① Initial $E_i = K_i + U_i$

$K_i = \frac{1}{2}mv^2 = \frac{1}{2}(0.4\,kg)(3\,m/s)^2 = 1.8\,J$

$U_i = \frac{1}{2}ks^2 = \frac{1}{2}(200\,N/m)(0.10\,m)^2 = 1.0\,J$

$\Rightarrow E_i = 2.8\,J$

(a) Final (at maximum stretch) $v=0 \Rightarrow K_f = 0$ $\quad U_f = \frac{1}{2}ks^2$

$E_f = K_f + U_f = E_i \Rightarrow \frac{1}{2}ks^2 = 2.8\,J \Rightarrow s = \sqrt{\frac{2(2.8J)}{200\,N/m}} = 0.17\,m$

(b) Final (at maximum speed) $s=0 \Rightarrow U_f = 0$ $\quad K_f = \frac{1}{2}mv^2$

$E_f = K_f + U_f = E_i \Rightarrow \frac{1}{2}mv^2 = 2.8\,J \Rightarrow v = \sqrt{\frac{2(2.8J)}{0.4\,kg}} = 3.7\,m/s$

(c) Time for one cycle $T = 2\pi\sqrt{\frac{m}{k}} = 0.28\,s$

$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{0.01\,J}{0.28\,s} = 0.036\,W$

② (a) Compression force $= Mg$ at equilibrium $F_{spring} = F_{grav}$

$Mg = k_s s \Rightarrow s = Mg/k_s$

$K_i = K_f = 0$ So $E_i = E_f \Rightarrow W_{net} = 0$ (take mass as system)

$W_{net} = W_{hand} + W_{grav} + W_{spring} = 0$

$W_{grav} = Mgs \quad W_{spring} = -\frac{1}{2}k_s s^2$

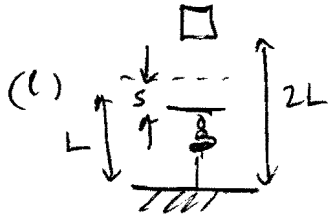
$W_{hand} = -W_{grav} - W_{spring} = -Mgs + \frac{1}{2}k_s s^2 = -Mg\left(\frac{Mg}{k_s}\right) + \frac{1}{2}k_s\left(\frac{Mg}{k_s}\right)^2 = -\frac{1}{2}\frac{(Mg)^2}{k_s}$

(b) Initial (as mass is released) $U_{spring} = 0$, $U_{grav} = 0$, $K_i = 0 \Rightarrow E_i = 0$

Final (as mass comes to rest) $U_{spring} = \frac{1}{2}k_s s^2$ $\quad U_{grav} = -mgs$ $\quad K_f = 0$

$E_i = E_f \Rightarrow 0 = \frac{1}{2}k_s s^2 - mgs$ $\quad$ or $\quad s = 2Mg/k_s$

(1)



Initial: $U_{grav}=0$, $U_{spring}=\frac{1}{2}k_s s^2$, $K_i=0$

Final: $U_{grav}=mg(L+s)$, $U_{spring}=0$, $K_f=\frac{1}{2}mv^2$

$$E_i=E_f \Rightarrow \frac{1}{2}k_s s^2=\frac{1}{2}mv^2+mg(L+s)$$

$$v=\sqrt{\frac{k_s}{m}s^2-2g(L+s)}$$

(3) $$k_s=\frac{F}{s}=\frac{268\ N}{0.0233\ m}=1.15\times10^4\ N/m$$

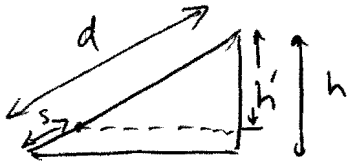
(a) Initial = release point $U_{spring}=0$ $U_{grav}=mgh=mgd\sin\theta$ $K_i=0$

Final = at rest on spring $U_{spring}=\frac{1}{2}k_s s^2$ $U_{grav}=0$ $K_f=0$

$$E_i=E_f \Rightarrow mgd\sin\theta=\frac{1}{2}k_s s^2$$

$$d=\frac{k_s s^2}{2mg\sin\theta}=1.045\ m$$

(b) Final = contacting spring $K_f=\frac{1}{2}mv^2$ $U_{spring}=0$ $U_{grav}=mg(h-h')=mgs\sin\theta$



$$E_i=mgd\sin\theta$$

$$E_i=E_f \Rightarrow mgd\sin\theta=\frac{1}{2}mv^2+mgs\sin\theta$$

$$v=\sqrt{2g(d-s)\sin\theta}=3.21\ m/s$$