Recitation Notes-April 25,2006
Ben Sauerwine

Sorry, I forgot to assign groups to do chapter reviews before the test on Tuesday! Here are what I consider the important points from each section.

Hall Effect:

When mobile charge carriers travel through a conductor with a magnetic field perpendicular to their direction of travel, they will be pushed according to the Lorentz force $\vec{F} = q\vec{v} \times \vec{B}$. Interestingly, the charge carrier will always be pushed in the same direction with the same applied voltage. For example:

A 5 volt battery pushes electrons from left to right, with a field coming out of the page. $\vec{F} = q\vec{v} \times \vec{B} \to -q(-\vec{v}) \times \vec{B}$. Alternatively, it could push "holes" from right to left, with a force $\vec{F} = q\vec{v} \times \vec{B} \to +q(+\vec{v}) \times \vec{B}$. Note that the signs cancel, and the force is thus the same! In this way, the Hall effect can tell us something about the nature of our conductor.

Do not remember the Hall Effect formula.

Voltmeters:

The loop and node rule were covered on the last test, but might appear again on this test. Please make sure you're familiar with them!

The easiest way to deal with a voltmeter is to treat it as a partial loop!

Start at the negative terminal, and then follow a path through the circuit **(Any path will do! It may loop back on itself, cross its own path or go in any direction you want! Potential is path-independent!)** At each point of interest in the circuit, you will then use your appropriate loop rule formula to find the voltage contribution of this piece. For example:

> Batteries: Add its voltage when you go from – to + terminal, subtract voltage when you go from + to -.
> Resistors: Subtract IR when you go in the direction of the current, add IR when you are going against the direction of the current.
> Capacitors: Same as a battery!

When you reach the positive terminal of your voltmeter, your total is your answer!

Capacitors:

In steady state, they have charged to the voltage applied on them. In the meantime, their voltage will read (assuming a constant DC voltage is applied to them):

$V = IR$

$$V_{battery} - \frac{q}{C} = \frac{dq}{dt} R$$

$$q(t) = c_1 e^{-\frac{t}{RC}} \quad \text{hom}\, ogeneous$$

$$q(t) = CV_{battery}\left(1 - e^{-\frac{t}{RC}}\right) \quad particular$$

What has happened here? I looked up the solution assuming that the voltage of the battery dropped out on the back of the test. Then, I realized that to start discharged and then charge to the desired point, I needed to add an overall constant. This is, pathetically, the general procedure for solving differential equations.

Lorentz Force:

Remember, magnetic field never does any work. It only redirects other work done by another force. That being said, the force due to the magnetic field is $\vec{F} = q\vec{v} \times \vec{B}$. You will be able to look up the magnetic field due to a moving point charge or a wire on the back sheet of the test, as well as this formula.

Dr. Swendsen's favorite application of this is in a moving bar that has a current in it. Here, if the current is perpendicular to the field, you may take $\begin{matrix} \vec{F} = \int Id\vec{l} \times \vec{B} \\ F = ILB \end{matrix}$ with an appropriate direction orthogonal to both (use the right hand rule) Your right thumb is the first part of the cross product, your right index finger is the second part, your palm is the direction the result points.

Now he says that the bar is moving at a constant velocity. This means that some applied force exactly cancels the force $F = ILB$. He usually gives the loop some resistance, so that you may also write $P = IV = I^2 R$. Now you may also use $\begin{matrix} Fdx = dW \\ F\frac{dx}{dt} = \frac{dW}{dt} \\ Fv = P = I^2 R \end{matrix}$. Now you have a relationship between power and current, velocity, force and power, between current and force, and you have some applied force formula. He typically asks you to solve for current, and to do this you take your $F_{applied} v = I^2 R$. With this, then you have a bridge into whatever variables you like.

Remember: If $\vec{v} \parallel \vec{B}$, (they're parallel), the cross product is zero and this force doesn't contribute.

Gauss's Law:

Simply, $\oint \vec{E} \cdot \hat{n} dS = \frac{\rho}{\varepsilon_0}$. What does this mean? Over the entire surface, if you sum the amount of electric field leaving the surface (e.g., the dot product with the surface normal) over the surface area e.g., dS, you'll get the amount of charge inside.

For the purposes of this class, you can expect that in all cases either the electric field will be uniform over the entire surface or it will somehow cancel with another surface or be driven out to infinity to give zero.

If a surface and field are given, then, you can take two routes to determine the amount of charge inside the surface: you can either add this integral for each surface (remember, $\hat{n}$ points out. For a flat surface with surface area A in a uniform electric field, over this subsurface, $\int_{subsurface} \vec{E} \cdot \hat{n} dS = A\vec{E} \cdot \hat{n}$, and the entire integral is the sum of this integral for all subsurfaces.

The other route you can take with Gauss's Law is to quickly determine the electric field of a distribution: if you have a symmetric distribution, you can expect the electric field from this distribution to be uniform across the symmetric surface. Typically, the surface normal of this is exactly in the direction of your electric field. Based on this, then, for a surface with electric field uniform and normal to the surface all about, $EA = \frac{\rho}{\varepsilon_0}$, where ρ is the total symmetric charge inside. In some cases, such as some of your homework problems, ρ is a function of the geometry of your Gaussian surface and A certainly is (typically, each is a function of r, be it the radius of a sphere or a cylinder). Based on this, you can find electric field strength as a function of radius.