Kuwait University **Physics Department**

Physics 102

Second Midterm Examination

Summer Semester 2010-2011

July 16th , 2012

Time: 6:00 pm – 7:30 pm

Name…………………………………………………….. Student No……………………….

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(Fundamental constants)

$k = \dfrac{1}{4\pi\varepsilon_o} = 9.0\times10^9\ N.m^2/C^2$	(Coulomb constant)
$\varepsilon_o = 8.85 \times 10^{-12}\ C^2/(N\cdot m^2)$	(Permittivity of free space)
$\mu_0 = 4\pi \times 10^{-7}$ T .m/A	(Permeability of free space)
$\lvert e \rvert = 1.60 \times 10^{-19}$ C	(Elementary unit of charge)
$N_A = 6.02 \times 10^{22}$	(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}	$\mu = 10^{-6}$	n = 10^{-9}	p = 10^{-12}
k = 10^{3}	M = 10^{6}	G = 10^{9}	T = 10^{12}

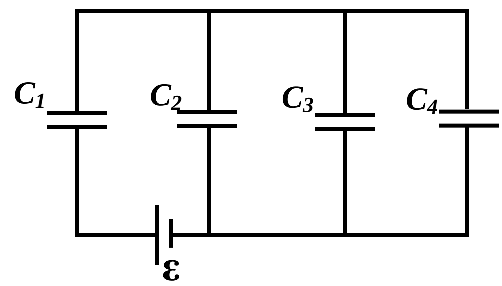
For use by Instructors only

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

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

PART I: Solve the following Problems. Show your solution in detail.

1. Given that C_1 = 50 μF, C_2 = 30 μF, C_3 = 36 μF, C_4 = 12 μF, and ε = 30 V. What is the energy stored in C_3.



$$C_{234} = C_2 + C_3 + C_4 = 78\,\mu F$$

$$C_{eq} = \frac{C_{234} \times C_1}{C_{234} + C_1} = 30.5\ \mu F$$

$$Q = C_e \varepsilon = 915 \mu C$$

$$V_3 = V_{234} = \frac{Q}{C_{234}} = 11.7\ \mathrm{V}$$

$$U_3 = \frac{1}{2} C V^2 = 2.47\ \mathrm{mJ}$$

2. A 30 μF capacitor is charged to an unknown potential V and then connected in parallel with an initially uncharged 10 μF capacitor. If the final potential difference across the 10 μF capacitor is 20 V, determine the potential V.

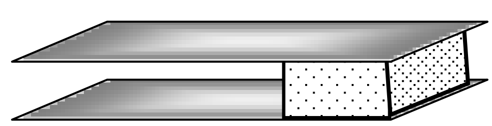
$$C_{eq} = C_1 + C_2 = 40\,\mu\mathrm{F}$$

$$V_f = \frac{Q}{C_{eq}} = \frac{VC_1}{C_{eq}}$$

$$20 = V\frac{30}{40}$$

$$V = 27\,\mathrm{V}$$

3. An isolated 240 μF air-filled parallel-plate capacitor is charged to 160 μC. If a dielectric material (K = 3.2) is inserted filling one third of the space between the plates, as shown. Calculate the work done by the external agent in the process.



$$C_f = C_{air} + C_\kappa$$

$$C_{air} = \varepsilon_o \frac{2A}{3d} = \frac{2}{3} C_i$$

$$C_\kappa = \kappa \varepsilon_o \frac{A}{3d} = \frac{\kappa}{3} C_i$$

$$\Delta U = W_{ex} = \frac{Q^2}{2}\left(\frac{1}{C_f} - \frac{1}{C_i}\right)$$

$$\Delta U = -\,22.5\,\mu\mathrm{J}$$

4. In a steady state current, how many electrons pass through a 20 Ω resistor in 10 minutes if there is a potential difference of 30 volts across it?

$$Q=Ne$$

$$V/R=Q/t$$

$$N=5.6 \times 10^{21}$$

5. Two real batteries with emf $\varepsilon_1 = \varepsilon_2 = \varepsilon$, but different internal resistances $r_1 = 0.5\ \Omega$ and $r_2 = 0.3\ \Omega$ are connected in series to an external resistance *R*. Find the value of *R* so the terminal voltage of ε_1 is zero.

$$0 = \varepsilon - ir_1$$

$$i = \frac{\varepsilon}{r_2 + R}$$

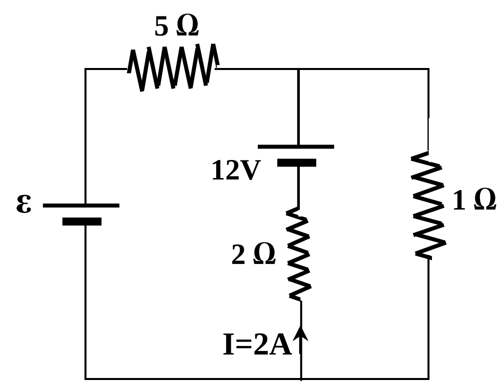
$$R = r_1 - r_2 = 0.2\,\Omega$$

6. In the circuit shown the current in the 2 Ω resistor is 2 A, as shown. Find the value of the emf ε.

$$-2\times 2+12-1\times I_3=0$$
$$I_3=8\,\text{A}$$

$$I_1=I_3-I=6\,\text{A}$$

$$\varepsilon-5I_1-1\times I_3=0$$
$$\varepsilon=38\,\text{V}$$



7. A conducting wire of 1.20 mm diameter carries a current of 3.00 A produced by an electric field of 120 V/m. Calculate the resistivity of the material.

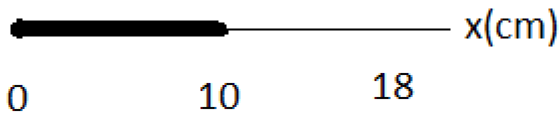
$$R=\rho\frac{L}{A}=\frac{V}{I}$$

$$\rho=\left(\frac{A}{I}\right)\left(\frac{V}{L}\right)=\left(\frac{\pi r^2}{I}\right)E$$

$$\rho=\frac{\pi\left(0.6\times 10^{-3}\right)^2}{3}\times 120=4.52\times 10^{-5}\ \Omega.m$$

8. A charge of uniform density is distributed along the x axis from the origin to the point x=10 cm. If the electric potential (relative to zero at infinity) is 5.8V at x = 18 cm, what is the linear charge density?

$$V = \int_0^{10} k \frac{\lambda dx}{18 - x}$$

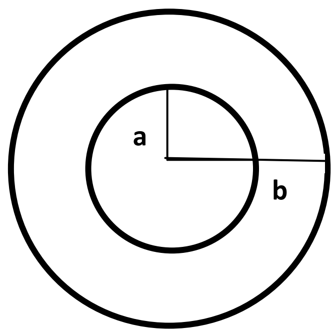


$$V = -k\lambda \ln \frac{8}{18} = k\lambda((0.81)$$

λ= 0.8 nC/m

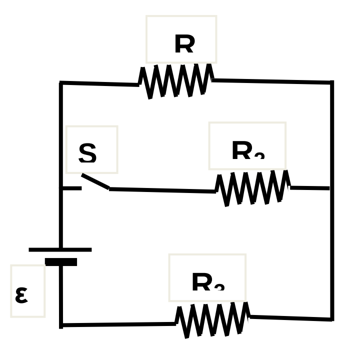
PART II: Conceptual Questions (1 point each). Tick the most suitable answer.

1. Relative to infinity, the potential at the center of a spherical charged conducting shell of radii *a* and *b* (*a* < *b*) carrying a charge *Q* is;
   a) *KQ/a*
   b) *KQ/b*
   c) 0
   d) *KQ(1/a-1/b)*

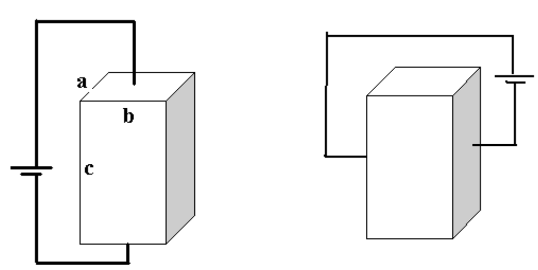


2. The electrostatic energy density inside a capacitor is uniform. The capacitor must be
   a) a spherical capacitor.
   b) a cylindrical capacitor
   c) a parallel-plate capacitor.
   d) a capacitor of any shape.

3. When the switch S is closed, the current through R_3
   a) remains the same.
   b) increases.
   c) decreases.
   d) can only be determined by knowing the values of the resistances.

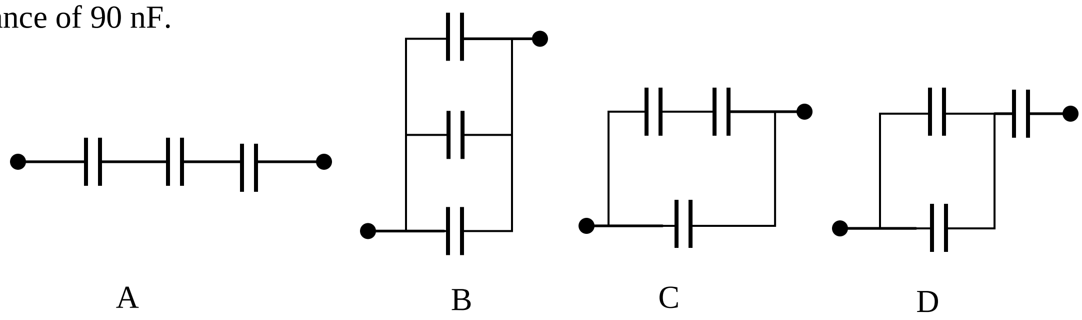


4. A conducting block of dimensions *a, b* = *a* and *c* = 3*a* is connected to an emf source ε in two different ways, as shown. Comparing the value of the drift velocity in the two cases (v_1 and v_2),
   a) $v_1 = v_2$.
   b) $v_1 = 3\ v_2$.
   c) $v_1 = v_2/3$
   d) $v_1 = 9v_2$.



Case 1 **Case 2**

5. You have three equal capacitors of capacitance 60 nF each. Which combination below yields an equivalent capacitance of 90 nF.
   a) A
   b) B
   c) C
   d) D



6. The junction Kirchhoff rule is a statement of
   a) energy conservation law.
   b) charge conservation law.
   c) Gauss' Law.
   d) Coulomb's Law.

7. An air-filled parallel plate capacitor made of two circular plates of radii *a* and separation *d* has a capacitance *C*. If the separation and the radii are decreased to half their initial values and a dielectric material of *K*=2 is inserted filling the whole region between the plates; the new capacitance is
   a) *C*.
   b) 2*C*.
   c) 4*C*.
   d) *C*/2.

8. For the circuit shown, all bulbs have the same resistance. Which bulb is brightest ?
   a) A
   b) B
   c) C
   d) B and C