Problems

Chapter 10

1. A loop antenna is made of a single loop of wire of diameter 10cm. The magnetic field due to radio waves can be assumed to be uniform within the loop. If the maximum rate of change of magnetic field within the loop is 0.20T/s, find the maximum possible emf that can be induced in the loop.

2. A single circular loop of wire has a radius of 10cm and a resistance of 5.0Ω. A uniform magnetic field perpendicular to the plane of the loop changes in magnitude with time as shown by the graph below. Find the induced current in the loop for time t in the following ranges (in seconds).

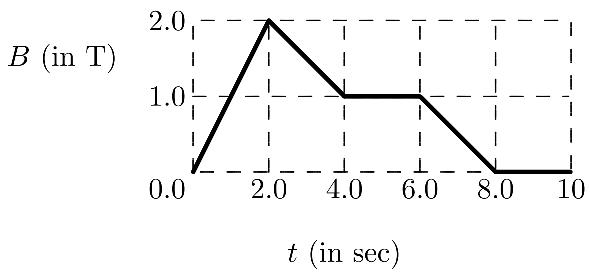
   (a) $0.0 < t < 2.0$.

   (b) $2.0 < t < 4.0$.

   (c) $4.0 < t < 6.0$.

   (d) $6.0 < t < 8.0$.

   (e) $8.0 < t < 10$.



3. A long solenoid has 100 turns per meter of its length and a diameter of 5.0cm. A 20 turn coil is wrapped around the solenoid on the outside. The resistance of the coil is 8.0Ω and its diameter is 6.0cm. If the solenoid current increases at a steady rate of 1.5 A/s, find the induced current in the coil outside.

4. A static magnetic field can be measured using a small coil connected to a device that measures net charge flow. If the coil is placed in a magnetic field and rotated (or moved in any way) over time, the change in flux is related to the net charge flow as follows.

$$\Phi_B(0) - \Phi_B(t) = Rq(t),$$

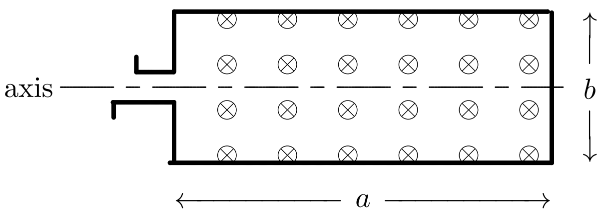
   where $\Phi_B(t)$ is the flux through the coil at any time t, $\Phi_B(0)$ is the same flux at $t = 0$, R is the total resistance of the coil and the charge measuring device and $q(t)$ is the total charge that flows through the coil upto time t starting at time $t = 0$. The measurement of the change in flux allows the measurement of magnetic field, if the change in angle of the coil is known.

   (a) Prove the above formula.

(b) A 50 turn circular coil of cross-sectional area $2.0 \times 10^{-4}\text{m}^2$ is placed in a uniform magnetic field such that the field is perpendicular to the plane of the coil. Then the coil is turned by $180°$ about one diameter. As a result, a charge of 5.5×10^{-3}C flows through the coil. If the resistance of the circuit is $R = 15\Omega$, find the magnitude of the magnetic field.

5. A simple alternating current generator is made of a rectangular coil of N turns. The length and breadth of the coil are a and b. The coil is placed in a uniform magnetic field $\vec{\mathbf{B}}$ such that its plane is initially perpendicular to the field. It is then rotated about an axis parallel to its length at a frequency f. Show that the emf generated in the coil is given by the following.

$$\mathcal{E} = 2\pi f N a b B \sin(2\pi f t) = \mathcal{E}_0 \sin(2\pi f t).$$

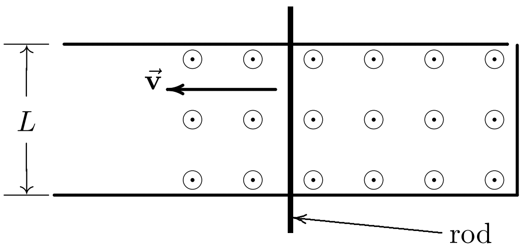


6. The figure below shows two parallel rails connected on the right side by a third rail. These rails have negligible resistance. A rod is sliding along these rails at a constant velocity $\vec{\mathbf{v}}$. A uniform magnetic field $\vec{\mathbf{B}}$ is seen coming out of the page. It is known that the magnitude of the magnetic field is $B = 0.50$T, the magnitude of the velocity is $v = 0.25$m/s, the distance between the rails is $L = 0.80$m and the resistance of the rod is 20Ω.

   (a) Find the emf generated in the rod.

   (b) Find the current in the rod.

   (c) Find the rate of heat loss in the rod.

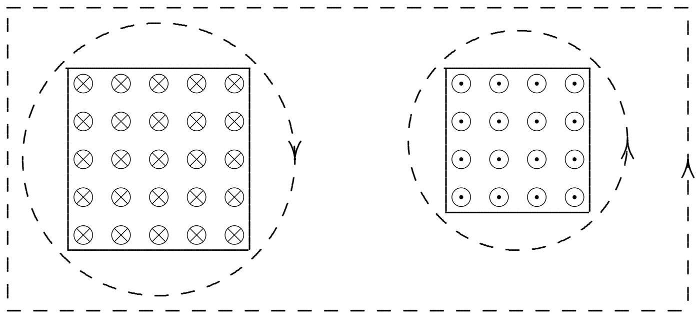


7. The figure below shows uniform magnetic fields restricted to two square regions. The magnitude of the magnetic field on the left is decreasing at the rate of 2.5T/s. The magnitude of the other one is increasing at the rate 4.0T/s. The directions of the fields are indicated in the figure. The square on the left has sides of 2.0m and the other one has sides of 1.5m.

   (a) Find the integral $\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}}$ along the circular path on th left.

   (b) Find the integral $\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}}$ along the circular path on th right.

   (c) Find the integral $\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}}$ along the rectangular path.



8. An inductor has a current i flowing through it. The emf across the inductor is found to be in the same direction as the current and it has a magnitude of 25V. The magnitude of the rate of change of current is 42A/s.

   (a) Determine if the current is increasing or decreasing.

   (b) Find the inductance of the inductor.

9. Two inductors of inductance L_1 and L_2 are connected in parallel while they are separated by a large enough distance to avoid mutual inductance. Show that the equivalent inductance L_{eq} of the combination is given by

$$\frac{1}{L_{\text{eq}}} = \frac{1}{L_1} + \frac{1}{L_2}.$$

10. A resistance R and an inductance L are connected in series to a battery. A steady current of 2.0A flows in it. When the battery is shorted and removed, the current drops to 0.50A in 0.010 seconds. If $R = 5.0\Omega$, find L.

11. A resistance R and an inductance L are connected in series to a battery of emf 5.0V. When the switch is turned on, the current rises from zero to 1.5A in 2.0 seconds. The resistance $R = 0.32\Omega$.

    (a) Find the inductance L.

    (b) Find the energy in the inductor when the current is 1.5A.