Kuwait University **Physics Department**

Physics 102

Second Midterm Examination

Spring Semester (2010 - 2011)
May 14, 2011

Time: 12:00 –13:30 PM

Name……**Student No**……

Instructors: Drs. Abdel-Karim, Afrousheh, Davis, Farhan, Habib, Kokaj, Lajko, Rakhshani, Rao, Razee, and Sharma

---

(Fundamental constants)

$k = \frac{1}{4\pi\varepsilon_o} = 9.0\times10^{9}\ \mathrm{N.m^2/C^2}$	(Coulomb constant)
$\varepsilon_o = 8.85 \times 10^{-12}\ \mathrm{C^2/(N\cdot m^2)}$	(Permittivity of free space)
$\mu_0 = 4\pi \times 10^{-7}$ T .m/A	(Premeability of free space)
$\lvert e \rvert = 1.60 \times 10^{-19}$ C	(Elementary unit of charge)
$N_A = 6.02 \times 10^{23}$	(Avogadro's number)
$g = 9.8$ m/s^2	(Acceleration due to gravity)
$m_e = 9.11 \times 10^{-31}$ kg	(Electron mass)
$m_p = 1.67 \times 10^{-27}$ kg	(Proton mass)

Prefixes of units

m = 10^{-3}	μ = 10^{-6}	n = 10^{-9}	p = 10^{-12}
k = 10^{3}	M = 10^{6}	G = 10^{9}	T = 10^{12}

For use by Instructors only

Prob.	1	2	3	4	5	6	7	8	Total
Marks									

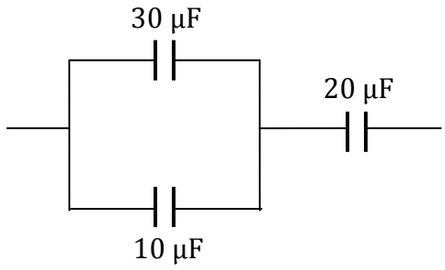
Ques.	1	2	3	4	5	6	7	8	Total
Marks									

Important Notes:

1. Do not start your exam until you are told to do so.
2. Answer all problems, show all your work and mark your final answer.
3. Your work in this booklet should be neatly presented.
4. Books, notes and mobile phones are not allowed during the exam.
5. You may use a non-programmable calculator.

Good Luck

1. In the system of capacitors shown below, the total energy stored is 60 μJ. Determine the charge on the 30 μF capacitor. **[4 Points]**



$C_{eq} = \frac{40}{3}\ \mu F$

$U = \frac{Q^2}{2C_{eq}} \rightarrow Q = 40\ \mu C$

$V = \frac{Q}{(30\ \mu F + 10 \mu F)} = 1\ V$

$Q_{30} = 30 \times 1 = 30\ \mu C$

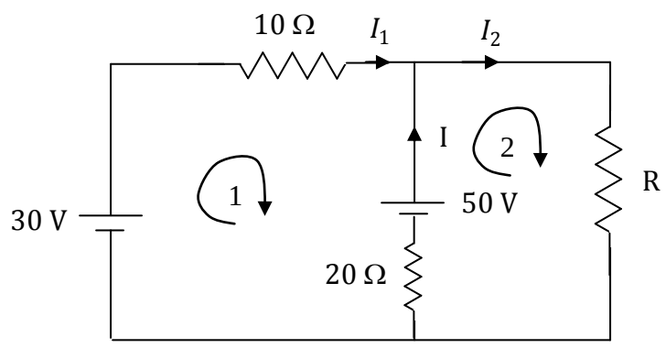
2. A capacitor C_1 is charged to a potential of 100 V. After it is disconnected from the source, C_1 is then connected to an uncharged capacitor $C_2 = 60$ μF. If the final potential difference across the 60 μF capacitor is 40 V, determine C_1. **[3 points]**

$Q_{total} = C_1 \times 100$

$Q_{total} = (C_1 + C_2) \times 40$

$2.5C_1 = C_1 + C_2 \rightarrow C_1 = 40\ \mu F$

3. In the circuit shown below, the current I is 1.5 A. Determine the resistance R. **[4 Points]**



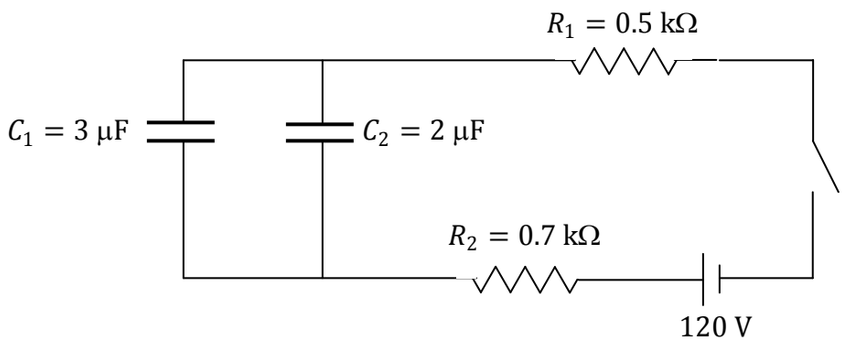
Junction: $I_2 = I_1 + I$

Loop (1) $I_1 = 1$ A

$I_2 = 2.5$ A

Loop (2) R = 8.0 Ω

4. The capacitors in the circuit shown below are initially uncharged. The switch is closed at $t = 0$. Determine the plate charge of capacitor C_1 at time $t = 2$ ms. **[4 Points]**



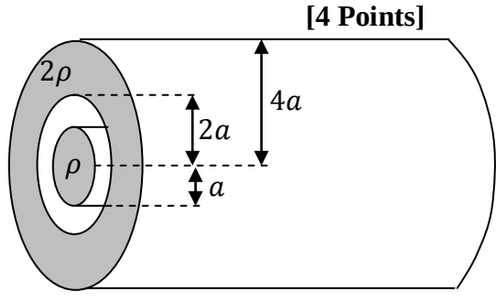
R = 1.2 kΩ , C = 5 μF

$Q = \varepsilon C(1 - e^{\frac{-t}{RC}}) = 170\ \mu C$

$V_1 = V_2 = \frac{Q}{C} = 34$ V

$Q_1 = V_1 \times C_1 = 102\ \mu C$

5. A conducting cylindrical wire of radius $r_1 = a$, resistivity ρ and length L is surrounded by a coaxial cylindrical shell of inner radius $r_2 = 2a$, outer radius $r_3 = 4a$, resistivity 2ρ and length L as shown in the figure. **[4 Points]**



a) Write down the resistance of the wire with radius r_1.

$R_1 = \frac{\rho L}{\pi a^2}$

b) Write down the resistance of the cylindrical shell.

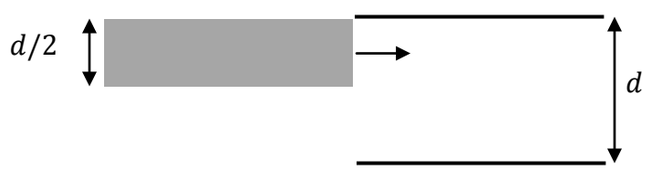
$R_2 = \frac{2\rho L}{\pi(16a^2 - 4a^2)} = \frac{\rho L}{6\pi a^2}$

c) Show that the resistance of the system of two conductors is given by $R = \frac{\rho L}{7\pi a^2}$.

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$R = \frac{\rho L}{7\pi a^2}$

6. A parallel-plate capacitor C_0 of plate area A and separation d is connected to a battery and has the stored energy of 6 μJ. While the battery is still connected, a dielectric slab of area A, thickness $d/2$ and dielectric constant $K = 3$ is inserted between the plates. Determine the final stored energy. **[4 Points]**

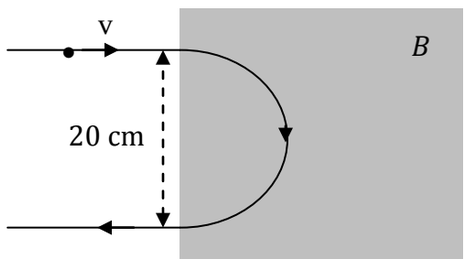


V is constant

$C = \frac{3}{2}C_0$

$U_{after} = \frac{1}{2}CV^2 = \frac{3}{2}U_{before} = 9\ \mu J$

7. A proton is accelerated from rest through a potential difference of 10 kV. It then enters a region having a uniform magnetic field $\vec{B}$ and exits the region as shown in the figure. Find the magnitude and direction of the magnetic field $\vec{B}$. **[5 Points]**



$\frac{1}{2}mv^2 = qV \rightarrow v = 1.38 \times 10^6\ m/s$

$R = \frac{mv}{qB} \rightarrow B = 0.14\ T$

B is outward

8. An electron with velocity $\vec{v} = 5.0 \times 10^5 \hat{j}$ m/s is at a point where the electric field is $\vec{E} = (3.0 \times 10^4 \hat{\imath} - 4.0 \times 10^4 \hat{j})$ N/C and the magnetic field is $\vec{B} = 2.0 \times 10^{-2} \hat{\imath}$ T. At that instant, what is the magnitude of the net force on the electron? **[4 Points]**

$\vec{F}_{electric} = q\vec{E} = -e(3.0 \times 10^4 \hat{\imath} - 4.0 \times 10^4 \hat{j})$ N

$\vec{F}_{magnetic} = q\vec{v} \times \vec{B} = e\ 10^4 \hat{k}$ N

$F = e(\sqrt{1+9+16}) \times 10^4 = 8.2 \times 10^{-15}$ N

Conceptual Questions

1. When a dielectric (K) is inserted inside a capacitor, the stored energy increases by a factor of 2. What is the ratio of the electric fields before and after the dielectric is inserted?

a) K

b) $1/K$

c) 2

d) 1

2. The identical circular plates of a capacitor (C_1) are a distance d apart. The radius of each plate is r. If r is **increased** by a factor of 2 and d is **decreased** by a factor of 2, the new capacitance is

a) C_1

b) $\frac{1}{2}C_1$

c) $8C_1$

d) $2C_1$

3. The electrical conduction properties of copper and rubber are different because

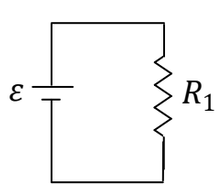
a) positive charges can move in copper but not in rubber.

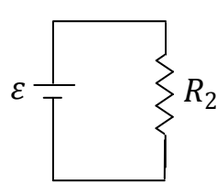
b) electrons can move in copper but not in rubber.

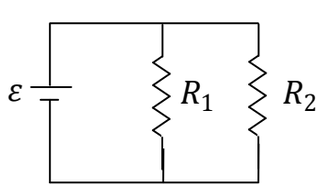
c) positive charges can move in rubber but not in copper.

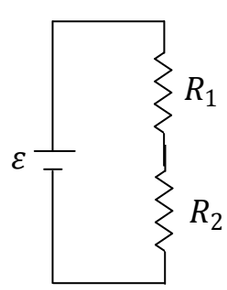
d) electrons can move in rubber but not in copper.

4. If $R_1 > R_2$, in which of the following four circuits is the power dissipation lowest?

a) 

b) 

c) 

d) 

5. Kirchhoff's loop rule:

a) cannot be used in loops with capacitors.

b) can only be used in loops with batteries.

[c] can be used in any loop provided it is closed.

d) cannot be used if the current changes with time.

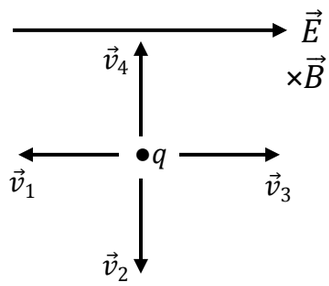
6. A point charge q can be launched with four different velocities inside a region of perpendicular electric and magnetic fields. For which velocity can the total force on charge q be zero?

a) $\vec{v}_1$

b) $\vec{v}_2$

c) $\vec{v}_3$

[d] $\vec{v}_4$



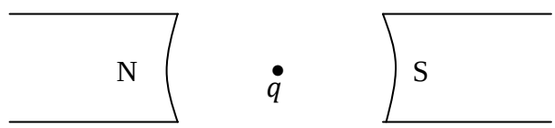
7. An electron is placed at rest between two poles of a permanent magnet as shown below. The magnetic force acting on the electron is

[a] zero.

b) towards N.

c) towards S.

d) upward.



8. In the circuit shown below the capacitor is initially uncharged. The current, I_0, through resistor R_1 just after switch S is closed is

a) $I_0 = \frac{\varepsilon}{R_1+R_2}$.

[b] $I_0 = \frac{\varepsilon}{R_1}$.

c) $I_0 = \frac{\varepsilon}{R_2}$.

d) zero.