Chapter 15 Problem 34

a) Find the force constant ~~(Spring Constant)~~ k

$m = 0.0500\,kg$

$\Delta x = 0.150\,m$

$v = 20.0\,m/s$

compressing the plunger requires work, which is stored as potential energy. For a spring

$$U_0 = \tfrac{1}{2} k x^2 \qquad \text{where } x = \Delta x$$

Initial Kinetic energy is $K_0 = 0$

Final Potential energy is $U_f = 0$

and final Kinetic energy is $K_f = \tfrac{1}{2} m v^2$

By conservation of energy

$$K_0 + U_0 = K_f + U_f$$

$$0 + \tfrac{1}{2} k x^2 = \tfrac{1}{2} m v^2 + 0 \rightarrow \frac{1}{2} k x^2 = \tfrac{1}{2} m v^2$$

Solve for k

$$k = \frac{m v^2}{x^2} = \frac{(0.0500\,kg)(20.0\,m/s)^2}{(0.150\,m)^2} = \boxed{889\,\frac{N}{m}}$$

b) What force is needed to compress the spring?

Initially the force is zero and then increases to a maximum when the spring is fully compressed.

By Hooke's Law $\|F\| = kx = \left(889\,\frac{N}{m}\right)(0.150\,m) = \boxed{133\,N}$