CSUC Spring Term 2020
Physics 204A sections 6, 7, 8

Reading and Problem Assignment ***Revised Schedule Week 11*** due Friday, April 10.

DEAR CLASS: In our new regimen you are asked to read the chapter and do these problems – but don't write them up for submission. At the end of the week I will post my own (handwritten) solutions. These are the problems you would have done in a regular semester and they exhibit the level of competency you must attain to as a technical person at this stage of your education. You will submit **only** the Portfolio Problems which are posted as a separate assignment. I intend to post the Portfolio Problems both on our class site and on Blackboard – but, as it stands now, you are to submit them on Blackboard.

I. Impulse and Momentum: Please read chapter **11** in your class text. This chapter represents the ***core content of this course***! I hope you savor these great problems!

II. ★ Problems for **Mastery**: Chapter **11** pp 286 -- - **DO NOT SUBMIT !**

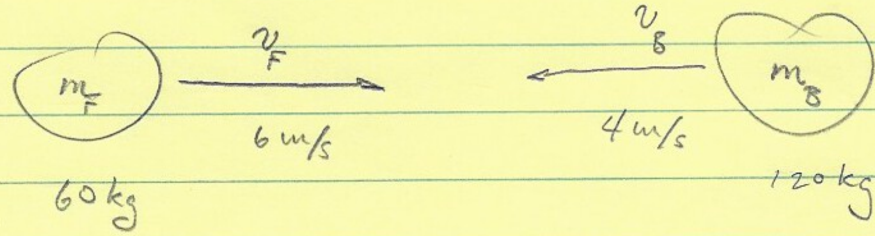
1. # 21, **2.** # 22, **3.** # 25, **4.** # 36, **5.** # 38, **6.** # 51, **7.** # 52, **8.** # 54, **9.** # 57

10. # 59, **11.** # 66 , **12.** # 71, **13.** # 74, **14.** # 81, **15.** # 83

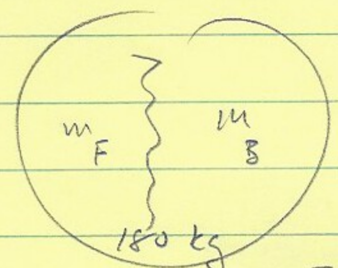
√ the single most important act in problem solving is drawing a ***good picture!***
√ spread out! - be neat - don't stint on space!
√ **never** insert numerical values until the algebra has been worked through -relationship is *shape*.

Set 11   Knight Chap. 11

1.) #21 pg 288



$\mu_k = .3$



$(180\,kg)\,V_{CM} = (6\,m/s)(60\,kg) + (-4\,m/s)(120\,kg)$

$$V_{CM} = \frac{360 - 480}{180} = -\frac{2}{3}\ m/s$$

negative!

$a_{CM} = \mu_k g$

$$\cancel{v_f^2}^{\,0} - v_i^2 = 2a\,\Delta x \quad \leadsto \quad \Delta x = -\frac{v_{CM}^2}{2a_{CM}}$$

$$\Delta x = -\frac{(2/3)^2}{2(.3)(9.8)} = -\frac{4}{9}\,\frac{1}{(.6)(9.8)} = -.0756\ m$$

$\Delta x \rightarrow$ Not very much!

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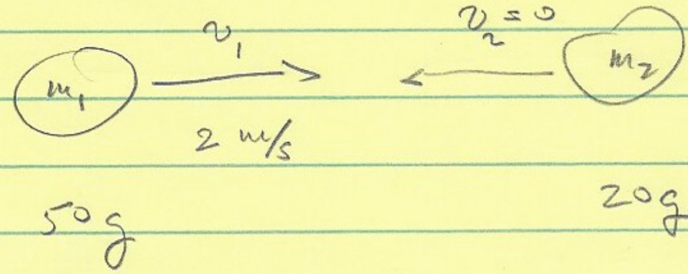
2.) #22 pg 288

Before



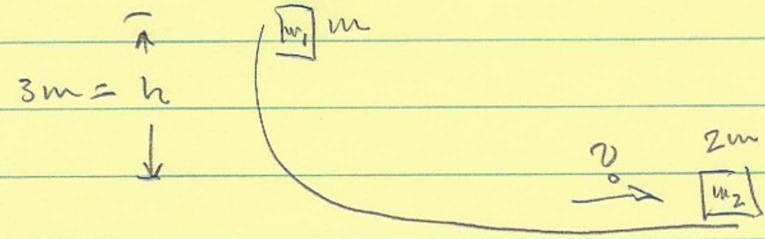
$$V_{cm} = \frac{50g\,(2\,m/s)}{70g} = \frac{10}{7}\,m/s = 1.42857\,m/s$$

$$v_{1f} = -v_{1i} + 2V_{cm} = .857\,m/s$$

$$v_{2f} = -\cancel{v_{2i}}^{\,0} + 2V_{cm} = 2.857\,m/s$$

Set 11 Knight Chp. 11 3/

3.) #25 pg 288



$mgh = \frac{1}{2} m v_0^2$

$\sqrt{2gh} = v_0$

$v_0 = 7.348$ m/s

a.) totally inelastic collision?

$$m v_0 = 3m v_f$$

so $$v_f = \frac{1}{3} v_0 = 2.45 \text{ m/s}$$

b.) totally elastic collision?

$$V_{cm} = \frac{m v_0 + 2m(0)}{3m} = \frac{1}{3} v_0$$

$$V_{f_1} = -v_0 + 2\left(\frac{1}{3} v_0\right) = -\frac{1}{3} v_0$$

$$v_{f_2} = 0 + 2\left(\frac{1}{3} v_0\right) = \frac{2}{3} v_0$$

Since m_1 recoils at $\frac{1}{3} v_0$ ... it has $\frac{m}{2}\left(\frac{1}{3} v_0\right)^2$ $= \frac{1}{9} KE_{in}$ ... it climbs to

$$(3m)\frac{1}{9} = \frac{1}{3} m.$$

Set 11 Knight Chap 11

4.) #36 pg 288

$$V_f = u_{ex} \ln\left(\frac{M_i}{M_f}\right)$$

So $4{,}000 \text{ m/s} = 2{,}500 \text{ m/s} \ln\left(\frac{M_i}{150 \text{ kg}}\right)$

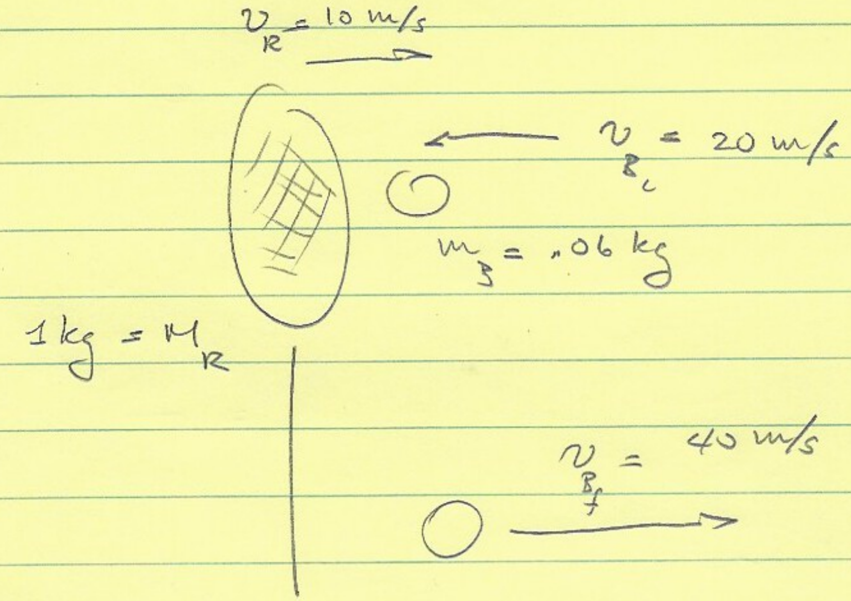
$$\frac{4}{2.5} = 1.6 = \ln\left(\frac{M_i}{150 \text{ kg}}\right)$$

$$4.95 = \frac{M_i}{150 \text{ kg}} \rightsquigarrow M_i = 743 \text{ kg}$$

So $M_{fuel} = (743 - 150) \text{ kg} = 593 \text{ kg}$ of fuel.

Set 11 Knight Chp. 11 5/

5.) #38 pp 288



$$P_{in} = (1\,kg)(10\,m/s) - (.06\,kg)(20\,m/s)$$

$$P_{in} = 8.8\ kg\,m/s$$

$$P_{out} = (1\,kg)\,V_{R_f} + (.06\,kg)(40\,m/s) = P_{in}$$

so ... $(1\,kg)\,V_{R_f} = (8.8 - 2.4)\,kg\,m/s = 6.4\ kg\,m/s$

a) $$V_{R_f} = 6.4\ m/s$$

b) $$P_{B_f} - P_{B_i} = \Delta P = (2.4 - (-1.2))\,kg\,m/s = 3.6\ kg\,m/s$$

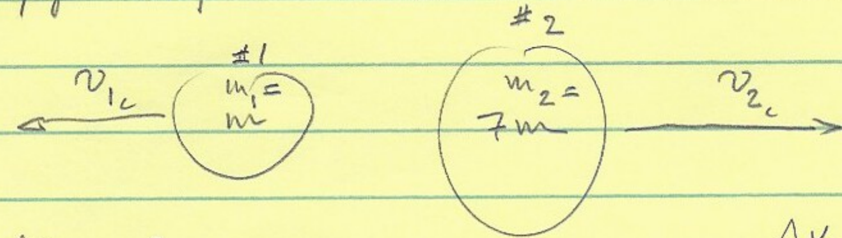
so $$\bar{F}_R = \frac{\Delta P}{\Delta t} = \frac{3.6\ kg\,m/s}{10^{-2}\,sec} = 360\ N$$

factor of 612

$$\bar{F}_{grav.} = mg = (.06\,kg)(9.8\,m/sec) = .588\ N$$

Set 11 Knight Chp. 11

6.) #51 pg 289



$\Delta x_1 = ?$ $\qquad\qquad$ $\Delta x_2 = 8.2\ m$

Since $m_1 v_{1_i} + m_2 v_{2_i} = P_{init} = 0$ ...

$$v_{1_i} = -\frac{m_2}{m_1} v_{2_i} = -7 v_{2_i}$$

Since both experience an accel $|a| = \mu_k g$ ...
(same <u>magnitude</u>) ... vel slide to a stop.

$$\cancel{v_{1_f}^2}^{\,0} - v_{1_i}^2 = 2a\Delta x_1$$

take ratios

$$v_{2_f}^2 - v_{2_i}^2 = -2a\Delta x_2$$

$$\left(\frac{v_{1_i}}{v_{2_i}}\right)^2 = -\frac{\Delta x_1}{\Delta x_2} \rightarrow \left(\frac{m_2}{m_1}\right)^2 = -\frac{\Delta x_1}{\Delta x_2}$$

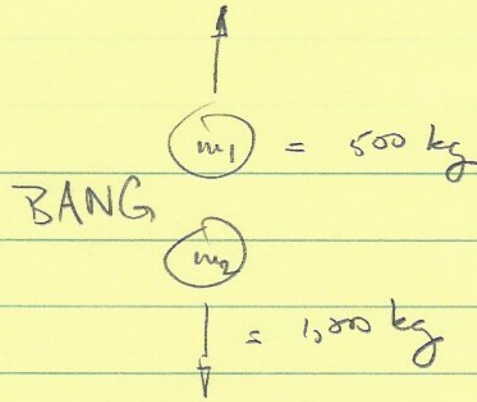
so $\Delta x_1 = -\Delta x_2 \left(\frac{m_2}{m_1}\right)^2 = -(8.2m)(49)$

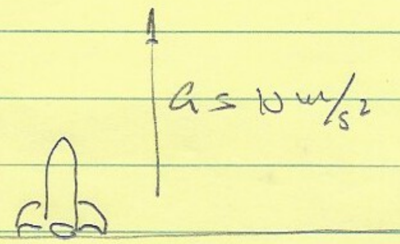
$$\Delta x_1 = -401.8\ m$$

nd/

$$m_1 \Delta x_1 + m_2 \Delta x_2 = M_{tot}\Delta x_{cm} \rightarrow -\frac{m_1 v_{1_i}^2}{2a} + \frac{m_2 v_{2_i}^2}{2a} = \frac{KE_{2_i} - KE_{1_i}}{a}$$

7.) #52 pp 290





after 2 sec...
it explodes!

$m_R = 1500$ kg

at explosion ... $t = 2\,sec$, $V_R = at = 20\,m/s$ and $h = \frac{1}{2}at^2 = 20\,m$

$$P_{tot} = m_R V_R = 1500\,kg\,(10\,m/s^2 \times 2\,sec) = 3\times10^4\,kg\,m/s$$

just after explosion...

$$m_1 v_1 + m_2 v_2 = P_{tot} = m_R V_R$$

m_1 recoils and reaches $h_{1_{max}} = 530\,m$

Since $\cancel{v_f^2}^{\,0} - v_{1_i}^2 = 2(-g)\Delta h_1 \Rightarrow$

$$v_{1_i}^2 = 2(9.8)(530-20) = 10^4 (m/s)^2$$

$$v_{1_i} = 10^2\,m/s$$

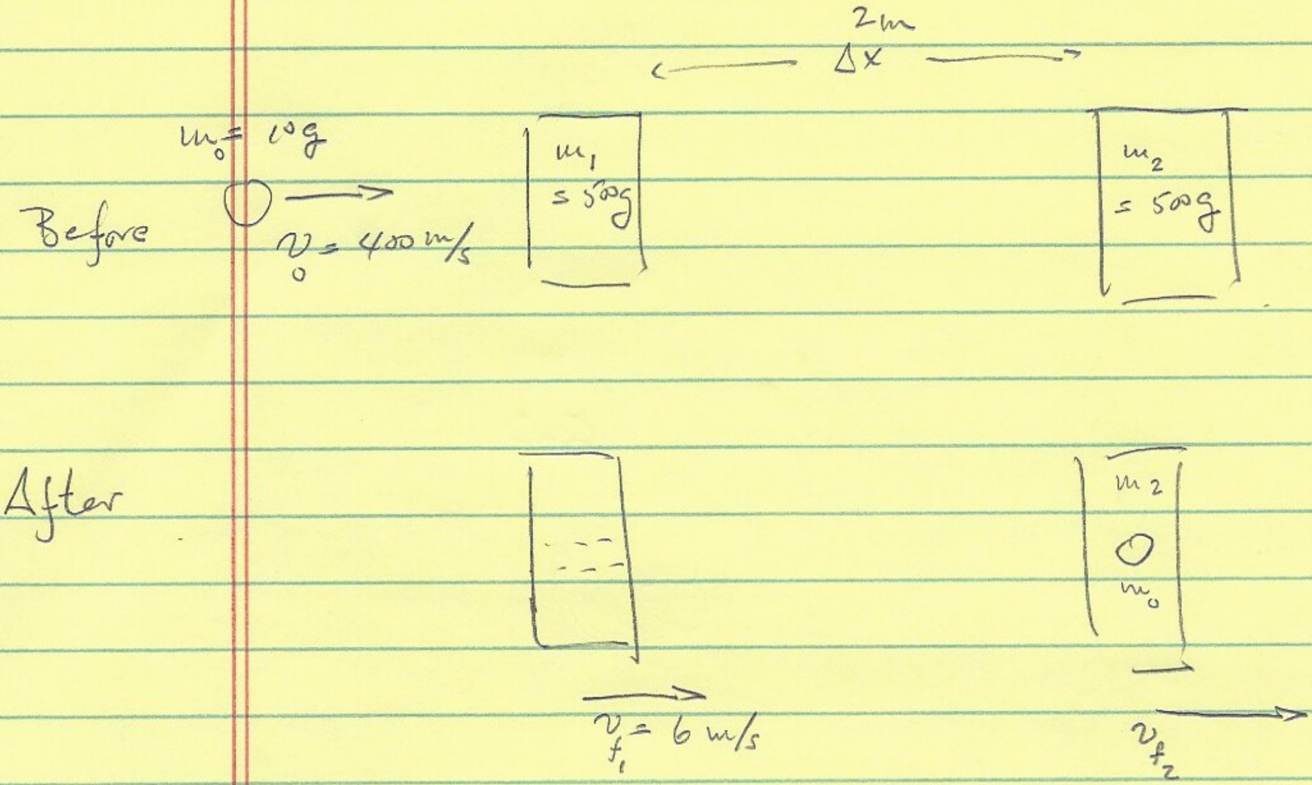
So $(500\,kg)(10^2\,m/s) + (1000\,kg)(V_{2_i}) = 3\times10^4\,kg\,m/s$

$$1000\,kg\,V_{2_i} = -2\times10^4\,kg\,m/s$$

$$V_{2i} = -20\,m/s$$

Set 11 Knight Chap 11

8.) #54 pg 290



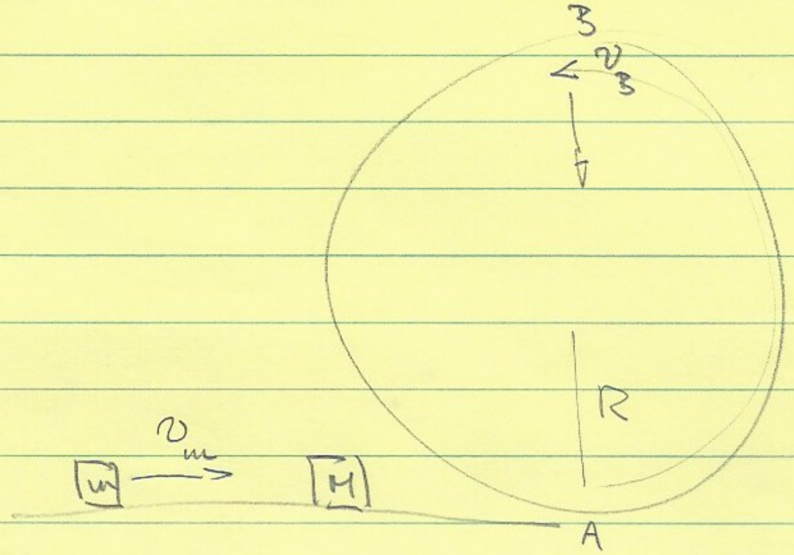
$$P_{in} = (.01\,kg)(4\times10^2\,m/s) = (.5\,kg)(6\,m/s) + (.51\,kg)\,v_{f_2}$$

$$\rightsquigarrow \quad 4\,kg\,m/s = 3\,kg\,m/s + .51\,kg\,v_{f_2}$$

$$\frac{1\,kg\,m/s}{.51\,kg} = v_{2f} = 1.96\,m/s$$

Set 11 Knight Chap 11 9/

9.) #57 pg 290



We need a final velocity at point B such that $ma = F$ at the top:

$$\Rightarrow m_{tot}\frac{v_B^2}{R} = m_{tot}\,g \;\Rightarrow\; v_B^2 = Rg$$

But! by energy cons. … $\frac{1}{2}m_{tot}v_A^2 = \frac{1}{2}m_{tot}v_B^2 + m_{tot}\,g\,2R$

so! $v_A^2 = v_B^2 + 4gR = 5Rg$

Now $V_{cm} = \frac{m}{m+M}v_m$

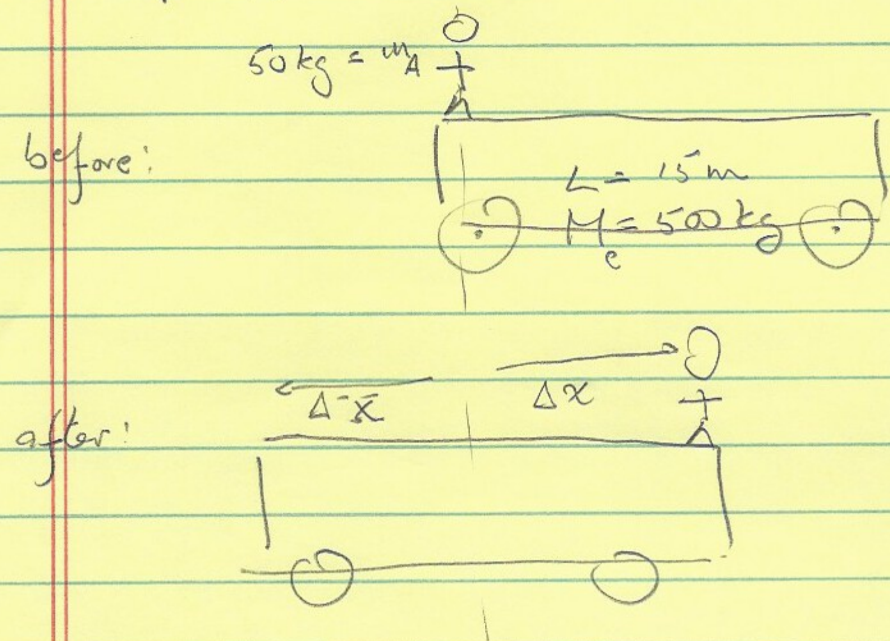
a) totally inelastic: $v_A = v_{cm}$ so $\left(\frac{m}{m+M}v_m\right)^2 = 5Rg$

$$\Rightarrow \boxed{v_m = \frac{m+M}{m}\sqrt{5Rg}}$$

b) totally elastic $v_A = 2v_{cm}$ so

$$\left(2\frac{m}{m+M}v_m\right)^2 = 5Rg \Rightarrow \boxed{\frac{m+M}{2m}\sqrt{5Rg} = v_m}$$

10.) # 59 pp 290

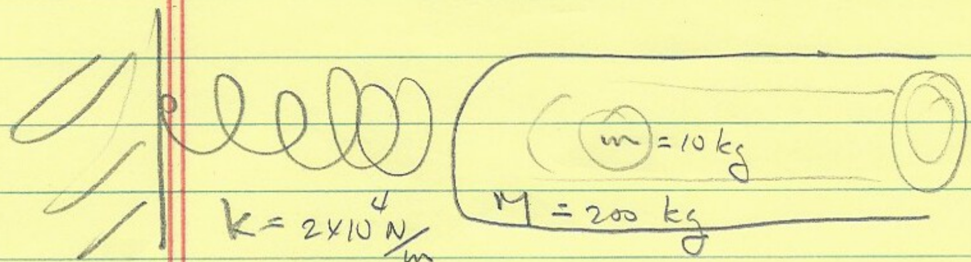


$$P_{tot} = m_A v_A + M_c V_c = 0 \quad \text{integrate!}$$

$$\left\{ \begin{array}{l} m_A \Delta x_A + M_c \Delta X_c = 0 \\ \Delta x_A - \Delta X_c = L \end{array} \right\} \quad \text{solve!} \quad \Delta x_A = \frac{M_c}{m_A + M_c} L$$

$$\text{So} \quad \Delta x_A = \frac{10}{11} L = \frac{10}{11}(15\,m) = 13.\overline{63}\ m$$

11.) #66 pg 290



The spring compresses $\Delta x = .5\,m$ on each shot.

The KE. of the cannon become P.E. —

So $\frac{1}{2} k \Delta x^2 = \frac{P_c^2}{2M_c}$ ... but $P_c + P_B = 0$

$\therefore$ so $M_c k \Delta x^2 = P_c^2 = P_B^2$

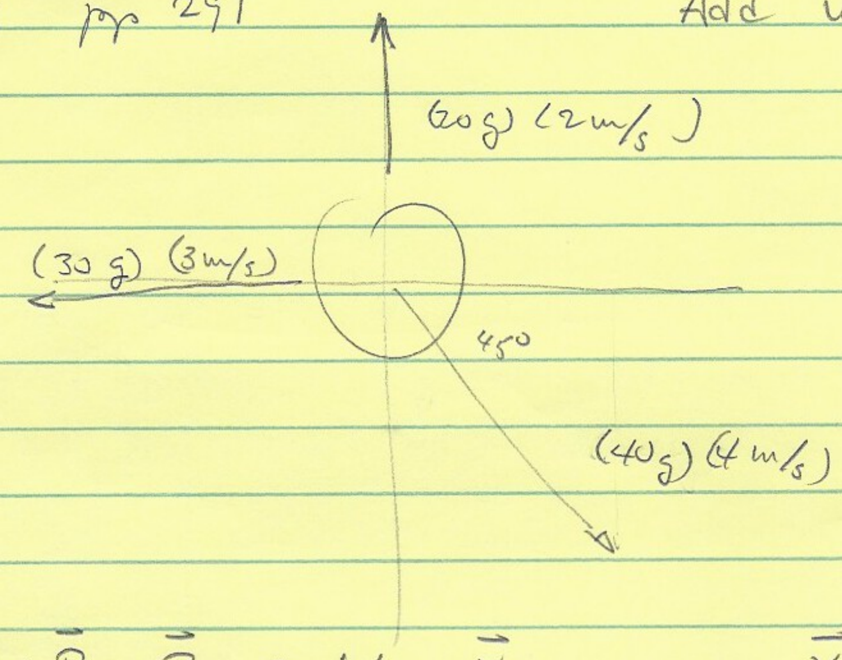
so $\sqrt{M_c k}\, \Delta x = m_B V_B$

$\Longrightarrow \frac{\sqrt{M_c k}}{m_B} \Delta x = V_B$

$\frac{\sqrt{(200\,kg)\, 2\times10^4\, N/m}}{10\,kg} (.5\,m) = 10^2\, m/s = V_{Ball}$

Set 11 Knight Chap 11 12/

12.) #71 pp 291 Add momenta!



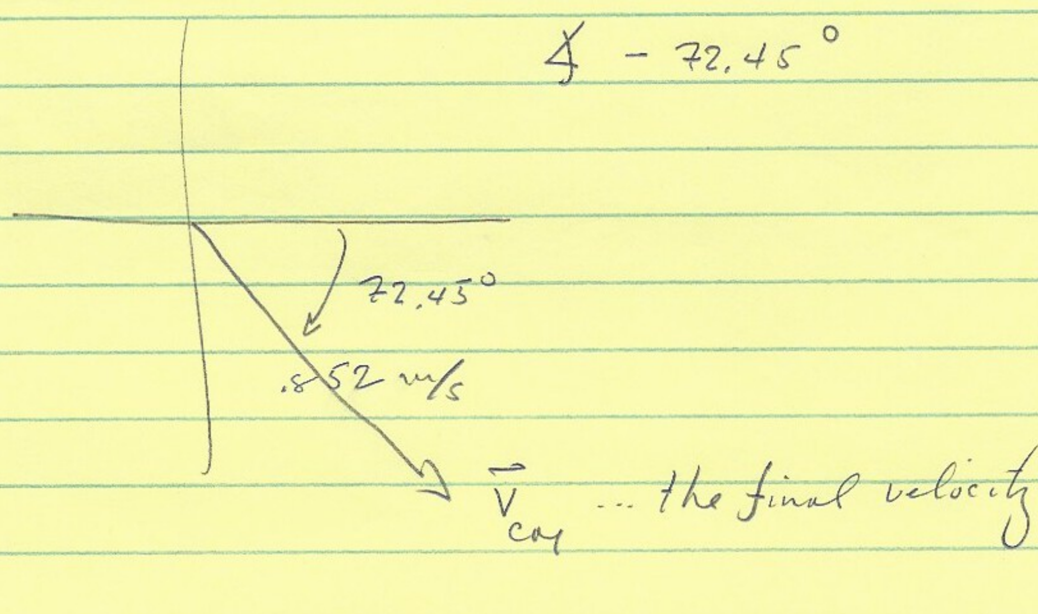
$\vec{P}_1 + \vec{P}_2 + \vec{P}_3 = M_{tot} \vec{V}_{CM}$ so $\vec{V}_{CM} =$

$\frac{3}{9}\langle -3\ m/s, 0 \rangle + \frac{2}{9}\langle 0, 2\ m/s \rangle + \frac{4}{9}\langle \frac{1}{\sqrt{2}}, \frac{-1}{\sqrt{2}} \rangle$ 4 m/s

$= \langle -1, 0 \rangle + \langle 0, \frac{4}{9} \rangle + \langle 1, -1 \rangle \frac{16}{9\sqrt{2}}$

$\vec{V}_{CM} = \langle .257, -.8126 \rangle$ mag .8523 m/s

$\measuredangle$ −72.45°



Set 11 Knight Chap 11

13.) # 74 pg 291

a) $V_f = (2{,}000\ m/s) \ln\left(\frac{200\ kg + 800\ kg}{200\ kg}\right) = 3.22 \times 10^3\ m/s$

b)

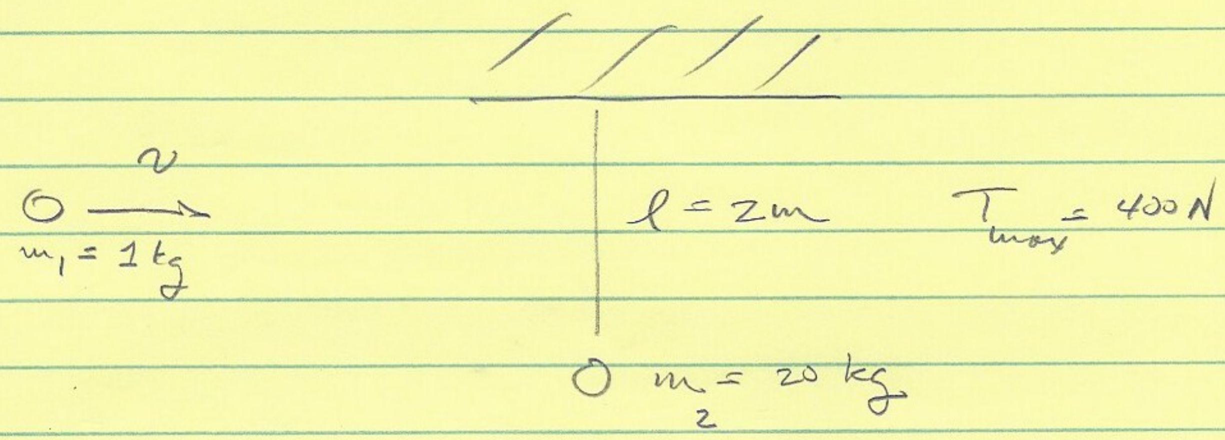
$\Delta V_1 = (2{,}000\ m/s) \ln\left(\frac{1000}{600}\right) = 1.02 \times 10^3\ m/s$

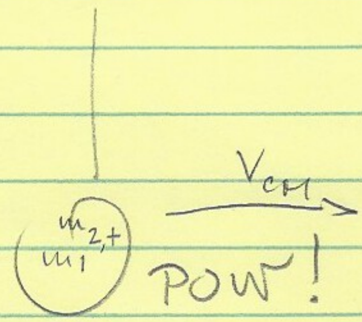
$\Delta V_2 = (2{,}000\ m/s) \ln\left(\frac{500}{100}\right) = 3.22 \times 10^3\ m/s$

$\Delta V_1 + \Delta V_2 = 4.24 \times 10^3\ m/s$ about 32% more!

Set 11 Knight Chap 11

14.) # 81 pp 291





$$\frac{m_1}{m_1+m_2} v = V_{CM} \rightsquigarrow v_{max} = \frac{m_1+m_2}{m_1} V_{CM_{max}}$$

Now use $m_{tot} a_c = F^{net} \rightsquigarrow m_{tot} \frac{V_{CM}^2}{l} = T - m_{tot} g$

So $V_{CM}^2 = l\left(\frac{T}{m_{tot}} - g\right) \rightsquigarrow V_{CM_{max}} = \sqrt{l\left(\frac{T_{max}}{m_{tot}} - g\right)}$

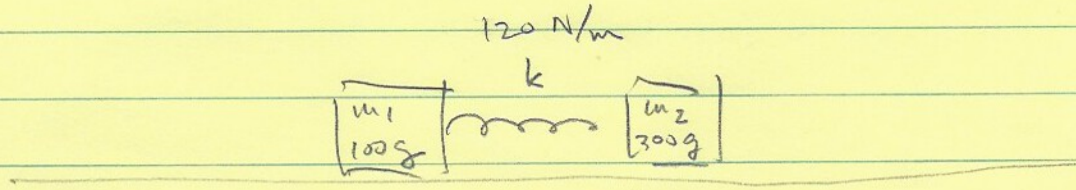
$$v_{max} = \frac{m_1+m_2}{m_1}\sqrt{l\left(\frac{T_{max}}{m_{tot}} - g\right)}$$

$$v_{max} = \frac{21}{1}\sqrt{2\left(\frac{400}{21} - 9.8\right)} = 90.3 \text{ m/s}$$

Set 11 | Knight Chap. 11 | 15/

15.) #83 pg 291

$V_{cm} = 1$ m/s



$\Delta x = 4$ cm

Enter the CM frame of reference of the masses

on release $P_1' + P_2' = 0$, & $\frac{P_1'^2}{2m_1} + \frac{P_2'^2}{2m_2} = \frac{1}{2} k \Delta x^2$

$$P_1'^2 \left(\frac{1}{m_1} + \frac{1}{m_2} \right) = k \Delta x^2$$

$$P_1'^2 = \frac{m_1 m_2}{m_1 + m_2} k \Delta x^2 \quad \text{so } P_1' = \sqrt{\frac{m_1 m_2}{m_1+m_2} k} \, \Delta x$$

$$v_{1f}' = \frac{-1}{m_1} \sqrt{\frac{m_1 m_2}{m_1 + m_2} k} \, \Delta x = -\frac{1}{.1} \sqrt{\frac{(.1)(.3)}{.4} 120} \, .04$$

$$v_{2f}' = \frac{1}{m_2} \sqrt{\frac{m_1 m_2}{m_1 + m_2} k} \, \Delta x = +\frac{1}{.3} \sqrt{\frac{(.1)(.3)}{.4} 120} \, .04$$

$v_{1f}' = -1.2$ m/s

$v_{2f}' = +.4$ m/s

} recover v_{1f}, v_{2f} by adding V_{cm} back on

$v_{1f} = -.2$ m/s

$v_{2f} = 1.4$ m/s