NAME:

POINTS:

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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] A flat copper ribbon 0.330mm thick carries a steady current of 50.0A and is located in a uniform 1.30T magnetic field directed perpendicularly to the plane of the ribbon. If a Hall voltage of 9.60 μV is measured across the ribbon, what is the charge density of the free electrons? Make a drawing and indicate the directions of the current, the magnetic field, the electric field, and the forces on the electrons.
   $n=12.8E28/m^3$

2. [10] A conductor in the shape of a circular loop with radius R=0.200m carries a current of 10.0A. Using the law of Biot-Savart, calculate the magnetic field at the center of the loop. Make a drawing with the loop, the direction of the current and the direction of the magnetic field. 3.96E-4 T

3. [10] State Ampere's law and calculate the magnetic field around a very long straight wire at a distance r from this wire. Make a drawing and show the current and the magnetic field. Show the surface and its boundary which you use to apply Ampere's law.

$B=\mu_0 I/2\pi r$

4. [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 magnetic 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.

E=-30.6 µT cos(377t)

5. [10] A conducting wire of radius 5.00mm carries a current of 20.0A. Use Ampere's law to calculate the magnetic field created inside of the wire and outside of it. Make a drawing and show the magnetic field with directions. Start with Ampere's law in the form of $curl\vec{B} = \mu_0 \vec{j}$. Explain how you proceed from there. State Stokes law.

   $a) r < R; B = \frac{\mu_0 I r}{2\pi R^2}; b) r > R; B = \frac{\mu_0 I}{2\pi r}$

6. [10] In an LR circuit: R=50.0Ω, L=0.900H in series; applied maximum voltage=100V, ω=200/s. Find the complex impedance, the complex current , its maximum and phase shift. Find the average power-loss. $\hat{Z}_{eq} = 187e^{i1.30}\Omega; \hat{I} = 0.535e^{i(\omega t-1.30)}A; \overline{P} = 6.70W$

7. [10] A 10.0 mH inductor carries a current $I = I_{\max} \sin \omega t$ with I_{max}=5.00A and a frequency of 100Hz. Calculate the back emf as a function of time. $\varepsilon = -L\frac{dI}{dt} = -31.4V\cos(100t)$

8. You are dealing with the following RC-circuit:
   $R = 150\Omega; \omega = 150/s; \varepsilon_{\max} = 310V; C = 25\mu F$

   a) Find the complex impedance and complex current of the circuit. Write your results in terms of the magnitude and the exponential value.
   $\hat{Z}_{eq} = 272\Omega e^{-i0.987}; \Phi = -56.7° = -0.987; \hat{I} = 0.552Ae^{i(\omega t+0.987)}$

   b) Find the maximum voltage across the capacitor.
   $125V$

   c)

9. [10] Prove and explain why the average power loss in an ac circuit is given by $P = I_{rms} V_{rms} \cos\Phi$

10. A transmission line that has a resistance per unit length of $4.50 \cdot 10^{-4} \frac{\Omega}{m}$ is to be used to transmit 5.00MW over 400 miles. The output voltage of the generator is 4.50kV.
a) What is the line loss if a transformer is used to step up the voltage to 500kV?
b) What fraction of the input power is lost to the line under these circumstances?
c) What difficulties would be encountered in attempting to transmit the 5MW at the generator voltage of 4.50kV?

(a) 29kW b)0.58% c) melt down.

Formulas:

(1.1)

$div\vec{E} = \frac{\rho}{\varepsilon_0}$;(1.2) $\vec{F}_B = q\vec{v} \times \vec{B}$

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

Field Code Changed

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

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

(1.6) $curl\vec{B} = \mu_0 \vec{j}$

(1.7) $dB = \frac{\mu_0 I}{4\pi} \frac{d\vec{s} \times \vec{r}}{r^3} = \frac{\mu_0 I}{4\pi} \frac{d\vec{s} \times \vec{u}_r}{r^2}$; Biot-Savart **;** $\frac{\mu_0}{4\pi} = 10^{-7}$

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

(1.9) Faraday's law $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ $\varepsilon = -N \frac{d\Phi_B}{dt}$

(1.10) $\varepsilon = -\frac{d}{dt}\left(\vec{B} \cdot \vec{A}\right) = -\frac{d}{dt}\left(BA\cos\theta\right) = -\frac{d}{dt}\left(BA\cos\omega t\right) = BA\omega \sin\omega t$

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

(1.12) $L = \frac{N\Phi_B}{I}$

(1.13) $U_B = \frac{1}{2}LI^2$ electromagnetic energy in an inductor

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

ac currents

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

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

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

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