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Circular Motion

AT Circular motion (21 S2)

Directions: Solve the following problems. Your work will be graded, not just the answer. This test is worth 50 points.

1) A car is driven on the road at 50 mi/hr. A tire on the car has a radius of 20 inches (1 in=2.54cm). Determine the frequency of the car tire.

$v = 2\pi r f$

$\left(50\frac{mi}{hr}\right)\left(\frac{1609 m}{1 mi}\right)\left(\frac{1 hr}{3600 s}\right) =$

$22.3 m/s$

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

$\left(20 in\right)\left(\frac{2.54 cm}{1 in}\right) = 50.8 cm$

$\frac{22.3 m/s}{2\pi (.508 m)} = 6.99 Rev/s$

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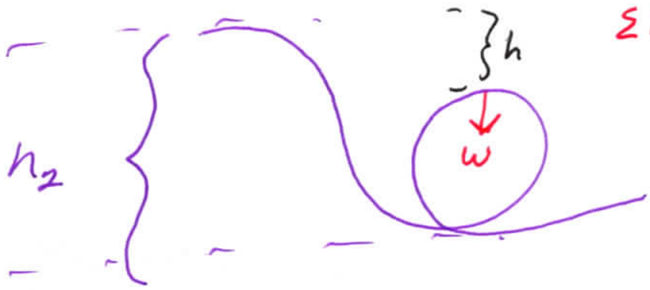
2) A looping coaster is constructed such that riders feel weightless at the top of the loop. Determine the apparent weight of a rider at the bottom of the loop. Express your response in terms of a multiplier of their "rest" weight (ie. 2.5 times heavier, etc). Assume that the entirety of the loop is circular.



$\Sigma F_y = -w = -ma_c$

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

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

$gr = v^2$

$PE = KE$

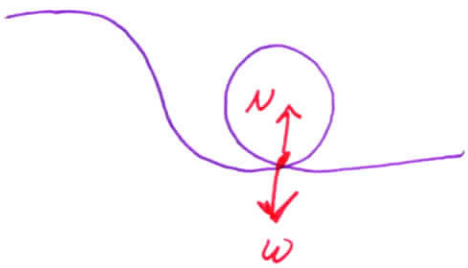
$mgh = \frac{1}{2}mv^2$

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

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

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

$^* h_2 = \frac{1}{2}r + 2r = \frac{5}{2}r$



$N \Rightarrow$ How the Rider Feels

$\Sigma F_y = N - w = ma_c$

$N = ma_c + mg$

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

$N = \frac{m(5gr)}{r} + mg$

$N = m[5g + g]$

$N = m6g = 6mg$

6 × Body Weight

$PE = KE$

$mgh_2 = \frac{1}{2}mv^2$

$^* gh_2 = \frac{1}{2}v^2$

$\frac{g5r}{2} = \frac{1}{2}v^2$

$5gr = v^2$

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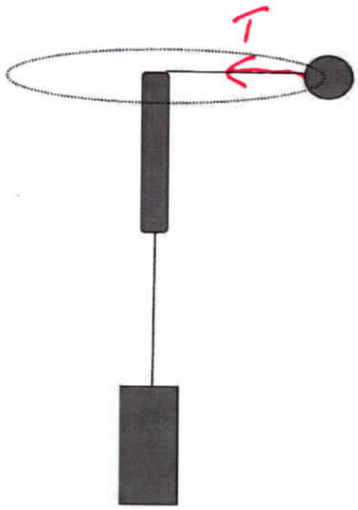
3) A stopper of 12g is spun, like in the lab, with the string going through a glass tube, with a speed of 16m/s around a circle of radius 63cm. Determine the weight of the hanger.



$$T = W$$

$$\Sigma F_x = T = ma_c$$

$$W = ma_c$$

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

$$W = \frac{(.012\,kg)(16\,m/s)^2}{.63\,m}$$

$$W = 4.88\,N$$

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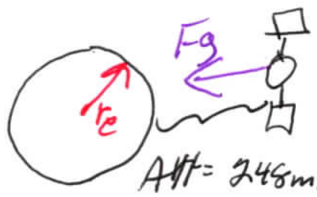
4) The ISS (International space station) orbits at an altitude of 248 miles. How long does it take the ISS to orbit once?



Alt = 248mi = 399032m

$r = r_e + Alt =$

$6.38\times10^6 m + 399032m = \underline{6.779\times10^6 m}$

$\Sigma F = F_g = \frac{m_s v^2}{r}$

$\frac{G m m_s}{r^2} = \frac{m_s 4\pi^2 r^2}{T^2 r}$

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

$T^2 = \frac{4\pi^2 r^3}{Gm} \Rightarrow \sqrt{\frac{4\pi^2(6.779\times10^6)^3}{(6.67\times10^{-11}\frac{Nm^2}{kg^2})(5.98\times10^{24} kg)}}$

5,550s = 92.5 min

T = ~~5132~~ s =

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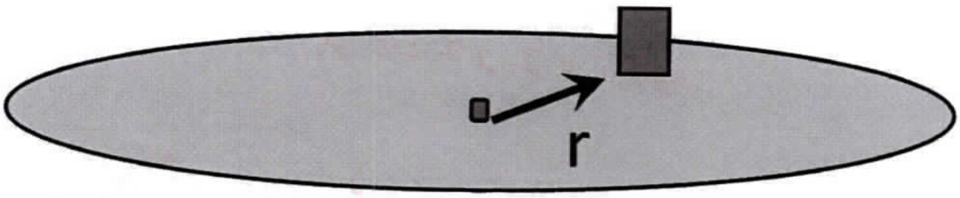
$\mu = .4$

5) A turn table has a frequency of 0.25 rev/s. A plastic block sits on the turntable. Determine the greatest distance from the center the block can be without sliding off of the rotating platform.



$\Sigma F_y = N - W = 0$

$N = W$

$N = mg$

$\Sigma F_x = F_f = ma_c$

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

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

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

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

$\frac{(.4)(9.8\,m/s^2)}{4\pi^2 (.25\,Rev/s)^2} = r$

$= r$ 1.6m

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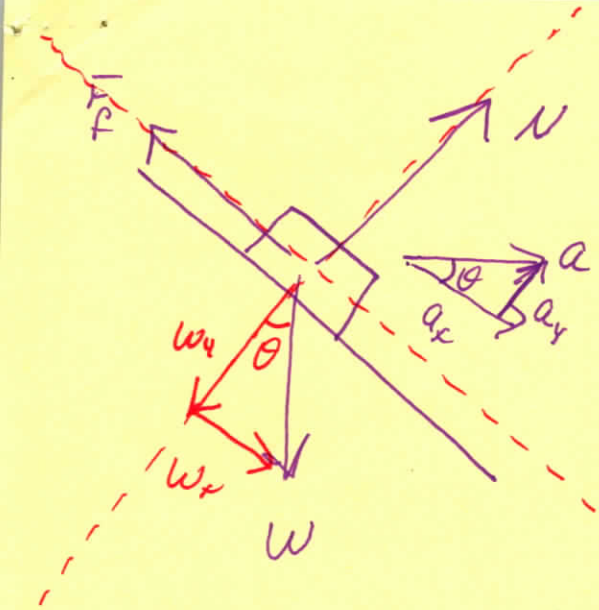
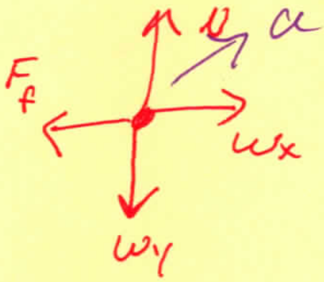
6) Determine the gravitational field strength 200 miles above the surface of the Earth.

$200mi = 3.22 \times 10^{5} m$

$$g = \frac{Gm}{r^2} = \frac{\left(6.67 \times 10^{-11} \frac{Nm^2}{kg^2}\right)\left(5.98 \times 10^{24} kg\right)}{\left(3.22 \times 10^{5} + 6.38 \times 10^{6} m\right)^2}$$

$g = 8.88 \, m/s^2$





$$\Sigma F_y = N - w_y = ma_{c_y}$$

$$N - w\cos\theta = ma_c \sin\theta$$

$$N = ma_c \sin\theta + w\cos\theta$$

$$N = ma_c \sin\theta + mg\cos\theta$$

$$\Sigma F_x = w_x - F_f = ma_{c_x}$$

$$w\sin\theta - \mu N = ma_c \cos\theta$$

$$mg\sin\theta - \mu[ma_c \sin\theta + mg\cos\theta] = ma_c\cos\theta$$

$$g\sin\theta - \mu a_c \sin\theta + \mu g\cos\theta = a_c \cos\theta$$

$$g\sin\theta + \mu g\cos\theta = a_c\cos\theta + \mu a_c \sin\theta$$

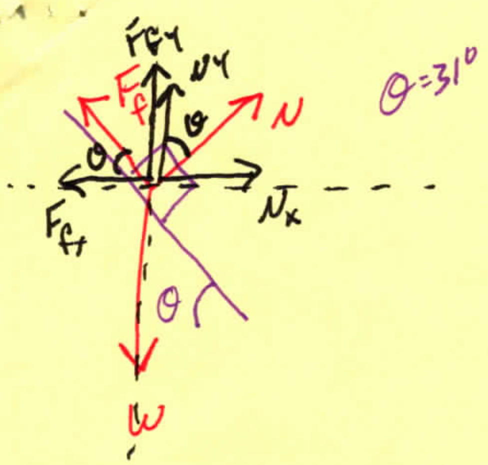
$$g\sin\theta + \mu g\cos\theta = a_c(\cos\theta + \mu\sin\theta)$$

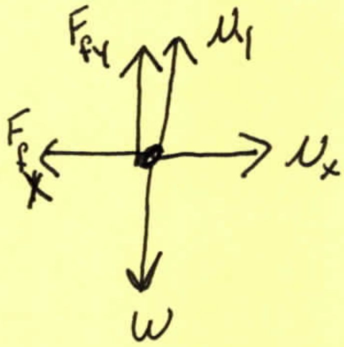
$$\frac{g\sin\theta + \mu g\cos\theta}{\cos\theta + \mu\sin\theta} = a_c$$

$$\frac{g[\sin\theta + \mu\cos\theta]}{\cos\theta + \mu\sin\theta} = a_c$$

$$\frac{g[\sin\theta + \mu\cos\theta]}{\cos\theta + \mu\sin\theta} = \frac{v^2}{r}$$

$$\sqrt{\frac{g[\sin\theta + \mu\cos\theta]r}{[\cos\theta + \mu\sin\theta]}} = v$$





$$\Sigma F_y = F_{f_y} + N_y - W = 0$$

$$F_f \sin\theta + N\cos\theta = W$$

$$\mu N \sin\theta + N\cos\theta = mg$$

$$N(\mu \sin\theta + \cos\theta) = mg$$

$$N = \frac{mg}{(\mu \sin\theta + \cos\theta)}$$

$$\Sigma F_x = N_x - F_{f_x} = ma_c$$

$$N \sin\theta - F_f \cos\theta = ma_c$$

$$N \sin\theta - \mu N \cos\theta = ma_c$$

$$N[\sin\theta - \mu \cos\theta] = ma_c$$

$$\frac{mg}{(\mu \sin\theta + \cos\theta)}[\sin\theta - \mu\cos\theta] = \frac{mv^2}{r}$$

$$\sqrt{\frac{g[\sin\theta - \mu\cos\theta]r}{[\mu \sin\theta + \cos\theta]}} = v$$

$$\sqrt{\frac{(9.8\frac{m}{s^2})[\sin(31^\circ) - (.46)\cos(31^\circ)](308m)}{[(.46)\sin(31^\circ) + \cos(31)]}} = v$$

2758.8

$$v = 18.25\frac{m}{s}$$

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[illegible]