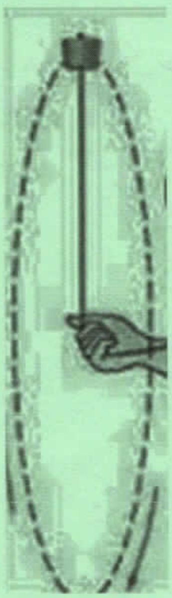
Level I Answer Key Pd 3

# Circular Motion

AT Circular Motion (21)

Directions: Solve the following problem. Show all work. Be neat. Your solution should mathematically read like an essay. This is worth 50 points.

1) A rubber stopper of mass 23g is at the end of a 1.2 m long string. The stopper is spun in a vertical circle such that it makes 25 revolutions in 12 seconds. Determine the period of the stopper.



$\frac{12s}{25Rev} = .48\ s/Rev$

$G=6.67x10^{-11}Nm^2/kg^2$ $m_{earth}=5.98x10^{24}kg$ $r_{earth}=6.38x10^6m$ $m_{moon}=7.35x10^{22}kg$ $r_{moon}=1.74x10^6m$

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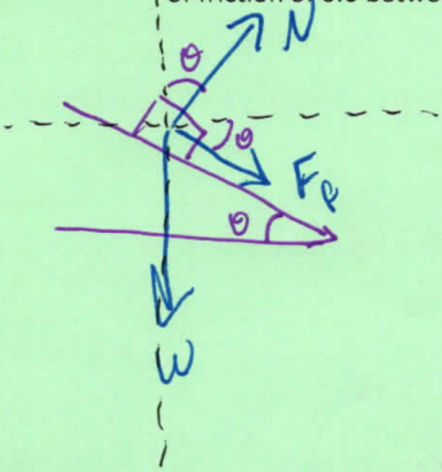
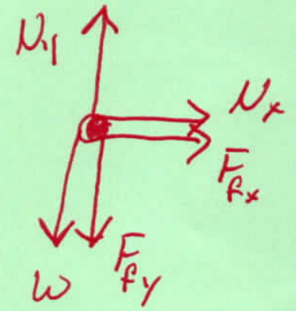
2) A modern Honda accord has a mass of about 1,400 kg. Determine the greatest speed that an Accord can go through a turn of radius 35m that is banked at 15 degrees. Assume a coefficient of friction of 0.6 between the tires and the pavement.




$$\Sigma F_x = N_x + F_{f_x} = ma$$
$$N\sin\theta + F_f\cos\theta = \frac{mv^2}{r}$$
$$N\sin\theta + \mu N\cos\theta = \frac{mv^2}{r}$$
$$N(\sin\theta + \mu\cos\theta) = \frac{mv^2}{r}$$

$$\Sigma F_y = N_y - W - F_{fy} = ma$$
$$N\cos\theta - W - F_f\sin\theta = 0$$
$$N\cos\theta = W + F_f\sin\theta$$
$$\cos\theta N = mg + \mu N\sin\theta \quad \text{(opps)}$$
$$N\cos\theta - \mu N\sin\theta = mg$$
$$N(\cos\theta - \mu\sin\theta) = mg$$
$$N = \frac{mg}{\cos\theta - \mu\sin\theta}$$

$$\frac{mg(\sin\theta + \mu\cos\theta)}{(\cos\theta - \mu\sin\theta)} = \frac{mv^2}{r}$$
$$\frac{g(\sin\theta + \mu\cos\theta)}{(\cos\theta - \mu\sin\theta)} = \frac{v^2}{r}$$
$$\frac{gr(\sin\theta + \mu\cos\theta)}{(\cos\theta - \mu\sin\theta)} = v^2$$
$$\sqrt{\frac{(9.8\frac{m}{s^2})(35m)(\sin 15 + (.6)(\cos 15))}{[\cos(15) - (.6)(\sin 15)]}} = v = ~~16~~ \text{ m/s}$$

18.83 m/s

$\sqrt{\ \ }$ ~~.442~~ .81

G=6.67x10$^{-11}$Nm$^2$/kg$^2$ $m_{earth}$=5.98x10$^{24}$kg $r_{earth}$=6.38x10$^6$m $m_{moon}$=7.35x10$^{22}$kg $r_{moon}$=1.74x10$^6$m

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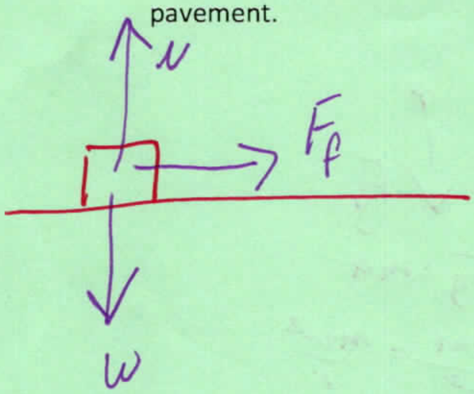
3) Determine the greatest speed that an Accord can go through a turn of radius 35m that is not banked; the turn is flat. Assume a coefficient of friction of 0.6 between the tires and the pavement.




$$\Sigma F_y: N - W = 0$$
$$N = W$$
$$N = mg$$

$$\Sigma F_x: F_f = ma$$
$$\mu N = \frac{mv^2}{r}$$
$$\mu mg = \frac{mv^2}{r}$$
$$\mu g = \frac{v^2}{r}$$
$$\sqrt{\mu g r} = \sqrt{(.6)(9.8\,m/s^2)(35\,m)} = 14.3\,m/s$$

Notice the Similarity/Diff w/ #2

$G = 6.67\times10^{-11} Nm^2/kg^2$ $m_{earth} = 5.98\times10^{24} kg$ $r_{earth} = 6.38\times10^6 m$ $m_{moon} = 7.35\times10^{22} kg$ $r_{moon} = 1.74\times10^6 m$

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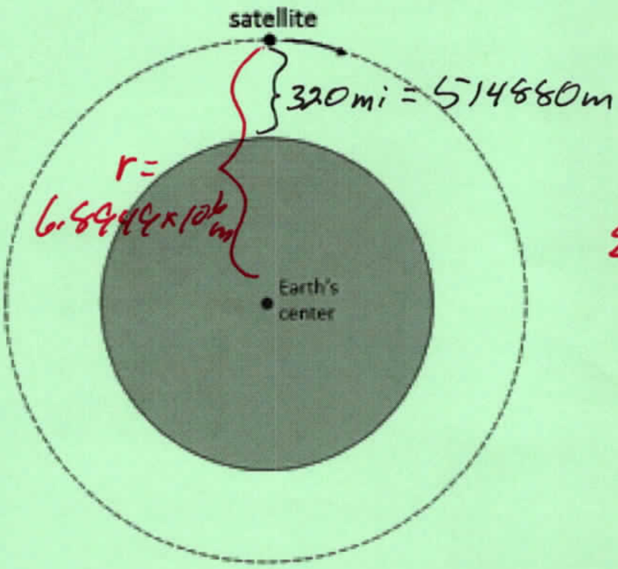
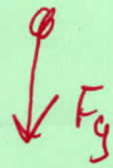
4) Determine how long it will take a satellite to orbit in a circular orbit that is 320 miles above the surface of the Earth.




$$\Sigma F = F_g = ma$$

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

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

$$\frac{Gm}{r} = \left(\frac{2\pi r}{T}\right)^2$$

$$\frac{Gm}{r} = \left(\frac{2\pi r}{T}\right)^2$$

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

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

$$T = \sqrt{\frac{4\pi^2 (6.8949\times10^6\,m)^3}{\left(6.67\times10^{-11}\,\frac{Nm^2}{kg^2}\right)\left(5.98\times10^{24}\,kg\right)}}$$

$$T = 5.69\times10^3\,s = 94\,min$$

94.9 min

$G=6.67x10^{-11}Nm^2/kg^2$ $m_{earth}=5.98x10^{24}kg$ $r_{earth}=6.38x10^6m$ $m_{moon}=7.35x10^{22}kg$ $r_{moon}=1.74x10^6m$

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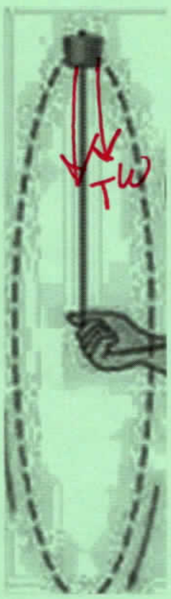
5) A rubber stopper of mass 23g is at the end of a 1.2 m long string. The stopper is spun in a vertical circle such that it makes 25 revolutions in 12 seconds. Determine the tension in the string when the stopper is at its highest point.





$$\Sigma F_y = -T - W = -ma$$

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

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

$$T + mg = m 4\pi^2 r f^2$$

$$T = m 4\pi^2 r f^2 - mg$$

$$T = m(4\pi^2 f^2 r - g)$$ ⇐ Should make sense...

$$T = (.023kg)\left[4\pi^2\left(\frac{25 Rev}{12s}\right)^2(1.2m) - 9.8\,m/s^2\right] = 4.5N$$

$G=6.67x10^{-11}Nm^2/kg^2$  $m_{earth}=5.98x10^{24}kg$  $r_{earth}=6.38x10^6m$  $m_{moon}=7.35x10^{22}kg$  $r_{moon}=1.74x10^6m$

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6) A rubber stopper of mass 23g is at the end of a 1.2 m long string. The stopper is spun in a vertical circle such that it makes 25 revolutions in 12 seconds. Determine the tension in the string when the stopper is at its lowest point.



$$\Sigma F_y = T - w = ma$$

$$T = ma + w$$

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

$$T = \frac{m4\pi^2 r^2 f^2}{r} + mg$$

$$T = m4\pi^2 r f^2 + mg$$

$$T = m\left[4\pi^2 r f^2 + g\right]$$

$$T = (.023\,kg)\left[(4\pi^2)(1.2\,m)\left(\frac{25\,Rev}{12\,s}\right)^2 + (9.8\,m/s^2)\right]$$

$$T = 4.95\,N$$

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