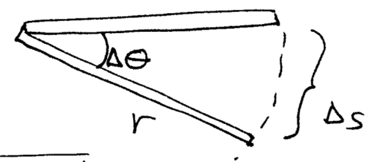
chapter 5

Homework Solutions

(1)

$\Delta S = r \Delta\theta$



in this case

$\Delta r = (8.0)\left(\frac{120}{57}\right) = \boxed{16.8 \text{ m}}$

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(7) $\omega = 33.3$ rpm

a) $\omega = 33.3 \times \frac{2\pi}{60} = 3.5$ rad/s

b) $V = r\omega = (0.13)(3.5) = 0.45$ m/s

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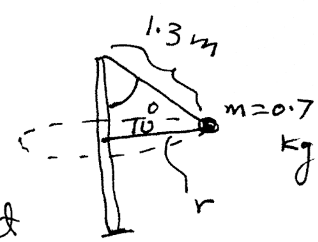
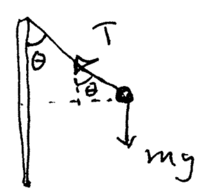
(11) tangential speed = linear speed



$r = 1.3 \sin 70^\circ = 1.2$ m

This is the radius of the circle that ball is going through.



$\Sigma F = 0 \Rightarrow \begin{cases} T\cos\theta - mg = 0 \\ T\sin\theta = ma = m\frac{v^2}{r} \end{cases}$

$T = \frac{mg}{\cos\theta} \Rightarrow \cancel{m}g\tan\theta = \frac{\cancel{m}v^2}{r} \rightarrow V = \sqrt{rg\tan\theta} = \boxed{5.9 \text{ m/s}}$

(See example 5.6 on the text)

(13)

$a_r = 980\ m/s^2$; $r =$ half rod length $= \frac{2}{2} = 1\ m$

a) $a_r = \frac{v^2}{r} \rightarrow v = \sqrt{r a_r}$

$v = \sqrt{(1)(980)} = 31.3\ m/s$

b)

b) $w = ?$ $\quad w = \frac{v}{r} = \frac{31.3\ m/s}{1\ m} = 31.3\ rad/s$ $\qquad d/s$

in rpm $\quad w = \frac{31.3}{2\pi}(60) = 299$ rpm

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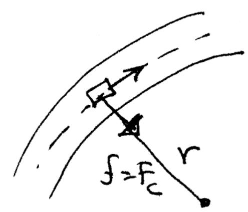
(24) $\quad r = 410\ m \qquad v = 32\ m/s$

$m = 1400\ kg$



a) $f \leq \mu_s N$

In this case, it could be any number between 0 to $\mu_s N$. Let's use

$$\sum F = m\frac{v^2}{r} \rightarrow f = \frac{mv^2}{r}$$

$$f = \frac{(1400)(32)^2}{410} = 3497\ N$$

b) The friction force could be $\leq \mu_s N$ as explained above.

25 $\quad r = 410\,m \quad v = 32\,m/s \quad m = 1400\,kg$

a) $\theta = 5^\circ$

In this case, the centripetal force is produced by both force of friction and the horizontal component of the normal force, i.e. $N\sin\theta$.
(Refer to the diagram given in the lecture)

$$\sum F = ma$$

$$f + N\sin\theta = m a \quad \left(a = \frac{v^2}{r}\right)$$

Also $\quad N\cos\theta - mg = 0 \Rightarrow N = \dfrac{mg}{\cos\theta}$

$$\Rightarrow f + mg\tan\theta = m\frac{v^2}{r}$$

$$f = m\left(\frac{v^2}{r} - g\tan\theta\right) = 1400\left(\frac{32^2}{410} - 9.8\tan 5^\circ\right)$$

$$\boxed{f = 2296\,N}$$

b) If $f = 0 \Rightarrow \sum F = ma \Rightarrow N\sin\theta = ma$

or $\underbrace{\left(\dfrac{mg}{\cos\theta}\right)}_{N}\sin\theta = m\dfrac{v^2}{r} \Rightarrow v = \sqrt{rg\tan\theta}$

$$v = \sqrt{(410)(9.8)(\tan\theta)} = \boxed{19\,m/s}$$

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1 rev in 6 h

a) Using $V = \sqrt{\frac{GM}{r}}$ and solving for r

$$\Rightarrow r = r = \frac{GM}{V^2}$$

but $V^2 = r^2 w^2 \rightarrow r^3 = \frac{GM}{w^2}$

$$r = \left(\frac{GM}{w^2}\right)^{1/3}$$

We need $\underline{\underline{w}}$

$$w = \frac{1 \text{ rev}}{6 \text{ h}} = \frac{(1)(2\pi) \text{ rad}}{6 \times 3600 \text{ s}} = 2.9 \times 10^{-4} \text{ rad/s}$$

$$\Rightarrow r = \left(\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{(2.9 \times 10^{-4})^2}\right)^{1/3} = \boxed{16514 \text{ km}}$$

Distance above the earth's Surface is

$$h = 16514 \text{ km} - 6400 \text{ km} = \boxed{10114 \text{ km}}$$

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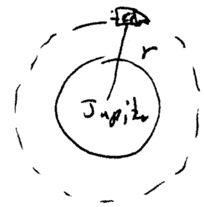
$r = 3R_J$

$g_{Jupiter} = 23 \ N/kg$

$T = ?$



$\Sigma F = ma$

$$\frac{G \cancel{m}_{spacecraft} M_{Jupiter}}{r^{\cancel{2}}} = \frac{\cancel{m} v^2}{\cancel{r}}$$

Also $v^2 = r^2 w^2 \Rightarrow w = \sqrt{\dfrac{GM_{Jupiter}}{r^3}}$

we need $M_{Jupiter}$.

$\downarrow$

Use $g_{Jupiter} = \dfrac{GM_{Jupiter}}{R^2_{Jupiter}}$

$$GM_{Jupiter} = g_{Jupiter} R^2_{Jupiter}$$

Now $w = \sqrt{\dfrac{g_J R_J^2}{(3R_J)^3}} = \sqrt{\dfrac{g_J}{27R_J}} = \sqrt{\dfrac{23}{(27)(71500,000)}}$

$w = 1.09 \times 10^{-4}$ rad/s

but $w = \dfrac{2\pi}{T} \rightarrow T = \dfrac{2\pi}{w} = 57535 \ s$

$= \boxed{16 \text{ hours}}$

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$\omega_i = 0$ $\quad \Delta t = 1\,s$ $\quad \Delta\theta = 90^\circ = \frac{\pi}{2} = 1.57$ rad.

a) We need α . $\Rightarrow$ $\Delta\theta = \omega_i \cdot \Delta t + \frac{1}{2}\alpha \Delta t^2$

$$\frac{\pi}{\cancel{2}} = 0 + \frac{1}{\cancel{2}}\alpha (1)^2 \Rightarrow \alpha = \pi = 3.14 \text{ rad}/s^2$$

To find the angle from $t=1$ to $t=2$ (i.e. the next 1-second)

We calculate $\Delta\theta$ for $t = 2$ seconds and then subtract $\frac{\pi}{2}$ which is $\Delta\theta$ for $t = 1\,s$.

$$\Delta\theta = \omega_i \cdot \Delta t + \frac{1}{2}\alpha \Delta t^2$$

$$\Delta\theta = 0 + \frac{1}{2}(3.14)(2)^2 = 6.28 \text{ radians}$$

Thus $\Delta\theta$ from $t=1$ to $t=2\,s$ $\Rightarrow$

$$\Delta\theta_{1\to2} = 6.28 - 1.57 = \boxed{4.71 \text{ radians}}$$

$= 270^\circ$

b) The same idea:

Answer $= 7.85$ radians

$= 450^\circ$

(50) $\omega_i = 0$ $\omega_f = 33.3$ rpm $\Delta t = 2$ s

a) $\alpha = ?$

$\omega_f = \omega_i + \alpha \Delta t$

but $\omega_f = 33.3 \times \frac{2\pi}{60} = 3.5$ rad/s

$\Rightarrow \omega_f = 0 + \alpha \Delta t$

$3.5 = \alpha(2) \rightarrow \alpha = 1.74$ rad/s²

b) $\Delta\theta = ?$

$\Delta\theta = \omega_i \Delta t + \frac{1}{2}\alpha \Delta t^2$

$\Delta\theta = 0 + \frac{1}{2}(1.74)(2)^2 =$ 3.5 rads

# of turns $\Delta\theta = \frac{3.5}{2\pi} = 0.55$ turns