Name______________________________

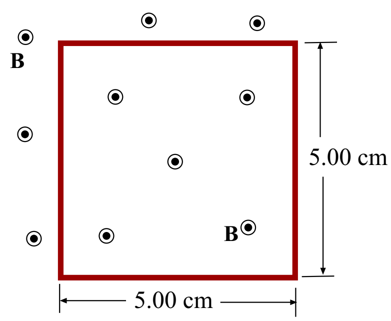
Apr. 16, 2008

Quiz #5 — Spring 2008

Phys 2020

1. a) A square conducting loop of side 5.00 cm is in the plane of the page; a (changing) magnetic field is directed out of the page, as shown here. The loop has a resistance of $10.0\,\Omega$.

If the magnitude of the B field increases from 0.10 T to 0.30 T in 0.300 s, find the (average) current in the loop during the time of this change.



The change in flux induces an emf and a current in the loop. The change in magnetic flux in the loop is

$$\Delta\Phi = \Delta(AB\cos\theta) = A\Delta B$$

since $\theta = 0$ (field is normal to loop's surface) and the area of the square is

$$A = a^2 = (0.050\ \mathrm{m})^2 = 2.5 \times 10^{-3}\ \mathrm{m}^2$$

we get

$$\Delta\Phi = A\Delta B = (2.5 \times 10^{-3}\ \mathrm{m}^2)(0.30\ \mathrm{T} - 0.10\ \mathrm{T}) = 5.0 \times 10^{-4}\ \mathrm{Wb}$$

The induced emf if

$$\mathcal{E} = \frac{\Delta\Phi}{\Delta t} = \frac{(5.0 \times 10^{-4}\ \mathrm{Wb})}{(0.300\ \mathrm{s})} = 1.67 \times 10^{-3}\ \mathrm{V}$$

and the current is

$$I = \frac{\mathcal{E}}{R} = \frac{(1.67 \times 10^{-3}\ \mathrm{V})}{(10.0\,\Omega)} = 1.67 \times 10^{-4}\ \mathrm{A}$$

b) While the magnetic field is changing, what is the direction of the current?

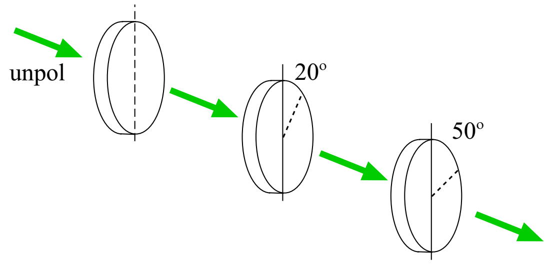
You must give a complete, clear (and correct) explanation. A simple answer will not suffice.

Since the B field is increasing, the flux is *increasing* in the out-of-page direction. To oppose this change we need to make flux in the into-the-page direction. Which current direction in the loop will do this?

Suppose the current is counter-clockwise. The right-hand rule says that in the loop's interior this gives a magnetic field out of the page, which we don't want. A clockwise current gives a magnetic field (and flux) into the page so the induced current must go $\boxed{\text{clockwise}}$.

2. Light which is initially *unpolarized* is incident on a polarizer with its axis vertical. It then passes through a polarizer with its axis at 20.0° from the vertical and then another polarizer with its axis at 50.0° from the vertical.

What fraction of the original light intensity gets though all the polarizers?



Light passing thru the first polarizer has its intensity diminished by a factor of $\frac{1}{2}$ and is now polarized vertically.

The next polarizer has its axis at 20.0° from the this direction so the intensity is diminished by a further factor of $\cos^2 20.0^\circ$ and the light is now polarized at 20.0° from the vertical.

The next polarizer has its axis at 50.0° from the vertical, but that is 30.0° *from the polarization direction of the incoming light*. So the intensity is diminished by a further factor of $\cos^2 30.0^\circ$ and the light is now polarized at 50.0° from the vertical.

The overall factor applied to the intensity (the fraction which gets through) is

$$\tfrac{1}{2}(\cos^2 20.0^\circ)(\cos^2 30.0^\circ) = 0.331$$

so $\boxed{0.331}$ of the light intensity gets through all the polarizers.

3. What is the energy of a photon of light whose wavelength is 540 nm?

$$E = hf = \frac{hc}{\lambda} = \frac{(6.626\times 10^{-34}\ \mathrm{J\cdot s})(3.00\times 10^{8}\,\frac{\mathrm{m}}{\mathrm{s}})}{(540\times 10^{-9}\ \mathrm{m})} = 3.68\times 10^{-19}\ \mathrm{J}$$

We can convert this to eV:

$$E = (3.68\times 10^{-19}\ \mathrm{J})\left(\frac{1\ \mathrm{eV}}{1.60\times 10^{-19}\ \mathrm{J}}\right) = 2.30\ \mathrm{eV}$$

You must show all your work and include the right units with your answers!

$e = 1.60\times 10^{-19}\ \mathrm{C}$ $\quad K = 8.99\times 10^{9}\ \frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}}$ $\quad \epsilon_0 = 8.854\times 10^{-12}\ \frac{\mathrm{C^2}}{\mathrm{N\cdot m^2}}$ $\quad \mu_0 = 4\pi\times 10^{-7}\ \frac{\mathrm{N}}{\mathrm{A^2}}$

$1\ \mathrm{eV} = 1.60\times 10^{-19}\ \mathrm{J}$ $\quad V = IR$ $\quad P = I^2R$ $\quad F = |q|vB\sin\alpha$ $\quad F = ILB\sin\alpha$ $\quad \mathcal{E} = vLB$

$$\Phi = AB\cos\theta \qquad \mathcal{E} = N\left|\frac{\Delta\Phi}{\Delta t}\right| \qquad v_L = L\frac{\Delta i_L}{\Delta t} \qquad v_{\mathrm{em}} = c = \frac{1}{\sqrt{\epsilon_0\mu_0}} \qquad \lambda f = c$$

$$I = \frac{P}{A} = \tfrac{1}{2}c\epsilon_0 E_0^2 = \tfrac{1}{2}\frac{c}{\mu_0}B_0^2 \qquad E_0 = cB_0 \qquad I = \frac{P_{\mathrm{source}}}{4\pi r^2} \qquad I = I_0\cos^2\theta$$

$$h = 6.626\times 10^{-34}\ \mathrm{J\cdot s} \qquad E = hf = \frac{hc}{\lambda} \qquad E = E_0 + K_{\max} \qquad \lambda = \frac{h}{p} \qquad E_n = \frac{h^2}{8mL^2}n^2 = n^2E_1$$