Name____

Physics 110 Quiz #5, November 1, 2013

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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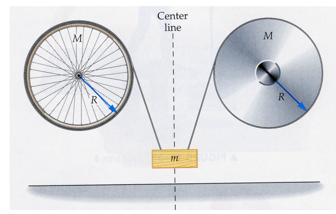
1. Two objects of equal mass and radius are shown on the right. A disk (on the right with moment of inertia $I = \frac{1}{2}MR^2$) and a hoop (on the left with moment of inertial $I = MR^2$) have a string wrapped around their circumferences. Hanging from the string, halfway between the disk and the hoop, is a block of mass m. The disk and the hoop are free to rotate about their centers. When the block is released from rest and allowed to fall, the block



   a. moves to the right of the centerline.
   b. moves to the left of the centerline.
   c. moves along the centerline.
   d. moves both left and right of the centerline or it oscillates about the centerline.

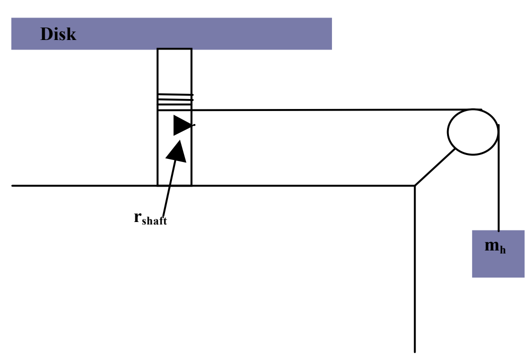
2. Suppose that we have the set-up shown below consisting of a shaft of radius $r_{shaft} = 0.5cm$ around which a massless string is wound and a disk of moment of inertial I is placed. The string is passed over a massless pulley where a mass $m_h = 200g$ is hung and allowed to fall from rest through a height $h = 1m$ acquiring a speed of $v = 1.84m/s$.

   a. Using energy ideas derive an expression for the moment of inertia of the disk and then evaluate your expression using the information given in the problem above.

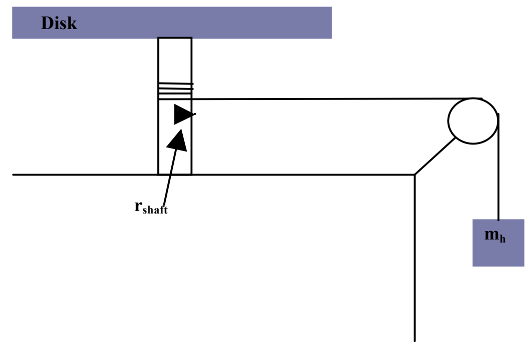
$$\Delta E = 0 = \Delta KE_T + \Delta KE_R + \Delta U_g = \left(\tfrac{1}{2}m_h v_f^2 - 0\right) + \left(\tfrac{1}{2}I\omega_f^2 - 0\right) + \left(0 - m_h g y_i\right)$$

$$0 = \left(\tfrac{1}{2}m_h v_f^2 - 0\right) + \left(\tfrac{1}{2}I\left(\frac{v_f}{r_{sh}}\right)^2 - 0\right) + \left(0 - m_h g h\right)$$

$$I = \left(\frac{2gh}{v_f^2} - 1\right)m_h r_{sh}^2 = \left(\frac{2\times 9.8\frac{m}{s^2}\times 1m}{\left(1.84\frac{m}{s}\right)^2} - 1\right)(0.2kg)(0.005m)^2 = 2.4\times 10^{-5}\,kg\cdot m^2$$



b. Using ideas of torque and forces derive an expression for the moment of inertia of the disk and then evaluate your expression using the information given in the start of the problem.



$$\sum \tau: \quad r_{sh}F_T = r_{sh}\left(m_h g - m_h a\right) = I\alpha = I\frac{a}{r_{sh}}$$

$$\rightarrow I = \left(\frac{g}{a} - 1\right)m_h r_{sh}^2 = \left(\frac{g}{\left(\frac{v_f^2}{2h}\right)} - 1\right)m_h r_{sh}^2 = \left(\frac{2gh}{v_f^2} - 1\right)m_h r_{sh}^2 = 2.4\times10^{-5}\,kg\cdot m^2$$

$$\sum F_y: \quad F_T - m_h g = -m_h a \rightarrow F_T = m_h g - m_h a$$

Useful formulas:

Motion in the r = x, y or z-directions

$$r_f = r_0 + v_{0r}t + \tfrac{1}{2}a_r t^2$$

$$v_{fr} = v_{0r} + a_r t$$

$$v_{fr}^{\ 2} = v_{0r}^{\ 2} + 2a_r \Delta r$$

Uniform Circular Motion

$$a_r = \frac{v^2}{r}$$

$$F_r = ma_r = m\frac{v^2}{r}$$

$$v = \frac{2\pi r}{T}$$

$$F_G = G\frac{m_1 m_2}{r^2}$$

Geometry /Algebra

Circles: $C = 2\pi r$, $A = \pi r^2$

Triangles: $A = \tfrac{1}{2}bh$

Spheres: $A = 4\pi r^2$, $V = \tfrac{4}{3}\pi r^3$

$$Quadratic\ equation: ax^2 + bx + c = 0,$$

$$whose\ solutions\ are\ given\ by:\ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Vectors

$$magnitude\ of\ a\ vector = \sqrt{{v_x}^2 + {v^2}_y}$$

$$direction\ of\ a\ vector \rightarrow \phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$$

Useful Constants

$$g = 9.8\,{}^{m}\!/_{s^2} \qquad G = 6.67\times10^{-11}\,{}^{Nm^2}\!/_{kg^2}$$

$$N_A = 6.02\times10^{23}\,{}^{atoms}\!/_{mole} \qquad k_B = 1.38\times10^{-23}\,{}^{J}\!/_{K}$$

$$\sigma = 5.67\times10^{-8}\,{}^{W}\!/_{m^2K^4} \qquad v_{sound} = 343\,{}^{m}\!/_{s}$$

Linear Momentum/Forces

$$\vec{p} = m\vec{v}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}\Delta t$$

$$\vec{F} = m\vec{a}$$

$$\vec{F}_s = -k\vec{x}$$

$$F_f = \mu F_N$$

Work/Energy

$$K_T = \tfrac{1}{2}mv^2$$

$$K_R = \tfrac{1}{2}I\omega^2$$

$$U_g = mgh$$

$$U_S = \tfrac{1}{2}kx^2$$

$$W_T = FdCos\theta = \Delta E_T$$

$$W_R = \tau\theta = \Delta E_R$$

$$W_{net} = W_R + W_T = \Delta E_R + \Delta E_T$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = 0$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = -\Delta E_{diss}$$

Heat

$$T_C = \tfrac{5}{9}\left[T_F - 32\right]$$

$$T_F = \tfrac{9}{5}T_C + 32$$

$$L_{new} = L_{old}(1 + \alpha\Delta T)$$

$$A_{new} = A_{old}(1 + 2\alpha\Delta T)$$

$$V_{new} = V_{old}(1 + \beta\Delta T):\ \beta = 3\alpha$$

$$PV = Nk_BT$$

$$\tfrac{3}{2}k_BT = \tfrac{1}{2}mv^2$$

$$\Delta Q = mc\Delta T$$

$$P_C = \frac{\Delta Q}{\Delta t} = \frac{kA}{L}\Delta T$$

$$P_R = \frac{\Delta Q}{\Delta T} = \varepsilon\sigma A\Delta T^4$$

$$\Delta U = \Delta Q - \Delta W$$

Rotational Motion

$$\theta_f = \theta_i + \omega_i t + \tfrac{1}{2}\alpha t^2$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega^2{}_f = \omega^2{}_i + 2\alpha\Delta\theta$$

$$\tau = I\alpha = rF$$

$$L = I\omega$$

$$L_f = L_i + \tau\Delta t$$

$$\Delta s = r\Delta\theta:\ v = r\omega:\ a_t = r\alpha$$

$$a_r = r\omega^2$$

Sound

$$v = f\lambda = (331 + 0.6T)\,\tfrac{m}{s}$$

$$\beta = 10\log\frac{I}{I_0};\quad I_o = 1\times10^{-12}\,\tfrac{W}{m^2}$$

$$f_n = nf_1 = n\frac{v}{2L};\ f_n = nf_1 = n\frac{v}{4L}$$

Fluids

$$\rho = \frac{M}{V}$$

$$P = \frac{F}{A}$$

$$P_d = P_0 + \rho gd$$

$$F_B = \rho gV$$

$$A_1v_1 = A_2v_2$$

$$\rho_1A_1v_1 = \rho_2A_2v_2$$

$$P_1 + \tfrac{1}{2}\rho v^2{}_1 + \rho gh_1 = P_2 + \tfrac{1}{2}\rho v^2{}_2 + \rho gh_2$$

Simple Harmonic Motion/Waves

$$\omega = \sqrt{\frac{k}{m}} = 2\pi f = \frac{2\pi}{T}$$

$$T_S = 2\pi\sqrt{\frac{m}{k}}$$

$$T_P = 2\pi\sqrt{\frac{l}{g}}$$

$$v = \pm\sqrt{\frac{k}{m}}A\left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$$

$$x(t) = x_{\max}\sin(\omega t)\ \ or\ \ x_{\max}\cos(\omega t)$$

$$v(t) = v_{\max}\cos(\omega t)\ \ or\ \ -v_{\max}\sin(\omega t)$$

$$a(t) = -a_{\max}\sin(\omega t)\ \ or\ \ -a_{\max}\cos(\omega t)$$

$$v_{\max} = \omega x_{\max};\ \ a_{\max} = \omega^2 x_{\max}$$

$$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = nf_1 = n\frac{v}{2L}$$

$$I = 2\pi^2 f^2 \rho v A^2$$