Chapter 5

$\boxed{5-7}$ $a_c = \dfrac{v^2}{r}$

let T be the time for one complete revolution, so that

$$v = \frac{2\pi r}{T}, \text{ then}$$

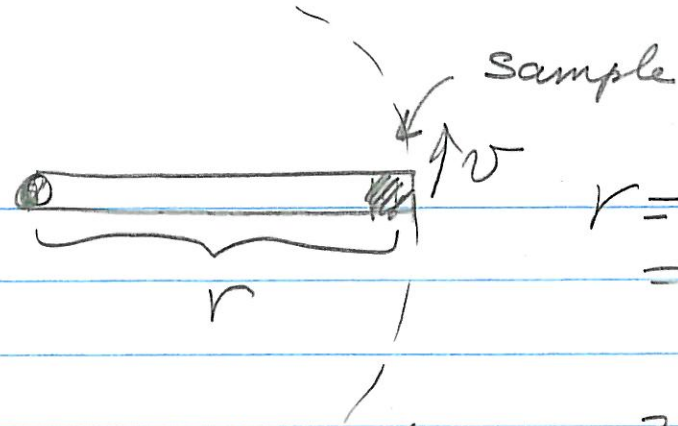
$$a_c = \frac{4\pi^2 r^{\cancel{2}}}{\cancel{r}\,T^2} = 4\pi^2 \frac{r}{T}$$

Then if both clock hands have the SAME r

$$\frac{a_{c,sec}}{a_{c,minute}} = \frac{\dfrac{\cancel{4\pi^2 r}}{T_{sec}^2}}{\dfrac{\cancel{4\pi^2 r}}{T_{min}^2}} = \left(\frac{T_{min}}{T_{SEC}}\right)^2$$

$$= \left(\frac{60\,min \times 60s}{60s}\right)^2 = \underline{\underline{3600}}$$

$\boxed{5-11}$



$r = 5\,cm$
$= 5\times10^{-2}\,m$

$$\frac{\cancel{m}v^2}{r} = F_c = \cancel{m}\times(6.25\times10^3\,g)$$

$$v^2 = 6.25\times10^3 \times 9.8 \times r$$

$$= 6.25\times10^3 \times 9.8 \times 5\times10^{-2}$$

$$= 3062.5\ m^2/s^2$$

$$v = 55.3\ m/s$$

Each Revolution covers $2\pi r = 0.31\,m$

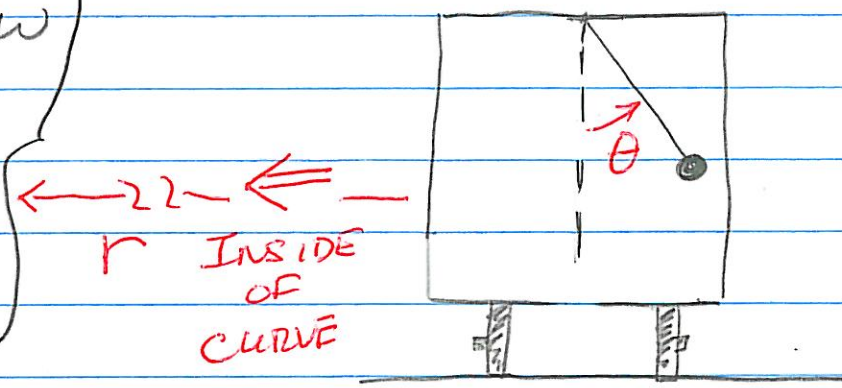
So there must be $\dfrac{55.3\ m/s}{0.31\ m/Rev}$

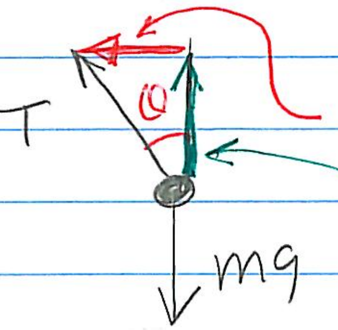
$= 176$ Rev per SEC

OR: $\underline{10562}$ Rev per min

5-21

BACK VIEW OF VAN AS IT TURNS LEFT





$T\sin\theta \rightarrow$ PROVIDES CENT FORCE

$T\cos\theta = mg$

$$T\sin\theta = mv^2/r$$

$$\left(\frac{\cancel{m}g}{\cos\theta}\right)\sin\theta = \frac{\cancel{m}v^2}{r}$$

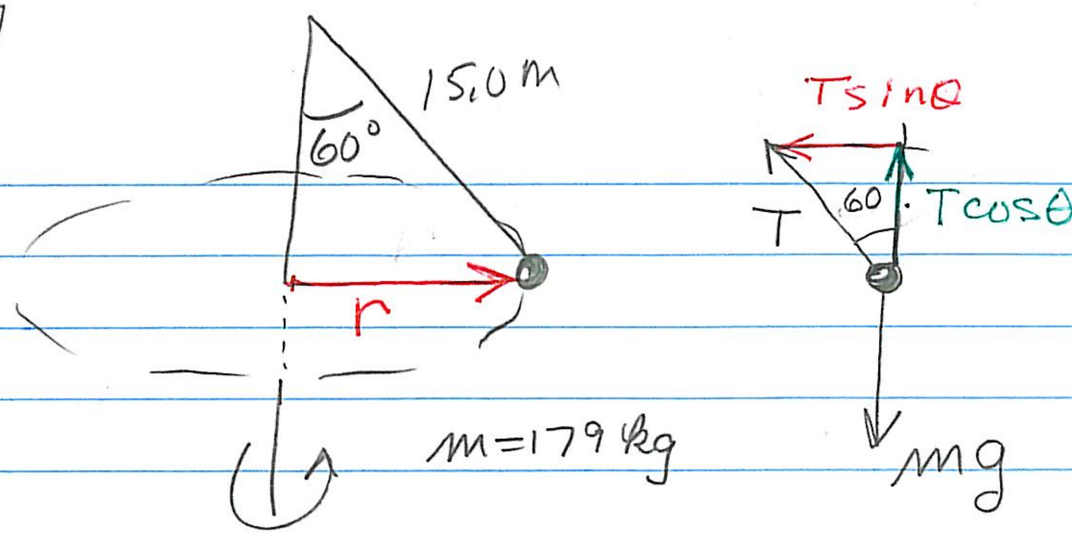
$$g\tan\theta = v^2/r$$

$$\tan\theta = v^2/rg$$

$$= (28\,m/s)^2/(150\cdot 9.8) = 0.53$$

$$\theta = 28^\circ$$

$\boxed{5\text{-}23}$



$$\begin{cases} T\cos\theta = mg \\ T\sin\theta = \dfrac{mv^2}{r} \end{cases}$$ (TOWARD CENTER)

NOTE: $r = 15 \sin 60° = 13\ m$

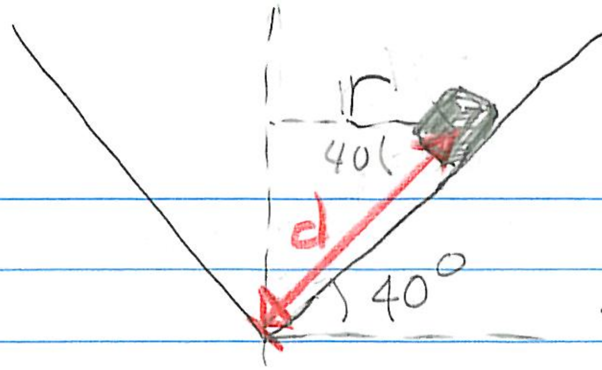
(a) $T = \dfrac{mg}{\cos\theta} = \dfrac{179 \cdot 9.8}{\cos 60} = \underline{3489\ N}$

(b) $v^2 = \dfrac{r\,(T\sin\theta)}{m}$

$$v = \sqrt{\frac{13 \times 3489 \times \sin 60}{179}}$$

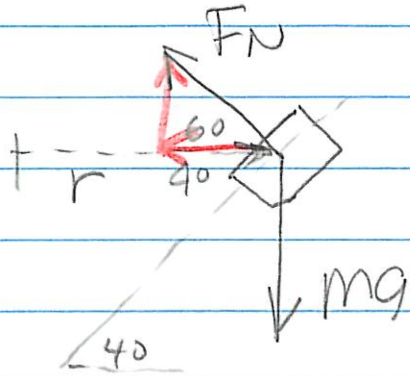
$$= \underline{14.8\ m/s}$$

$\boxed{5\text{-}29}$



$r = d\sin 50$

$v = 34\,m/s$



Vertical: $F_N \sin 50 = mg$

INWARD: $F_N \cos 50 = \dfrac{mv^2}{r}$

$F_N = mg/\sin 50$

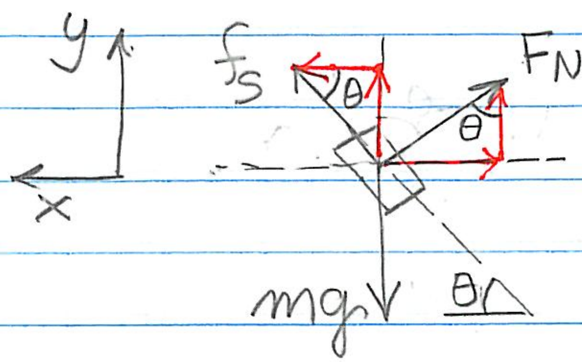
$\dfrac{\cancel{m}g}{\sin 50} \cdot \cos 50 = \dfrac{\cancel{m}v^2}{r}$

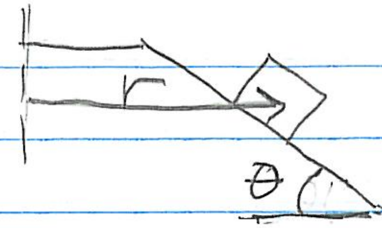
$r = d\cancel{\sin 50} = \dfrac{v^2 \cancel{\sin 50}}{g\cos 50}$

$d = v^2/g\cos 50 = \dfrac{(34)^2}{9.8\cos 50}$

$\underline{d = 184\ m}$

$\boxed{5\text{-}30}$





$\theta = 36^\circ$, $\mu_s = 0.760$

$r = 11\ m$

angles $= \theta = 36^\circ$

are indicated. Components of all forces in the x and y directions must be found. The x-direction is the radially inward direction - this is the direction of the centripetal force.

$$y: \quad F_N \cos\theta + f_s \sin\theta - mg = 0 \qquad (1)$$

$$x: \quad f_s \cos\theta - F_N \sin\theta = mv^2/r \qquad (2)$$

$$f_s = \mu_s F_N \qquad (3)$$

$(3) \to (1)$ $\quad F_N \cos\theta + \mu_s F_N \sin\theta = mg$

$$F_N (\cos\theta + \mu_s \sin\theta) = mg$$

$$F_N = \frac{mg}{\cos\theta + \mu_s \sin\theta}$$

(OVER)

5-30, continued

$$F_N = m \frac{9.8}{\cos 36 + 0.76 \sin 36} = 7.8\,m \quad (4)$$

$$(2) \quad \mu_s F_N \cos\theta - F_N \sin\theta = mv^2/r$$

$$F_N(\mu_s \cos 36 - \sin 36) = mv^2/r$$

$$7.8\cancel{m}(0.76 \cos 36 - \sin 36) = \cancel{m}v^2/r$$

$$7.8(0.027) = v^2/r$$

$$0.21 = v^2/r$$

$$v^2 = 0.21 \cdot r = 0.21 \cdot 11 = 2.32$$

$$v = 1.52\ \text{m/s} = 2\pi r/T$$

$$T = 2\pi r/v = 2\pi \cdot 11/1.52$$

$$T = 45.4\ \text{s}$$

$\boxed{5\text{-}33}$

An object of mass m in a circular orbit of radius r around a planet of mass M satisfies

$$F_g = \frac{G\cancel{m}M}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$$

The relation between orbital speed and orbital radius is then

$$v = \sqrt{\frac{GM}{r}}$$

The ratio of $v_2 : v_1$ for 2 satellites is

$$\frac{v_2}{v_1} = \sqrt{\frac{r_1}{r_2}} \Rightarrow v_2 = \sqrt{\frac{r_1}{r_2}} \cdot v_1$$

$$v_2 = \sqrt{\frac{5.25 \times 10^6}{8.6 \times 10^6}} \cdot 1.7 \times 10^4 \text{ m/s}$$

$$v_2 = 1.33 \times 10^4 \text{ m/s}$$

$\boxed{5\text{-}35}$

For circular orbits

$$\frac{G\cancel{m}M_E}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$$

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

also $v = 2\pi r/T \Rightarrow r = \frac{vT}{2\pi}$

Then $\frac{GM_E}{(vT/2\pi)} = v^2$

OR $\frac{2\pi GM_E}{T} = v^3$

$\therefore \quad v^3 \propto \frac{1}{T}$

$\Rightarrow \quad \left(\frac{v_B}{v_A}\right)^3 = \frac{T_A}{T_B} \quad , v_A = 3v_B$

$$\frac{T_A}{T_B} = \left(\frac{1}{3}\right)^3 = \frac{1}{27}$$

$\boxed{5\text{-}36}$

$$\frac{G \cancel{m} M_E}{R_{EM}^{2}} = \frac{\cancel{m} v^2}{\cancel{R_{EM}}}$$

in terms of the orbital period, T $\qquad v = \dfrac{2\pi R_{EM}}{T}$

$$\frac{G M_E}{R_E} = \frac{4\pi^2 R_{EM}^2}{T^2}$$

or $\qquad T^2 = \left(\dfrac{4\pi^2}{G M_E}\right) R_{EM}^3$

$$T^2 = \frac{4\pi^2}{6.67\times10^{-11} \cdot 5.98\times10^{24}} \cdot (3.85\times10^{8})^3$$

$$= 5.65\times10^{12}\ s^2$$

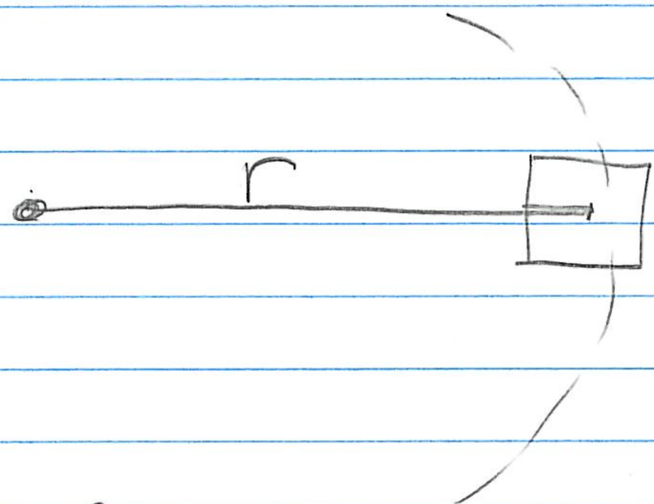
$$T = 2.38\times10^{6}\ s \times \frac{1\,min}{60\,s} \times \frac{1\,hr}{60\,min} \times \frac{1\,day}{24\,hrs}$$

$$= \underline{27.5\ days}$$

$\boxed{5-53}$

Want: $a_c = 7.5g$

$r = 15\,m$



$$\frac{v^2}{r} = 7.5g$$

so $v^2 = 7.5 \cdot g \cdot r$

$$v = \sqrt{7.5 \cdot 9.8 \cdot 15}$$

$$\underline{v = 33\ m/s} \times \frac{1\,mph}{0.447\,m/s}$$

about 74 mph