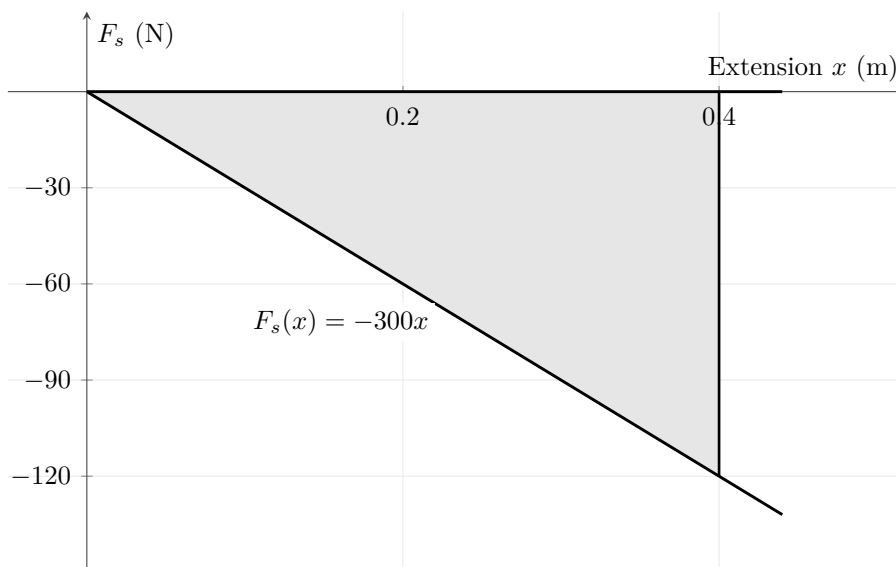


Question 10

A vertical spring attached to a ceiling has natural length 1 m and spring constant $k = 300$ N/m. An external agent stretches it downward from length 1 m to 1.4 m.

Find the work done by the spring during this motion.



The shaded area represents negative work done by the spring.

Question 10 – Solution

1. Define displacement from natural length.

Let x be extension measured positively downward. The spring lengths correspond to

$$x_0 = 1 - 1 = 0, \quad x_1 = 1.4 - 1 = 0.4 \text{ m.}$$

2. Use the signed force exerted by the spring.

The spring pulls upward, opposite the positive direction. Therefore,

$$F_s(x) = -kx = -300x \text{ N.}$$

The question asks for work done by the spring itself.

3. Set up the signed work integral.

$$W_s = \int_0^{0.4} F_s(x) dx = \int_0^{0.4} -300x dx.$$

4. Integrate and apply the bounds.

$$W_s = [-150x^2]_0^{0.4} = -150(0.4)^2 = -150(0.16) = -24.$$

5. State the result and interpret its sign.

$$\boxed{W_s = -24 \text{ J.}}$$

The negative sign indicates that the spring force opposes the motion. Its elastic potential energy increases by $\frac{1}{2}k(0.4)^2 = 24 \text{ J}$, consistent with $W_s = -\Delta U$.