key Level I Physics Pd3

Circular Motion

AT Circular Motion (15).doc

Directions: Answer the following questions. Each is worth 5 points. Additional needed information can be found on the last page.

1) Standing next to your car tire, you measure the height of the tire to be 63cm. Determine the frequency of the tire when driving at 60 mph.

$d = 63cm$

$r = 31.5cm = .315m$

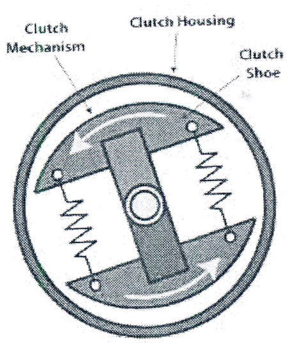
$\left(\frac{60 mi}{hr}\right)\left(\frac{1600 m}{1 mi}\right)\left(\frac{1 hr}{3600 s}\right) = 26.67 m/s$

$v = 2\pi r f$

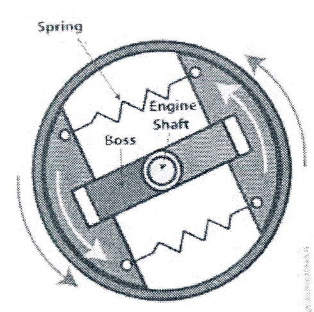
$\frac{v}{2\pi r} = f = \frac{26.67 m/s}{2\pi(.315 m)} = 13.4 Rev/s$

2) Essay: Respond to this question using statements, diagrams, and maybe equations. Please skip the wordy fluff. Keep your response to important concepts that demonstrate your understanding of the material.

Question: How/why do centrifugal clutches work? Additional info: If you know what a centrifugal clutch is, then skip this part and write your answer. This section is just to explain the clutch. With things like chain saws, string trimmers, snowmobiles, and four wheelers, there is a need for the engine to remain running (rotating) without the working part of the machine running. (The chain on the chain saw doesn't move, the string on the string trimmer doesn't move, and the four-wheeler and snowmobile remain motionless. When the engine is revved up, the clutch engages the "driven" part and starts rotating. To make this happen, the rotating engine shaft is connected to a rotating assembly consisting of masses held in near the engine shaft with springs. When the engine RPM increases, the weights press against inside of a drum, causing the drum to rotate. This drum is attached to the shaft that turns the string trimmer spool, makes the chain go around on the chain saw, etc. There are diagrams to help show the device, and a video to see the operation. Ask if you have questions.



Centrifugal Clutch With Engine Running at Idle Speed



Centrifugal Clutch With Engine Running at Operational Speed

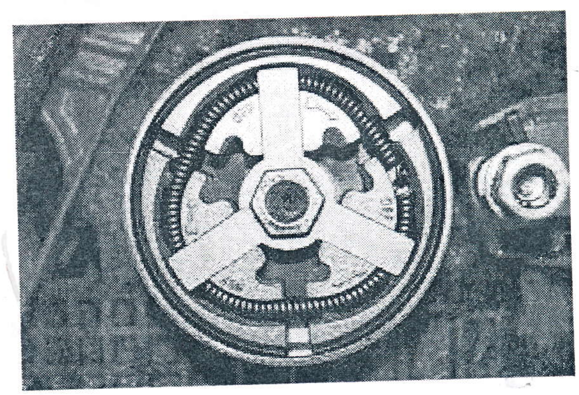
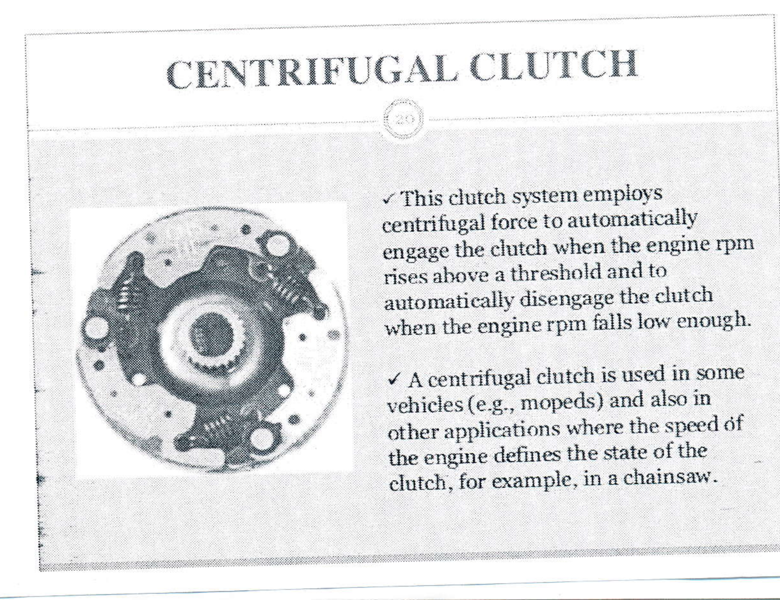


Figure 1: Clutch installed on a chainsaw



3) Determine the linear speed of a satellite that orbits in the in a half geosynchronous orbit (period of 12 hours).

$F_c = F_G$

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

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

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

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

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

Figure 2: Typical explanation of the clutch

$\left(v^2\right)^3 = \left(\frac{Gm}{\sqrt[3]{\frac{GmT^2}{4\pi^2}}}\right)^3$

$v^6 = \frac{G^3m^3}{\frac{GmT^2}{4\pi^2}}$

$v^6 = \frac{G^2m^2 4\pi^2}{T^2}$

$v = \left(\frac{G^2m^2 4\pi^2}{T^2}\right)^{1/6} = \frac{(6.67\times10^{-11})^2(5.98\times10^{24})^2(4)(3.14)^2}{\left((12hr)\left(\frac{3600s}{1hr}\right)\right)^2}$

$v = \left(3.362\times10^{21}\right)^{1/6}$

$v = 3.87\times10^{3}\ m/s$

$r = \sqrt[3]{\frac{(6.67\times10^{-11})(5.98\times10^{24})(12hr\cdot3600s)^2}{4\pi^2}}$

$r = 2.6\times10^{7}m$

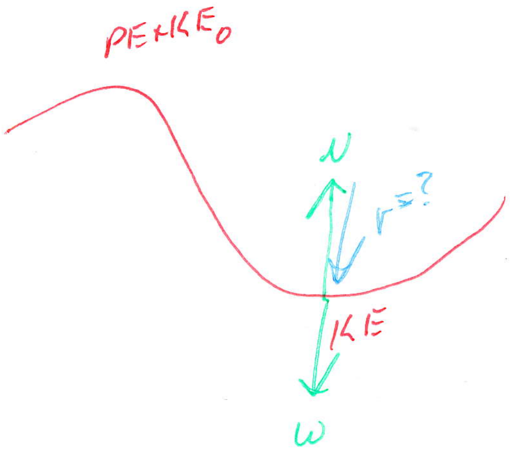
$v^2 = \frac{(6.67\times10^{-11})(5.98\times10^{24})}{2.6\times10^{7}m}$

$v = 3.8\times10^{3}\ m/s$

(Number 2 continued… Space to actually respond)

When Spring Cannot Supply Need Force For Weights To accel, ~~[illegible]~~ Springs Stretch Until Inside of Drum Supplies Needed F_c Then Friction

4) A roller coaster tops a 35 m tall hill moving at 6 m/s and goes screaming **down the hill** to ground level. Determine the radius of the upward turn at the bottom of the hill so that the riders feel no more than 3.8 g.



$PE + KE_0 = KE$

$mgh + \frac{1}{2}mv_0^2 = \frac{1}{2}mv^2$

$\sqrt{2\left(gh + \frac{1}{2}v_0^2\right)} = v$

no accel

$N = W$

To Feel 3.8g

$m(1g) = W$

$m(1g) = mg$

$N - W = ma_c$ → So...

$N - W = ma_c$

$N = ma_c + W$

$N = ma_c + mg$

$(m)(3.8g) = ma_c + mg$

$3.8g = a_c + g$

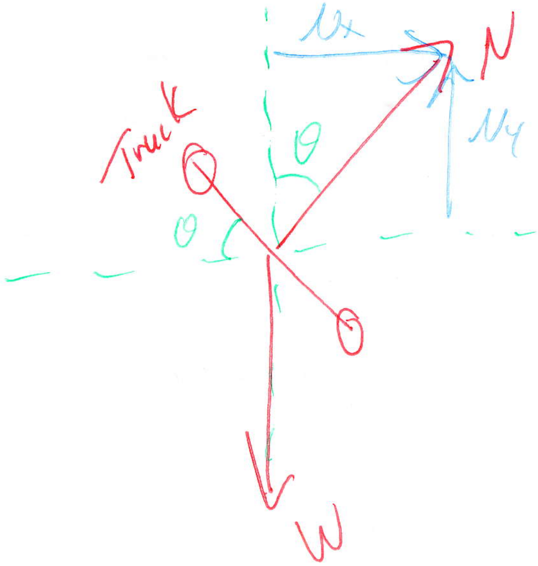
$2.8g = a_c$

$2.8g = \frac{v^2}{r}$

$r = \frac{v^2}{2.8g} = \frac{2\left(gh + \frac{1}{2}v_0^2\right)}{2.8g}$

$r = \underline{26m}$

5) A roller coaster approaches a level turn of radius 26 m with a speed of 12 m/s. Determine the "ideal" banking of the turn such that the riders feel no lateral (sideways) "forces;" All forces acting on the riders are perpendicular to the seat by the seat, and weight too. Measure the angle with respect to the horizontal such that zero degrees is a flat, unbanked turn.



$$\Sigma F_y = N_y - w = 0$$

$$N\cos\theta = w$$

$$N\cos\theta = mg$$

$$\Sigma F_x = N_x = ma_c$$

$$N\sin\theta = \frac{mv^2}{r}$$

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

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

$$\theta = \tan^{-1}\left(\frac{v^2}{gr}\right)$$

$$\theta = \tan^{-1}\left(\frac{(12\,\text{m/s})^2}{(9.8\,\frac{\text{m}}{\text{s}^2})(26\,\text{m})}\right)$$

$$\theta = 29.5^\circ$$

6) Determine the gravitational field strength 15 miles above the surface of the moon.

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

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

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

$$\frac{(6.67\times10^{-11})(7.35\times10^{22}\,kg)}{(1.74\times10^{6}\,m + ((15\,mi)\,1600\,m/mi))^2}$$

$$g = 1.58\ m/s^2$$

7) What is the period of the minute hand on an analog clock. Answer in any quantity of your choosing.

1 hr

60min

3600s