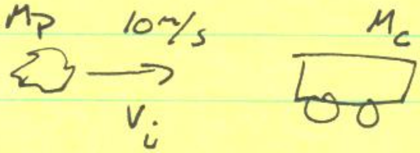
Practice Exam #3

1) C.O.M = point that is equivalent to entire object for translational motion. ie replace extended object w/ point mass of same mass & motion will be the same for C.O.M. as the point mass.

2

initial situation



final situation

By conservation of momentum

$$P_f = P_i$$

$$M_c V_f + M_p V_f = M_p V_i$$

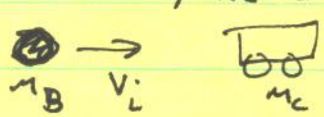
$$V_f (M_c + M_p) = M_p V_i$$

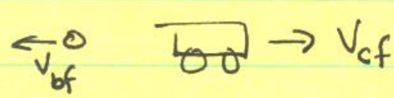
$$V_f = \frac{M_p}{M_p + M_c} V_i = \frac{0.05\,kg}{0.05 + 0.02\,kg} V_i = \frac{5}{7}\, 10\,m/s$$

$$\simeq 7\,m/s$$

b) for a totally elastic collision both momentum & KE are conserved

initial sit.





conservation of momentum gives

$$\cancel{M_B} V_i = \cancel{M_B} V_{bf} + \frac{M_c}{M_B} V_{cf}$$

conservation of KE gives

$$\tfrac{1}{2} M_B V_i^2 = \tfrac{1}{2} M_B V_{bf}^2 + \tfrac{1}{2} M_c V_{cf}^2$$

$$V_i^2 = V_{bf}^2 + \frac{M_c}{M_B} V_{cf}^2$$

$$V_{bf} = V_i - \frac{M_c}{M_B} V_{cf}$$

$$V_{bf}^2 = V_i^2 + \left(\frac{M_c}{M_B} V_{cf}\right)^2 - 2 V_i \frac{M_c}{M_B} V_{cf}$$

combining the result from C.O.P & C.O.KE we have

$$\cancel{V_i^2} = \cancel{V_i^2} + \left(\frac{M_c}{M_B} V_{cf}\right)^2 - 2 V_i \frac{M_c}{M_B} V_{cf} + \frac{M_c}{M_B} V_{cf}^2$$

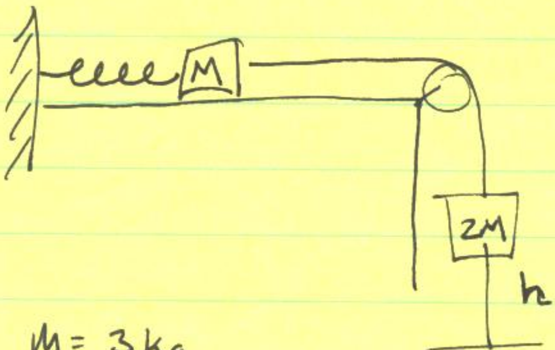
$$0 = \frac{m_c}{m_b} V_{cf}^2 - 2V_i V_{cf} + V_{cf}^2$$

so either $V_{cf} = 0$ or

$$V_{cf}\left(1 + \frac{m_c}{m_b}\right) = 2V_i$$

$$V_{cf} = \frac{2}{1+\frac{m_c}{m_b}} V_i = \frac{2m_b}{m_c+m_b} V_i \simeq 14\ m/s$$

3



$M = 3\,kg$

The blocks are initially at rest

Lets use conservation of energy

moments of interest

① moment of release

② moment when the objects

moment 1 $\quad E_1 = \cancel{KE_1}^{\,0} + PE_1$ all obj. initially at rest

$= 0 + PE_{1g} + \cancel{PE_{1s}}^{\,0}$ spring initially at natural length.

$= 2mgh_1$

moment 2 $\quad E_2 = KE_2 + PE_2$

$= \frac{1}{2} mV^2 + \frac{1}{2} 2mV^2 + 2mgh_2 + \frac{1}{2} k\Delta x^2$

By conservation of Energy

$$2mgh_1 = \tfrac{1}{2} 3mV^2 + 2mgh_2 + \tfrac{1}{2} k\Delta x^2$$

$$KE_2 = \tfrac{1}{2} 3mv^2 = 2mg(h_1 - h_2) - \tfrac{1}{2} k\Delta x^2$$

Notice that $h_1 - h_2 = \Delta x = 0.08m$

so

$KE_2 = 2mg\ \Delta x - \frac{1}{2} k \Delta x^2$

$= 6kg\ 9.8\ m/s\ \ 0.08m - \frac{1}{2}\ 100\frac{N}{m}\ (0.08m)^2$

$= 4.7 J - 0.32 J$

$\simeq 4.4 J$

b) the hanging mass has 2/3 of the mass of the system so it has 2/3 of the kinetic Energy.

$KE_{2m} = \frac{2}{3} KE_{Total} \approx 3 J$

c) we are now interested in a third moment

3 moment masses stop again

we now want to compare E_1 & E_3

$E_3 = \cancel{KE_3}^{0} + PE_3$

$= 0 + PE_{3g} + PE_{3s}$

$= 0 + 2mgh_3 + \frac{1}{2} k \Delta x_3^2$

$= E_1$ by conservation of Energy

$= 2mgh_1$

$2mgh_1 - 2mgh_3 = \frac{1}{2} k \Delta x_3^2$

$2mg(h_1 - h_3) = \frac{1}{2} k \Delta x_3^2$

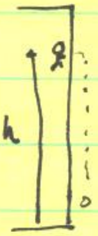
$h_1 - h_3 = \Delta x_3$ so

$2mg\ \cancel{\Delta x_3} = \frac{1}{2} k \Delta x_3^{\cancel{2}}$ if $\Delta x_3 \neq 0$ then

$\Delta x_3 = \frac{4mg}{k}$

$= \frac{4 \times 3kg\ 9.8\ m/s^2}{100 N} = 1.18m$

4



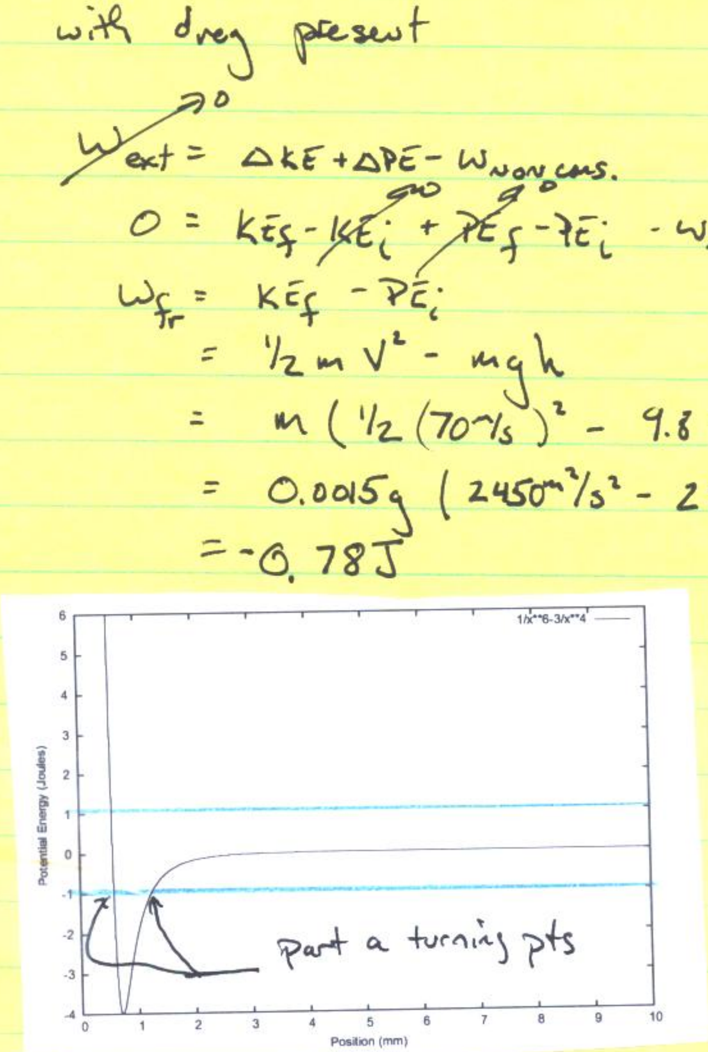
using conservation of Energy
i = moment of release
f = just before impact

$$E_i = \cancel{KE_i}^{\,0} + PE_i$$
$$E_f = KE_f + \cancel{PE_f}^{\,0}$$
$$KE_f = PE_i$$
$$\tfrac{1}{2}\cancel{m}v_f^2 = \cancel{m}gh$$
$$v_f^2 = 2gh$$
$$v_f = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 303 \tfrac{m^2}{s^2}}$$
$$= 77\ m/s$$

b with drag present

$$\cancel{W_{ext}}^{\,0} = \Delta KE + \Delta PE - W_{non\ cons.}$$
$$0 = KE_f - \cancel{KE_i}^{\,0} + \cancel{PE_f}^{\,0} - PE_i - W_{non\ cons}$$
$$W_{fr} = KE_f - PE_i$$
$$= \tfrac{1}{2} m v^2 - mgh$$
$$= m\left(\tfrac{1}{2}(70\ m/s)^2 - 9.8\ m/s^2\ 303m\right)$$
$$= 0.0015g\left(2450\ m^2/s^2 - 2969.\ m^2/s^2\right)$$
$$= -0.78J$$

5 a)



b) the object is stopped @ the turning pts.

c) at 1 mm $U = -2J$

$$E = KE + U$$

$$KE = E - U = -1 - (-2) = 1J$$

$$\frac{1}{2}mv^2 = KE$$

$$v \quad \sqrt{v^2} = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2J}{0.0015\,kg}} = 36.5\,m/s$$

d) with a total Energy of 1J there is only 1 turning pts

the ptcl will move to the left stop and then move to the right. nothing will stop it and it will go to $x = +\infty$.