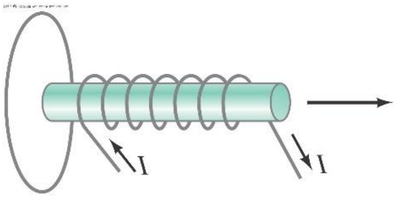
CHAPTER 30

INDUCTION AND INDUCTANCE

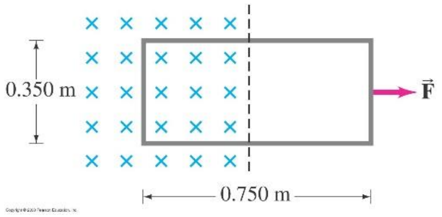
PROBLEM SET

1) A circular wire loop of radius $r = 12\ \text{cm}$ is immersed in a uniform magnetic field $B = 0.500\ \text{T}$ with its plane normal to the direction of the field. If the field magnitude then decreases at a constant rate of $-0.010\ \text{T/s}$ at what rate should r increase so that the induced emf within the loop is zero? **[Answer: 1.2 mm/s]**

2) If the solenoid in Fig. 29–39 is being pulled away from the loop shown, in what direction is the induced current in the loop? **[Answer: counterclockwise]**



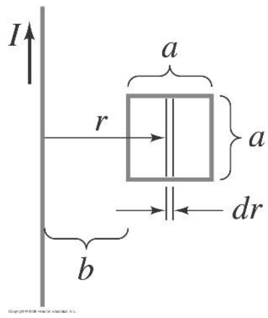
3) Part of a single rectangular loop of wire with dimensions shown in Fig. 29–40 is situated inside a region of uniform magnetic field of 0.650 T. The total resistance of the loop is 0.280 Ω. Calculate the force required to pull the loop from the field (to the right) at a constant velocity of 3.40 m/s. Neglect gravity. **[Answer: 0.628 N]**

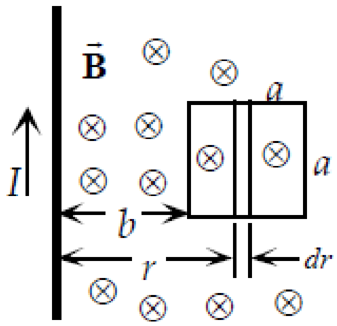


4) *** A 22.0-cm-diameter coil consists of 28 turns of circular copper wire 2.6 mm in diameter. A uniform magnetic field, perpendicular to the plane of the coil, changes at a rate of 8.65×10^{-3} T/s .Determine (a) the current in the loop, and (b) the rate at which thermal energy is produced.**[Answer: a) 0.15 A, b) $\mathbf{1.4 \times 10^{-3}}$ W]**

5) (a) Determine the magnetic flux through a square loop of side **a** (Fig. 29–43) if one side is parallel to, and a distance **b** from, a straight wire that carries a current I. (b) If the loop is pulled away from the wire at speed ***v***, what emf is induced in it? (c) Does the induced current flow clockwise or counterclockwise? (d) Determine the force F required to pull the loop away.

[Answer: a) $\frac{\mu_0 I a}{2\pi}\ln\left(1+\frac{a}{b}\right)$ **b)** $\frac{\mu_0 I a^2 v}{2\pi b(b+a)}$ **c) clockwise** **d)** $\frac{\mu_0^2 I^2 a^4 v}{4\pi^2 R b^2 (b+a)^2}$ **]**

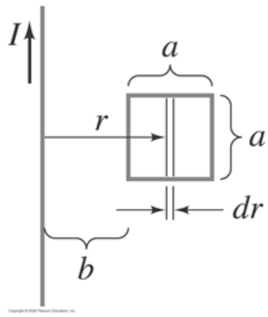




6) *** Determine the emf induced in the square loop in Fig. 29–43 if the loop stays at rest and the current in the straight wire is given by $I(t) = (15.0\text{ A})\sin(2500\,t)$ where t is in seconds. The distance a is 12.0 cm, and b is 15.0 cm.

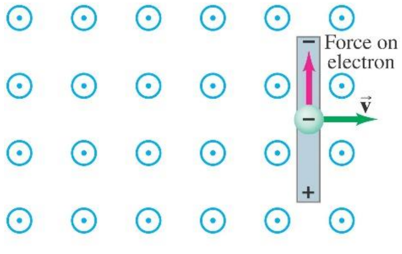
[Answer:

$\left(5.3\times10^{-4}\text{ V}\right)\cos(2500t)$ **]**



7) The moving rod in Fig. 29–12b is 12.0 cm long and is pulled at a speed of 15.0 cm/s. If the magnetic field is 0.800 T, calculate the emf developed.

[Answer: $1.44\times10^{-2}\ V$]

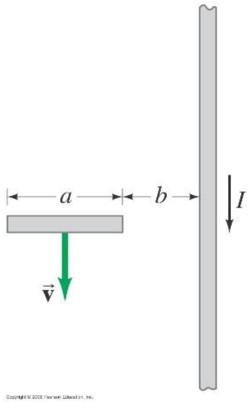


(b)

8) A short section of wire, of length a, is moving with velocity $\vec{v}$ parallel to a very long wire carrying a current I as shown in Fig. 29–45. The near end of the wire section is a distance b from the long wire. Assuming the vertical wire is very long compared to $a+b$, determine the emf between the ends of the short section. Assume $\vec{v}$ is (a) in the same direction as I, (b) in the opposite direction to I.

[Answer: a) toward the wire b) away from the wire

$$\frac{\mu_0 I v}{2\pi}\ln\left(\frac{b+a}{b}\right) \qquad \frac{\mu_0 I v}{2\pi}\ln\left(\frac{b+a}{b}\right)$$ **]**

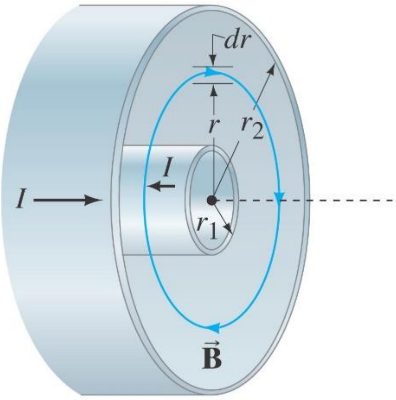


9) If the current in a 280-mH coil changes steadily from 25.0 A to 10.0 A in 360 ms, what is the magnitude of the induced emf? **[Answer: 12 V]**

10) *** Determine the total energy stored per unit length in the magnetic field between the coaxial cylinders of a coaxial cable (Fig. 30–5) by using Eq. 30–7 for the energy density and integrating over the volume. [$\boldsymbol{u = energy\ density = \frac{1}{2}\frac{B^2}{\mu_0}}$]

[Answer:

$$\frac{\mu_0 I^2}{4\pi}\ln\left(\frac{r_2}{r_1}\right)$$ **]**



(a)