key Level I Physics pd:1

Circular Motion

AT Circular Motion (16)

Directions: Solve the following problems. Show all work and circle your answers. Each question is worth 10 points. This test is worth 50 points.

Mass of Earth 5.98×10^{24}kg

Mass of Moon 7.35×10^{22}kg

Mass of Mars 6.39×10^{23}kg

Radius of Earth 6.38×10^{6}m

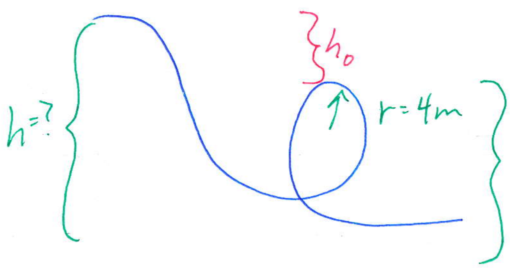
Radius of Moon 1.74×10^{6}m

Radius of Mars 3.34×10^{6}m

Universal Constant of Gravitations 6.67×10^{-11}Nm^2/kg^2

A roller coaster drops down from its initial hill, through a loop, and around a turn. The radius of curvature of the bottom of the loop is 12m, the radius at the top of the loop is 4m. The height of the top of the loop is 21 m. After the loop, the train returns to the ground in which the track makes a banked turn to the left with a radius of curvature of 28m. Assume no energy is lost on the roller coaster.

1) How high is the hill? Riders feel 1.5 times their body weight while upside down at the top of the loop.



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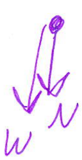


$N = 1.5mg$

$\Sigma F_y = -N - W = -ma_c$

$N + W = ma_c$

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

$1.5mg + mg = \frac{mv^2}{r}$

$2.5mg = \frac{mv^2}{r}$

$2.5g = \frac{v^2}{r}$

PE = KE

$mgh_0 = \frac{1}{2}mv^2$

$gh_0 = \frac{1}{2}v^2$

$2gh_0 = v^2$

$2.5g = \frac{2gh_0}{r}$

$1.25 = \frac{h_0}{r}$

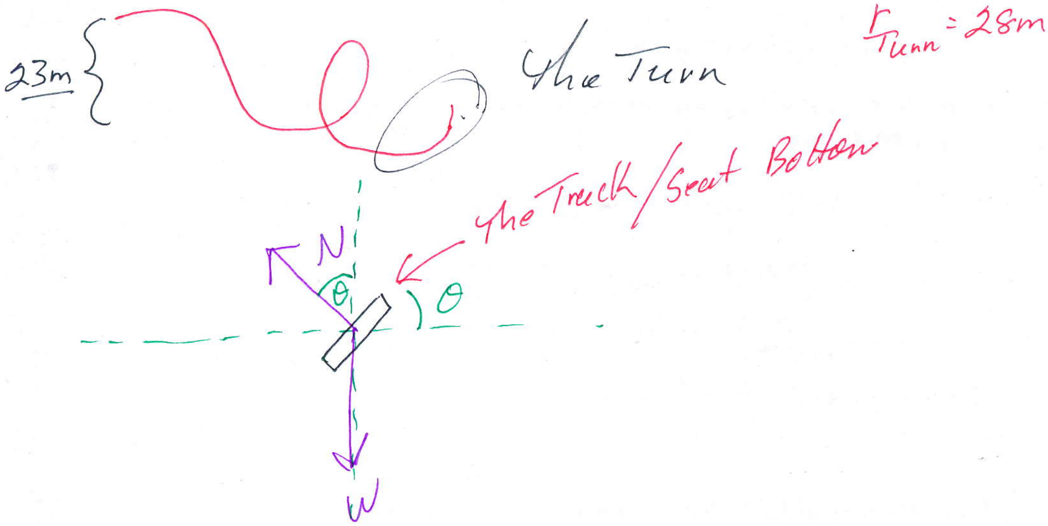
$1.25r = h_0$

$(1.25)(4m) = h_0$

$5m = h_0$

$h = h_0 + h_L = 26m$

2) When traveling around the turn after the loop, riders are supported only by the seat bottom. Determine the banking of the turn, as measured from the ground.



$\Sigma F_y = N_y - w = 0$

$N\cos\theta - w = 0$

$N\cos\theta = w$

$N = \frac{w}{\cos\theta}$

$\Sigma F_x = N_x = ma_c$

$N\sin\theta = ma_c$

$\frac{w\sin\theta}{\cos\theta} = ma_c$

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

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

$KE = PE$

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

$v^2 = 2gh$

$g\tan\theta = \frac{2gh}{r}$

$\tan\theta = \frac{2h}{r}$

$\theta = \tan^{-1}\left[\frac{(2)(2\cancel{8}6m)}{28m}\right]$

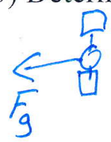
$\theta = \cancel{59}^{0}$

61^{0}

key Level I Physics Pd 1

A satellite is in a geostationary orbit around the Earth.

3) Determine the height above the surface of the Earth of the satellite.



$\Sigma F = F_g = ma_c$

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

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

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

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

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

$r = \sqrt[3]{\frac{(6.67\times10^{-11}\,\frac{Nm^2}{kg^2})(5.98\times10^{24}\,kg)(86400\,s)^2}{4\pi^2}}$

$r = 4.22\times10^{7}\,m$

$h = r - r_e = 3.59\times10^{7}\,m$

4) How fast is this satellite moving?

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

$\sqrt{\frac{(6.67\times10^{-11}\,\frac{Nm^2}{kg^2})(5.98\times10^{24}\,kg)}{(4.22\times10^{7}\,m)}} = 3{,}074\,m/s$

5) What is the gravitational field strength where this satellite is orbiting?

$W = F_g$

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

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

$g = \frac{(6.67 \times 10^{-11}\ Nm^2/kg^2)(5.98 \times 10^{24}\ kg)}{(4.22 \times 10^{7}\ m)^2}$

$g = .22\ m/s^2$