WEEK 11: Go to class 21, 22

Homework assignments

CLASS 21:

EXAM III

CLASS 22:

LENZ' LAW: ("Nature abhors a change in [magnetic] flux.")

Now what's the direction of this Emf? It turns out there's a simple way to remember how to figure out the direction. As the textbook's author eloquently states, "Nature abhors a change in [magnetic] flux.". What this means is that the Emf that is generated by changing flux will try to keep the flux from changing. I like to think of it as a 'reactionary' force. Like most reactionary forces, it is unsuccessful in the long run, but that doesn't keep it from trying. The induced Emf produces a current in the loop which creates a magnetic field which tries to keep the flux from changing. What does this mean for you practically? It means you have to keep that right hand ready in order to figure out the direction of the induced Emf. But work backwards. Figure out which way the induced magnetic field would have to point to maintain the flux, then figure out the direction that current would have to flow to produce that magnetic field, then figure out what kind of Emf would produce that current. Easy as that.

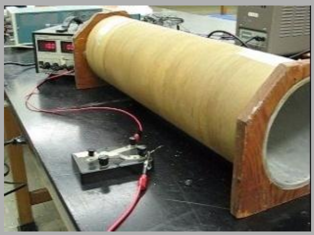
A couple of video examples of Lenz' Law in action:

Magnetic damping
http://www.youtube.com/watch?v=d8l6gAnhykU

Floating superconductor
http://www.youtube.com/watch?v=rE-N4u-itsQ

INDUCTANCE: $L = \Phi / I$, $E = -L\dfrac{dI}{dt} = -L\dot{I}$

The book talks about two types of electromagnetic inductance: mutual inductance and self-inductance. We will focus on self-inductance. This is the physical phenomenon that takes place in those electrical components called inductors with which you may have played in the lab. Consider a solenoid. If you run current through it, it produces a magnetic field perpendicular to the plane of the coils. This produces a flux through the coils, and therefore the solenoid does not like you changing the current through it, because that will change the magnetic flux through the coils. This means that changing the current induces an Emf in the solenoid, in a direction which tries to keep the current from changing. (Any device in which the coils that have flux in them are the same ones that produce the magnetic field is such a 'self-inductor', known more familiarly as an 'inductor'.)



Emf induced in an inductor
http://www.youtube.com/watch?v=qF2LqeYZnSE

ENERGY IN MAGNETIC FIELDS: $U = \frac{1}{2}LI^2$, $u = \dfrac{1}{2}\dfrac{B^2}{\mu_0}$ (Compare to $U = \dfrac{1}{2}\dfrac{Q^2}{C}$ and $u = \frac{1}{2}\varepsilon_0 E^2$.)

Remember how energy is stored in electric fields? Time for another electrostatic-magnetostatic analogy. If I turn off the current in the solenoid, this induces an Emf. Where does the energy come from to cause this Emf, and to temporarily power the current to continue to flow? We can think of it as stored in the magnetic field. Just as, if we have a charge stored in a capacitor, we can short out the capacitor and get current to flow. Where did that energy come from? From either the stored energy of the charge, or the stored energy of the electric field within the plates. (Either point of view is equivalent.) So the energy density in electric field is proportional to E^2, and the energy density in a magnetic field is proportional to B^2. The energy stored in a capacitor goes as Q^2, and the energy stored in an inductor goes as I^2

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