University of Bahrain
College of Science
Department of Physics

PHYCS 102
Test (1)

Time: 11:00 – 11:50 am

Date: 20^{th} March 2001

Name:---ID#--------------------------
Sec:-------------

Qts	Marks	
1		
2		
3		
4		____ 10
Total	100	

Important data:

$e^- = e^+ = 1.6 \times 10^{-19} C$

$m_e = 9.11 \times 10^{-31} kg$

$m_p = 1.67 \times 10^{-27}$ kg

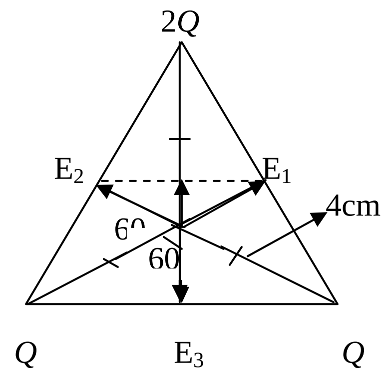
$g = 10 \; m/s^2$

$k = \frac{1}{4\pi\varepsilon_o} = 9 \times 10^9 \; \frac{Nm^2}{C^2}$

Q1. Three charges are located at the corners of an equilateral triangle as shown in the figure. The electric field at the central point (a) is 2.5×10^3 N/C. Compute the following:

a) the value of (Q)

b) the electrical potential at point (a).



a)

$$E_1 = E_2 = K\frac{Q}{(0.04)^2}$$

$$E_3 = k\frac{2Q}{(0.04)^2}$$

$$E_T = 2.5 \text{ x} 10^3 = K\frac{2Q}{(0.04)^2} - 2\left(K\frac{Q}{(0.04)^2}\right)\cos 60$$

$$= K\frac{Q}{(0.04)^2} \quad \therefore Q = 4.44 \text{ x } 10^{-10} C$$

b)

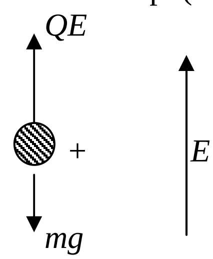
$$V_a = K\frac{Q}{0.04} + K\frac{Q}{0.04} + K\frac{2Q}{0.04}$$

$$= 4K\frac{Q}{0.04} = 399.6V$$

Q2. An oil drop of charge *Q* and mass 0.1g is hanging at rest in an upward electric field E = 2000 N/C.

a) Calculate *Q* (magnitude and sign)

b) If E is increased to 3000 N/C find the acceleration of the drop. (Consider the motion in the vacuum).



a) $mg = QE$

$Q = 0.5 \times 10^{-6} c$

b) $\Sigma F = QE - mg = ma$

$= (0.5 \times 10^{-6})(3000) - 0.1 \times 10^{-3} \times 10 = ma$

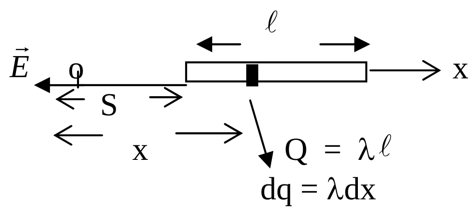
$a = 5 \text{ m/s}^2$

Q3. A rod of length ℓ carrying (Q) is laying on the x-axis as shown in figure (a).

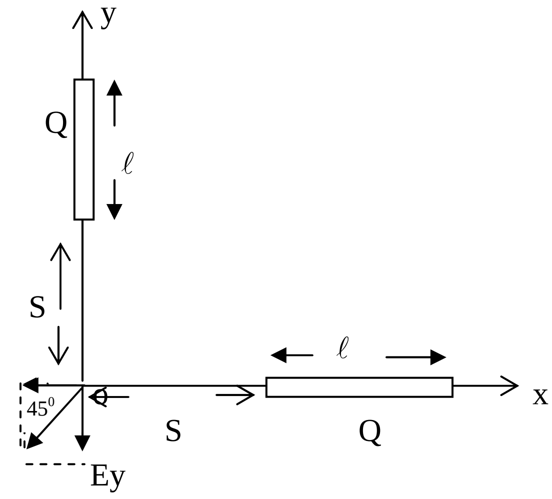
a. Show that the electric field at point O is given by:

$$E = \frac{-Q}{4\pi\varepsilon_o \; d(\ell + d)} \vec{i}$$

b. If an identical rod is placed along the y-axis as shown in figure (b). Find the magnitude and direction of the resultant electric field at point O.



(a)



(b)

a. $$dE = K\frac{\lambda \; dx}{x^2} \;\therefore\; \vec{E} = \left(-\vec{i}\right)\int_S^{S+\ell} K\lambda \frac{dx}{x^2} = \frac{KQ}{S(\ell + S)}\left(-\vec{i}\right)$$

b. $$E_x = Ey \;\;\therefore\;\; E_{res} = \sqrt{E_x^2 + Ey^2} = \sqrt{2}\;\; Ex$$

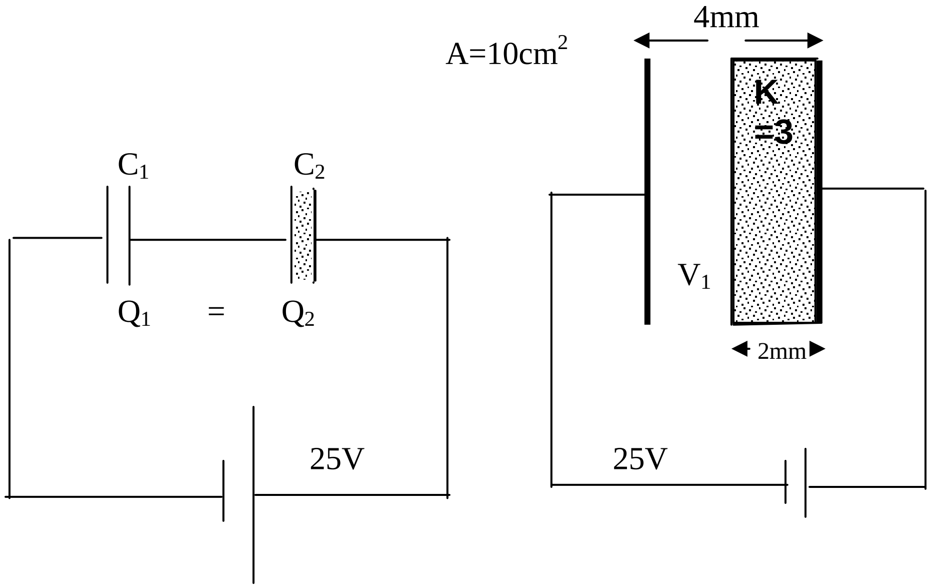
$$= \sqrt{2}\;\; \frac{KQ}{S(\ell + S)}$$

$\vec{E}$ makes 225^o with + x direction.

Q4. A parallel plate capacitor is half filled with a slab of dielectric constant K=3 as shown in the figure below. A voltage of 25 Volts is applied across the capacitor.

a. Find the equivalent capacitance.

b. Find V_1 and V_2 and the charge on each plate.



a.
$$C_1 = \frac{\varepsilon_o A}{d} = \frac{8.85 \text{ x } 10^{-12} \text{ x } 10 \text{ x } 10^{-4}}{2 \text{ x } 10^{-3}} = 4.425 \text{ pF}$$

$$C_2 = K\frac{\varepsilon_o A}{d} = 13.275 \text{ pF}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = 3.318 \text{ pF}$$

b. $Q_1 = Q_2 = Q = C_{eq} \text{ x } 25 = 82.96$ pc

$$V_1 = \frac{Q_1}{C_1} = 18.748 \text{ V}$$

$$V_2 = \frac{Q_2}{C_2} = 6.249 \text{ V}$$

Q4. An infinitely long coaxial cylinders of length L and radii a and b are shown in the figure below. The inner cylinder is an insulator and carrying a charge per unit volume ρ ($\rho = q_a/V_a$). The outer cylinder is a thin conductor and carries a charge per unit length λ ($\lambda = q/L$).

Show that:

a) The electric field at a point inside the insulating cylinder, a distance r from the origin is given by:

$$E = \frac{\rho\, r}{2\varepsilon_o}$$

b) The electric field at a point outside the configuration at a distance R from the center is given by:

$$E = \frac{\lambda + \pi a^2 \rho}{2\pi \varepsilon_o R}$$