Lecture 23 Shadowitz 11.1

The learning objectives for exam 3 are that you will be able to:
-memorize Stokes theorem
-memorize Divergence theorem
-memorize differential and integral forms of conservation of charge
-understand Ohm's law and why the relaxation method can be used to determine the current density.
-know how to calculate the vector potential given a current distribution
-understand how to calculate the work required to assemble a current distribution in the many ways we discussed.
-be able to calculate the Faraday E due to a changing B using the integral form of Faraday's law.

You will be given in the exam the triangle diagrams and formulas related to energy in a charge distribution. This is posted on the wiki.

Homeorks will be outside my door.

Ask questions about this rubric based on
-incongruous
-congruous
-modifying
-analogy
-causal/creative
-informational

InkSurvey questions:

-(informational) When do I use which new eqns? Is there a practice exam?

Apart from the memorization questions don't expect a plug and chug exam since you are given eqns. Try to understand where the fundamental equations are used. Look at the lecture notes and hmwk solns.

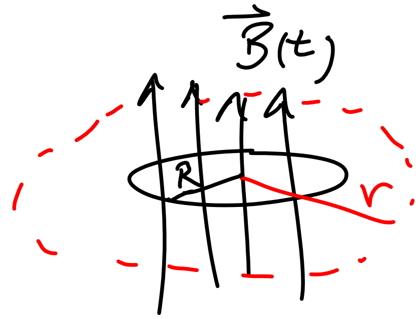
-(congruous) How do I calculate E(r) if E goes in a circle?

$$\oint \vec{E}\cdot d\vec{r} = \oint |\vec{E}||d\vec{r}|\cos 0$$

(const)

$$= |\vec{E}| \oint |d\vec{r}| = E\,2\pi r$$

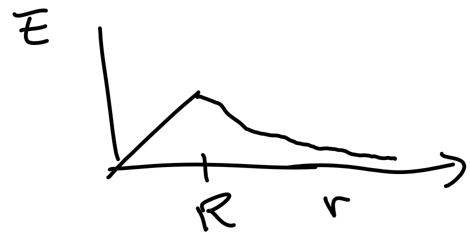
$$= -\frac{d\Phi_m}{dt} = -\frac{dB}{dt}\pi R^2$$



$$E\,2\pi r = -\frac{d}{dt}\int \vec{B}\cdot d\vec{a}$$

$$= -\frac{d}{dt} B\,\pi r^2$$

$$E \propto \frac{1}{r}$$



-(infomational) When do you use $\vec{A} = \frac{\mu_0}{4\pi}\int \frac{\vec{J}\,d\tau}{r}$ & $\nabla\times\vec{A} = \vec{B}$ to find $\vec{A}$?

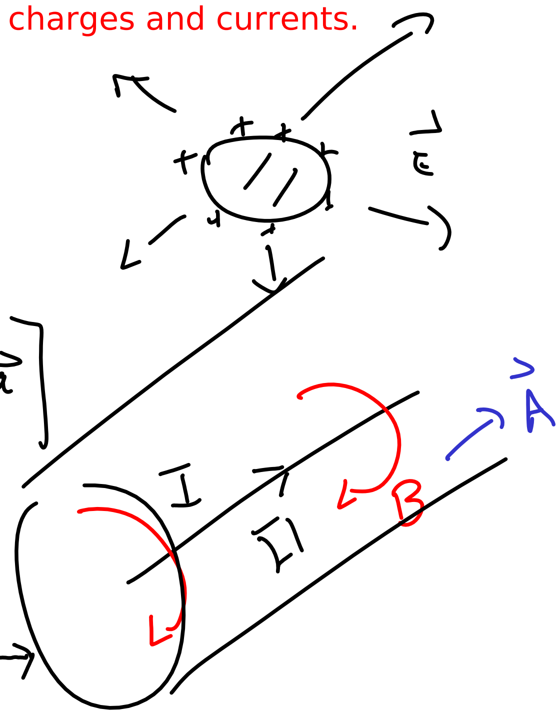
If you are given $\vec{J}$, $\vec{K}$, or I in a finite region then

If you know $\vec{B}$ then set up ODE or PDE from

Questions

-(analogy) Compare work required to assemble charges and currents.

$$W = \frac{\epsilon_0}{2}\left[\int E^2\,d\tau + \oint V\,\vec{E}\cdot d\vec{a}\right]$$



$$W = \frac{1}{2\mu_0}\left[\int B^2\,d\tau - \oint(\vec{A}\times\vec{B})\cdot d\vec{a}\right]$$

vol within   surface

-(informational) What does magnetic energy mean?

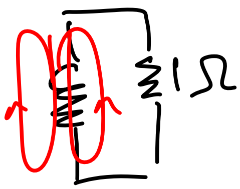
$KE = \frac{1}{2} m v^2$ → energy stored in a cap or inductor

$C = 1$ Farad $\quad L = 1$ Henry

$V = 100V \quad I = 100$ Amps

$\frac{1}{2} C V^2$

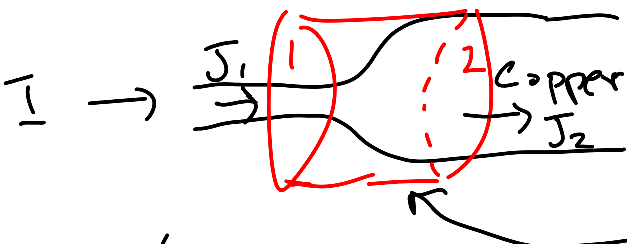
$\frac{1}{2} L I^2$



$I^2 R = 10^4$

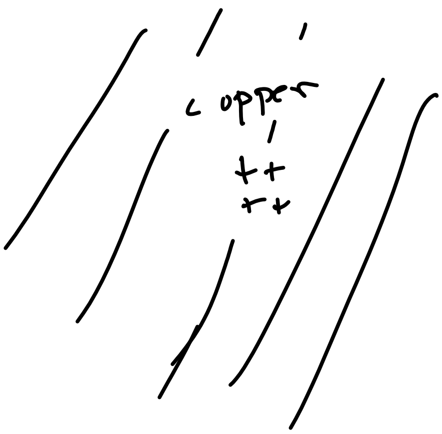
Huge thermal loss in storing car's KE in B of the inductor but little in cap.

(informational) What is conservation of charge used for?



$\vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t} = 0 \quad \vec{J} = \rho \vec{v}$

$\oint \vec{J} \cdot d\vec{a} = 0 \quad J_1 A_1 - J_2 A_2 = 0$



$\vec{J} = \sigma \vec{E} \quad \vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t} = \sigma \underbrace{\vec{\nabla} \cdot \vec{E}}_{\rho/\epsilon_0}$

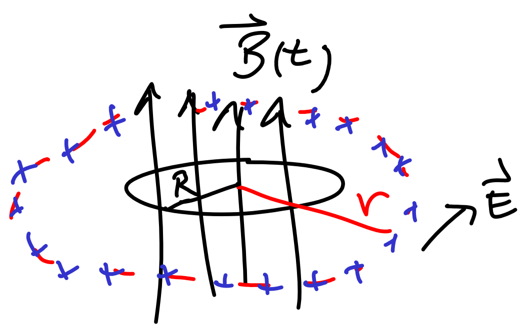
$\sigma \frac{\rho}{\epsilon_0} = -\frac{\partial \rho}{\partial t}$

$\rho = \rho_0 e^{-\frac{\sigma}{\epsilon_0} t}$

↖ zero everywhere except initial space

http://en.wikipedia.org/wiki/Poynting%27s_theorem

-(informational) Hmwk problem 2.



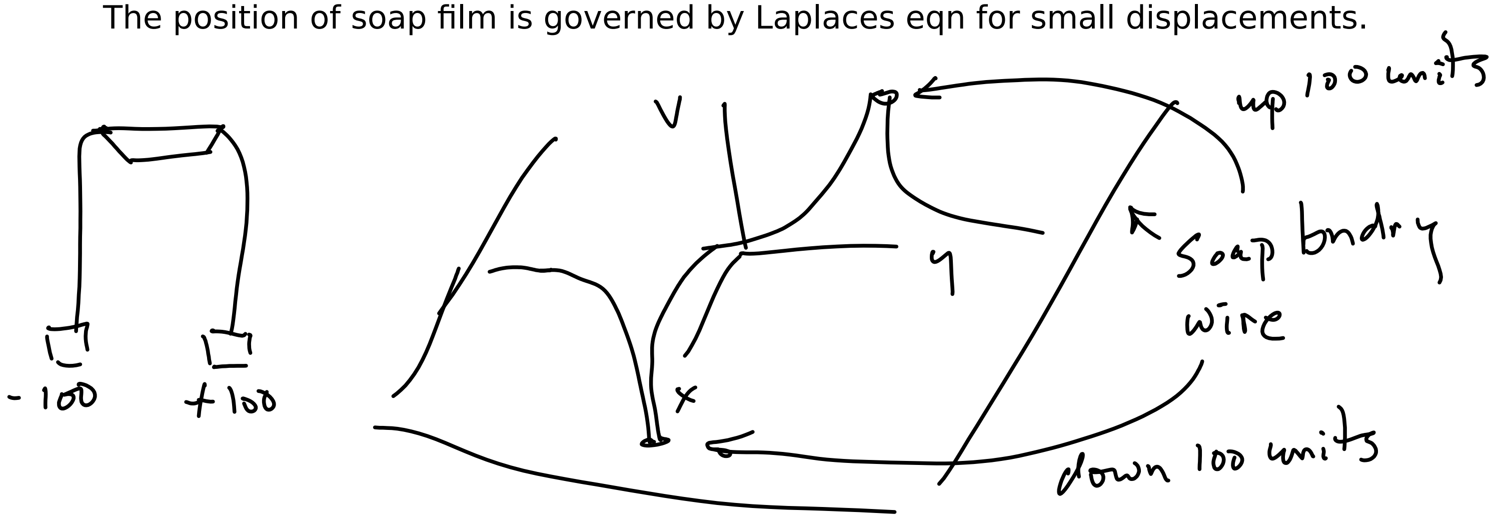
$$d\vec{F} = dq\,\vec{E}, \qquad dq = \lambda r\,d\theta$$

$$\text{torque} = \vec{r}\times\vec{F} = \frac{d\vec{L}}{dt}, \qquad \vec{F} \leftarrow \frac{dB}{dt}$$

How can the wheel have zero ang. mom. and then some after B is turned off.
The EM field must contain ang. mom. or we must throw away conservation of ang. mom.

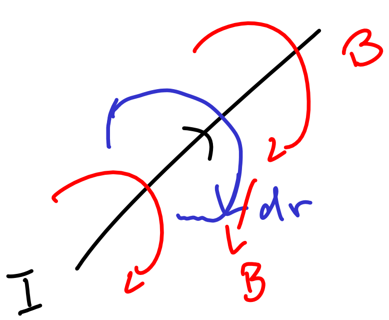
-(informational) Any way to solve Laplace's eqn without a computer?

The position of soap film is governed by Laplaces eqn for small displacements.



-(congruous) What path to choose in applying integral forms of ME's.

You first need to determine the direction of the vector then choose the surface parallel or perpendicular to that vector to for line integrals the path perpendicular or parallel to that vector.



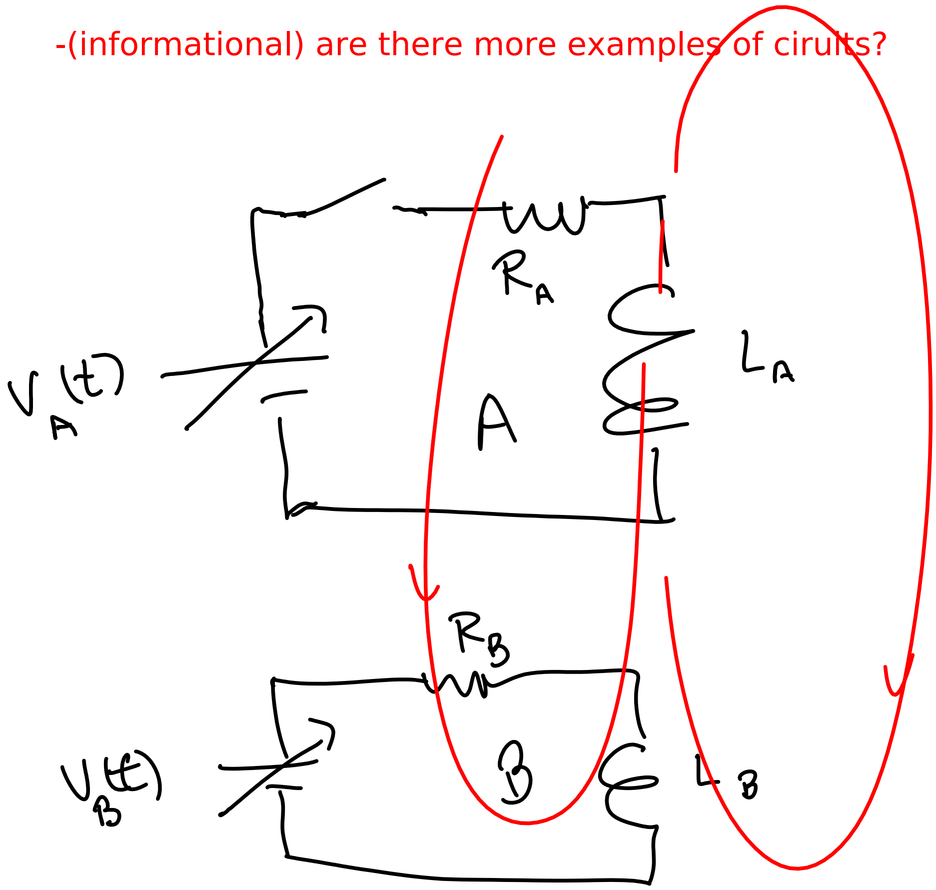
$$\oint \vec{B}\cdot d\vec{r} = \oint |\vec{B}|\,|d\vec{r}|\cos 0 = B\underbrace{\oint dr}_{2\pi r}$$

Ampere's law always works it just isn't easy to calculate for other paths.

-(analogy) Is there a field generated when the acceleration of gravity changes?

Yes, the changing mass current density generates a analog to B and when this change with time it generates a g.

-(informational) are there more examples of cirults?



$$V_A - I_A R_A - L_A \frac{dI_A}{dt} - M \frac{dI_B}{dt} = 0$$

$$V_B - I_B R_B - L_B \frac{dI_B}{dt} - M \frac{dI_A}{dt} = 0$$

I_A & I_B are total currents in each circuit

Perturbation theory

$$\frac{V_A}{R_A} - \frac{I_A R_A}{R_A} - \frac{L_A}{R_A}\frac{dI_A}{dt} - \frac{M}{R_A}\frac{dI_B}{dt} = 0$$

ϵ a small # compared with other coeffs

$$\frac{V_B}{R_B} - \frac{I_B R_B}{R_B} - \frac{L_B}{R_B}\frac{dI_B}{dt} - \frac{M}{R_B}\frac{dI_A}{dt} = 0$$

$$I_A = i_{0A} + \epsilon i_{1A} + \epsilon^2 i_{2A} + \dots$$

$$I_B = i_{0B} + \epsilon i_{1B} + \epsilon^2 i_{2B} + \dots$$

Plug these into the two ODE's and write an ODE of each power of ϵ

-(informational) I often don't understand exactly what you mean in hmwk questions.

In the real world there will be many ambiguous issues you have to address. How are you going to deal with that? email me to get clarification.