Kuwait University **Physics Department**

Physics 102

First Mid Term Examination

March 22, 2007

11.00 am – 12.30 pm

Name..................................... **Student No...................**

Instructors: Drs. Abdel Karim, K. Bhatia, E. Davis, A. Farhan, Y. Kokay, P. Lajko, H. Manaa, M. Marafi, S. Razee, M. Sharma.

Note : The points for each problem are given on right margin. The conceptual questions carry 1 point each.

(Fundamental constants)

$k = \dfrac{1}{4\pi\varepsilon_o} = 9.0\times10^9\ N.m^2/C^2$	(Coulomb constant)
$\varepsilon_o = 8.85\times10^{-12}\ C^2/(N\ \ m^2)$	(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)

<u>Prefixes of units</u>

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

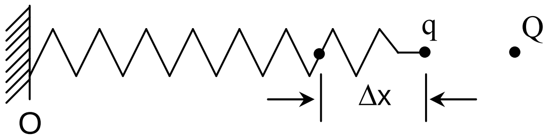
For use by Instructors only

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

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

1. A point charge q = 20μC is attached to a horizontal spring of 30cm length and spring constant k=10N/m. If a charge Q is placed at 50cm from the origin O the spring is stretched by Δx = 10cm. Calculate the charge Q. **3 Points**

   a. 0.55 nC
   b. 5.5×10^3 C
   c. 0.55 μC
   d. 180 μC
   e. 55 nC



Solution:

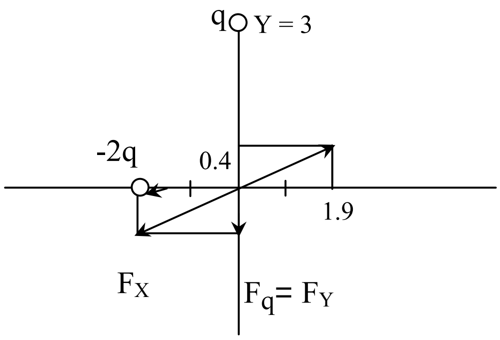
$$Kx = \frac{kQq}{(0.10\,m)^2}$$

$$10\text{ N/m}.(10^{-2}\,m) = \frac{(9\times10^9)(20\times10^{-6})}{(0.10\,m)^2}Q$$

$$Q = 5.5 \times 10^{-8}\text{C} = 55\text{ nC}$$

2. Two point charges –2q and q are placed at x = –2cm and y = 3cm axis as shown in fig. Calculate the x and y coordinates of a 3rd charge –2q so that the net electric field at origin is zero. **4 Points**

   a. x = 13.1cm, y = 0.81cm
   b. x = 1.9cm, y = 0.4cm
   c. x = 1.8cm, y = 1.9cm
   d. x = 0.1cm, y = 12.5cm
   e. x = 2cm, y = -3cm



Solution:

$$E_Y = \frac{k.2q}{(0.02)^2}$$

$$E_y = \frac{kq}{(0.03)^2}$$

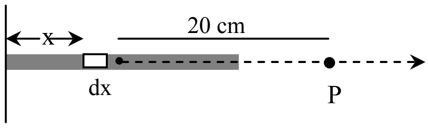
$$\vec{E} = -\frac{kq}{(0.03)^2}\hat{j} - \frac{2kq}{(0.02)^2}\hat{i} + \vec{E}_3 = 0$$

$$E_{3x} = \frac{2kq}{(0.02)^2} \qquad E_{3y} = \frac{kq}{(0.03)^2}$$

$$\rightarrow \frac{2kq}{r^3}x = \frac{2kq}{(0.02)^2} \qquad \frac{2kq}{r^3}y = \frac{kq}{(0.03)^2}$$

Solve to get x = 1.9 cm $\Rightarrow$ y = 0.4cm

3. A rod of 10 cm length has a uniform linear charge density of 20 μC/m. What is the force on a proton placed along the axis at a distance 20cm from the center of the rod? **4 Points**



a. 7.4×10^{-16} N

b. 8.4×10^{5} N

c. 7.7×10^{-14} N

d. 4.6×10^{3} N

e. 2.1×10^{5} N

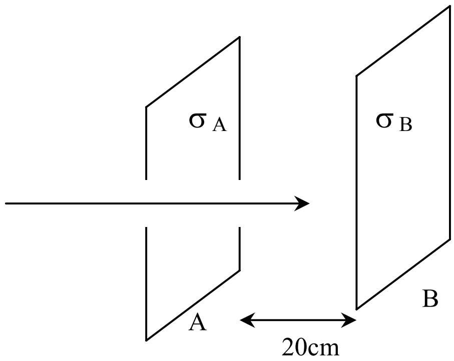
Solution:

$$E = k\lambda \int_0^{0.1} \frac{dx}{(0.25-x)^2}$$

$$F = qE = kq\lambda \left. \frac{1}{0.25-x} \right|_0^{0.10} = kq\lambda \left[\frac{1}{0.15} - \frac{1}{0.25} \right]$$

$$= 7.68 \times 10^{-14}\ N$$

4. An α particle ($m_\alpha = 4m_p$ and $q = +2e$) moving along x-axis enters region of electric field generated by two large non-conducting plates A and B with charge density $\sigma_A = 10\ \mu C/m^2$ and $\sigma_B = 30\ \mu C/m^2$. What is the minimum velocity for α particle to reach the plate B? Separation between the plates is 20cm. **4 Points**



a. 1.1×10^{6} m/s
b. 4.6×10^{6} m/s
c. 2.3×10^{6} m/s
d. 9.2×10^{6} m/s
e. 1.8×10^{6} m/s

Solution:

$$E = E_A - E_B$$
$$= \frac{\sigma_A}{2\varepsilon_o} - \frac{\sigma_B}{2\varepsilon_o}$$
$$= -1.13 \times 10^{6}\ N/C$$

$$a = \frac{(2e)E}{m_\alpha}$$

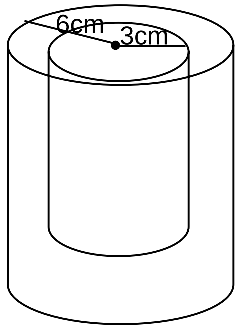
$$v_o^2 = 2a(0.2)$$

$$v_o = 4.6 \times 10^{6}\ m/s$$

5. Two long charged concentric cylinders have radii 3.0cm and 6.0cm. Outer cylinder is hollow. The charge per unit length on the inner cylinder is 5 μC/m and on the outer cylinder it is -7μC/m. The electric field at r=4 cm from the central axis is

3 Points

a. 3.2×10^6 N/C
b. 4.5×10^6 N/C
c. 1.2×10^6 N/C
d. 2.3×10^6 N/C
e. 6.6×10^6 N/C



Solution:

$$\oint EdA = \frac{q_{enc}}{\varepsilon_o}$$

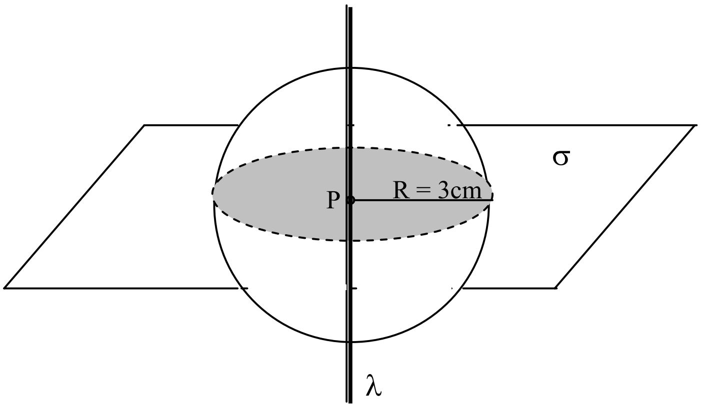
$$E\,(2\pi)\,(0.04\text{m})h = \frac{\lambda h}{\varepsilon_o}$$

$$E = \frac{5\times10^{-6}}{(2\pi)(0.04\text{m})\,8.85\times10^{-12}}$$

$$E = 2.3 \times 10^6 \text{ N/C}$$

6. A infinite vertical wire carrying a linear charge density $\lambda = -8$ nC/m intersects an infinite horizontal sheet, carrying surface charge with uniform density $\sigma = 1\,\mu$C/m , at point P. The sheet bisects a sphere that has the point P at its center. The flux through the surface of the sphere is:

3 Points



a. 2.65×10^2 Nm²/C
b. 2.82×10^{-3} Nm²/C
c. -4.8×10^3 Nm²/C
d. 3.5×10^5 Nm²/C
e. 1.4×10^{-12} Nm²/C

olution:

$Q_1 = \lambda L = \lambda.2R$

$Q_1 = -0.48\times10^{-9}$C

$$Q_2 = \sigma\, A = \sigma.\pi R^2$$

$$= 1\times\pi\,(0.03)^2\times10^{-6} = 2.8\times10^{-9}\,C$$

$$\phi = \frac{q_{encl}}{\varepsilon_0} = \frac{Q_1 + Q_2}{\varepsilon_o} = 2.65 \times 10^2 \text{ Nm}^2\text{/C}$$

7. In the figure below, if the work done in bringing a point charge of 300 μC from infinity to the point P is 13.5 J. What is the unknown point charge Q? q_1, q_2 are point charges.

3 Points

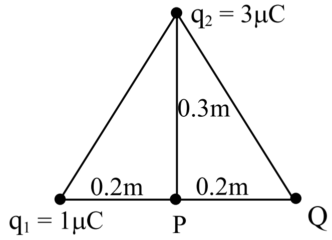
a. -1 μC

b. 1 μC

c. –2 μC

d. 3 μC

e. 2 μC



Solution:

$$k\left(\frac{q_1}{0.2}+\frac{q_2}{0.3}+\frac{Q}{0.2}\right)=V_P$$

$$qV_P = W$$

$$300\,\mu C\left(k\left(\frac{q_1}{0.2}+\frac{q_2}{0.3}+\frac{Q}{0.2}\right)\right)=13.5$$

Q = –2 μC

8. The electric field outside a charged long straight wire is given by $E = -\frac{500}{r}$ V/m, where r is perpendicular distance from the wire, and it is directed radially inward. Find the value $V_B - V_A$ if r_B = 60cm and r_A = 30 cm.

3 Points

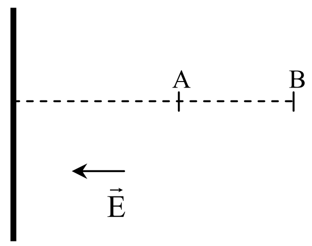
a. 347.0 V

b. 200.0 V

c. 407.3 V

d. –200 V

e. –347.0 V



Solution:

$$V_B - V_A = -\int_{r_B}^{r_A} \vec{E}\, d\vec{r}$$

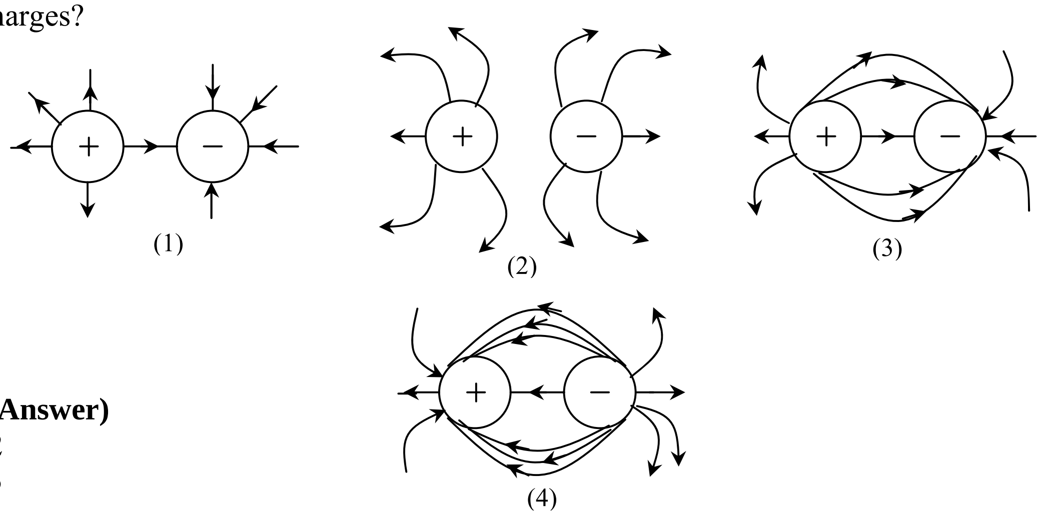
$$= 500\int_{0.3}^{0.6}\frac{1}{r}dr$$

$$=500\ \ln r\ \Big|_{0.3}^{0.6}$$

$$=346.6\ \text{V}$$

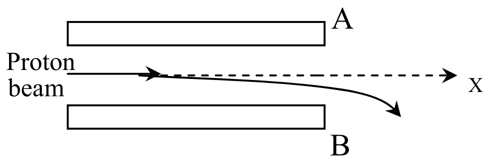
Conceptual Questions

1. In the figures shown, which represents the field lines due to two spheres with equal and opposite charges?



a. 1
b. 2
c. 3 **(Answer)**
d. 3 & 2
e. 1 & 3

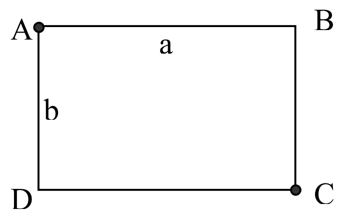
2. A beam of protons is deflected as it moves between oppositely charged parallel plates.



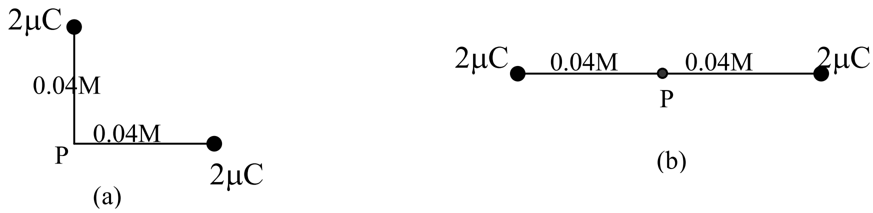
a. Both plates have the same potential.
b. The plate A is at higher potential then plate B. **(Answer)**
c. The plate B is at higher potential then the plate A.
d. The proton beam is accelerated in x direction.
e. The horizontal motion of the beam depends on the separation of plates A and B.

3. Two charges are located at the opposite corners (A and C) of a square. We do not know the magnitude or sign of these charges. What can be said about the potential at corner B relative to the potential at corner D?

a. It is the same as that at D.
b. It is different from that at D.
c. It is the same as that at D only if the charges at A and C are equal. **(Answer)**
d. It is the same as that at D only if the charges at A and C are equal in magnitude an opposite in sign.
e. Is the same if the charge located at A is 4 times smaller than the charge located at C.



4. Two positive 2μC point charges are placed as shown in part (a) of the figure. The distance from each charge to the point P is 0.04m. Then the charges are rearranged as shown in part (b) of the figure. Which statement is now true concerning $\vec{E}$ and V at point P?



a. The electric field and the electric potential are both zero.

b. $\vec{E} = 0$, but V is the same as before the charges were moved. **(Answer)**

c. $V = 0$, but $\vec{E}$ is the same as before the charges were moved.

d. $\vec{E}$ is the same before the charges were moved, but V is less than before.

e. Both $\vec{E}$ and V have changed and neither is zero.

5. The flux through the closed surfaces S_1, S_2, S_3, S_4 is:

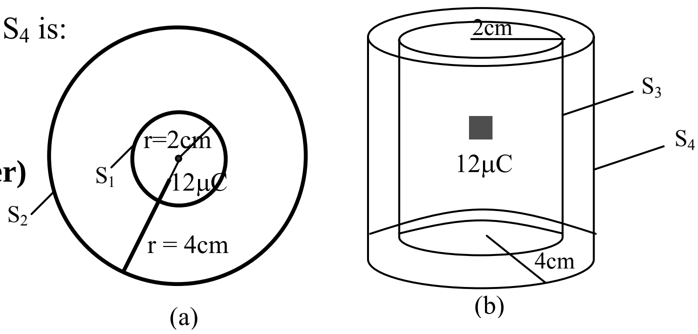
a. Through S_1 is biggest

b. Through S_2 is greater than through S_1

c. Through S_4 is biggest

d. Is the same through S_1, S_2, S_3, S_4. **(Answer)**

e. Through surface S_3 is smallest



6. The electric field at a point in space is a measure of

a. the total charge on an object at that point.

b. The electric force on any charged object at that point.

c. The charge-to-mass ratio of an object at that point.

d. The electric force per unit mass on a point charge at that point.

e. The electric force per unit charge on a point charge at that point. **(Answer)**

7. The correct unit for the electric field is:

a. $\frac{C}{N}$ b. $\frac{V}{m}$ **(Answer)** c. C/V d. $\frac{C^2}{V}$ e. CV

8. Two charge particles attract each other with a force of magnitude F acting on each. If the charge of one is doubled and the distance separating the particles is also doubled, the force acting on each of the two particles has magnitude.

a. F/2 **(Answer)** b. F/4 c. F d. 2F e. 4F