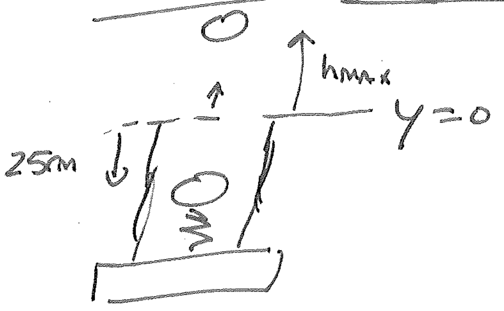
Physics 160

Extra Credit #19

FUN WITH A SPRING GUN



Part (a): If we assume NO FRICTION, THEN gravity & spring only force doing work ⇒ TOTAL ENERGY Conserved. & Potential Energy

AFTER BALL is RELEASED, GRAVITY still Acting ⇒ still A CONSERVATIVE Force

$m = 1.5kg$, $K = 667 N/m$

Spring at EQUILIBRIUM at $y=0$

b) FIND muzzle velocity ⇒ V at $y=0$

Spring at EQUILIBRIUM at $y=0$ ⇒ $S_1 = -25cm = -0.25m$

$S_2 = 0$

Problem took AWAY OUR FREEDOM of CHOICE: $y_2 = 0$ so y_1 must be $-25cm$

Since it is Below 0 ⇒ $y_1 = -0.25m$, $y_2 = 0$

RELEASED FROM REST ⇒ $V_1 = 0$, $V_2 = ?$

$$\frac{1}{2}mV_1^2 + mgy_1 + \frac{1}{2}KS_1^2 = \frac{1}{2}mV_2^2 + mgy_2 + \frac{1}{2}KS_2^2$$

$$(1.5kg)(9.8m/s^2)(-0.25m) + \frac{1}{2}(667N/m)(0.25m)^2 = \frac{1}{2}(1.5kg)V_2^2$$

$$\Rightarrow -3.675J + 20.84375J = \frac{1}{2}(1.5kg)V_2^2$$

$$\Rightarrow 17.16875J = \frac{1}{2}(1.5kg)V_2^2$$

$$\Rightarrow V_2 = \sqrt{\frac{2(17.16875J)}{1.5kg}} = 4.78m/s$$

c) Find Max Height:

We can start at ~~...~~ $y=0$ or ~~...~~ when ball was at $-25cm$, because

At both, the total energy was $17.16875J$.

At max height $E = 17.16875J$ as well. The only difference is that

at max height, the energy is all in the form of gravitational potential

$$\Rightarrow 17.16875J = mg\,h_{MAX} = (1.5kg)(9.8m/s^2)\,h_{MAX}$$

$$\Rightarrow h_{max} = \frac{17.16875J}{(1.5kg)(9.8m/s^2)} = 1.17m$$

d) Which would increase h_{max}:

(1) Reducing K $\Rightarrow$ less total energy $\Rightarrow$ wouldn't go as high.

(2) increasing K $\Rightarrow$ more energy $\Rightarrow$ Yes, would go higher.

(3) Decreasing distance $\Rightarrow$ Does help with gravitational potential but the decrease in elastic energy is more important

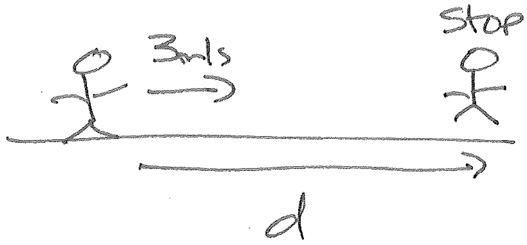
(4) increasing distance $\Rightarrow$ Helps

(5) Decreasing mass of ball $\Rightarrow$ Does increase h_{max}, $U_g = mgy \Rightarrow$ less mass allows y to be bigger.

(6) increasing mass $\Rightarrow$ Hurts

(7) changing angle doesn't help or hurt h_{max} (assuming you launch at $y=0$) $\rightarrow$ gravity only cares about y, so for same energy h_{max} is the same

Sliding in Socks



$\mu_K = 0.25$

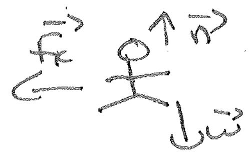
Friction only force doing work

$\Rightarrow W_{other} = W_F$, $y_1 = y_2 = 0$

$s_1 = s_2 = 0$

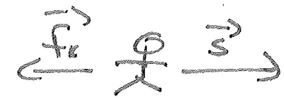
$\Rightarrow \frac{1}{2}mv_1^2 + W_F = \frac{1}{2}mv_2^2$

Friction : $f_K = \mu_K n$



$n = w = mg$

$\Rightarrow f_K = \mu_K mg$ so constant and 180° from displacement



$\therefore W_F = \mu_K mg\, d \cos 180° = -\mu_K mg d$

$\Rightarrow \frac{1}{2}mv_1^2 - \mu_K mgd = \frac{1}{2}mv_2^2$

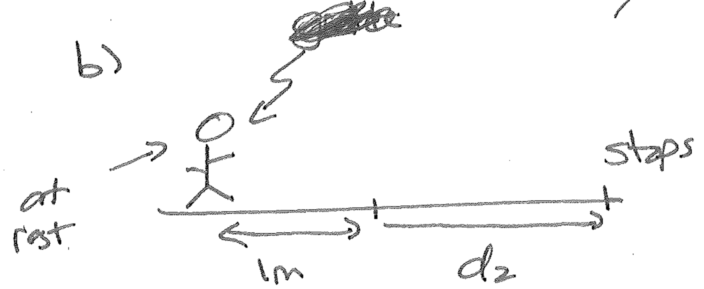
$v_1 = 3\,m/s,\ v_2 = 0 \Rightarrow \frac{1}{2}v_1^2 = \mu_K g d \Rightarrow d = \frac{v_1^2}{2\mu_K g} = \frac{(3\,m/s)^2}{2(0.25)(9.8\,m/s^2)}$

$\Rightarrow d = 1.8367\,m$

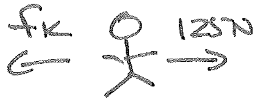
$= 1.84\,m$

Greta, $M_G = 20\text{kg}$, $\mu_K = 0.25$

b)



over 1m ZAK pushes with Force 125N



So Friction AND ZAK DO work

$$\Rightarrow W_{other} = W_f + W_{ZAK}$$

$$\therefore \quad \frac{1}{2}mV_1^2 + W_f + W_{ZAK} = \frac{1}{2}mV_2^2$$

$$V_1 = 0, \; V_2 = 0 \Rightarrow W_f + W_{ZAK} = 0$$

Friction opposite to motion, Acts over a total distance of $(1m + d_2)$ AND HAS magnitude $\mu_K n = \mu_K M_G g$ (Greta)

$$\Rightarrow W_f = -\mu_K M_G g\,(1m + d_2)$$

ZAK's force is parallel to motion AND ONLY Acts over 1m $\Rightarrow W_{ZAK} = F_{ZAK}(1m)$

$$\therefore \; -\mu_K M_G g\,(1m + d_2) + F_{ZAK}(1m) = 0 \Rightarrow -0.25(20\text{kg})(9.8\text{m/s}^2)(1m + d_2) + 125N(1m) = 0$$

$$\Rightarrow -49N\,(1m + d_2) + 125J = 0 \Rightarrow -49J - 49N d_2 + 125J = 0$$

$$\Rightarrow d_2 = \frac{125J - 49J}{49N} = \frac{76J}{49N} = 1.551m$$