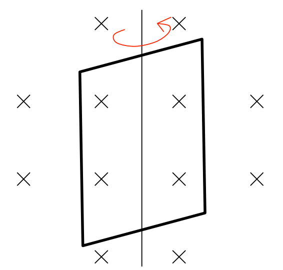
Problem 31.36

a.) A 100 turn square coil rotates in a periodic way. The flux through the coil will vary as:



$$\Phi_B = \vec{B} \bullet \vec{A}$$
$$= |\vec{B}||\vec{A}| \cos \omega t$$

The induced EMF is:

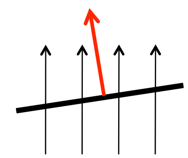
$$\varepsilon = -N \frac{d\Phi_B}{dt}$$
$$= -N \frac{d(BA \cos \omega t)}{dt}$$
$$= NBA\omega \sin \omega t$$

This will be maximum when the sine is equal to "1.' With this:

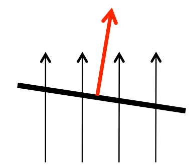
$$\varepsilon_{MAX} = \quad N \quad B \quad A \quad \omega$$
$$= (100 \text{ turns})(2\text{x}10^{-5} \text{ T})(.2 \text{ m})^2 \left[\left(1.5\text{x}10^3 \frac{\text{rev}}{\text{min}}\right) \left(\frac{2\pi \text{ rad}}{1 \text{ rev}}\right) \left(\frac{1 \text{ min}}{60 \text{ sec}}\right) \right]$$
$$= 1.26\text{x}10^{-2} \text{ V}$$

b.) The maximum EMF will happen when the flux is changing as fastest as it can. This happens when the flux is zero, or when the plane of the coil is parallel to the magnetic field. Not obvious? Visualize the situation. When the magnetic field and the area vector are aligned, a change in the angular position will not change the flux much. This slowly changing flux generates a small induced EMF. When the magnetic field and area vectors are close to perpendicular to one another, a small angular change can will swing the flux from one direction to the other very quickly. This quick change of flux will produce the "maximum EMF." A graphic of this is presented on the next page.

With vectors close to parallel:

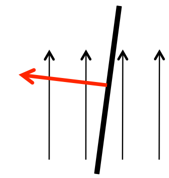


After small angular change:

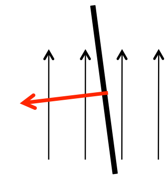


Notice that there are essentially the same number of field lines through the coil after the small angular change. This translates to a small change in flux.

With vectors close to perpendicular:



After small angular change:



Notice the flux actually changes direction after the small angular change. This translates to a fast change in flux.