34.38. Model: Assume the wire is infinitely long.

Visualize: See Figure P34.38. The current through the wire produces a steady magnetic field, but the magnetic field strength depends on the distance from the wire. The loop moves away from the wire at constant speed. The flux through the loop varies due to its motion. Faraday's law gives the magnitude of the induced emf, and Ohm's law will yield the current strength. The direction of the magnetic field is into the paper at the location of the loop. The magnetic field is perpendicular to the plane of the loop, so $\vec{B}\cdot d\vec{A} = BdA$.

Solve: The flux through the loop is decreasing as it moves away from the wire. Lenz's law implies that the induced current is clockwise in order to increase the flux. Using the results of Example 34.5, which treats the rectangular loop as a series of tall infinitesimally thin strips,

$$\Phi_{\text{m}} = \frac{\mu_0 I(4.0 \text{ cm})}{2\pi}\ln\left(\frac{x+1.0 \text{ cm}}{x}\right)$$

where x is the distance from the wire to the closer edge of the loop, and changes with time. Note $\frac{d\Phi_{\text{m}}}{dt} = \frac{d\Phi_{\text{m}}}{dx}\frac{dx}{dt} = \frac{d\Phi_{\text{m}}}{dx}v$, where $v = \frac{dx}{dt}$ is the velocity of the loop.

The induced emf is thus

$$\mathcal{E} = \left|\frac{d\Phi_{\text{m}}}{dx}\frac{dx}{dt}\right| = \frac{\mu_0 I(4.0 \text{ cm})}{2\pi}\frac{1.0 \text{ cm}}{x(x+1.0 \text{ cm})}v$$

At x = 2.0 cm,

$$\mathcal{E} = \frac{\mu_0 I}{2\pi}(4.0 \text{ cm})\left(\frac{1.0 \text{ cm}}{2.0 \text{ cm}(3.0 \text{ cm})}\right)(10 \text{ m/s}) = 1.3\times10^{-6} \text{ V}$$

Since the loop resistance is R = 0.020 Ω, the induced current is thus

$$I_{\text{loop}} = \frac{\mathcal{E}}{R} = 6.7\times10^{-5} I$$

Assess: The induced emf is proportional to the current in the wire. For reasonable currents (~1 A) the induced emf is reasonable.

34.52. Model: Assume the magnetic field is uniform over the region where the bar is sliding and that friction between the bar and the rails is zero.

Visualize: Please refer to Figure P34.52. The battery will produce a current in the rails and bar and the bar will experience a force. With the battery connected as shown in the figure, the current in the bar will be down and by the right-hand rule the force on the bar will be to the right. The motion of the bar will change the flux through the loop and there will be an induced emf that opposes the change.

Solve: **(a)** As the bar speeds up the induced emf will get larger until finally it equals the battery emf. At that point, the current will go to zero and the bar will continue to move at a constant velocity. We have

$$\mathcal{E} = Blv_{\text{term}} = \mathcal{E}_{\text{bat}} \Rightarrow v_{\text{term}} = \frac{\mathcal{E}_{\text{bat}}}{Bl}$$

(b) The terminal speed is

$$v_{\text{term}} = \frac{1.0\ \text{V}}{(0.50\ \text{T})(0.060\ \text{m})} = 33\ \text{m/s}$$

Assess: This is pretty fast, about 70 mph.

34.76. Model: Assume negligible resistance in the *LC* part of the circuit.

Visualize: With the switch in position 1 for a long time the capacitor is fully charged. After moving the switch to position 2, there will be oscillations in the *LC* part of the circuit.

Solve: **(a)** After a long time the potential across the capacitor will be that of the battery and $Q_0 = C\Delta V_{\text{batt}}$. When the switch is moved, the capacitor will discharge through the inductor and *LC* oscillations will begin. The maximum current is

$$I_0 = \omega Q_0 = \omega C\Delta V_{\text{batt}} = \frac{C\Delta V_{\text{batt}}}{\sqrt{LC}} = \sqrt{\frac{C}{L}}\Delta V_{\text{batt}} = \sqrt{\frac{(2.0\times10^{-6}\ \text{F})}{(50\times10^{-3}\ \text{H})}}(12\ \text{V}) = 7.6\times10^{-2}\ \text{A} = 76\ \text{mA}$$

(b) The current will be a maximum one-quarter cycle after the maximum charge. The period is

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{LC} = 2\pi\sqrt{(50\times10^{-3}\ \text{H})(2.0\times10^{-6}\ \text{F})} = 2.0\ \text{ms}$$

So the current is first maximum at $t_{\text{max}} = \frac{1}{4}T = 0.50$ ms.