Name_____

Physics 110 Quiz #3, April 25, 2025

*Please show all work, thoughts and/or reasoning 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. The *Globe of Death* or *Sphere of Fear* is a daredevil's delight. The sphere (shown below) consists of a steel ball of diameter $D=5.3\text{m}$ ($\sim 16$ feet). The daredevil rides a motorcycle around the inside of the sphere in circles and it takes about $0.93\text{s}$ to make one complete loop around any circular path. What is the assumed constant speed of a rider around the ball?

https://dailyvoice.com/pa/cornwall-mount-gretna/motorcycle-globe-of-death-coming-to-lebanon-area-fair/

$$v=\frac{2\pi R}{T}=\frac{\pi D}{T}=\frac{\pi(5.3\text{m})}{0.93\text{s}}=17.9\frac{\text{m}}{\text{s}}$$

2. Suppose that a rider rides their motorcycle around in a vertical circle. What is the force on the rider and motorcycle from the cage when the motorcycle and rider are at the bottom of the loop? Express your answer in terms of the weight of the rider and motorcycle $F_W$.

Taking up as the positive y-direction we have:

$$F_N\text{-}F_W=ma_c=\frac{mv^2}{R}\rightarrow F_N=mg+\frac{mv^2}{R}=mg\left(1+\frac{v^2}{Rg}\right)=F_W\left(1+\frac{\left(17.9\frac{\text{m}}{\text{s}}\right)^2}{\frac{5.3\text{m}}{2}\times 9.8\frac{\text{m}}{\text{s}^2}}\right)$$

$$F_N=13.3F_W$$

3. Again, suppose that a rider rides their motorcycle around in a vertical circle. What is the force on the rider and motorcycle from the cage when the motorcycle and rider are at the top of the loop? Express your answer in terms of the weight of the rider and motorcycle $F_W$.

   Taking up as the positive y-direction we have:

   $-F_N-F_W=-ma_c=-\frac{mv^2}{R}\rightarrow F_N=\frac{mv^2}{R}-mg=mg\left(\frac{v^2}{Rg}-1\right)$

   $F_N = F_W\left(\frac{\left(17.9\frac{m}{s}\right)^2}{\frac{5.3m}{2}\times 9.8\frac{m}{s^2}}-1\right)$

   $F_N=11.3F_W$

4. With what minimum speed would the motorcycle and rider need to have to just barely hang on when they go around the top of the vertical loop? Hint: Think about the forces involved and what happens to one of the forces if the bike just barely loses contact with the cage.

   Barely hang on means that the normal force goes to zero.

   $F_N=\frac{mv^2}{R}-mg=0\rightarrow\frac{mv^2}{R}=mg\rightarrow v_{min}=\sqrt{Rg}=\sqrt{\frac{5.3m}{2}\times 9.8\frac{m}{s^2}}=5.1\frac{m}{s}$

5. Suppose the rider wanted to ride their motorcycle in a horizontal circle at the center of the sphere. What speed would be needed to keep the motorcycle and rider in a horizontal circle of diameter D? Assume that the coefficient of friction is $\mu=0.8$.

   x-direction (taking into the sphere as positive):

   $F_N=\frac{mv^2}{R}=\frac{mg}{\mu}\rightarrow v=\sqrt{\frac{Rg}{\mu}}=\sqrt{\frac{\frac{5.3m}{2}\times 9.8\frac{m}{s^2}}{0.8}}=5.7\frac{m}{s}$

   y-direction (taking up as positive):

   $F_{fr}-F_W=\mu F_N-mg=ma_y=0\rightarrow\mu F_N=mg\rightarrow F_N=\frac{mg}{\mu}$