4/26 In Class Tutorial and Practice Problems
Magnetic Flux and Faraday's Law

Magnetic Flux

Recall that magnetic flux is defined by:

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

1. A circular loop of wire of radius 15cm is in the xy-plane. What is the area vector, $\vec{A}$, for the loop? (There are two correct answers.)

2. A circular loop of wire of radius 15cm is in the plane of the table. There is a magnetic field of 5mT in the region. What is the flux through the loop if the $\vec{B}$ field is:

   (a) Into the table?

   (b) To the right?

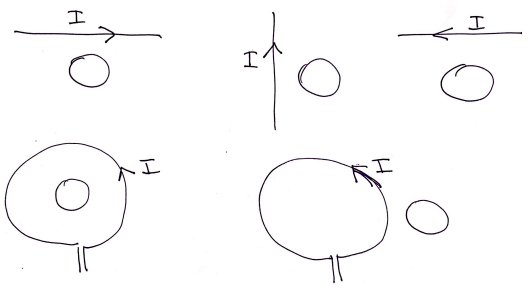
   (c) Toward the back of the table (still horizontal)?

   (d) At an angle of 30° with respect to the table?

Lenz's Law

Lenz's Law says that the direction of the induced current is such that the induced magnetic field (caused by the induced current) *opposes* the change in magnetic flux. For example, if the number of field lines (through a surface) in a direction increases, the induced current will act in such a way to decrease the field lines in that direction.

3. For the following figures (there are five separate two-wire configurations), there is a current in the long straight wire or big loop; Its direction is labeled. For the small loops, there is no current except the induced current. For each of the following, what is the direction of the induced current in the small loop if the current I is increasing? (Draw all of them on the board as part of showing your work.)



4. How would your answers to the last problem change if the given current were decreasing (instead of increasing)?

Faraday's Law

Faraday's Law says that the emf induced in a wire loop is given by:

$$\mathcal{E} = -N\frac{d\Phi_B}{dt}$$

where N is the number of turns of wire in the loop, and Φ_B is the magnetic flux through the loop.

5. A circular loop of wire of radius 15cm is in the plane of the white board. There is a magnetic field of 5mT in the region. Over 4s, the field changes uniformly from 5mT out of the board to 5mT into the board. What is the emf induced in the loop? What direction will the induced current be?

6. A circular loop of wire of radius 15cm is in the plane of the white board. There is a magnetic field of 5mT into the board in the region. Over 4s, the radius of the loop changes uniformly from 15cm to 5cm. What is the emf induced in the loop? What direction will the induced current be?

7. A loop of wire of area A is in the xy-plane. There is a magnetic field, $\vec{B} = B_0 e^{-at}\hat{z}$ in the region. Find the emf induced in the loop (as a function of a, A, B_0, and t.)

8. A long straight wire carrying a current I straight up as shown, is next to a rectangular loop of wire that is a distance c from the wire. The loop has dimensions $a \times b$ as shown. If the current (in the long straight wire) varies over time such that $I = I_0 \sin \omega t$, find the induced emf in the rectangular loop (in terms of a, b, c, I_0, ω and any physical constants.) Hint: I found the flux for this one in class–you must do the integral for this one!