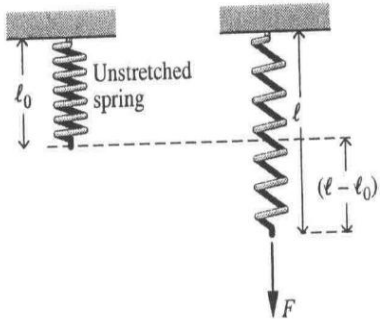


PROBLEM 2.45

KNOWN: Data is provided for a spring stretched by a force applied at its end.

FIND: Obtain an expression for the work done in stretching the spring and evaluate the work using given data.

SCHEMATIC & GIVEN DATA:



$$F = k(l - l_0)$$

$$l_0 = 3 \text{ cm}$$

$$l_1 = 6 \text{ cm}$$

$$l_2 = 10 \text{ cm}$$

$$k = 10^4 \text{ N/m}$$

Fig. P2.41

ENGR. MODEL:

1. The spring is the closed system.
2. The moving boundary is the only work mode.
3. Hooke's law applies.

ANALYSIS: (a) The work done in stretching the spring is given by

$$W = - \int_1^2 F dl$$

Letting $x = l - l_0$, this becomes

$$W = - \int_1^2 kx dx = -k \left[\frac{x_2^2}{2} - \frac{x_1^2}{2} \right]$$

$$= -\frac{k}{2} \left[(l_2 - l_0)^2 - (l_1 - l_0)^2 \right] \quad \leftarrow$$

(b) When $(l_1 - l_0) = 3 \text{ cm}$ and $(l_2 - l_0) = 7 \text{ cm}$,

$$W = \left(-\frac{10^4 \text{ N/m}}{2} \right) \left[(7 \text{ cm})^2 - (3 \text{ cm})^2 \right] \left| \frac{1 \text{ m}}{10^2 \text{ cm}} \right|^2 \left| \frac{1 \text{ J}}{1 \text{ N}\cdot\text{m}} \right|$$

$$= -20 \text{ J} \quad \leftarrow$$