Name____

Physics 110 Quiz #5, May 17, 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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A $200kg$ playground merry-go-round with a $2.5m$ radius is subject to a frictional torque of $27N \cdot m$.

1. If the merry-go-round goes around with a linear (tangential) velocity of $6\frac{m}{s}$ on the outside edge, what is the angular velocity? Assume that the merry-go-round is rotating counterclockwise as viewed from above the merry-go-round.

$v = r\omega \rightarrow \omega = \frac{v}{r} = \frac{6\frac{m}{s}}{2.5m} = 2.4\frac{rad}{s}$ out of the page.

2. What magnitude force must be applied by one of the child's parents pushing perpendicular to and on the outside edge to keep the merry-go-round moving at a constant angular velocity?

$$\sum \tau: \quad \tau_{parent} - \tau_{friction} = I\alpha = 0 \rightarrow \tau_{parent} = \tau_{friction} = 27N \cdot m$$

$$\tau_{friction} = rF_{parent} \rightarrow F_{parent} = \frac{\tau_{friction}}{r} = \frac{27N \cdot m}{2.5m} = 10.8N$$

3. When the parent gets tired and lets go, how long does the merry-go-round take to stop? (Note: The moment of inertia for a disk spun about its center is $\frac{1}{2}mr^2$.)

$$\omega_f = \omega_i - \alpha t$$

$$\alpha = \frac{\tau}{I} = \frac{\tau}{\frac{1}{2}mr^2} = \frac{27N \cdot m}{\frac{1}{2} \times 200kg \times (2.5m)^2} = 0.04\frac{rad}{s^2}$$

$$\therefore t = \frac{\omega_i}{\alpha} = \frac{2.4\frac{rad}{s}}{0.04\frac{rad}{s^2}} = 55.6s$$

4. When a parent lets go, how many revolutions does the merry-go-round make in coming to rest?

Assuming that $\theta_i = 0$ when the parent lets go, we have

$$\theta_f = \theta_i + \omega_i t - \tfrac{1}{2}\alpha t^2 = \left(2.4\,\tfrac{rad}{s} \times 55.6s\right) - \tfrac{1}{2}\left(0.04\,\tfrac{rad}{s^2}\right)(55.6s)^2 = 71.6rad$$

$$\#\,\text{rev} = \theta_f \times \frac{1\text{rev}}{2\pi rad} = 71.6rad \times \frac{1\text{rev}}{2\pi rad} = 11.4\text{rev}$$

5. Suppose that both parents apply the same magnitude of force calculated in part 2 perpendicular to the outside edge. In this case, with the frictional torque still present, the merry-go-round will

a. rotate slower.
b. rotate at a constant rate.
c. rotate faster.
d. There is not enough information given in order answer this question.

The actual answer depends on how the force is applied to the outside edge. Here we don't know.

Useful formulas:

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

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

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

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

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	*Triangles*	*Spheres*
$C = 2\pi r$	$A = \frac{1}{2}bh$	$A = 4\pi r^2$
$A = \pi r^2$		$V = \frac{4}{3}\pi r^3$

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

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

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

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

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

$K_t = \frac{1}{2}mv^2$

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

$U_g = mgh$

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

$W_T = FdCos\theta = \Delta E_T$

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

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

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

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

Heat

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

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

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

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

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

$PV = Nk_BT$

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

$\Delta Q = mc\Delta T$

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

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

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

Rotational Motion

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

$\omega_f = \omega_i + \alpha t$

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

$\tau = I\alpha = rF$

$L = I\omega$

$L_f = L_i + \tau\Delta t$

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

$a_r = r\omega^2$

Fluids

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

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

$P_d = P_0 + \rho gd$

$F_B = \rho gV$

$A_1v_1 = A_2v_2$

$\rho_1A_1v_1 = \rho_2A_2v_2$

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

Simple Harmonic Motion/Waves

$\omega = 2\pi f = \frac{2\pi}{T}$

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

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

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

$x(t) = A\sin\left(\frac{2\pi t}{T}\right)$

$v(t) = A\sqrt{\frac{k}{m}}\cos\left(\frac{2\pi t}{T}\right)$

Sound

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

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

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