Name____

Physics 120 Quiz #5, May 7, 2014

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.

____

An amusement park ride consists of a large vertical cylinder of radius R that spins about an axis through its center sufficiently fast that any person inside is held up against the wall when the floor drops away. Suppose the coefficient of static friction between the wall and any rider is μ.

a. Derive an expression for the maximum period of revolution necessary to keep the person from falling when the floor is dropped? Your expression should contain no numbers.

Assuming that the rider is at the following point, $\langle R,0,0\rangle$ with the origin at the center of the ride, the net force is given as $\vec{F}_{net} = \langle -F_N, F_{fr} - F_w, 0\rangle = \frac{d\vec{p}}{dt} = \left\langle -\frac{mv^2}{R}, 0, 0\right\rangle$. The result can easy be generalized to any point in the x-z plane. In the y-direction we have $F_{fr} - F_w = 0 \rightarrow \mu F_N - mg = 0 \rightarrow F_N = \frac{mg}{\mu}$ and in the x-direction we have $-F_N = -\frac{mg}{\mu} = -\frac{mv^2}{R} \rightarrow v = \sqrt{\frac{Rg}{\mu}}$. The speed is constant and is given by $v = \frac{2\pi R}{T}$. Equating these two expressions for the speed we can calculate the period of revolution. We have

$$v = \sqrt{\frac{Rg}{\mu}} = \frac{2\pi R}{T} \rightarrow T = 2\pi\sqrt{\frac{R\mu}{g}}$$

b. If the ride has a radius of $R = 4m$, what is the minimum speed necessary to keep the person from falling when the floor is dropped? Assume that $\mu = 0.4$.

From part a, $v = \sqrt{\frac{Rg}{\mu}} = \sqrt{\frac{4m \times 9.8 \frac{m}{s^2}}{0.4}} = 9.9 \frac{m}{s}$.

c. What is the reaction force of the wall on a rider if the rider has a mass of $60kg$?

From part a, $F_N = \frac{mg}{\mu} = \frac{60kg \times 9.8\frac{m}{s^2}}{0.4} = 1470N$ directed toward the center of the ride always.

d. The period of revolution of the ride and the minimum speed a rider has when riding the ride are

1. the same for all riders.
2. different for each rider since each person has a different mass but the relation cannot be predicted.
3. smaller for riders with larger masses.
4. larger for riders with smaller masses.

Physics 120 Equation Sheet

$\vec{r} = <r_x, r_y, r_z> = |\vec{r}| \cdot \hat{r}$

magnitude of a vector : $r = |\vec{r}| = \sqrt{r_x^2 + r_y^2 + r_z^2}$

unit vector : $\hat{r} = \dfrac{\vec{r}}{|\vec{r}|}$

$\vec{v} = \dfrac{\Delta \vec{r}}{\Delta t};\ \vec{v}_{avg} = \dfrac{\vec{v}_i + \vec{v}_f}{2}$

$\vec{r}_f = \vec{r}_i + \vec{v}_{avg} \Delta t$

$\vec{F}_{net} = \dfrac{\Delta \vec{p}}{\Delta t}$

$\vec{p} = \gamma m \vec{v};\ \lim\limits_{v<<c}(\vec{p}) \sim m\vec{v}$

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

$\vec{r}_f = \vec{r}_i + \vec{v}_i \Delta t + \dfrac{\vec{F}_{net}}{2m}(\Delta t)^2$

$\vec{F}_G = -\dfrac{GM_1M_2}{r^2}\hat{r}$

$\vec{F}_g \sim m\vec{g}$

Constants:

$g = 9.8 \frac{m}{s^2}$

$G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$

$m_e = 9.11 \times 10^{-31} kg$

$m_p = 1.67 \times 10^{-27} kg$

$m_E = 6 \times 10^{24} kg$

$R_E = 6.4 \times 10^6 m$

$N_A = 6.02 \times 10^{23}$

$c = 3 \times 10^8 \frac{m}{s}$

$\dfrac{d\vec{p}}{dt} = \vec{F}_{net}$

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

$F_{fr} = \mu F_N$

$k_{parallel} = \sum\limits_{i=1}^{N} k_i$

$\dfrac{1}{k_{series}} = \sum\limits_{i=1}^{N} \dfrac{1}{k_i}$

$\rho = \dfrac{m}{V}$

$Y = \dfrac{k_{IAB}}{d}$

$\text{Stress} = Y \times \text{Strain};\ \text{Stress} = \dfrac{F}{A};\ \text{Strain} = \dfrac{\Delta l}{l}$

$\vec{F}_{\parallel} = \dfrac{dp}{dt}\hat{p}$

$\vec{F}_{\perp} = p\dfrac{d\hat{p}}{dt} \rightarrow |\vec{F}_{\perp}| = \dfrac{mv^2}{R};$

$\vec{F}_{Net} = \vec{F}_{\parallel} + \vec{F}_{\perp} = \dfrac{d\vec{p}}{dt} = \dfrac{dp}{dt}\hat{p} + p\dfrac{d\hat{p}}{dt}$

$\Delta E = \Delta Q + \Delta W$

$\Delta W = \Delta KE = \int \vec{F} \cdot d\vec{r};\quad \vec{F} \cdot d\vec{r} = F_x dx + F_y dy + F_Z dz$

$KE = (\gamma - 1)mc^2;\ \lim\limits_{v<<c}(KE) \sim \dfrac{1}{2}mv^2$

$E_T = \gamma mc^2;\ E_T^2 = p^2c^2 + m^2c^4$