21.45. Model: The steel wire is under tension and it vibrates with three antinodes.
Visualize: Please refer to Figure P21.45.
Solve: When the spring is stretched 8.0 cm, the standing wave on the wire has three antinodes. This means $\lambda_3 = \frac{2}{3}L$ and the tension T_S in the wire is $T_S = k(0.080\text{ m})$, where k is the spring constant. For this tension,

$$v_{\text{wire}} = \sqrt{\frac{T_S}{\mu}} \Rightarrow f\lambda_3 = \sqrt{\frac{T_S}{\mu}} \Rightarrow f = \frac{3}{2L}\sqrt{\frac{k(0.08\text{ m})}{\mu}}$$

We will let the stretching of the spring be Δx when the standing wave on the wire displays two antinodes. This means $\lambda_2 = L$ and $T_S' = kx$. For the tension T_S',

$$v'_{\text{wire}} = \sqrt{\frac{T_S'}{\mu}} \Rightarrow f\lambda_2 = \sqrt{\frac{T_S'}{\mu}} \Rightarrow f = \frac{1}{L}\sqrt{\frac{k\Delta x}{\mu}}$$

The frequency f is the same in the above two situations because the wire is driven by the same oscillating magnetic field. Now, equating the two frequency equations,

$$\frac{1}{L}\sqrt{\frac{k\Delta x}{\mu}} = \frac{3}{2L}\sqrt{\frac{k(0.080\text{ m})}{\mu}} \Rightarrow \Delta x = 0.18\text{ m} = 18\text{ cm}$$