$mgh = \frac{1}{2}mv + \frac{1}{2}Iw^2$ $\quad$ $0.75\,mv^2 = mgh$

9. $2.2 - 0.27 = 1.93\,m$

$t_1 = \frac{1.93}{V_{i_1}}$

let the vertical distance of falling be ΔX

$\Delta X = \frac{1}{2}at^2 = \frac{1}{2}\cdot g\cdot\left(\frac{1.93}{V_{i_1}}\right)^2 = \frac{18.63}{V_{i_1}^2}$ ①

$\because$ Conservation of energy

$\therefore \frac{1}{2}mv_{i_1}^2 = \frac{1}{2}KX_1^2$

$V_{i_1}^2 = \frac{0.011^2\cdot K}{m}$ $\xrightarrow{\text{Substitude this into ①}}$ $\Delta X = 18.63\times\frac{m}{0.011^2\cdot K} = \frac{153966.94\cdot m}{K}$

$\because$ the right time need to hit the center of the box is $t_2 = \frac{2.2}{V_{i_2}}$

$\therefore \Delta X = \frac{1}{2}at^2 \Rightarrow \frac{153966.94\cdot m}{K} = \frac{1}{2}\cdot g\cdot\frac{2.2^2}{V_{i_2}^2} \Rightarrow V_{i_2}^2 = \frac{K}{6362.27\cdot m}$

$\therefore \frac{1}{2}KX_2^2 = \frac{1}{2}mV_{i_2}^2 \Rightarrow \frac{m}{2}\cdot\frac{K}{6362.27\cdot m} = \frac{1}{2}K\cdot X_2^2 \Rightarrow X_2 = 0.012m$

$= 1.2cm$

10. (a) $mgh = \frac{1}{2}mv^2 + \frac{1}{2}Iw^2$

$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$

$0.75v^2 = gh$

$v^2 = \frac{gh}{0.75}$

$v^2 = \frac{30}{0.75}$

$V = 6.33\,m/s$

(b) $\frac{1}{2}Iw^2 = \frac{1}{2}\cdot\left(\frac{1}{2}\cdot m\cdot r^2\right)\cdot\left(\frac{v}{r}\right)^2$

$= \frac{1}{4}\cdot m\cdot v^2$

$= \frac{1}{4}\cdot 2\cdot 6.33^2$

$= 20.04\,J$

$2a\cdot\frac{3}{\sin 30^\circ} = V_f^2 - v_i^2 = 40$

$6a = 20$

$a = 3.33\,m/s^2$