

Ch. 13 Prob. 87

$$N = 500 \text{ turns}$$

$$A = 0.250 \text{ m}^2$$

$$B = 5.00 \times 10^{-5} \text{ T}$$

$$\mathcal{E} = 12.0 \text{ kV} = 12 \times 10^3 \text{ V}$$

a) Find the angular velocity of the coil.

For a coil



$$\mathcal{E} = NBA \omega \sin(\omega t)$$

$$\text{so } \mathcal{E}_{\text{max}} = NBA \omega$$

Solving for the angular velocity

$$\omega = \frac{\mathcal{E}_{\text{max}}}{NBA} = \frac{12 \times 10^3 \text{ V}}{(500)(5.00 \times 10^{-5} \text{ T})(0.250 \text{ m}^2)}$$

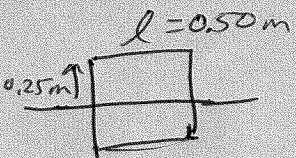
$$\omega = 1.92 \times 10^6 \text{ rad/s}$$

$$= 1.92 \times 10^6 \text{ rad/s} \left(\frac{1 \text{ cycle}}{2\pi \text{ rad}} \right) \left(\frac{60 \text{ s}}{1 \text{ min}} \right)$$

$$= \boxed{1.83 \times 10^7 \text{ rpm}}$$

b) Why is this unreasonable?

If the loop is a square, the edge of the loop is travelling



$$v = \frac{l}{2} (\omega) = \frac{0.50 \text{ m}}{2} (1.92 \times 10^6 \text{ rad/s})$$

$$v = 4.80 \times 10^5 \text{ m/s}$$

This is 0.16% of the speed of light. (No mechanical system can operate at this speed. Think of the friction!)

c) What is responsible?

Either the 12 kV required or the fact that you want earth's magnetic field to do this.
If $B = 1 \text{ T}$, then $\omega = 96 \text{ rpm}$