PHYSICS 211
Final Spring 2008-2009
TIME: 120 minutes

June 2, 2009

DO NOT OPEN THIS EXAM BEFORE YOU ARE TOLD TO BEGIN

NAME____

ID Number ________________________

Useful information
$\varepsilon_0=8.85\text{x}10^{-12}\ C^2/N.m^2$
μ_0=4p x 10^{-7} Tm/A
$q = 1.6 \times 10^{-19}$ C
$m_e = 9.1\text{x}10^{-31}$ kg
$m_p = 1.67\times10^{-27}$ kg
$k_e=8.9875\text{x}10^9\ Nm^2/C^2$

Grading

A	
B	
TOTAL	

Part A: Multiple choice questions (22) each question is 2%

1. The average power input to a series alternating current circuit is minimum when

a. there are only a resistor and capacitor in the circuit.
b. there are only a resistor and inductor in the circuit.
c. there is only a resistor in the circuit.
d. $X_L = X_C$ and the circuit contains a resistor, an inductor and a capacitor.
e. there is only a capacitor in the circuit.

2. When a switch is closed to complete a DC series RL circuit,

a. the electric field in the wires increases to a maximum value.
b. the magnetic field outside the wires increases to a maximum value.
c. the rate of change of the electric and magnetic fields is greatest at the instant when the switch is closed.
d. all of the above are true.
e. only (a) and (c) above are true.

3. An induced emf is produced in

a. a closed loop of wire when it remains at rest in a nonuniform static magnetic field.
b. a closed loop of wire when it remains at rest in a uniform static magnetic field.
c. a closed loop of wire moving at constant velocity in a nonuniform static magnetic field.
d. all of the above.
e. only b and c above.

4. Gauss's Law states that the net electric flux, $\oint \mathbf{E} \cdot d\mathbf{A}$, through any closed surface is proportional to the charge enclosed: $\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q}{\varepsilon_0}$. The analogous formula for magnetic fields is:

a. $\oint \mathbf{B} \cdot d\mathbf{A} = 0$.

b. $\oint \mathbf{B} \cdot d\mathbf{A} = \frac{q_{\text{mag}}}{\varepsilon_0}$.

c. $\oint \mathbf{B} \cdot d\mathbf{A} = \frac{I}{\mu_0}$.

d. $\oint \mathbf{B} \cdot d\mathbf{A} = \frac{I}{\mu_0 \varepsilon_0}$.

e. $\oint \mathbf{B} \cdot d\mathbf{A} = -\frac{d\Phi}{dt}$.

5. One reason why we know that magnetic fields are not the same as electric fields is because the force exerted on a charge $+q$

a. is in opposite directions in electric and magnetic fields.
b. is in the same direction in electric and magnetic fields.
c. is parallel to a magnetic field and perpendicular to an electric field.
d. is parallel to an electric field and perpendicular to a magnetic field.
e. is zero in both if the charge is not moving.

6. The algebraic sum of the changes of potential around any closed circuit loop is

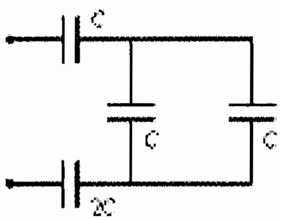
a. zero.
b. maximum.
c. zero only if there are no sources of emf in the loop.
d. maximum if there are no sources of emf in the loop.
e. equal to the sum of the currents in the branches of the loop.

7. A nichrome wire and an aluminum wire, each with the same initial resistance, have the same change in resistance when heated separately. ($\rho_{\text{Al}} = 2.82 \times 10^{-8}\ \Omega \cdot \text{m}$; $\alpha_{\text{Al}} = 3.9 \times 10^{-3}/°\text{C}$; $\rho_{\text{nichrome}} = 1.50 \times 10^{-6}\ \Omega \cdot \text{m}$; $\alpha_{\text{nichrome}} = 0.40 \times 10^{-3}/°\text{C}$.) The ratio of the temperature change of the nichrome wire to the temperature change of the aluminum wire is

a. 0.019.
b. 0.10.
c. 0.18.
d. 9.8.
e. 53.

Score:

8. Determine the equivalent capacitance of the combination shown when $C = 12$ pF.



a. 48 pF
b. 12 pF
c. 24 pF
d. 6.0 pF
e. 59 pF

9. The electric field in the region defined by the *y-z* plane and the positive *x* axis is given by $E = ax$, where a is a constant. (There is no field for negative values of *x*.) As x increases in magnitude, relative to $V = 0$ at the origin, the electric potential in the region defined above is

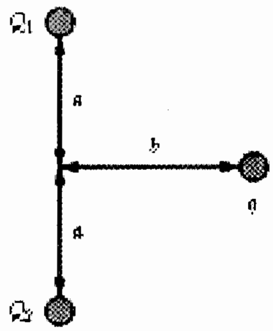
a. a decreasing function proportional to $-|x^2|$.
b. a decreasing function proportional to $-|x|$.
c. constant.
d. an increasing function proportional to $+|x|$.
e. an increasing function proportional to $+|x^2|$.

10. Which one of the following is not an expression for electric charge?

a. $\int_{\text{volume}} \rho \, dV$
b. $\int_{\text{area}} \sigma \, dA$
c. $\int_{\text{line}} \lambda \, d\ell$
d. $\int_{\text{area}} \mathbf{E} \cdot d\mathbf{A}$
e. $\varepsilon_0 \int_{\text{area}} \mathbf{E} \cdot d\mathbf{A}$

Score:

11. If $a = 3.0$ mm, $b = 4.0$ mm, $Q_1 = 60$ nC, $Q_2 = 80$ nC, and $q = 32$ nC in the figure, what is the magnitude of the total electric force on q?



a. 1.6 N
b. 1.3 N
c. 1.9 N
d. 2.2 N
e. 0.040 N

Score:

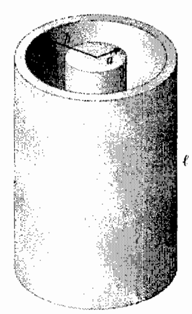
Part B- Problems (78 %)

1. **(20)** Consider a long conducting wire with radius a much smaller than its length l and a linear charge density $\lambda = Q/l$.

(a)(6) Determine the electric field (E) at a distance r from the wire center with $r > a$.

We insert a cylinder with radius b and the same length l around this wire.

(b)(6) Determine the potential difference between the wire and the cylinder.



(c)(4) Determine the capacitance of this cylindrical capacitor.

(d)(4) Determine the analytical expression of the energy stored per unit length by this capacitor as a function of λ, b and a.

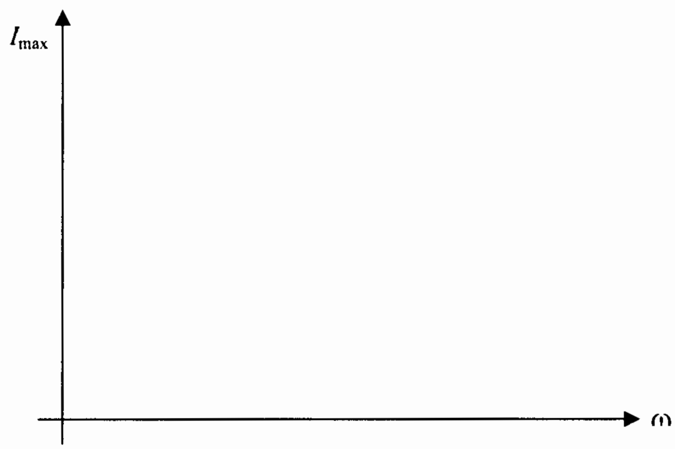
Score:

2.(32) We consider a circuit composed of an AC power source, supplying a current $I = I_{max}\sin(\omega t)$, a resistor R and an inductor L.

(a)(5) Determine the impedance of the circuit

(b)(4) Determine the expression of the circuit phase.

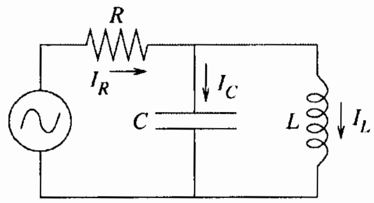
(c)(5) Discuss the behavior of this circuit of low frequencies ($\omega \to 0$) and for ($\omega \to \infty$) and plot the current I_{max} vs. ω



(d)(4) Determine the expression of the average power dissipated in this circuit as a function of R, L, I_{max} and ω.

Score:

We insert a capacitor in parallel to the inductor as shown in the figure below and the AC power source produces now $\mathcal{E} = \mathcal{E}_0 \cos(\omega t)$.



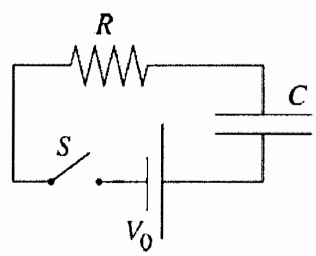
(e)(4) What are the maximum values of I_L, I_c and I_R in the case where $\omega \to 0$

(f)(4) What are the maximum values of I_L, I_c and I_R in the case where $\omega \to \infty$

(g)(6) Determine the currents I_L, I_c and I_R as a function of $\mathcal{E}$, R, L and C

Score:

3.(26) A resistor, R, a capacitor C a switch S and a batter with emf V_0 are in series as shown in the figure below. The switch is closed at t=0. At that time the capacitor holds no charge.



For t>0

a. **(8)** Write down the differential equation for the charge Q on the lower plate of the capacitor.

b. (4) Show by substitution into your equation that $Q = CV_0(1\text{-}e^{-t/\tau})$ is the correct solution provided that t is chosen properly. Determine τ.

Score:

c. (5) What is the current in the circuit at time t_1 ($t_1 > 0$)?

d. (5) How much energy is stored in the capacitor at time t_1?

e. (4) How much heat has been generated in the resistor between $t = 0$ and t_1?

Score:

SCRATCH PAPER
Nothing on this page will be graded

Score:

Score:________