**Kuwait University** **Physics Department**

# Physics 102

**Final Examination**

**January 9, 2008**

**Time: 11.00 a.m. – 1.00 p.m.**

Name……………………………. Student No……………….

Instructors: Drs. AbdelKarim, Bhatia, Farhan, Kokaj, Davis, Manaa, Lajko, Razee,

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**(Fundamental constants)**

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

**Prefixes of units**

| | | | |
|---|---|---|---|
| $m = 10^{-3}$ | $\mu = 10^{-6}$ | $n = 10^{-9}$ | $p = 10^{-12}$ |
| $k = 10^{3}$ | $M = 10^{6}$ | $G = 10^{9}$ | $T = 10^{12}$ |

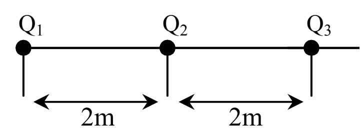
**For use by Instructors only**

| Prob. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Marks | | | | | | | | | | | |

| Ques. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Marks | | | | | | | | | | | |

**Part - I**

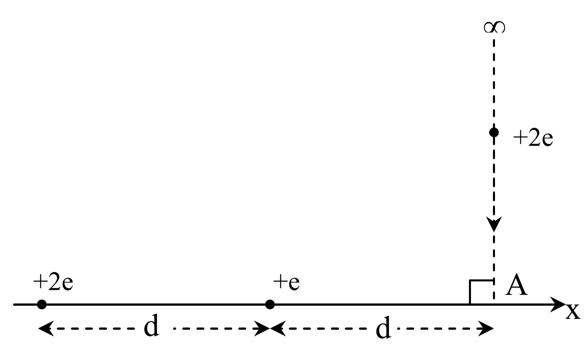
1. Three equal, point charges $Q_1$, $Q_2$, $Q_3$ are placed along a straight line, with the distance between neighbouring charges being 2 m as shown in figure below. If $Q_1 = Q_2 = Q_3$ & the magnitude of the net force acting on charge $Q_3$ is 1.125N. What is the magnitude of the charge? **(2 points)**




$$k\frac{q^2}{(4^2)} + k\frac{q^2}{(2^2)} = 1.25N$$

**q = 20μC**

2. In the figure a particle of charge +2*e* is moved in from infinity to a point *A* on the x-axis. How much work is done if the distance *d* = 4m. **(2 points)**




Calculating the net potential at A

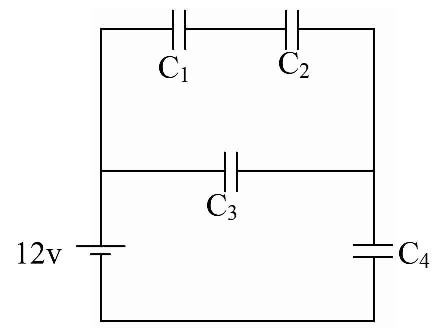
Calculating the work

$$W = \frac{1}{4\pi\varepsilon_o}\left[\frac{(2e)(2e)}{2d} + \frac{2e(e)}{d}\right] = \frac{e^2}{\pi\varepsilon_o d}$$

**W = 2.3 × 10$^{-28}$J**

3. In the figure $C_1 = C_2 = C_4 = 8\mu F$ and $C_3 = 4\ \mu F$. What is the potential difference across $C_4$?

**(2 points)**




$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C_{12} = 4\mu f$$

$$C_{123} = C_{12} + C_3$$

$$C_4 = C_{123}$$

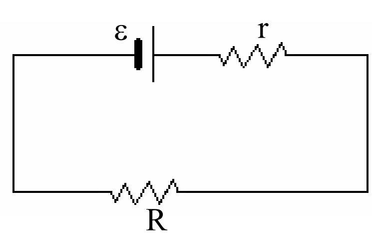
$$q_T = C_{1234} .12V$$

$$V_4 = \frac{q_T}{8\mu T}$$

**V = 6V**

4. In the circuit shown, $\varepsilon$ is the emf and $r$ is its internal resistance. The circuit has a current of 0.5A when $R = 10\Omega$ and a current of 0.27A when $R = 20\Omega$. Find the emf $\varepsilon$ of battery.

**(3 points)**




$$I_1 = \frac{\varepsilon}{R_1 + r}$$

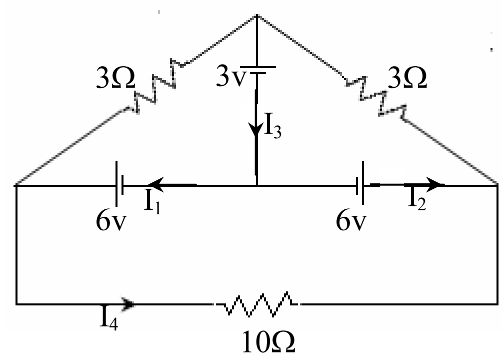
$$I_2 = \frac{\varepsilon}{R_2 + r}$$

$\frac{I_1}{I_2}$ ; r = 1.74 Ω

ε = I ( R + r)

**ε = 5.9V**

5. Find the currents $I_1$, $I_2$, $I_3$ and $I_4$ in the circuit shown. **(4 Points)**




$6 - 6 - 10I_4 = 0$,

$\mathbf{I_4 = 0}$

$+6 - 3I_1 - 3 = 0$

$\mathbf{I_1 = 1A}$

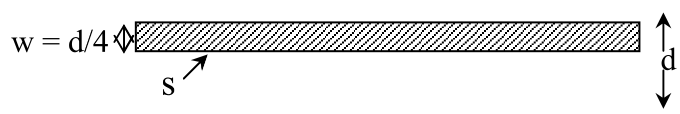
$-6 + 3 + 3I_2 = 0$

$\mathbf{I_2 = +1A}$

$I_1 + I_2 = I_3$

$\mathbf{I_3 = 2A}$

6. A parallel plate capacitor has plate area *A* & plate separation *d=4cm*. A dielectric slab of area *A* & width $w$ = d/4 is placed against the positively charged plate. The positive plate is at 100 V & the negative plate at 0 V. Calculate the voltage at the air-dielectric interface S if the dielectric constant is K = 3. **(3 points)**




$100 = V_A + V_K$

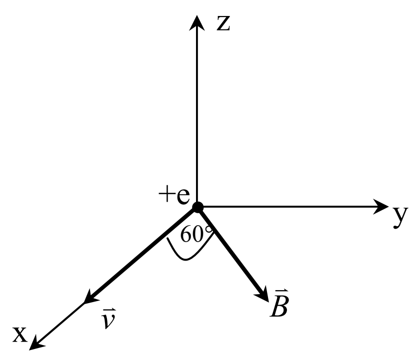
$C_A V_A = C_K V_K$

$V_K = 10V$

$V_A = 100V - 10V$

**= 90 V**

7. A proton moves with a speed of $8 \times 10^6$m/s along the x axis. It enters a region where there is a magnetic field of magnitude 2.5T, directed at angle of 60° to x-axis and lying in xy plane as shown in the figure. What are the magnitude and direction of the initial acceleration of the proton? **(3 points)**

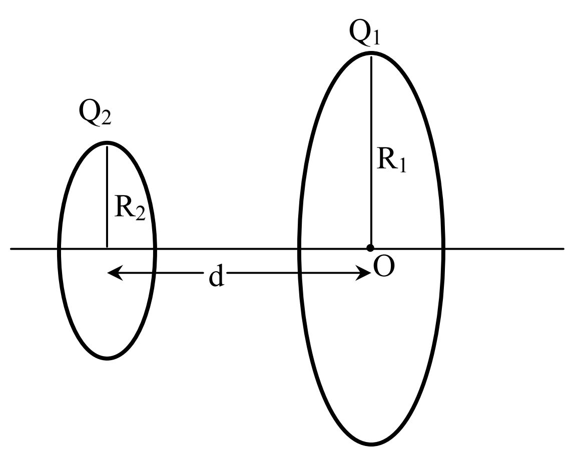



$$\vec{F} = q\vec{v} \times \vec{B}$$

$$\vec{a} = \frac{qvB\sin\theta}{m}\vec{k}$$

$$a = 1.7 \times 10^{15}\ m/s^2$$

8. Two rings of radii $R_1 = 0.2$m & $R_2 = 0.1$m carrying charges $Q_1 = 200\ \mu$C, $Q_2 = -400\mu$C have a common axis & are aligned parallel to each other with their centers being separated by a distance of d = 1m (see figure). Determine the magnitude & direction of the electric field at the center O of the larger ring. **(3 points)**



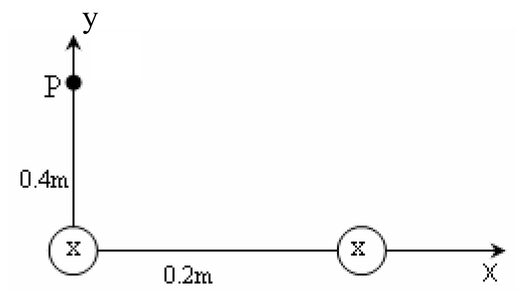

$$E_1 = 0$$

$$E_2 = \frac{Q_2 d}{4\pi\varepsilon_o\left(d^2 + R_2^2\right)^{3/2}} = 3.5 \times 10^6\ \frac{N}{C}$$

Direction: along the axis to the left.

9. Two long straight wires perpendicular to the xy-plane, as shown in the fig., carry equal currents of 5A. Find components of $\vec{B}$ at the point P(0,0.4m) on the y-axis.

**(4 points)**




$$B_1 = \frac{\mu_\circ I}{2\pi(0.4)} = 2.5\mu T$$

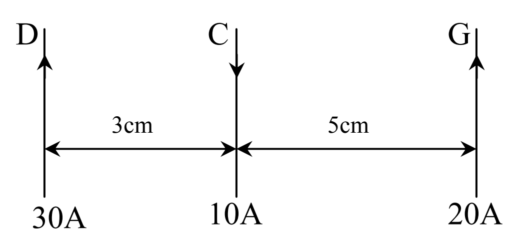
$$B_2 = \frac{\mu_\circ I}{2\pi\sqrt{0.2}} = 2.24\mu T$$

$B_x = 2.5 + 2.24 \cos\theta = 4.5\mu T$

$B_y = 2.24 \text{ sing } \theta = 1\mu T$

$\vec{B} = (4.5\hat{i} + 1\hat{k})\,\mu T$

10. Three long parallel wires carry currents as shown in the figure below. Find the magnitude of the force experienced by a 25cm length of wire C. **(3 points)**




$$B_D = \frac{\mu(30A)}{2\pi(0.03)} = 2\times10^{-4}T$$

$$B_G = \frac{\mu(20A)}{2\pi(0.05)} = 0.8\times10^{-4}T$$

$B = 2 \times 10^{-4} - 0.8 \times 10^{-4} = 1.2 \times 10^{-4}$ T

$F = ILB \sin\theta =$ **$3 \times 10^{-4}$ N**

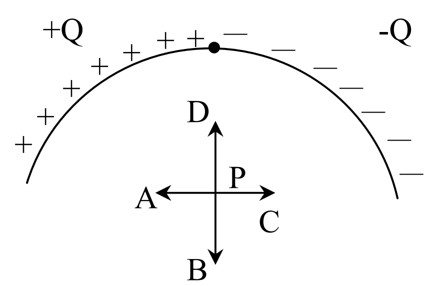
**Part – II**

Each question carries one point.

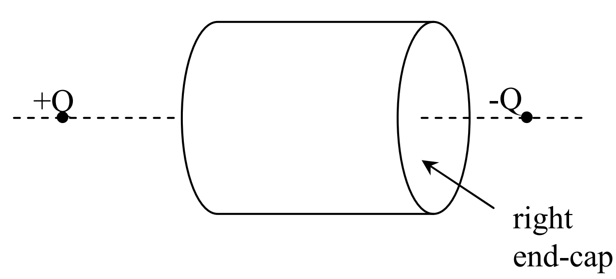
1. A moving charge
   a. is actually an electric current.
   b. produces an electric field.
   c. produces a magnetic field.
   d. all of the above.

2. Which of the following does NOT produce a magnetic field?
   a. A varying current-carrying wire
   b. A moving electric charge
   c. A stationary electric charge
   d. A closed electric circuit consisting of an emf source & a resistor.

3. As shown in the figure, an insulting rod is bent into the shape of a semi-circle. The left half has a charge +Q uniformly distributed along its length & the right half has a charge –Q similarly distributed. What vector shows the correct direction of the electric field at the center P?
   a. A
   b. B
   c. C
   d. D
   e. There is no electric field at P.




4. Positive & negative point charges of equal magnitude lie along the symmetry axis of a cylinder & their distances from the nearest end-caps are equal. What is the sign of the flux through the right end-cap?
   a. Positive
   b. Negative
   c. There is no flux through the right end-cap.



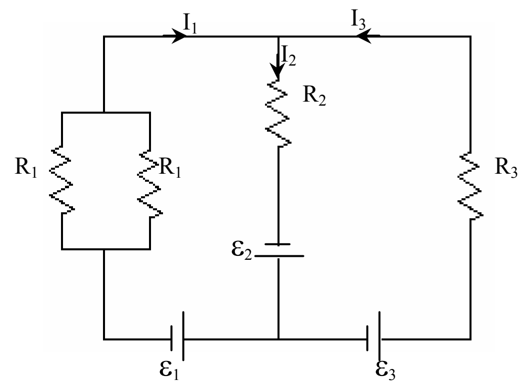

5. A very large horizontal insulating plane is uniformly & negatively charged. The magnitude of the electric field at 0.1m from the plane is $2.5 \times 10^5$ N/C. What is the surface charge density of the plane?
   a. $-3.2 \times 10^{-6}$ C/m$^2$
   b. $-3.5 \times 10^{-6}$ C/m$^2$
   c. $-3.9 \times 10^{-6}$ C/m$^2$
   d. $-4.1 \times 10^{-6}$ C/m$^2$
   e. $-4.4 \times 10^{-6}$ C/m$^2$

6. Which of the following equations is NOT a valid Kirchoff loop equation for the circuit?

✓ a. $\varepsilon_1 - \varepsilon_2 + I_2 R_2 + I_1 R_1 = 0$

b. $\varepsilon_1 + \varepsilon_3 - I_3 R_3 + \frac{1}{2} I_1 R_1 = 0$

c. $\varepsilon_2 + \varepsilon_3 - I_3 R_3 - I_2 R_2 = 0$




7. In a velocity selector, electric & magnetic fields are perpendicular to each other, & the electric & magnetic forces on a charged particle cancel if $\vec{E} + \vec{v} \times \vec{B} = 0$. Which of the following conditions on the direction of the velocity $\vec{v}$ can result in zero net force on the particle, assuming $\vec{E}$ & $\vec{B}$ are both non-zero?

a. $\vec{v}$ parallel to $\vec{E}$

b. $\vec{v}$ parallel to $\vec{B}$

✓ c. $\vec{v}$ parallel to $\vec{E} \times \vec{B}$

d. All of the above.

e. None of the above.

8. Many computer keyboard buttons are constructed of parallel – plate capacitors. When a key is pushed down, the soft insulator between the movable plate & the fixed plate is compressed. When a key is pressed down, the capacitance

✓ a. increases

b. decreases

c. remains the same

d. changes in a way that we cannot determine because the electric circuit connected to the keyboard may cause a change in a potential difference.

9. Consider two long, straight wires separated by 1m. In the figure below, the current through wire one is 1 A & is directed out of the plane of the page. Wire two is observed to be attracted toward wire one with a force per unit length of $2 \times 10^{-7}$ N/m. The current in wire two is

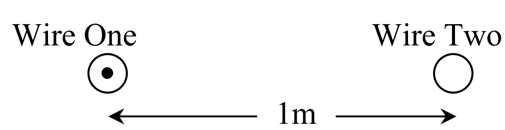
✓ a. 1 A out of page

b. 1 A into page

c. 2 A into page

d. 2 A out of page

e. 3 A out of page



10. Four long straight wires carry equal currents. The wires are parallel & pass through the corners of a square. The directions of the currents are shown in the figure. What is the direction of the net magnetic field at point P, the center of the square?

a. Toward the top of the page.
b. Toward the bottom of the page.
c. Toward the left.
✓d. Toward the right.
e. Out of the plane of the page.
f. Into the plane of the page.