1) 6-21

$M_{moon} = 7.35 \times 10^{22}$ kg

$R_{moon} = 1.74 \times 10^{6}$ m

$$g_{moon} = \frac{G M_{moon}}{R_{moon}^2} = \frac{\left(6.67\times10^{-11} \frac{N\,m^2}{kg^2}\right)\left(7.35\times10^{22}\,kg\right)}{\left(1.74\times10^{6}\,m\right)^2}$$

$$\boxed{g_{moon} = 1.6\ m/s^2}$$

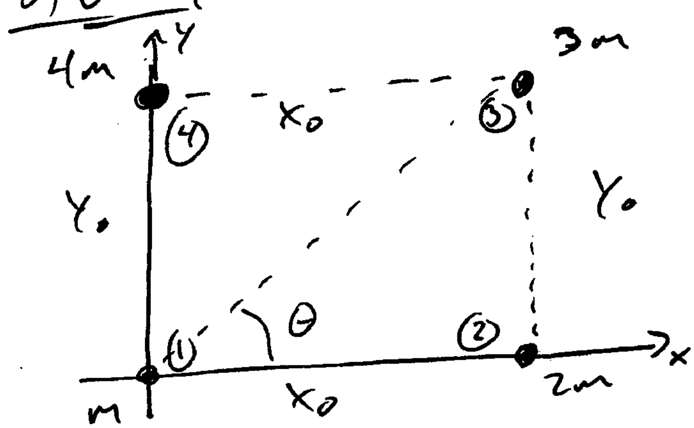
2) 6-7

$$g_{satellite} = G\frac{M_{\oplus}}{(R_{\oplus} + 3\times10^5\,m)^2} = \frac{\left(6.67\times10^{-11}\frac{Nm^2}{kg^2}\right)\left(5.98\times10^{24}\,kg\right)}{\left(6.38\times10^{6}\,m + 3\times10^{5}\,m\right)^2}$$

$$\boxed{g_{satellite} = 8.9\ m/s^2}$$

STILL PRETTY BIG

3) 6-11



$$\vec{F}_{NET} = \sum_{i=2}^{4} \vec{F}_{1i}$$

$$\vec{F}_{12} = +G\frac{(m)(2m)}{x_0^2}\hat{i}$$

$$\vec{F}_{14} = +G\frac{(m)(4m)}{Y_0^2}\hat{j}$$

$$|\vec{F}_{13}| = G\frac{(m)(3m)}{(x_0^2+Y_0^2)}$$

WE NEED TO GET THE DIRECTION OF $\vec{F}_{13}$

3) 6-111 (CONTINUED)

$$\text{proj}_x \vec{F}_{13} = F_{13}\cos\theta\,\hat{i} = F_{13}\frac{x_0}{\sqrt{x_0^2+y_0^2}}\hat{i}$$

$$\text{proj}_y \vec{F}_{13} = F_{13}\sin\theta\,\hat{j} = F_{13}\frac{y_0}{\sqrt{x_0^2+y_0^2}}\hat{j}$$

SO,

$$\vec{F}_{13} = G\frac{3m^2}{(x_0^2+y_0^2)^{3/2}}\left(x_0\hat{i} + y_0\hat{j}\right)$$

THEN,

$$\boxed{\vec{F}_{NET} = \sum_{i=2}^{4} F_{1i} = Gm^2\left\{\left(\frac{2}{x_0^2} + \frac{3x_0}{(x_0^2+y_0^2)^{3/2}}\right)\hat{i} + \left(\frac{4}{y_0^2} + \frac{3y_0}{(x_0^2+y_0^2)^{3/2}}\right)\hat{j}\right\}}$$

4) IF THE EARTH'S ORBIT IS CIRCULAR THEN THE FORCE OF GRAVITY ON THE EARTH FROM THE SUN IS A CENTRIPETAL FORCE

THEN

$$G\frac{M_\odot M_\oplus}{R^2} = M_\oplus\frac{V^2}{R}$$

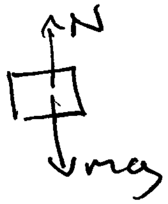
IF WE SOLVE FOR THE SUN'S MASS ($M_\odot$) WE HAVE

$$M_\odot = \frac{RV^2}{G}.$$ SINCE THE ORBIT IS CIRCULAR, $V = \frac{2\pi R}{T}$

$$\rightarrow M_\odot = \frac{R\left(\frac{2\pi R}{T}\right)^2}{G} = \frac{4\pi^2R^3}{T^2G}.$$ PLUGGING

IN THE #'s $$M_\odot = \frac{4\pi^2(1.5\times10^8)^3}{(6.67\times10^{-11})[(365)(24)(3600)]^2} \approx \boxed{2\times10^{30}\text{ kg}}$$

5) 6-29



$$\sum F = N - mg = ma$$

SPRING SCALE MEASURES N SO

$$\rightarrow N = m(a+g)$$

(a) $N = m(a+g) = (53\text{ kg})(9.8\text{ m/s}^2)$

$$\boxed{N = 520\text{ N}}$$

(b) $N = m(a+g) = (53\text{ kg})(0.33g + g) = (53\text{ kg})(1.33 \cdot 9.8\text{ m/s}^2)$

$$\boxed{N = 690\text{ N}}$$

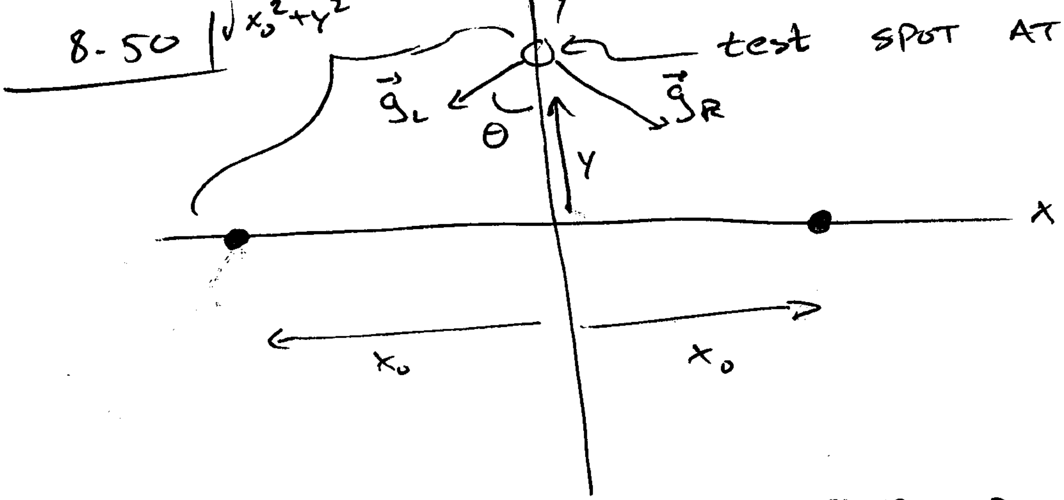
(c) $N = m(-0.33g + g) = (53\text{ kg})(0.67 \cdot 9.8\text{ m/s}^2)$

$$\boxed{N = 350\text{ N}}$$

(d) $N = m(-g + g) = 0$

$$\boxed{N = 0}$$

8-50



IN GENERAL, ~~FOR A~~ THE FIELD FROM A SINGLE POINT MASS IS

$$\vec{g}(\vec{r}) = -G\frac{M}{|\vec{r}|^2}\hat{r}$$

IN THIS CASE, THE X-COMPONENTS ARE EQUAL AND OPPOSITE, AND THUS CANCEL

THE Y-COMPONENTS ARE EQUAL AND IN THE SAME DIRECTION

$$g_y = 2\left(-G\frac{M}{x_0^2+y^2}\cos\theta\right) \quad \text{BUT} \quad \cos\theta = \frac{y}{\sqrt{x_0^2+y^2}}$$

SO $$\boxed{g_y = -2G\frac{my}{(x_0^2+y^2)^{3/2}}}$$

THEN $$\boxed{\vec{g} = -2G\frac{my}{(x_0^2+y^2)^{3/2}}\hat{j}}$$

(b) AT MAXIMA (OR MINIMA) $\frac{dg}{dy} = 0$

SO, $$0 = \frac{d}{dy}\left(2Gm\frac{y}{(x_0^2+y^2)^{3/2}}\right)$$ {USE PRODUCT RULE}

$$0 = \frac{d}{dy}(2Gmy)\left(\frac{1}{(x_0^2+y^2)^{3/2}}\right) + (2Gmy)\frac{d}{dy}\left(\frac{1}{(x_0^2+y^2)^{3/2}}\right)$$

(USE CHAIN RULE!)

$$0 = 2Gm\left(\frac{1}{(x_0^2+y^2)^{3/2}}\right) + 2Gmy\left(\frac{3}{2}(x_0^2+y^2)^{1/2}\right)2y$$

$$\rightarrow \boxed{y = \frac{x_0}{\sqrt{2}}}$$

11) 8-50 (CONTINUED)

PLUG THIS INTO g TO GET g_{max}

$$g_{max} = 2Gm \frac{x_0/\sqrt{2}}{\left(x_0^2 + x_0^2/2\right)^{3/2}}$$

$$= \frac{2Gm\,x_0}{(2)^{1/2}\left(x_0^2 + x_0^2/2\right)^{3/2}}$$

NOW MULTIPLY BY $\frac{2}{2}$

$$g_{max} = \frac{4Gm\,x_0}{(2)^{3/2}\left(x_0^2 + x_0^2/2\right)^{3/2}} = \frac{4Gm\,x_0}{\left(2x_0^2 + x_0^2\right)^{3/2}}$$

$$g_{max} = \frac{4Gm\,x_0}{(3)^{3/2}\,x_0^3} = \boxed{0.77\,\frac{Gm}{x_0^2}}$$

9-13) THERE IS NOT NET EXTERNAL FORCE

SO MOMENTUM IS CONSERVED

$$P_f = m_b V_b + m_p V_p$$

$$P_i = 0$$

SO $m_b V_b + m_p V_p = 0$

$$\longrightarrow m_b V_b = -m_p V_p$$

$$m_b = 59 \text{ kg}$$
$$m_p = 5.7 \text{ kg}$$
$$V_p = 10 \text{ m/s}$$

$$V_b = \frac{-(5.7\text{kg})(10\text{m/s})}{(59\text{kg})}$$

$$V_b = -0.97 \text{ m/s}$$

V_b IN OPPOSITE DIRECTION OF V_p

9-27

RAIN IS FALLING AT A RATE OF

$$5\ \text{cm/hr}\left(\frac{1\ \text{m}}{100\ \text{cm}}\right)\left(\frac{1\ \text{hr}}{3600\ \text{s}}\right) = \underbrace{1.39\times10^{-5}\ \frac{\text{m}}{\text{s}}}$$

RATE DEPTH IS ADDED, NOT A VELOCITY!

THEN THE VOLUME COLLECTED EVERY SECOND IS

$$\left(1.39\times10^{-5}\ \frac{\text{m}}{\text{s}}\right)\left(1\ \text{m}^2\right) = 1.39\times10^{-5}\ \text{m}^3/\text{s}$$

THEN THE MASS ADDED PER SECOND IS

$$m = \left(1.39\times10^{-5}\ \text{m}^3/\text{s}\right)\left(1\times10^{3}\ \frac{\text{kg}}{\text{m}^3}\right) = 1.39\times10^{-2}\ \text{kg/s}$$

NOW, WE CAN FIND THE MOMENTUM OF THIS WATER THAT IS LOST EVERY SECOND

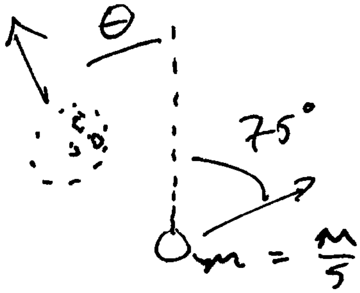
$$\Delta p = \left(1.39\times10^{-2}\ \text{kg}\right)\left(8.0\ \text{m/s}\right)$$

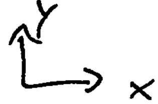
$$\Delta p = 0.11\ \frac{\text{kg m}}{\text{s}}$$

THE AVERAGE FORCE IS THEN

$$\frac{\Delta p}{\Delta t} = \frac{0.11\ \text{kg m/s}}{1\ \text{s}} = 0.11\ \text{kg m/s}^2 = \boxed{0.11\ \text{N}}$$

9-88





M

$\vec{V}_0 = (13\ \text{m/s})\hat{j}$

PROBLEM STATES THAT THE COLLISION IS ELASTIC

SO WE CAN CONSERVE ENERGY AND MOMENTUM

$E_i = \frac{1}{2}M|\vec{V}_0|^2 \qquad E_f = \frac{1}{2}M|\vec{V}_{b_f}|^2 + \frac{1}{2}\left(\frac{M}{5}\right)|\vec{V}_{p_f}|^2$

$\cancel{P_i = MV_0}$

$\vec{P}_i = M\vec{V}_0 \qquad \vec{P}_f = M\vec{V}_{b_f} + \frac{M}{5}\vec{V}_{p_f}$

BREAK THESE INTO X, Y COMPONENTS

$P_{i_x} = 0 \qquad P_{f_x} = M\underbrace{V_{b_{fx}}}_{= V_{b_f}\sin\theta} + \frac{M}{5}\underbrace{V_{p_{fx}}}_{V_{p_f}\sin 75°} \cancel{= M V_{b_f}\cos\theta}$

$\cancel{P_{f_x}}\ P_{i_y} = MV_0 \qquad P_{f_y} = M\underbrace{V_{b_{fy}}}_{V_{b_f}\cos\theta} + \frac{M}{5}\underbrace{V_{p_{fy}}}_{V_{p_f}\cos 75°}$

9-88 (CONT)

SO WE HAVE:

$$\begin{cases} \frac{1}{2} M V_0^2 = \frac{1}{2} M V_{bf}^2 + \frac{1}{2}\left(\frac{M}{5}\right) V_{pf}^2 & (1) \\ 0 = -M V_{bf} \sin\theta + \frac{M}{5} V_{pf} \sin 75^\circ & (2) \\ M V_0 = M V_{bf} \cos\theta + \frac{M}{5} V_{pf} \cos 75^\circ & (3) \end{cases}$$

3 EQUATIONS WITH ~~IN~~ 3 UNKNOWNS (V_{pf}, V_{bf}, θ)

A) FIND V_{pf}:

FROM (2) $\quad M V_{bf} \sin\theta = \frac{M}{5} V_{pf} \sin 75$

SO $\quad \cancel{V_{pf} = \frac{5 V_{bf} \sin\theta}{\sin 75}} \quad 5 V_{bf} \sin\theta = V_{pf} \sin 75$

FROM (1) $\quad V_0^2 = V_{bf}^2 + \frac{1}{5} V_{pf}^2 \rightarrow 5 V_{bf}^2 = 5V_0^2 - V_{pf}^2 \quad (\star)$

FROM (3) $\quad 5 V_0 = 5 V_{bf} \cos\theta + V_{pf} \cos 75$

$\quad \hookrightarrow 5 V_{bf} \cos\theta = 5V_0 - V_{pf} \cos 75$

SO WE HAVE

$$5 V_{bf} \sin\theta = V_{pf} \sin 75$$

$$5 V_{bf} \cos\theta = 5V_0 - V_{pf} \cos 75$$

SQUARE BOTH TO GET

$$25 V_{bf}^2 \sin^2\theta = V_{pf}^2 \sin^2 75$$

$$25 V_{bf}^2 \cos^2\theta = (5V_0 - V_{pf} \cos 75)^2 = 25V_0^2 + V_{pf}^2 \cos^2 75 - 10 V_0 V_{pf} \cos 75$$

AND ADD THEM (REMEMBER $\sin^2\theta + \cos^2\theta = 1$)

9-88 (CONT)

$$25 V_{bf}^2 = 25V_0^2 + V_{pf}^2 - 10 V_0 V_{pf} \cos 75)$$

$= 5(5 V_{bf}^2)$ PLUG IN ☆ FROM PREVIOUS PAGE...

$$5(5V_0^2 - V_{pf}^2) = 25V_0^2 + V_{pf}^2 - 10V_0 V_{pf} \cos 75$$

$$\cancel{25V_0^2} - 5V_{pf}^2 = \cancel{25V_0^2} + V_{pf}^2 - 10V_0 V_{pf} \cos 75$$

REARRANGE TO GET

$$6V_{pf}^2 = 10V_0 V_{pf} \cos 75$$

$$V_{pf} = \frac{10}{6} V_0 \cos 75 = \boxed{5.6 \text{ m/s} = V_{pf}}$$

B) NOW THAT WE KNOW $|\vec{V}_{pf}|$, WE CAN USE ☆ TO GET V_{bf}

$$V_{bf}^2 = V_0^2 - \frac{1}{5} V_{pf}^2 = (13)^2 - \frac{1}{5}(5.6)^2$$

$$\boxed{V_{bf} = 12.8 \text{ m/s}}$$

C) SINCE $V_{pf} \sin 75° = V_{bf} \sin \theta$

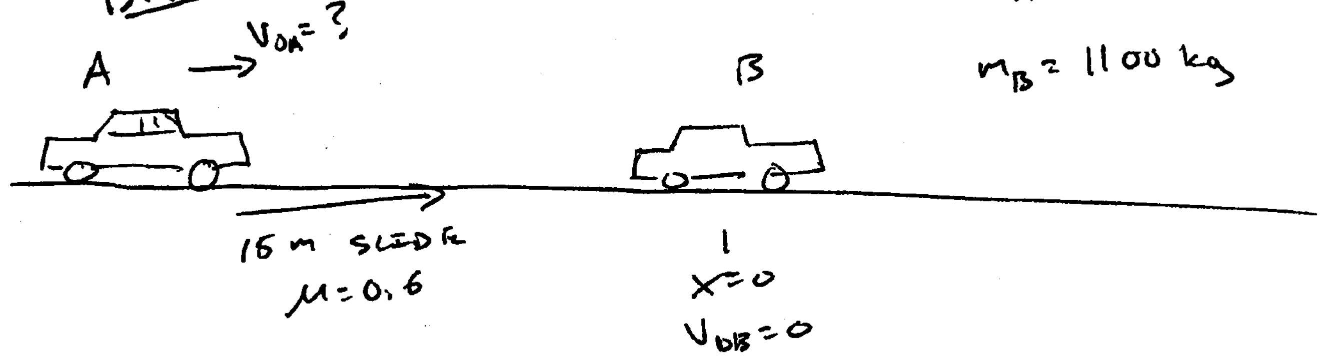
$$\theta = \arcsin\left(\frac{V_{pf} \sin 75°}{V_{bf}}\right) = \boxed{4.9° = \theta}$$

9.95

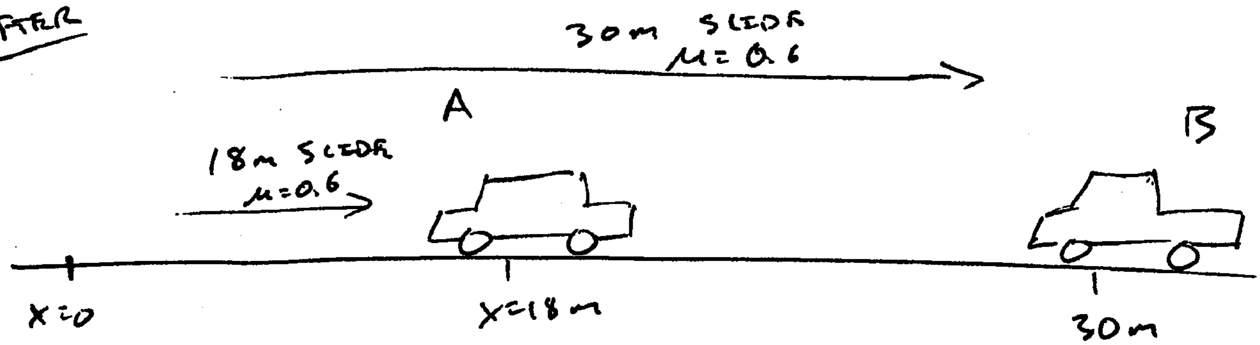
BEFORE

$m_A = 1500$ kg

$m_B = 1100$ kg



AFTER



WE NEED TO FIND V_{0A} = VELOCITY OF A BEFORE HE APPLIES THE BRAKES

FIRST WE CAN FIND IT IN TERMS OF THE VELOCITY OF A JUST BEFORE THE COLLISION.

$$\Delta K.E. = \boxed{\frac{1}{2} m_A V_{fA}^2 - \frac{1}{2} m_A V_{0A}^2 = -\mu m_A g d \qquad (1)}$$

WE ALSO KNOW THAT MOMENTUM IS CONSERVED DURING THE COLLISION. SO

$$\boxed{m_A V_{fA} = m_A V_A + m_B V_B \qquad (2)}$$

(V_A, V_B ARE VELOCITIES RIGHT AFTER THE COLLISION)

2

9.95 (CONTINUED)

AND AFTER THE COLLISION WE KNOW THAT

$$-\mu m_A g d_A = -\frac{1}{2} m_A V_A^2 \quad (3)$$

$$-\mu m_B g d_B = -\frac{1}{2} m_B V_B^2 \quad (4)$$

WE NOW NEED TO USE (1), (2), (3), (4) TO FIGURE OUT V_{0A}.

FROM (3) AND (4) WE KNOW

$$V_A = \sqrt{2\mu_k g d_A} = 14.7\ m/s$$

$$V_B = \sqrt{2\mu_k g d_B} = 18.9\ m/s$$

NOW, USING THESE IN (2)

$$m_A V_{Af} = m_B(18.9\ m/s) + m_A(14.7\ m/s)$$

$$\boxed{V_{Af} = 28.6\ m/s}$$

NOW WE CAN USE THIS IN (1)

$$\cancel{V_{A0} = \left(\left(\frac{m_B}{m_A}\right.\right.} \quad V_{A0} = \left(V_{Af}^2 + 2\mu g d\right)^{1/2}$$

$$\boxed{V_{A0} = 31.6\ m/s = 114\ km/hr > 90\ km/hr}$$