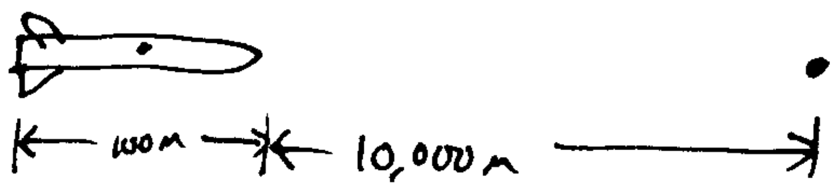
54

(a) LOOK AT THE CENTER OF THE SHIP



$$F_G = \frac{G M_B M_S}{r^2} = \frac{6.67\times10^{-11}(100)(2\times10^{30})(1000)}{(10{,}050)^2} = 1.32\times10^{17}\ N$$

(b)

$$F_{FRONT} = \frac{G M_B M_S}{r_F^2} = 1.334\times10^{17}\ N \qquad F_{BACK} = \frac{G M_B M_S}{r_B^2} = 1.308\times10^{17}\ N$$

$$\Delta F = 2.6\times10^{15}\ N$$

← WHICH IS A FORCE RIPPING THE SHIP APART . . .

HOW ABOUT THE SIDE-TO-SIDE CRUSHING FORCE?

AP PHYSICS – CH 7

Q5: GREATER DIAMETER ⇒ GREATER CIRCUMFERENCE. THIS MEANS THE WHEELS WILL GO AROUND FEWER TIMES WHILE COVERING THE SAME DISTANCE. SINCE THE SPEEDOMETER COUNTS WHEEL ROTATIONS IT WILL READ LOWER THAN THE ACTUAL VALUE.

Q7: CONSTANT VELOCITY SHOULD BE REPLACED WITH CONSTANT SPEED. VELOCITY IS A VECTOR AND ALTHOUGH THE MAGNITUDE STAYS CONSTANT, THE MAGNITUDE IS CONSTANTLY CHANGING. SPEED IS JUST THE MAGNITUDE OF VELOCITY.

Q12: IF a IS $\perp$ TO v --- YOU'LL GET A CIRCLE!
IF a IS $\parallel$ TO v --- YOU'LL GET LINEAR MOTION!

① CIRC

$$\cancel{60{,}000\ \text{mi}\left(\frac{5280\ \text{ft}}{\text{mi}}\right)\left(\frac{\pi\ \text{ft}}{4\ \text{ft}}\right)}$$ OOPS

DIA

$$60{,}000\ \text{mi}\left(\frac{5280\ \text{ft}}{1\ \text{mi}}\right) = 3.168\times10^{8}\ \text{ft} = x$$

$$\theta = \frac{x}{r} = \frac{3.168\times10^{8}\ \text{ft}}{1.0\ \text{ft}} = 3.168\times10^{8}\ \text{RAD}$$

$$3.168\times10^{8}\ \text{RAD}\left(\frac{1\ \text{REV}}{2\pi\ \text{RAD}}\right) = 5.0\times10^{7}\ \text{REV}$$

③ $$\omega = \frac{\theta}{t} = \frac{2\pi\ \text{RAD}}{365\ \text{DAYS}}\left(\frac{1\ \text{DAY}}{24\ \text{HR}}\right)\left(\frac{1\ \text{HR}}{3600\ \text{s}}\right) = 2\times10^{-7}\ \text{RAD/s}$$

$$\omega = \frac{\theta}{t} = \frac{360\ \text{DEG}}{365\ \text{DAYS}} \approx 1\ \text{DEG PER DAY}$$

(5) "OPEN WIDE..."

$\theta = ?$

$\omega_i = 0$

$\omega_f = 2.51\times10^4$ REV/MIN $= 2628$ RAD/s

$\alpha = ?$

$t = 3.20s$

$$\omega_f = 2.51\times10^4 \text{ REV/MIN}\left(\frac{2\pi \text{ RAD}}{1 \text{ REV}}\right)\left(\frac{1 \text{ MIN}}{60 \text{ s}}\right) = 2628 \text{ RAD/s}$$

a) $\alpha = ?$ USE DEF. OF ANG. ACC.

$$\omega_f = \omega_i + \alpha t$$
$$2628 = 0 + \alpha(3.20)$$
$$\alpha = 821 \text{ RAD/s}^2$$

b) $\theta = ?$ USE NO α EQN

$$\theta = \tfrac{1}{2}(\omega_f + \omega_i)t$$
$$\theta = \tfrac{1}{2}(2628 + 0)3.2 = 4205 \text{ RAD}$$

(9) $d_M = 7.60m$ ② $450 \text{ REV/MIN}\left(\frac{2\pi \text{ RAD}}{\text{REV}}\right)\left(\frac{1 \text{ MIN}}{60 \text{ s}}\right) = 47.1 \text{ RAD/s} = \omega_M$

$d_T = 1.02m$ ② $4138 \text{ REV/MIN}\left(\frac{2\pi \text{ RAD}}{\text{REV}}\right)\left(\frac{1 \text{ MIN}}{60 \text{ s}}\right) = 433 \text{ RAD/s} = \omega_T$

$$V_M = r\omega_M = \frac{d_M\omega_M}{2} = 179 \text{ m/s}$$
$$V_T = r\omega_T = \frac{d_T\omega_T}{2} = 221 \text{ m/s}$$

NEITHER IS ABOVE $V_{SOUND} = 343$ m/s

(10) SPEED UP...

$\theta = ?$

$\omega_i = 0$

$\omega_f = 5.0$ REV/s $= 31.4$ RAD/s

$\alpha = ?$

$t = 8.0s$

$$\theta = \tfrac{1}{2}(\omega_i + \omega_f)t$$
$$= \tfrac{1}{2}(0 + 31.4)8.0$$

SLOW DOWN...

$\theta = ?$

$\omega_i = 31.4$ RAD/s

$\omega_f = 0$

$\alpha = ?$

$t = 12.0s$

$$\theta = \tfrac{1}{2}(\omega_f + \omega_i)t$$
$$\theta_2 = 188.4 \text{ RAD}$$

SO TOGETHER...

$$\theta = \theta_1 + \theta_2$$
$$= 314 \text{ RAD}$$
$$= 49.9 \text{ REV}$$

(21) IN GENERAL... $f = F_c \rightarrow \mu n = \frac{mv^2}{r} \rightarrow \mu mg = \frac{mv^2}{r}$ DO YO[U] UNDERS[TAND] WHY?

SO $v^2 = \mu rg$ OR $v = \sqrt{\mu rg}$

NOW WE DON'T KNOW μ BUT IT IS THE SAME FOR BOTH CORNERS .. SO FORM A RATIO!

$$\frac{v'}{v} = \frac{\sqrt{\mu r' g}}{\sqrt{\mu r g}} = \sqrt{\frac{r'}{r}}$$

$$\frac{v'}{32.0} = \sqrt{\frac{75}{150}} \rightarrow v' = 32.0\sqrt{\frac{75}{150}} = 22.6 \text{ m/s}$$ DOES THAT MAKE SENS[E]

(22) $r = 61.0$ m

$$v = 86.5 \text{ km/hr}\left(\frac{1000 \text{ m}}{1 \text{ km}}\right)\left(\frac{1 \text{ hr}}{3600 \text{ s}}\right) = 24 \text{ m/s}$$

$$a_c = \frac{v^2}{r} = \frac{(24)^2}{61} = 9.44 \text{ m/s}^2 \qquad \frac{a_c}{g} = .963 \text{ g's}$$

(25) THE WEIGHT OF THE CENTER MASS IS THE TENSION IN THE CORD

$$F_c = T \rightarrow \frac{mv^2}{r} = Mg \rightarrow v^2 = \frac{M}{m}rg \rightarrow v = \sqrt{\frac{M}{m}rg} = 6.26 \text{ m/s}$$

a) $T = \frac{mv^2}{r} = \frac{(.25)(6.26)}{}$ OH WAIT! HOW ABOUT $T = Mg = 9.80$ N

b) THE ONLY HORIZONTAL FORCE IS THE TENSION ... SO 9.80 N

c) 6.26 m/s

(28) AT POINT "A"

$\uparrow n$

$\downarrow mg$

$$n - mg = F_c \quad \text{so} \quad n = \frac{mv^2}{r} + mg$$

$$\frac{500(20)^2}{10} + 600(9.80)$$

$$n = 2.5 \times 10^4\,N$$

AT POINT "B"

$\uparrow n$

$\downarrow mg$

$$mg - n = F_c$$

$$\text{so} \quad n = mg - \frac{mv^2}{r}$$

SO MAX SPEED WHEN $n = 0$

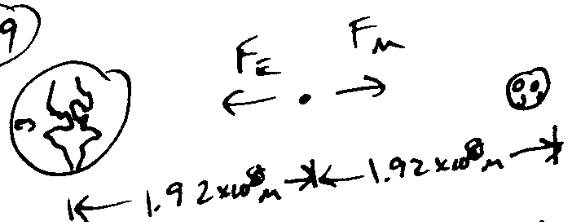
$$g = \frac{v^2}{r} \qquad v = \sqrt{rg}$$

$$= \sqrt{15(9.8)}$$

$$v = 12\,m/s$$

THERE'S ANOTHER THING WE COULD DO WITH THIS....

(29)



$$M_E = 5.98 \times 10^{24}\,kg \qquad M_M = 7.36 \times 10^{22}\,kg$$

$$F_E = \frac{G M_E M_s}{d^2} \qquad F_M = \frac{G M_M M_s}{d^2}$$

$$F_T = F_E - F_M = \frac{G M_s}{d^2}(M_E - M_M) = \frac{6.67 \times 10^{-11}(3 \times 10^4)}{(1.92 \times 10^8)^2}(5.91 \times 10^{24})$$

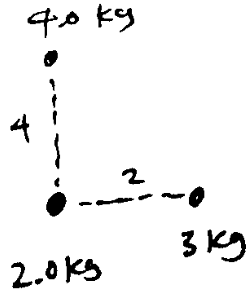
~~$F_T = 3.2 \times 10^8\,N$ TOWARDS THE EARTH~~

$$F_T = 320\,N$$

THERE IS A POINT (MUCH CLOSER TO THE MOON) WHERE

$F_T = 0$ 'COZ $F_E = F_M$ ...

(31)



F_4 IS THE FORCE FROM THE 4.0 kg OBJECT

F_3 " " " " " 3.0 kg "

$$F_4 = \frac{G m_1 m_2}{d^2} = \frac{6.67\times10^{-11}(2.0)(4.0)}{4^2} = 3.335\times10^{-11}\ \text{N}\ \hat{y}$$

$$F_3 = \frac{G m_1 m_2}{d^2} = \frac{6.67\times10^{-11}(2.0)(3.0)}{2^2} = 1.00\times10^{-10}\ \text{N}\ \hat{x}$$

$$F_T = \sqrt{F_4^2 + F_3^2} = 1.05\times10^{-10}\ \text{N}$$

$$\theta = \tan^{-1}\left(\frac{F_4}{F_3}\right) = \left(\frac{3.335\times10^{-11}}{1.0\times10^{-10}}\right) = 18^\circ \text{ ABOVE X AXIS}$$

(36)

$$V_{ORBIT} = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM_E}{2R_E}} = \sqrt{\frac{6.67\times10^{-11}(5.98\times10^{24})}{2(6.37\times10^6\ \text{m})}} = 5.59\times10^3\ \text{m/s}$$

$$T = \frac{2\pi r}{v} = 1.43\times10^4\ \text{s}$$

$$F = \frac{G M_E m}{2R_E^2} = \frac{(6.67\times10^{-11})(5.98\times10^{24})(600)}{\left(2(6.37\times10^6)\right)^2} = 1474\ \text{N}$$

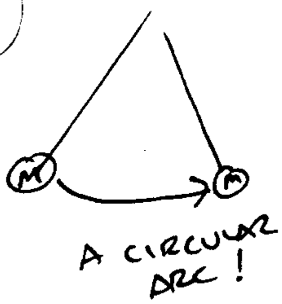
(38)

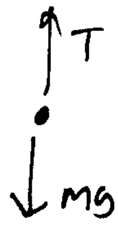
$$PE = -\frac{GMm}{r} = -\frac{6.67\times10^{-11}(5.98\times10^{24})(100)}{(2.00\times10^6 + 6.37\times10^6)} = -4.8\times10^9\ \text{J}$$

DON'T FORGET!

$$F = \frac{GMm}{r^2} = \frac{|PE|}{r} = 569\ \text{N}$$

(48)





BUT $T - mg = F_c$

$$T - mg = \frac{mv^2}{r} \quad \text{so} \quad T = m\left(\frac{v^2}{\ell} + g\right)$$

$$= (.400)\left(\frac{3^2}{.8} + 9.8\right)$$

$$= 8.42\,N$$

BY CONSERVATION OF ENERGY

$$K = U$$

$$\tfrac{1}{2}mv^2 = mg\ell(1-\cos\theta)$$

$$\frac{v^2}{2g\ell} = 1 - \cos\theta \qquad \cos\theta = 1 - \frac{v^2}{2g\ell} \quad \text{so} \quad \theta = \cos^{-1}\left(1 - \frac{v^2}{2g\ell}\right)$$

$$\theta = 65^\circ$$

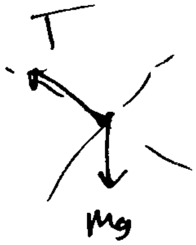
AT THE TOP

$v = 0$
SO NO F_c IS NEEDED...

$$T\cos\theta = mg \quad \text{so} \quad T = \frac{mg}{\cos\theta} = \frac{(.400)9.80}{\cos 65^\circ} = 9.28$$

NO WAY!

~~RECALL~~ THIS IS NOT IN EQUILIBRIUM...
SO LET'S JUST CALCULATE THE RADIAL FORCE... TILT THE COORDINATE SYSTEM!



$$\text{so} \quad F_{RAD} = T - mg\cos\theta = F_c = \frac{mv^2}{r}$$

$$T - mg\cos\theta = 0 \rightarrow T = mg\cos\theta$$

$$T = (.400)(9.8)\cos 65^\circ$$

$$T = 1.65\,N$$