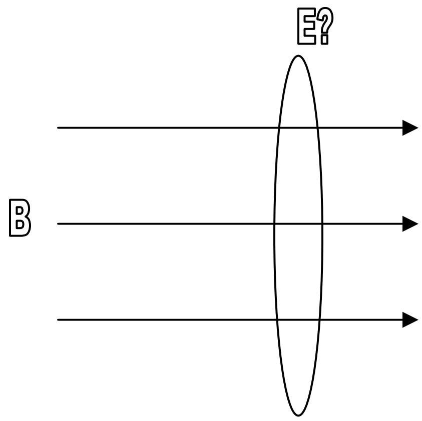
Ben Sauerwine
Recitation Notes May 2

Faraday's Law: Gives electric fields from changing magnetic fields.

Typically, we work with a circular surface with a central or uniform magnetic field. In this way, we take:

$$emf = \oint_{path} \vec{E} \cdot d\vec{l} = -\frac{d}{dt} \oint_{surface} \vec{B} \cdot \hat{n}$$

Suppose, for example, I have a circular disk with some magnetic field going through the center in a circularly symmetric fashion,




$$IR = V = 2\pi r E = -\frac{d}{dt} \oint_{surface} \vec{B} \cdot \hat{n}$$

22.3) The magnetic field produced by the outer loop is at the center, approximately:

$$B_{loop}(z,t) = \frac{\mu_0}{4\pi} \frac{2\pi R^2 I(t)}{\left(z^2 + R^2\right)^{\frac{3}{2}}} = \frac{\mu_0}{2R} I(t)$$

$$B_{loop}(0, t = 3) = \frac{\mu_0}{2(.5)} I(3) = \frac{\mu_0}{2(.5)} 3$$

$$B_{loop}(0, t = 3.2) = \frac{\mu_0}{2(.5)} I(3.2) = \frac{\mu_0}{2(.5)} (-5)$$

$$-\frac{d\Phi}{dt} \approx -A \frac{dB}{dt} = -\left(\pi (0.005)^2\right) \frac{\frac{\mu_0}{2(.5)}(-5-3)}{3.2-3} = 4 \frac{\mu_0}{R} \frac{\pi (0.005)^2}{0.2}$$

$$V = 2\pi (0.005) E = 4 \frac{\mu_0}{(.5)} \frac{\pi (0.005)^2}{0.2} \quad E = 4 \frac{\mu_0}{2\pi} \frac{\pi (0.005)^2}{(.5)(0.2)(0.005)}$$

The current from the outer loop goes from clockwise to counterclockwise, so its field goes from into the page to out of the page. Thus, the electric field will move to try to produce a field that would oppose this change. If the current in the inner loop increased in the clockwise direction, then, then, it would produce an opposing flux out of the page as desired, and so the electric field in the inner loop points clockwise.

Using V = IR, then, the magnitude and direction of the average current will be

$$IR = V = 2\pi(0.005)E = 4\frac{\mu_0}{(.5)}\frac{\pi(0.005)^2}{0.2}$$

$$I = \frac{V}{5} = \frac{2\pi(0.005)E}{5} = 4\frac{\mu_0}{5(.5)}\frac{\pi(0.005)^2}{0.2}$$

22.10) Suppose a North magnetic monopole passed through a loop of wire. The magnetic flux would increase in the direction of the monopole's velocity as it approached, peak and discontinuously switch signs at the center (manifesting itself as a very sudden and dramatic change in flux), and then the flux would continue increasing in the direction of the monopole velocity as the monopole continued off to infinity.

22.11) a) In the proton's circular orbit, it sees a magnetic field into the page. Thus, the force on a proton going counterclockwise is inward, which will provide centripetal acceleration.

b)

$$qvB = m\frac{v^2}{r}$$

$$\frac{qrB}{m} = v$$

$$B \approx B_{loop}(0) = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I(t)}{\left(z^2 + R^2\right)^{\frac{3}{2}}} = \frac{\mu_0}{2R}I_0$$

$$\frac{qr}{m}\frac{\mu_0}{2R}I_0 = v$$

c)

As one decreases the current slowly, I see that in order to oppose a net outward change of flux the electric field inside will try to create an inward flux to oppose it. Thus, the electric field will be in the clockwise direction.

d)

Since the proton is going counterclockwise and the electric field is going clockwise, the proton will slow down.