Kuwait University **Physics Department**

Physics 102

Final Examination

Spring Semester (2010 - 2011)
June 8, 2011

Time: 11:00 AM – 1:00 PM

Name……**Student No**……

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

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(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	9	10	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.

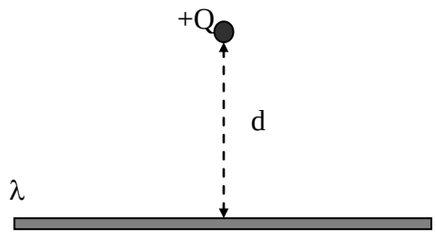
Good Luck

1. A solid ball of radius R has a uniform volume charge density. If the magnitude of the electric field on the surface of the ball is $9000\ \mathrm{V/m}$, what is the field magnitude at a distance of $r = R/3$ from the center of the ball? **[3 Points]**

$$E(r = R) = \frac{kQ}{R^2} = 9000$$

$$E(r = R/3) = \frac{kQr}{R^3} = \frac{1}{3}\frac{kQ}{R^2} = 3000\ \mathrm{V/m}$$

2. A very long bar, carrying a uniform linear charge density λ, is at a distance $d = 0.3$ m from a positive point charge ($Q = 3.0\ \mu C$) as shown in the figure. The point charge is attracted by the bar with a force of 0.36 N. Find the value of λ (sign and magnitude). **[4 Points]**

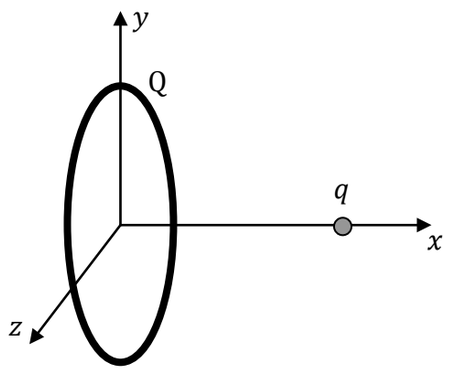


$$F = Q\frac{2k\lambda}{d}$$

$$|\lambda| = \frac{Fd}{2kQ} = 2 \times 10^{-6}\ \mathrm{C/m}$$

$$\lambda = -2\ \mu\mathrm{C/m}$$

3. In the figure shown, point charge $q = -5.0$ μC is released from rest at $x = 0.6$ m on the axis of a ring of radius $R = 0.8$ m carrying a charge Q $= +3.0$ μC. What is the kinetic energy of point charge q as it passes through the center of the ring? **[4 Points]**



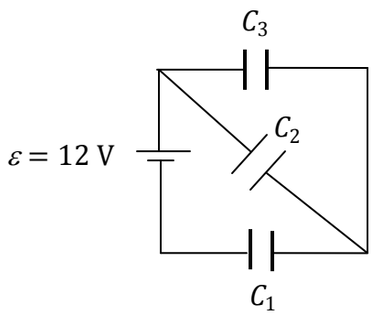
$$U(x) = \frac{kqQ}{\sqrt{x^2 + R^2}}$$

$$U(x = 0) + K = U(x = 0.6) + 0$$

$$K = kqQ\left(\frac{1}{\sqrt{0.6^2 + 0.8^2}} - \frac{1}{\sqrt{0 + 0.8^2}}\right)$$

$$K = 0.034 \text{ J}$$

4. The capacitors in the figure below are $C_1 = 5$ μF, $C_2 = 3$ μF and C_3 is unknown. The charge on C_1 is 25 μC. Find the energy stored in capacitor C_3. **[4 Points]**



$$V_1 = \frac{q_1}{C_1} = 5 \text{ V}$$

$$V_2 = V_3 = 12 - 5 = 7 \text{ V}$$

$$q_3 = 25 - 3 \times 7 = 4 \text{ μC}$$

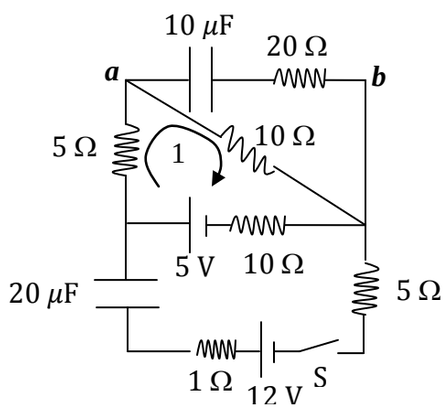
$$U_3 = \frac{1}{2} q_3 V_3 = 14 \text{ μJ}$$

5. A cylindrical conductor of length 60 cm and radius 2.0 mm carries a current of 3.0 A. If it takes 5000 s for each electron to travel the length of the conductor, calculate the number of electrons in one cubic meter of the conductor. **[3 Points]**

$$v_d = \frac{0.60}{5000} = 1.2 \times 10^{-4} \text{ m/s}$$

$$n = \frac{I}{eAv_d} = \frac{I}{e\pi r^2 v_d} = 1.24 \times 10^{28} \text{ m}^{-3}$$

6. In the following circuit, find the potential difference between points ***a*** and ***b*** long time after the switch S is closed. **[4 Points]**



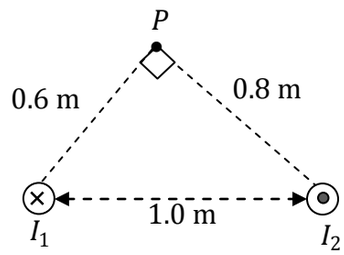
$at\ t = \infty$: $only\ loop\ 1\ remains$

$$I = \frac{5}{5 + 10 + 10} = 0.2 \text{ A}$$

$$V_{R=10\Omega} = V_{ab}$$

$$V_a - V_b = 10 \times 0.2 = 2 \text{ V}$$

7. Two long, straight, parallel wires are 1.0 m apart and carry currents of $I_1 = 6.0$ A into the page and $I_2 = 2.0$ A out of the page. What is the magnitude of the net magnetic field at point P? **[4 Points]**



$$B_1 = \frac{\mu_0 I_1}{2\pi \times 0.6} = 2\ \mu\text{T}$$

$$B_2 = \frac{\mu_0 I_2}{2\pi \times 0.8} = 0.5\ \mu\text{T}$$

$$B = \sqrt{2^2 + 0.5^2} = 2.06\ \mu\text{T}$$

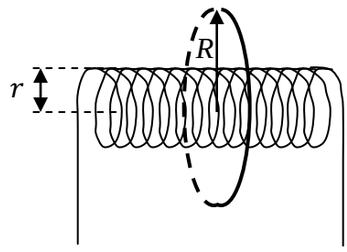
8. A long straight wire carries a current of 2.50 A. An electron is traveling at 5.90×10^4 m/s directly toward the wire. What is the magnitude of the force that the magnetic field of the current exerts on the electron when it is 4.30 cm from the wire? **[3 Points]**

$$F = evBsin90^\circ$$

$$F = \frac{ev\mu_0 I}{2\pi r}$$

$$F = 1.10 \times 10^{-19}\ \text{N}$$

9. A long, thin solenoid that has 880 turns per meter and radius $r = 2.4$ cm goes through a conducting loop of radius $R = 5.0$ cm. The current in the solenoid is increasing at uniform rate of 5 A/s. What is the magnitude of the induced emf in the loop? **[4 Points]**



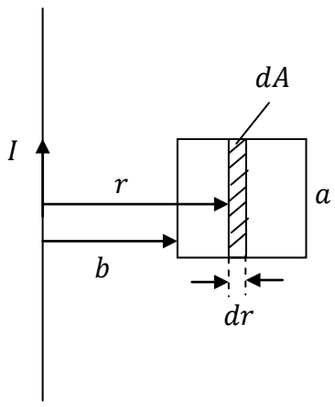
$$\varepsilon = \left|\frac{d\Phi_B}{dt}\right|$$

$$\Phi_B = BA = \mu_0 nI\pi r^2$$

$$\varepsilon = \pi r^2 \mu_0 n \left|\frac{dI}{dt}\right|$$

$$\varepsilon = 1.00 \times 10^{-5}\ \text{V}$$

10. The figure below shows a long straight wire carrying a current I and a square loop of side a close to it. **[4 Points]**



a) Write down the magnetic flux through the surface element dA shown in the figure.

$$d\Phi_B = \vec{B}.\overrightarrow{dA} = \frac{\mu_0 I}{2\pi r} a.dr$$

b) Find the magnetic flux through the surface of the square loop.

$$\Phi_B = \int_b^{a+b} \frac{\mu_0 I}{2\pi r} a.dr = \frac{\mu_0 aI}{2\pi} \ln\left(1 + \frac{a}{b}\right)$$

Conceptual Questions

1. Two identical conducting spheres with charges $+q$ and $-3q$ are held apart. The spheres are connected momentarily by a thin conducting wire. After the wire is removed, the magnitude of electric force on each sphere is:

   a) Zero.

   b) Larger than before.

   × c) Smaller than before.

   d) Same as before.

2. The electric field close to the surface of a conductor with surface charge density σ is

   × a) Normal to the surface with a magnitude σ/ε_o.

   b) Normal to the surface with a magnitude $\sigma/2\varepsilon_o$.

   c) Parallel to the surface with a magnitude σ/ε_o.

   d) Parallel to the surface with a magnitude $\sigma/2\varepsilon_o$.

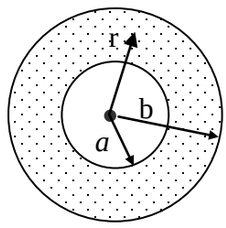
3. A conducting spherical shell with inner radius *a* and outer radius *b* carries charge *Q*. The electric potential (with respect to infinity) at a< r <b is:

   a) *2kQ/(b+a)*

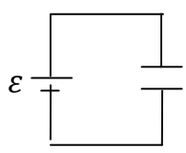
   b) Zero.

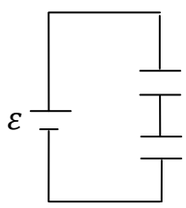
   c) *kQ/a*.

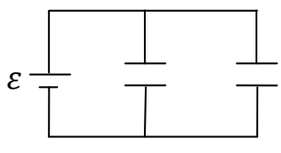
   × d) *kQ/b*.

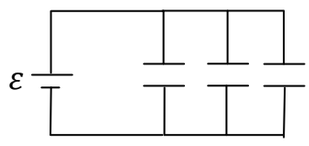


4. In which of the following cases is the total stored energy lowest? All capacitors and batteries are identical.

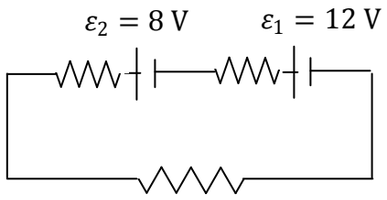
a) 

× b) 

c) 

d) 

5. In the circuit shown below:



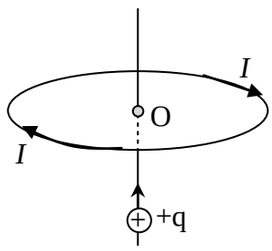
a) Battery ε_1 has input and ε_2 has output power.

b) Battery ε_1 has output and ε_2 has input power.

× c) Both batteries have output power.

d) Both batteries have input power.

6. A circular loop of wire lies in a horizontal plane and carries a current *I*. A positively charged particle moves upward along the axis. What is the direction of the magnetic force that the loop exerts on the charged particle as it moves?



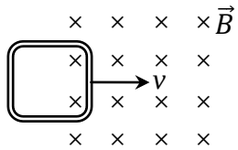
a) Upward at all times.

b) Downward at all times.

c) Upward when the particle is below O, and downward when the particle is above O.

× d) Zero at all times.

7. A square loop of wire is moving at a constant speed *v* into a uniform magnetic field as shown in the figure. As the loop moves further into the field region, what are the directions of the induced current *I* in the loop and the magnetic field B' at the center of the loop produced by this current?



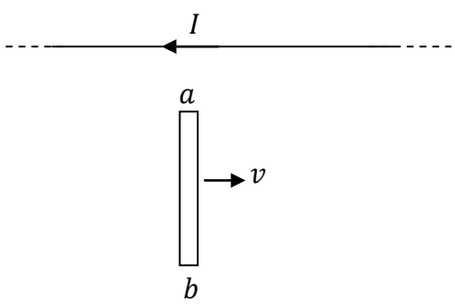
a) *I* is zero and B' is into the plane of the figure.

b) *I* is zero and B' is out of the plane of the figure.

× c) *I* is counter clockwise and B' is out of the plane of the figure.

d) *I* is clockwise and B' is into the plane of the figure.

8. A conducting rod is moving near a long straight wire that carries a current *I*. If V_a and V_b are electric potentials of the two ends of the rod, which statement is correct?



a) $V_a > V_b$.

× b) $V_b > V_a$.

c) $V_a = V_b \neq 0$.

d) $V_a = V_b = 0$.