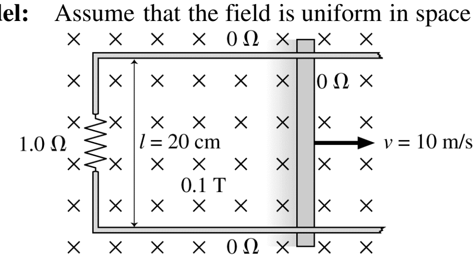
33.43. Model: Assume that the field is uniform in space over the loop.

Visualize:



The moving slide wire in a magnetic field develops a motional emf and a corresponding current in the wire and the rails. The current through the resistor will cause energy dissipation and subsequent warming.

Solve: **(a)** The induced emf depends on the changing flux, not on where the resistance in the loop is located. We have

$$\mathcal{E}_{\text{loop}} = vlB = (10\text{ m/s})(0.20\text{ m})(0.10\text{ T}) = 0.20\text{ V}$$

The total resistance around the loop is due entirely to the carbon resistor, so the induced current is

$$I = \mathcal{E}_{\text{loop}}/R = (0.20\text{ V})/(1.0\text{ }\Omega) = 0.20\text{ A}$$

(b) To move with a constant velocity the acceleration must be zero, so the pulling force must balance the retarding magnetic force on the induced current in the slide wire. Thus,

$$F_{\text{pull}} = F_{\text{mag}} = IlB = (0.20\text{ A})(0.20\text{ m})(0.1\text{ T}) = 4.0\times10^{-3}\text{ N}$$

(c) The current in the resistor will result in power being dissipated. The power is

$$P = I^2R = (0.20\text{ A})^2\,(1\text{ }\Omega) = 0.040\text{ W} = 0.040\text{ J/s}$$

During a 10 second period $Q = 0.40$ J of energy is dissipated by the current, increasing the internal energy of the carbon resistor and raising its temperature. This is, effectively, a heat source. The heat is related to the temperature rise by $Q = mc\Delta T$, where c is the specific heat of carbon. Thus,

$$\Delta T = \frac{Q}{mc} = \frac{0.40\text{ J}}{(5.0\times10^{-5}\text{ kg})(710\text{ J / kg °C})} = 11\text{°C}$$

Assess: This is a significant change in the temperature of the resistor.