PHYSICS 211
Final Spring 2009-2010
TIME: 90 minutes

February 5, 2010

DO NOT OPEN THIS EXAM BEFORE YOU ARE TOLD TO BEGIN

The usage of programmable calculators is strictly forbidden

NAME____

ID Number _______________________

Useful information

ε_0=8.85x10^{-12} $C^2/N.m^2$

μ_0=4p x 10^{-7} Tm/A

$q = 1.6 \times 10^{-19}$ C

m_e= 9.1x10^{-31} kg

m_p= 1.67×10^{-27} kg

k_e=8.9875x10^9 Nm^2/C^2

Grading

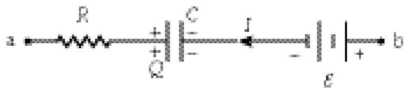
A (24)	
B (76)	
TOTAL	

Score:________

☐ Check if solution is continued on the back.

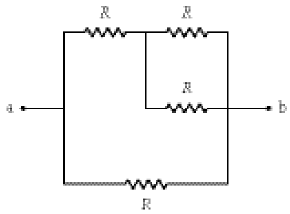
Part A:
Multiple choice questions (24) each question is 2%

1. If R = 2.0 kΩ, C = 4.0 mF, E = 8.0 V, Q = 20 mC, and I = 3.0 mA, what is the potential difference $V_b - V_a$?



a. +7.0 V
b. +19 V
c. +9.0 V
d. –3.0 V
e. –14 V

2. What is the equivalent resistance between points a and b when R = 30 Ω?



a. 27 Ω
b. 21 Ω
c. 24 Ω
d. 18 Ω
e. 7.5 Ω

3. 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.

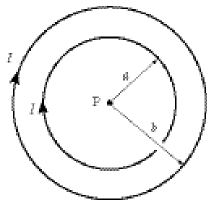
4. What is the magnitude of the magnetic force on a charged particle (Q = 5.0 μC) moving with a speed of 80 km/s in the positive x direction at a point where B_x = 5.0 T, B_y = –4.0 T, and B_z = 3.0 T?

a. 2.8 N
b. 1.6 N
c. 1.2 N
d. 2.0 N
e. 0.4 N

Score:________

☐ Check if solution is continued on the back.

5. What is the magnitude of the magnetic field at point P if $a = R$ and $b = 2R$?



a. $\dfrac{3\mu_0 I}{4R}$

b. $\dfrac{\mu_0 I}{4R}$

c. $\dfrac{2\mu_0 I}{3R}$

d. $\dfrac{\mu_0 I}{3R}$

e. $\dfrac{3\mu_0 \pi I}{4R}$

6. Two current loops are coaxial and coplanar. One has radius *a* and the other has radius *2a*. Current *2I* in the outer loop is parallel to current *I* in the inner loop. The magnitude of the magnetic field at the center of the two loops is

a. 0.

b. $\dfrac{\mu_0 I}{4a}$.

c. $\dfrac{\mu_0 I}{2a}$.

d. $\dfrac{\mu_0 I}{a}$.

e. $\dfrac{2\mu_0 I}{a}$.

7. The correct form of Ampere's law for circuits with gaps in them is

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

b. $\oint \mathbf{B} \cdot d\mathbf{s} = I_{enclosed}$.

c. $\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I_{enclosed}$.

d. $\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I_{enclosed} + \mu_0 \varepsilon_0 \dfrac{d\Phi_E}{dt}$.

e. $\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I_{enclosed} + \mu_0 \varepsilon_0 \dfrac{d\Phi_E}{dt} - \dfrac{\varepsilon_0}{(\mu_0)^2} \dfrac{d\Phi_B}{dt}$.

Score:________

☐ Check if solution is continued on the back.

8. A 50-turn circular coil (radius = 15 cm) with a total resistance of 4.0 Ω is placed in a uniform magnetic field directed perpendicularly to the plane of the coil. The magnitude of this field varies with time according to $B = A \sin(\alpha t)$, where $A = 80\ \mu$T and $\alpha = 50\pi$ rad/s. What is the magnitude of the current induced in the coil at t = 20 ms?

a. 11 mA
b. 18 mA
c. 14 mA
d. 22 mA
e. zero

9. 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.

10. A charge of 5.0 pC is distributed uniformly on a spherical surface (radius = 2.0 cm), and a second charge of –2.0 pC is distributed uniformly on a concentric spherical surface (radius = 4.0 cm). Determine the magnitude of the electric field 3.0 cm from the center of the two surfaces.

a. 30 N/C
b. 50 N/C
c. 40 N/C
d. 20 N/C
e. 70 N/C

11. If the input to an *RLC* series circuit is $V = V_m \cos \omega t$, then the current in the circuit is

a. $\frac{V_m}{R} \cos \omega t$

b. $\frac{V_m \cos \omega t}{\sqrt{R^2 + \omega^2 L^2}}$

c. $\frac{V_m \sin \omega t}{\sqrt{R^2 + (\omega L + 1/\omega C)^2}}$

d. $\frac{V_m \cos(\omega t - \phi)}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$

e. $V_m \sqrt{R^2 + (\omega L - 1/\omega C)^2} \cos \omega t$

12. 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.

Score:________

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Part B- Problems (76 %)

1. **(26)** Consider a long cylinder with radius R and a length l that is very large when compared to R so as to neglect the cylinders end edge effects. The charge density distribution in the cylinder is not uniform but grows linearly with radius according to $\rho(r) = \alpha r$

(a) **(5)** Show that the electric field **inside** the cylinder at a distance r from its axis has the expression $E = (1/3)\alpha r^2$.

(b) **(5)** Show that the electric field **outside** the cylinder at a distance r from its axis has the expression $E = (1/3)\alpha R^3/r$

(c) **(2)** Assume that these charges are now moving with a drift velocity v_d, determine the expression of the current density **inside** the cylinder.

Score:________

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(d) (3) Show that the *total current* expression is $I = (2/3)\alpha q v_d r^3$.

(e) (6) Let us assume that the current density can be put in the form $j=br$. Show that the expression of the magnetic field at a distance r **outside** the cylinder is $B=\mu_0 b R^3/3r$

(f) (5) Do the same as in (d) for a distance smaller than the radius of the cylinder.

Score:________

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2. (25) 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) (3) Consider that the **resistance alone** is connected to the power supply, determine the expression of the potential difference across it.

(b) (3) Consider that the **inductor alone** is connected to the power supply, determine the expression of the potential difference across it.

(c)(5) When both R and L are put in the series, determine the impedance of the circuit.

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

Score:________

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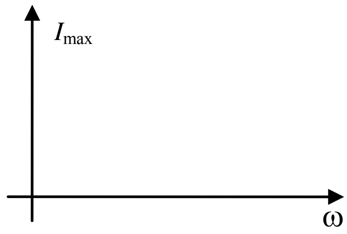
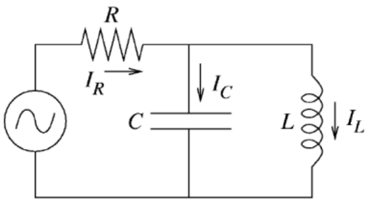
(e)(4) Discuss the behavior of this circuit of low frequencies ($\omega \to 0$) and for ($\omega \to \infty$) and plot the current I_{max} vs. ω



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



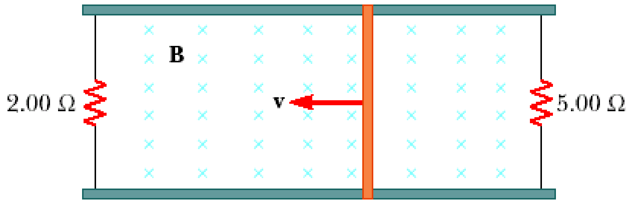
(f)(3) What are the maximum values of I_L, I_c and I_R in the case where $\omega \to 0$

(f)(3) What are the maximum values of I_L, I_c and I_R in the case where $\omega \to \infty$

Score:________

☐ Check if solution is continued on the back.

3.(25) A conducting rod of length $\ell = 35.0$ cm is free to slide on two parallel conducting bars as shown in the Figure below. Two resistors $R_1 = 2.00\ \Omega$ and $R_2 = 5.00\ \Omega$ are connected across the ends of the bars to form a loop. A constant magnetic field $B = 2.50$ T is directed perpendicularly into the page. An external agent pulls the rod to the left with a constant speed of $v = 8.00$ m/s.



(a) **(4)** Using Faraday's law, find the **analytical expression** and the **value** of the emf caused by the motion of the bar.

(b) **(5)** Consider the motion of free electrons in the bar. Show that the **same emf expression** can be found when equilibrium is reached between the electric and the magnetic forces.

(c) **(2)** Show on the figure above the direction of the currents in the two resistors, and justify below.

Score:________

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(d) **(6)** Determine the value of the current in both resistors.

(e) **(3)** Find the total power delivered to the resistance of the circuit.

(f) **(5)** Find the magnitude of the applied force that is needed to move the rod with this constant velocity.

Score:________

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SCRATCH PAPER

Nothing on this page will be graded

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