4. A 9.6-cm-diameter circular loop of wire is in a 1.10-T magnetic field. The loop is removed from the field in 0.15 s. What is the average induced emf?

We assume the plane of the coil is perpendicular to the magnetic field. The magnitude of the average induced emf is given by Eq. 21-2a.

\[
\mathcal{E} = -\frac{\Delta \Phi}{\Delta t} = -\frac{\Delta B}{\Delta t} = -\frac{\pi (0.048 \text{ m})^2 (0 - 1.10 \text{ T})}{0.15 \text{ s}} = 0.0531 \text{ V}
\]

14. The moving rod in Fig. 21-12 is 13.2 cm long and generates an emf of 120 mV while moving in a 0.90-T magnetic field. (a) What is its speed? (b) What is the electric field in the rod?

(a) The velocity is found from Eq. 21-3.

\[
\mathcal{E} = Blv \quad \rightarrow \quad v = \frac{\mathcal{E}}{Bl} = \frac{0.12 \text{ V}}{(0.90 \text{ T})(0.132 \text{ m})} = 1.01 \text{ m/s}
\]

(b) Because the outward flux is increasing, the induced flux will be into the page, so the induced current is clockwise. Thus the induced emf in the rod is down, which means that the electric field will be down. The magnitude of the electric field is the induced voltage per unit length.

\[
E = \frac{\mathcal{E}}{l} = \frac{0.12 \text{ V}}{0.132 \text{ m}} = 0.909 \text{ V/m, down}
\]

23. A simple generator has a 320-loop square coil 21.0 cm on a side. How fast must it turn in a 0.650-T field to produce a 120-V peak output?

From Eq. 21-5, the peak voltage is \( \mathcal{E}_{\text{peak}} = NBA \). Solve this for the rotation speed.

\[
\mathcal{E}_{\text{peak}} = NBA \quad \rightarrow \quad \omega = \frac{\mathcal{E}_{\text{peak}}}{NBA} = \frac{120 \text{ V}}{320(0.650 \text{ T})(0.210 \text{ m})} = 13.08 \text{ rad/s}
\]

\[
f = \frac{\omega}{2\pi} = \frac{13.08 \text{ rad/s}}{2\pi \text{ rad/rev}} = 2.08 \text{ rev/s}
\]

33. Neon signs require 12 kV for their operation. To operate from a 240-V line, what must be the ratio of secondary to primary turns of the transformer? What would the voltage output be if the transformer were connected backward?

We find the ratio of the number of turns from Eq. 21-6.

\[
\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{12000 \text{ V}}{240 \text{ V}} = 50
\]
If the transformer is connected backward, the role of the turns will be reversed:

\[
\frac{N_s}{N_p} = \frac{V_s}{V_p} \rightarrow \frac{1}{50} = \frac{V_s}{240 \text{ V}} \rightarrow V_s = \frac{1}{50} (240 \text{ V}) = 4.80 \text{ V}
\]

41. What is the inductance \( L \) of a 0.60-m-long air-filled coil 2.9 cm in diameter containing 10,000 loops?

Use the relationship for the inductance of a solenoid, as given in Example 21-14.

\[
L = \frac{\mu_0 N^2 A}{l} = \frac{(4\pi \times 10^{-7} \text{ T} \cdot \text{m}/\text{A})(10000)^2 \pi (1.45 \times 10^{-2} \text{ m})^2}{0.60 \text{ m}} = 0.138 \text{ H}
\]

47. The magnetic field inside an air-filled solenoid 36 cm long and 2.0 cm in diameter is 0.80 T. Approximately how much energy is stored in this field?

The magnetic energy in the field is derived from Eq. 21-10.

\[
u = \frac{\text{Energy stored}}{\text{Volume}} = \frac{1}{2} \frac{B^2}{\mu_0} \rightarrow
\]

Energy = \( \frac{1}{2} \frac{B^2}{\mu_0} \text{ (Volume)} = \frac{1}{2} \frac{B^2}{\mu_0} \pi r^2 L = \frac{1}{2} \frac{(0.80 \text{ T})^2}{4\pi \times 10^{-7} \text{ T} \cdot \text{m}/\text{A}} \pi (0.010 \text{ m})^2 (0.36 \text{ m}) = 28.8 \text{ J} \)