Electricity, Magnetism, Light

Series 29 – Faraday's Law

Solutions to Homework Set #9

Prob #14 This is like the example in the book.

$\mathcal{E} = Bl v$ $B = 0.450\,T$, $l = 0.35\,m$, $v = 3.40\,m/s$

$I = \frac{\mathcal{E}}{R}$ $R = 0.230\,\Omega$

$F = IlB$ (you should work out the number.) $= \underline{\underline{0.367\,N}}$

Prob #23

(a) $\mathcal{E} = Blv = 0.15\,V$

(b) $I = \mathcal{E}/R = (0.15\,(V))(2.2\Omega + 26.0\Omega) = 5.4 \times 10^{-3}\,A$

(c) the induced current in the rod will flow down. Because this current is in an outward pointing magnetic field, there will be a magnetic force to the left. To keep the rod moving, there must be an equal external force to the right, which is

$F = IlB = 4.5 \times 10^{-4}\,N.$

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Prob. #27

(a) At a distance r from the long wire, the magnetic field is directed into the paper with magnitude

$$B = \mu_0 I / 2\pi r$$

Because the field is not constant over the short section, we find the induced emf by induction. We choose a differential element dr a distance r from the long wire. the induced emf in this element is

$$d\mathcal{E} = Bv\,dr$$

toward the long wire. We find the total emf by integrating

$$\mathcal{E} = \int_b^{a+b} Bv\,dr = \frac{\mu_0 I v}{2\pi}\int_b^{a+b}\frac{dr}{r} = \frac{\mu_0 I v}{2\pi}\ln\left(\frac{a+b}{b}\right)$$

toward the long wire

(b) If the current is in the opposite direction to I, the only change will be in the direction of the emf:

$$\mathcal{E} = \frac{\mu_0 I v}{2\pi}\ln\left(\frac{a+b}{b}\right)$$ away from the long wire.

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Prob. # 59

the magnitude of the average induced emf is

$$\mathcal{E} = \frac{\Delta\Phi_B}{\Delta t}$$

So the average current is

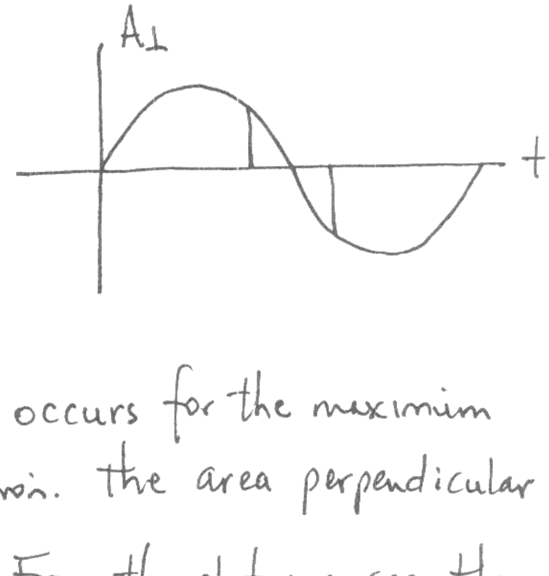
$$I = \frac{\mathcal{E}}{R} = \frac{1}{R}\frac{\Delta\Phi_B}{\Delta t}$$

The charge moving past a fixed point is

$$q = I\Delta t = \frac{\Delta\Phi_B}{R} = \frac{B}{R}\Delta A$$

The number of electrons is

$$N = \frac{q}{e} = \left(\frac{B}{eR}\right)\Delta A$$



The maximum number of electrons occurs for the maximum change in area in a 90° rotation. the area perpendicular to the field varies sinusoidally. From the plot we see the greatest change occurs when the coil moves from an angle of 45° with the field to an angle of 45° on the other side. Thus we have

$$N_{max} = \frac{(0.15T)\pi(.030m)^2}{(1.6\times10^{-19}C)(0.025\Omega)}\frac{1}{[\cos 45° - (-\cos 45°)]} = 1.5\times10^{17}$$