Level I Key Pd 1

CIRCULAR MOTION

AT CIRCULAR MOTION (12)

Directions: Solve the following problems. Each is worth 3 point. Show all work and circle your answer.

1) Determine the period for a satellite that orbits the moon at a speed of 3,800 m/s

$F_c = F_G$

$\frac{mv^2}{r} = \frac{Gmm}{r^2}$

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

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

$F_c = F_G$

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

$\frac{4\pi^2 r^2}{T^2} = \frac{Gm_m}{r}$

$\frac{4\pi^2 r^3}{Gm_m} = T^2$

$\sqrt{\frac{4\pi^2 \left(\frac{Gm_m}{v^2}\right)^3}{Gm_m}} = T$

$\sqrt{\frac{4\pi^2 G^3 m_m^3}{G m_m v^6}}$

$\sqrt{\frac{4\pi^2 G^2 m_m^2}{v^6}}$

There Are Easier Methods To Solve This

$\frac{4(3.14)^2 (6.67\times10^{-11})^2 (.0735\times10^{24}\,kg)^2}{(3800\,m/s)^6}$

$3.15\times10^5\,s = 5.25\times10^3\,min = 6.7\times10^1\,hrs = 3.6\,Days$

$5.6\times10^2\,s$

560 s

9 min

Unit Clk

$\frac{\left(\frac{m^2}{kg^2}\right)^2 (kg)^2}{m^6/s^6}$

$\frac{v^2 m^4\, kg^2\, s^6}{kg^4\, m^6}$

$\frac{kg^2 m^2 m^4 kg^2 s^6}{s^4 kg^4 m^6}$

* Note * Unit Analysis showed I Failed To Take the Square Root of my Answer

M_{moon} 0.0735×10^{24}kg M_{earth}= 5.98×10^{24}kg R_{earth}= 6.38×10^6m R_{moon}=1.74×10^6m

$G=6.67\times10^{-11}\,Nm^2/kg^2$

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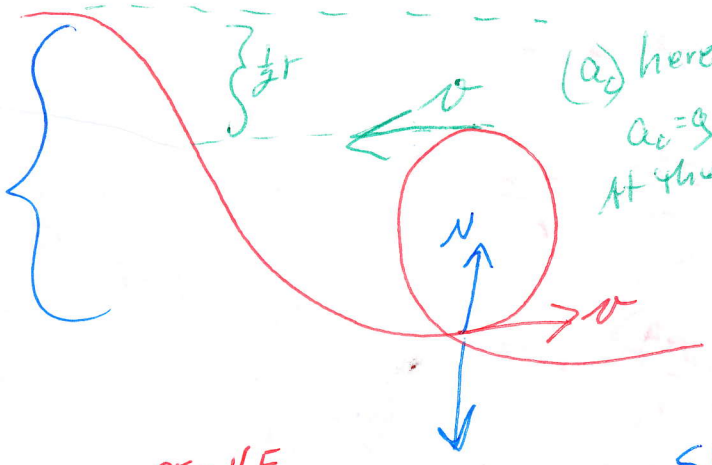
$m = 65kg$

2) How heavy will a person feel at the bottom of a loop in a roller coaster with a circular loop if the radius of the loop is 12 meters? Assume the hill is just high enough for the roller coaster to "Make it" through the circular loop with the riders feeling weightless at the top of the loop, and the roller coaster is frictionless.



$h = \frac{5r}{2}$ (from Prior In Class)

(a) there must be $a_c = g$ to be weightless At the top

$a_c = g = \frac{v^2}{r}$

$gr = v^2$

$PE = KE$

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

$gh = \frac{1}{2}v^2$

$gh = \frac{1}{2}gr$

$h = \frac{1}{2}r$

$PE = KE$

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

$\sqrt{2gh} = v$ At the Bottom

$\Sigma F_y = N - W = ma$

$N - mg = ma_c$

$N = ma_c + mg$

$N = m\left(\frac{v^2}{r} + g\right)$

$N = m\left(\frac{2gh}{r} + g\right)$

$N = mg\left(\frac{2h}{r} + 1\right)$

$N = mg\left(\frac{(2)5r}{2r} + 1\right)$

$N = mg\left(\frac{5}{1} + 1\right) = mg(6)$

M_{moon} $0.0735 \times 10^{24}kg$ $M_{earth} = 5.98 \times 10^{24}kg$ $R_{earth} = 6.38 \times 10^{6}m$ $R_{moon} = 1.74 \times 10^{6}m$

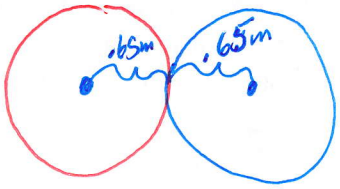
$G = 6.67 \times 10^{-11} Nm^2/kg^2$

$(65kg)(9.8 m/s^2)(6)$

3,822 N

7,007

3) Determine the gravitational attraction between two spheres that have a mass of 150 kg and a radius of 0.65 m. The two spheres are touching.



$$F = \frac{Gmm}{r^2}$$

$$F = \frac{\left(6.67\times10^{-11}\ \frac{Nm^2}{kg^2}\right)(150\,kg)^2}{[(2)(.65m)]^2}$$

$$F = 6.9\times10^{-7}\ N$$

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$G=6.67\times10^{-11}Nm^2/kg^2$

4) Just for fun, you take a foot-powered scooter (Like a RAZOR, but with bigger wheels). You figure out how to mount a motor from a string trimmer to the back of the scooter, and a way to connect a sprocket to the back wheel so that the scooter will be chain-driven. The back wheel has a diameter of 4 inches. The small trimmer motor runs at 3,000RPM. The only sprocket available to mount onto the motor has 12 teeth around its perimeter. Determine how many teeth should be on the sprocket that you purchase to mount onto the back wheel if you would like the scooter to go no faster than 20 miles/hour.

$\left(\frac{20\text{mi}}{\text{hr}}\right)\left(\frac{1\text{hr}}{60\text{min}}\right)\left(\frac{5280\text{ft}}{1\text{mi}}\right)\left(\frac{12\text{in}}{1\text{ft}}\right) = 21120\ \text{in/min}$

Wheel

$\left(\frac{21120\text{ in}}{\text{min}}\right)\left(\frac{1\text{ Rot}}{2\pi(2\text{inch})}\right) = 1682\ \text{Rot/min} \Rightarrow$

~~12 Teeth / 3,000 RPM = x Teeth / 1682 RPM~~

$\frac{3{,}000\text{ RPM}}{1682\text{ RPM}} = 1.78$ Revs of motor To Rev of Wheel

~~x Teeth / 12 Teeth~~ 16

22 Teeth

$\left[\frac{36{,}000\text{ Teeth of Chain}}{\text{min}}\right]\left[\frac{1\text{ Rot}}{x\text{ Teeth of Sprocket on Wheel}}\right]\left[\frac{2\pi(2\text{in})}{1\text{ Rot}}\right] = 21120\ \frac{\text{in}}{\text{min}}$

$\left(\frac{1682\text{ Rot}}{\text{min}}\right)\left(\frac{x\text{ Teeth}}{1\text{ Rot}}\right)\left(\frac{1\text{ Rot}}{}\right)$

$\frac{452{,}160\text{ (Teeth) in}}{x\text{ (Teeth) min}} = 2120\ \frac{\text{in}}{\text{min}}$

Motor

$\left(\frac{3{,}000\text{ Rev}}{\text{min}}\right)\left(\frac{12\text{ Teeth}}{1\text{ Rev}}\right) = \left[\frac{36{,}000\text{ Teeth}}{\text{min}}\right]$ of the Chain from the motor

$\frac{452{,}160}{21120} = x\text{ (Teeth}$

$21.6 = x$

≈ 22 Teeth

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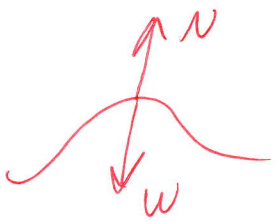
$G=6.67\times10^{-11}\text{Nm}^2/\text{kg}^2$

5) A road is built over a knob (up a hill, then back down again) such that the curvature of radius is 14 m. Determine the greatest speed you can travel over this knob and maintain control of your car.



$v = 0$ @ No Control

$-w = -ma_c$

$mg = \frac{mv^2}{r}$

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

$gr = v^2$

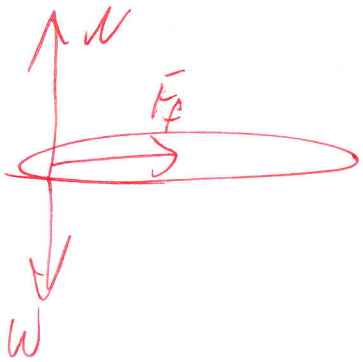
$(9.8\,m/s^2)(14\,m) = v^2$

$11.7\,m/s$

M_{moon} 0.0735×10^{24}kg M_{earth}= 5.98×10^{24}kg R_{earth}= 6.38×10^{6}m R_{moon}=1.74×10^{6}m

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

6) Image a large rotating platform that you can stand on. This platform rotates at a rate of 15 revs every 7 seconds. If the coefficient of friction between you shoes and the platform is 0.5, determine the greatest distance from the center that you could stand without slipping.



$\Sigma F_y = N - w = ma = 0$

$N = w$

$N = mg$

$\Sigma F_x = F_f = ma_c$

$\mu N = \frac{mv^2}{r}$

$\mu mg = \frac{mv^2}{r}$

$\mu g = \frac{v^2}{r}$

$\mu g = \frac{(2\pi r f)^2}{r}$

$\mu g = \frac{4\pi^2 r^2 f^2}{r}$

$\mu g = 4\pi^2 r f^2$

$\frac{\mu g}{4\pi^2 f^2} = r$

$\frac{(.5)(9.8\ m/s^2)}{4\pi^2 (15\ Rev/7s)^2} = .027m$

M_{moon} 0.0735×10^{24}kg M_{earth}= 5.98×10^{24}kg R_{earth}= 6.38×10^{6}m R_{moon}=1.74×10^{6}m

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