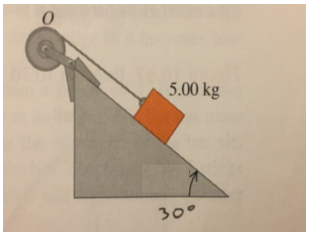


Figure 5: Block on Inclined Surface

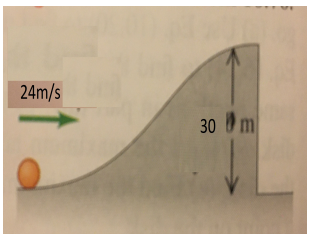


Figure 6: Ball Rolling Up Hill

7 Ball Rolling Up Hill

A solid uniform ball rolls without slipping up a hill that is 30m tall at its peak. At the base of the hill it is moving horizontally at 24m/s. At the top of the hill it is also moving horizontally and then it goes over the cliff. (a) How far from the foot of the cliff does the ball land? (b) How fast is it moving when it lands? **(a) is 1 point (b) is 2 points**

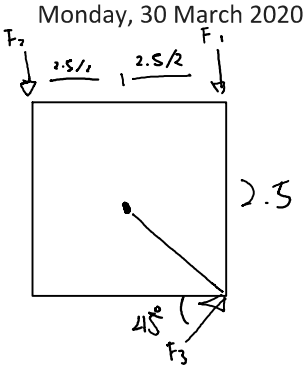
8 Drawbridge

A uniform drawbridge 9m long is attached to the roadway by a frictionless hinge at one end and can be raised by a cable at the other end. The bridge is at rest suspended 30 degrees above the horizontal when the cable breaks. (a) Find the angular acceleration of the drawbridge just as the cable breaks. (b) What is the angular speed of the drawbridge when it becomes horizontal? **(a) is 1 point (b) is 2 points**

Physics 2 Homework 1

Monday, 30 March 2020 13:54

#1



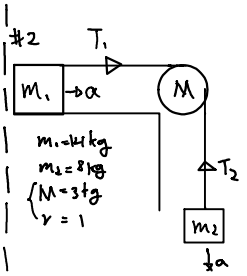
$F_1 = 18\ N$
$F_2 = 20\ N$
$F_3 = 11\ N$

$9\times2.5 - 10\times2.5 - 11\times\sqrt{(1.25)^2\times2}$

$= -21.9454\ Nm$

21.9454 Nm counter clockwise ✓

#2



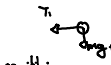
$m_1 = 4\ kg$
$m_2 = 8\ kg$
$M = 3\ kg$
$r = 1$

$T_1 = m_1 a$
$m_2 a = m_2 g - T_2$
$T_2 = m_2 g - m_2 a$

$T_{net} = I\alpha$
$(T_2 - T_1)r = \frac{1}{2}Mr^2 \times \frac{a}{r}$
$T_2 - T_1 = \frac{1}{2}Ma$
$(m_2 g - m_2 a) - (m_1 a) = \frac{1}{2}Ma$

$a \approx 3.3396\ m/s^2$
$\approx 3.34\ m/s^2$ ↑

$T_1 = 4\times3.3396$
$T_2 = 8\times9.81 - 8\times3.3396$
$T_1 = 13.35\ N$
$T_2 = 51.76\ N$



equilibrium
Hence horizontal
$F_N = T_1 = 13.35$
$F_T = mg + T_2 = 81.44\ N$ ✓

#3

$I = MR^2$

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

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

$2gh = r^2\omega^2 + v^2$

$gh = r^2\omega^2$

$\omega = \sqrt{\frac{gh}{r^2}}$ $r = \frac{1}{20}m$, $h = \omega l$,

$\omega = \sqrt{\frac{0.8\times9.81}{(1/20)^2}}$

$\omega = 280.2024\ rad/s$

$v = r\omega$
$= 1/20 \times 280.2$
$= 2.801\ m/s$ ✓

#4

Initial moment of Inertia
$I_1 = I_0 + \frac{1}{12}MR^2$

Final
$I_2 = I_0 + mr^2$

$I_1\omega_1 = I_2\omega_2$

$\omega_2 = \frac{I_1}{I_2}\omega_1$

$\omega_2 = \frac{I_0 + \frac{1}{12}mR^2}{I_0 + mr^2}\omega_1$

$I_0 = 0.5\ kgm^2$
$m = 9\ kg$
$R = 2m$
$r = 0.25m$
$\omega_1 = 0.4$

$\omega_2 = 0.4\ \frac{0.5 + \frac{1}{12}\times9\times4}{0.5 + 9\times0.25^2}$

$\approx 1.3776\ rev/s$
$\approx 1.38\ rev/s$ ✓

#5

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$, $\omega = \frac{v}{r}$, $I = \frac{1}{2}m(r_2^2 + r_1^2)$

$2gh = v^2 + \frac{1}{2}(r_1^2 + r_2^2)\times\frac{v^2}{r_2^2}$

$r_1 = 0.3$, $r_2 = 0.6$
$h = 2m$

$4\times9.81 = v^2 + \frac{1}{2}\times0.45\times\frac{v^2}{0.36}$

$4\times9.81 = 1.625v^2$

$v \approx 4.91\ m/s$ ✓

#6

$f = \mu N$
$N = mg\cos\theta$
$F = ma$
$= mg\sin\theta - T - \mu N$
$= mg\sin\theta - T - \mu mg\cos\theta$
$a = g\sin\theta - \frac{T}{m} - \mu g\cos\theta$

or
$I = \frac{1}{2}mr^2$
$0.25 = \frac{1}{2}\times30\times r^2$
$r = 0.1291$

$T = \frac{(2.3)(\sin(30) - 0.3\cos(30))}{\frac{0.5}{30\times0.13} + \frac{1}{2}} = 8.836\ N$

hence $a \approx 0.5891$

$Tr = I\alpha = I\frac{a}{r}$

$\frac{Tr^2}{I} = a$

If pully like yoyo: Omit rad

$\frac{Tr^2}{I} = g\sin\theta - \frac{T}{m} - \mu g\cos\theta$

$m = 5\ kg$
$\theta = 30°$
$\mu = 0.3$
$r = 0.4\ m$
$I = 0.25\ kgm^2$

$g(\sin\theta - \mu\cos\theta) = \frac{Tr^2}{I} + \frac{T}{m}$

$g(\sin\theta - \mu\cos\theta) = (\frac{r^2}{I} + \frac{1}{m})T$

$T = \frac{g(\sin\theta - \mu\cos\theta)}{(\frac{r^2}{I} + \frac{1}{m})}$

$T = 28.05\ N$ ✓

$a = \frac{2.805}{0.5\times0.4^2} = 0.8776\ m/s^2$

1.795

#7

$\frac{1}{2}I\omega_1^2 + \frac{1}{2}mv_1^2 = mgh + \frac{1}{2}I\omega_2^2 + \frac{1}{2}mv_2^2$

$\frac{2}{5}mr^2\frac{v_1^2}{r^2} + mv_1^2 = 2mgh + mv^2 + \frac{2}{5}mr^2\frac{v^2}{r^2}$

$\frac{2}{5}v_1^2 + v_1^2 = 2gh + v^2 + \frac{2}{5}v^2$

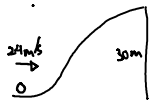
$\frac{7}{5}v_1^2 = 2gh + \frac{7}{5}v^2$

$v = \sqrt{(\frac{7}{5}v_1^2 - 2gh)\frac{5}{7}}$

$v = \sqrt{v_1^2 - \frac{10}{7}gh}$

$v_1 = 24$, $h = 30$

$v = 12.9728\ m/s$



$S = ut + \frac{1}{2}at^2$

$t = \sqrt{\frac{2h}{g}}$

$S_x = Vt$

$= \sqrt{\frac{2h}{g}} \times \sqrt{v_1^2 - \frac{10}{7}gh}$

$= \sqrt{\frac{2\times30}{9.81}} \times 12.9728$

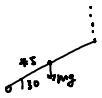
$\approx 20.84\ m$

$V_y = gt$
$= \sqrt{g^2}\times\sqrt{\frac{2h}{g}}$
$= \sqrt{2gh}$
$= \sqrt{2\times9.81\times30}$
$= 24.261\ m/s$

$\sqrt{(24.261)^2 + (12.4728)^2}$

$\approx 27.2794\ m/s$
$\approx 27.3\ m/s$ ✓

#8



$I = \frac{ml^2}{3}$

$T = mg\cos\theta \times \frac{l}{2}$

$\frac{ml^2}{3}\alpha = mg\cos\theta \times \frac{l}{2}$

$\frac{l^2}{3}\alpha = g\cos\theta \times \frac{l}{2}$

$\alpha = \frac{3g}{2l}\cos\theta$

$\alpha = 1.46$

$4.5\sin\theta = h$

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

$\frac{l^2}{6}m\omega^2 = mg(\frac{l}{2}\sin\theta)$

$m\omega^2 = \frac{3mg}{l}\sin\theta$

$\omega^2 = \frac{3g}{l}\sin\theta$

$\omega = \sqrt{\frac{3g}{l}\sin\theta}$

$\omega = 1.279\ rad/s$