4 (a).

$\vec{f} \leftarrow \quad \rightarrow d\vec{x}$

$$W = \int \vec{f} \cdot d\vec{x} = \int_0^x -(kx + cx^3)\, dx = -k\frac{x^2}{2} + \left(-c\frac{x^4}{4}\right)$$

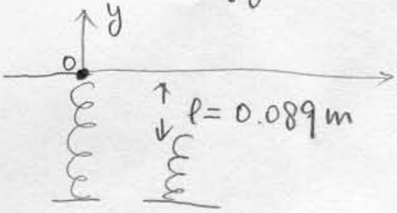
$$= -\frac{kx^2}{2} - \frac{cx^4}{4}$$

The force exerted by this spring is conservative.

(b) From the calculation in part (a). we find when compresed by the same amount, this spring need more energy compared to $\frac{k}{2}x^2$ in Hook's law's case.

Then the ball will go higer than the Hook's law spring.

(c). Energy conservation:



$$-mgl + \frac{kl^2}{2} + \frac{cl^4}{4} = mgx$$

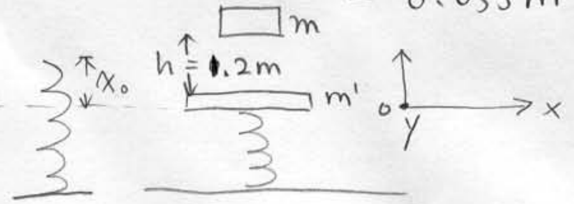
$$mg(l+x) = \frac{kl^2}{2} + \frac{cl^4}{4}$$

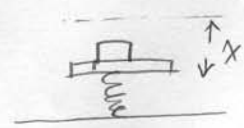
$$l + x = \frac{\frac{kl^2}{2} + cl^4/4}{mg}$$

$$x = \frac{kl^2/2 + cl^4/4}{mg} - l$$

$$= 0.055\,m$$

5.6. (a) Energy conservation:





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

$$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 1.2} \doteq 4.85\,m/s$$

(b) Momentum conservation:

$$mv = (m + m')v' \Rightarrow v' = \frac{mv}{m + m'} = \frac{0.23}{0.23 + 0.11} v \doteq 3.28\,m/s$$

(c) Energy conservation:

$$x_0 = \frac{m'g}{k} \doteq 2.57 \times 10^{-3}\,m$$

$$\frac{k}{2}x_0^2 + \frac{1}{2}(m+m')v'^2 = \frac{k}{2}(x_0 + x)^2 - (m+m')gx$$

$$x = 0.0988\,m$$