FREQUENTLY ASKED QUESTIONS

April 10, 2003

Content Questions

Could we see some examples of Biot-Savart Law problems with integrals?

I probably won't do any of these in recitation, in favor of problems more like ones you will get on exams. But I did put some worked out examples on the handouts page: see problems 36 and 37.

What are the two right hand rules and when do you use them?

One RHR tells you how to relate force, velocity and magnetic field for a charged particle moving in a magnetic field. The other RHR tells you how to relate magnetic field and current.

How did the tutorial we did today relate to Faraday's Law and the relation between induced EMF and change in flux? How did the equations we saw at the beginning of class relate to the problems?

In R01 we didn't quite get far enough in the tutorial to the place where Faraday's Law (which relates change in flux to induced EMF) is applied: please see the rest of the tutorial. The first part of the tutorial basically just tried to show how you can get an induced current (and its direction) by thinking directly about magnetic forces on charged particles in a loop. But you could also think of this in terms of Faraday's Law as: since flux through the loop changes, EMF (and hence current) is created. We did cover some Lenz's Law ideas in the first part of the tutorial, i.e. that induced current is such that it opposes the motion (we showed this explicitly for the case of a loop moving in a non-uniform magnetic field). In the next pages of the tutorial, some EMFs are calculated using Faraday's Law. We'll see some examples next recitation.

What exactly is Lenz' Law?

Lenz's Law tells you about the *sign* of EMFs induced by a changing magnetic field. The induced EMF (or current) in a loop is in such a direction that it *opposes* the change in flux through the loop. *"Loops hate change"*: the induced EMF or current is in such a way that it creates an induced field to oppose the change.

What exactly is an "area vector"?

It's just a vector associated with an area that has magnitude equal to the area, and direction normal to the area. It's useful in the definition of a flux: $\Phi = \vec{B} \cdot \vec{A}$.

In today's tutorial, how did you get the direction of B_{ind} at the top and bottom of the loop?

The B field at the top and bottom of the loop was not an induced field – it was the *external* field from the solenoid. The direction was shown in the picture: it radiates out from the end of the solenoid. The induced field, on the other hand, was perpendicular to the loop, with direction given by the RHR with the induced current.

In today's tutorial, where did the little bar magnets come from to find if the loop was attracted or repelled?

A magnetic dipole field – one with field lines pointing away from one end and getting sucked back in on the opposite end – is equivalent to a bar magnet. By convention, magnetic field lines point away from the north pole. The solenoid produces a dipole field so it's equivalent to a bar magnet. The loop with current through it also produces a dipole field, so it's equivalent to a bar magnet too. Depending on whether the loop was being pushed towards or away from the solenoid, the orientation of the equivalent magnets was repulsive or attractive.

In today's tutorial, how does a loop of current cause a change in B_{ind}? Does I change to compensate?

Current produces a B field according to Biot-Savart. For a simple loop the field is perpendicular to the loop axis (see example 28-10 in your text.) In this tutorial example, several things happen: the loop moves towards (or away from) the solenoid. This movement causes magnetic forces on the charges in the wire, which induces a current in the loop (as we worked out explicitly in the tutorial; you can also think of this in terms of Faraday's Law: the flux through the loop changes, so a current is induced). Then, the induced current in the loop causes an induced magnetic dipole in the loop. This magnetic field either increases or decreases the external flux, in whichever direction such that it opposes the change. The current I does change according to the rate of change of flux (but in this example we were just concerned with directions and qualitative behavior).

In today's tutorial, could you clarify part C?

I hope the tutorial solution will clarify a bit. The idea here is to show that both the field and flux due to the induced current in the loop *need not oppose the external field's flux.* Rather, they oppose the **change** in flux. This is important! The induced current opposes the **change** in flux, not the flux itself. Let me say it one more time. The induced current opposes the **change** in flux, not the flux itself.

In today's tutorial, what would be the force on a charged particle on the sides rather than the top or bottom? Would the magnetic field and velocity be parallel so zero force?

If the flux lines at the lines were really perpendicular to the loop, there would be zero force. However, for a solenoid, the flux lines are actually flaring out from the end of the solenoid in 3 dimensions. So at the side of the loop, $\vec{v}$ is to the right (say), but $\vec{B}$ is coming out of the page (or in, depending on which side). So $\vec{v} \times \vec{B}$ is up (or down). If you work it out, you will see that this contributes to the current going around the loop.

How does the induced magnetic field try to reduce the magnetic flux?

The induced current makes a field that either adds to the external flux by being in the same direction (for the case where the flux is decreasing), or else it subtracts from the external flux by being in the opposite direction (for the case where the flux is increasing.

How can induced flux be related to change in external flux?

Induced flux is produced by induced current, and induced current is related to rate of change of external flux according to Faraday's Law, $\varepsilon_{\text{ind}} = -d\Phi_B/dt$.

In the last Biot-Savart problem on CyberTutor, where does the $d\vec{l}$ go? What happens to it in the final answer?

I think $d\vec{l}$ should be in the final answer. In fact, units aren't even correct in the given answer. The formula given for $\vec{B}$ is in terms of an infinitesimal length $d\vec{l}$, so the LHS should be an infinitesimal contribution $d\vec{B}$. Please make comments to the CyberTutor people so they can fix this.

In experiment MF, the μ_0 we came up with is the right number, but the wrong order of magnitude. Should we worry about that?

Yes, you should worry– you should get the right order of magnitude. Make sure to check your units, and that you're working in a consistent system of units (cgs or mks).

Can you cover some of the demos?

Yes, but please tell me which ones! There are a lot of them and I can't cover them all. If you describe which ones you're confused about, I can try to explain.

Tidbits

Here is a Lenz's Law animated demo:
`http://micro.magnet.fsu.edu/electromag/java/lenzlaw/`