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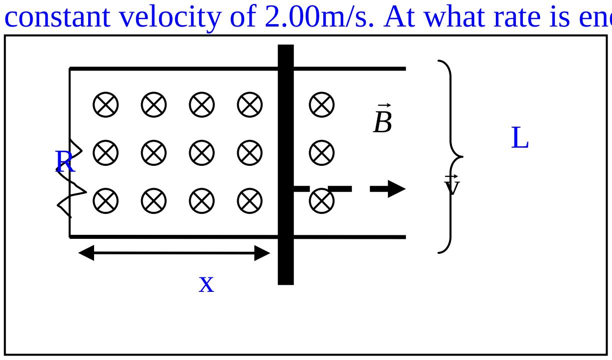
Midterm 3 physics 230, chapters 29-33 December 3, 2009

NOTE: TO ENSURE FULL CREDIT EMPHASIZE YOUR ANSWERS AND **INCLUDE DIMENSIONS**. SPECIFY WHICH PRINCIPLES OR LAWS YOU ARE USING. EXPLAIN BRIEFLY WHAT YOU ARE TRYING TO DO. ORGANIZE YOUR WORK LOGICALLY. USE DRAWINGS! Use the correct number of significant figures. **USE scientific notation for numbers larger than 1000 and smaller than 1/1000. Unless otherwise specified, do not use more than 3 significant figures.**

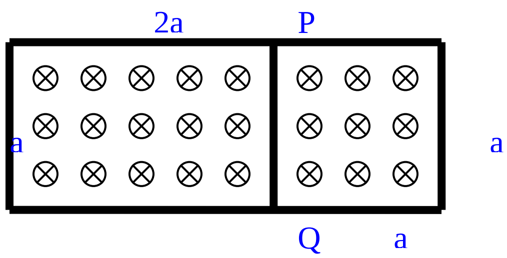
1. [10] The picture below shows a bar that can slide on two frictionless rails. The resistor is 6.00Ohms, and a 2.50T magnetic field is directed perpendicularly into the plane. Let L=1.20 m. Calculate the applied force necessary to move the bar to the right with a constant velocity of 2.00m/s. At what rate is energy delivered to the resistor?



2. [10] State Ampere's law in its differential and integral form and use it to calculate the magnetic field inside a toroid with 500 turns in a rectangular shape. The inner radius of the toroid is 3.00cm and the outer radius is 7.00cm. Find the magnetic field at a distance from the center of 2.00 cm, 5.00cm, and 8.00cm at a distance r from the center.The current in the toroid is 10.0A. Make a drawing and show the current and the magnetic field. Show the surface which you use to apply Ampere's law.

3. [10] Use the law of Biot-Savart $d\vec{B} = \frac{\mu_0}{4\pi}\frac{d\vec{s} \times \vec{r}}{r^3}$ to calculate the magnetic field created by an electron in Bohr's model of an atom, at the center of the atom. The radius of the circular path is 0.529E-10m, and the speed of the electron is 2.19E6m/s. **Make a drawing and show the directions of all vectors.** Explain why certain components of the magnetic field do not contribute to your result. Show your line integral and the value of ds. What is the angle between $d\vec{s}$ *and* $\vec{r}$.

4. [10] In the figure below find the current in the branch PQ of the circuit.



The circuit is a rectangle of sides 3a and a as indicated, a=65.0cm. It is located in a magnetic field $B(t)=\left(1.00E-3T/s\right)\cdot t$ The resistance per length of wire is 0.100 Ohms/m.Hint, insert resistors into the branches, and emf's, then apply Kirchhoff's rules.

5. [10] In a certain region of space we have a uniform magnetic field, which varies with time like $B = B_0 \sin \omega t$ B_0=2.50μT and the frequency is 60.0Hz. Find the electric field induced by this magnetic field in a loop of wire of radius r=6.50cm.Make a drawing and show the magetic field as well as the electric field directions. Use Faraday's law in its form $curl\vec{E} = -\frac{\partial \vec{B}}{\partial t}$ Explain how you proceed from there.

6. [10] An LC-circuit consists of a 20 mH inductor and a 0.500 μF capacitor. If the maximum instantaneous current is 0.100 A, what is the greatest potential difference across the capacitor?

7. [10] The rotating loop in an ac generator is a square 10.0cm on the side. It is rotated at 60.0Hz in a uniform field of 0.800T. a) Calculate the flux through the loop as a function of time, and the emf induced in the loop.

8. [10] An LC circuit contains an 82.0mH inductor and a 25μF capacitor that initially carries a 220 μC charge. The switch is originally open for t<0 and then closed at t=0.Write down the differential equation for this resulting freely oscillationg circuit. From your knowledge about harmonic oscillations find the solution for the oscillating charge. What is the angular frequency of the oscillation?

9. [10] Electric power is being transmitted at the rate of 5.00MW over a distance of 500km. The resistance per unit length in the powerlines is 4.50E-4Ohm/m. The generator produces a voltage of 4.50kV. To which voltage does a step up transformer have to increase the voltage such that the power loss in the line would only be 0.800%.

10. [10]

Explain why the equations $\vec{E} = -\overrightarrow{grad} \cdot V$ and $curl\vec{E} = -\frac{\partial \vec{B}}{\partial t}$ are in general incompatible.

Formulas:

$$div\vec{E} = \frac{\rho}{\varepsilon_0}; \vec{F}_B = q\vec{v} \times \vec{B}$$

$$d\vec{F}_B = I\left(d\vec{s} \times \vec{B}\right)$$

$\vec{\mu} = I\vec{A} =$ magnetic dipole moment

$$U_B = -\vec{\mu} \cdot \vec{B}; \vec{\tau}_B = \vec{\mu} \times \vec{B}$$

$$curl\vec{B} = \mu_0 \vec{j}$$

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{s} \times \vec{r}}{r^3} = \frac{\mu_0 I}{4\pi} \frac{d\vec{s} \times \vec{u}_r}{r^2}; \frac{\mu_0}{4\pi} = 10^{-7}$$

$$curl\vec{B} = \mu_0 \left(\vec{j} + \underbrace{\varepsilon_0 \frac{\partial \vec{E}}{\partial t}}_{\vec{j}_d} \right)$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \quad \varepsilon = -N \frac{d\Phi_B}{dt} \quad \varepsilon = -\frac{d}{dt}\left(\vec{B} \cdot \vec{A}\right) = -\frac{d}{dt}\left(BA\cos\theta\right) = -\frac{d}{dt}\left(BA\cos\omega t\right) = BA\omega \sin\omega t$$

$$\varepsilon_L = -N\frac{d\Phi_B}{dt} = -L\frac{dI}{dt}$$

$$L = \frac{N\Phi_B}{I}$$

$$U_B = \frac{1}{2}LI^2$$

$$u_E = \frac{1}{2}\varepsilon_0 E^2; u_B = \frac{B^2}{2\mu_0}$$

$$\hat{I}(t) = \frac{\hat{V}(t)}{\hat{z}_{eq}}; I_{rms} = \frac{I_{\max}}{\sqrt{2}}; V_{rms} = \frac{V_{\max}}{\sqrt{2}}$$

$$\hat{Z}_L = i\omega L \Rightarrow \hat{I}(t) = \frac{\hat{V}(t)}{i\omega L}; I_{\max} = \frac{V_{\max}}{\omega L}$$

$$\hat{Z}_C = \frac{1}{i\omega C} \Rightarrow \hat{I}(t) = i\omega C\hat{V}(t); I_{\max} = \omega C V_{\max}$$

$$P = \hat{V}_{rms}\hat{I}_{rms}\cos\Phi$$