X1.5a **1150**

PHYS-1150(5) (Kaldon-40527) **Name** S O L U T I O N

WMU - Fall 2006

Exam 1A - 100,000 points **Book Title** ______

Rev. 09/27/06 Tu.6

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Short Answers Should Be Short! – Feel Free to Ask Any Questions

EXAM 1 [FORM - A]

PHYS-1150 (KALDON-5)

FALL 2006

WMU

$k = 8.988 \times 10^{9}\ N \cdot m^2 / C^2$

$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2 / N \cdot m^2$

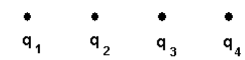
$e = 1.602 \times 10^{-19}\ C$

An electron walks into a bar and asks for a drink. He gets it and is charged \$5. A proton comes into the bar and he pays \$5 for a drink. A neutron walks in, asks for a drink, but when the bartender gives it to him, never asks for any money. When the neutron walks out, the electron and the proton are upset. "How come he didn't have to pay?" "Yeah!" "That guy? He's a neutron – no charge."

I love this joke!

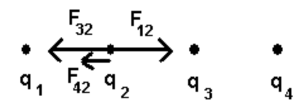
If Three Charges Are Good, Then Four Are Better (50,000 points)

1.) Four identical 15.0 nC (= +15.0 × 10 $^{-9}$ C) charges, q_1, q_2, q_3 and q_4, are equally spaced apart by a distance of 5.00 cm each. Find the total electric force, $\vec{F}_E$, acting on q_2. *If you are clever, you don't have to work so hard.*



By Symmetry,

$$\vec{F}_{12} + \vec{F}_{32} = 0 \quad ; r = 10.0cm = 0.100m$$
$$\vec{F}_E = \vec{F}_{12} + \vec{F}_{32} + \vec{F}_{42} = \vec{F}_{42}$$
$$F_{42} = \frac{kq_2q_4}{r^2} = \frac{kq^2}{r^2}$$
$$= \frac{\left(8.988 \times 10^{9}\ {}^{N \cdot m^2}/_{C^2}\right)\left(15.0 \times 10^{-9}\ C\right)^2}{(0.100m)^2}$$
$$= 0.0002022N = 2.022 \times 10^{-4}\ N$$
$$\vec{F}_{42} = -2.022 \times 10^{-4}\ N\hat{i} = 2.022 \times 10^{-4}\ N@180.0°$$



(b) If instead of +15.0 nC, what charge would q_4 have to have if the total electric field, $\vec{E}$, acting on q_1 is zero?

$$E_2 = \frac{kq_2}{r^2} = \frac{\left(8.988\times10^9\ {}^{N\cdot m^2}/_{C^2}\right)\left(15.0\times10^{-9}\,C\right)}{\left(0.0500m\right)^2} = 53{,}930N/C$$

$$E_3 = \frac{kq_3}{r^2} = \frac{\left(8.988\times10^9\ {}^{N\cdot m^2}/_{C^2}\right)\left(15.0\times10^{-9}\,C\right)}{\left(0.100m\right)^2} = 13{,}480N/C$$

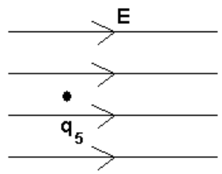
$$E_4 = -\left(E_2+E_3\right) = -\left(53{,}930N/C + 13{,}480N/C\right) = -67{,}410N/C$$

$$E_4 = \frac{kq_4}{r^2}$$

$$q_4 = \frac{E_4 r^2}{k} = \frac{\left(-67{,}410N/C\right)\left(0.150m\right)^2}{\left(8.988\times10^9\ {}^{N\cdot m^2}/_{C^2}\right)} = -1.688\times10^{-7}\,C = -168.8nC$$

You can put the negative sign in by hand – since q_2 and q_3 are both positive charges, q_4 has to be negative for $E_{total} = 0$.

A single charge $q_5 = -72.5\times10^{-9}\,C$ and mass $m = 0.0135\,kg$, sits in a constant electric field $\vec{E} = +1190N/C\,\hat{i}$. Find (c) the electric force vector, $\vec{F}_E$, and (d) the acceleration in the *x*-direction, a_x .



(c)

$$\vec{F}_E = q\vec{E}$$

$$F_E = qE = \left(-72.5\times10^{-9}\,C\right)\left(1190N/C\right) = -0.00008628N = -8.628\times10^{-5}\,N$$

(d)

$$F_x = ma_x$$

$$a_x = \frac{F_x}{m} = \frac{-8.628\times10^{-5}\,N}{0.0135kg} = -0.006391m/s^2$$

(e) Find the number of electrons *added* or *subtracted* which would be needed to neutralize q_5.

$$q = \pm Ne$$

$$N = \frac{q}{e} = \frac{-72.5\times10^{-9}\,C}{1.602\times10^{-19}\,C} = -452{,}600{,}000{,}000$$

Since the charge is negative, we have to SUBTRACT or REMOVE 452,600,000,000 electrons to neutralize q_3

A Capital Capacitance Experience (50,000 points) *If you don't get an answer to (a), use C = 621 pF.*

2.) A parallel plate capacitor consists of two metal plates, each *0.0700 m* wide by *0.124 m* long, with a gap $d = 1.15\ mm$. (a) Calculate the capacitance, C, of this capacitor. $\varepsilon_0 = 8.85\times10^{-12}\ F/m$

$$A = (0.0700m)(0.124m) = 0.008680m^2$$
$$C = \varepsilon_0 \frac{A}{d} = \left(8.85\times10^{-12}\ F/m\right)\frac{(0.008680m^2)}{(0.00115m)}$$
$$= 6.680\times10^{-11}\ F = 66.80\ pF$$

(b) Find the charge $\pm Q$ on the plates with $\Delta V = 555$ volts.

$$C = \frac{Q}{V}$$
$$Q = CV = \left(6.680\times10^{-11}F\right)(555volts)$$
$$= 3.707\times10^{-8}\ C$$

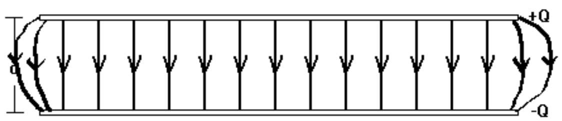
(c) Find the strength of the E-field between the plates with $\Delta V = 555$ volts.

$$V = Ed$$
$$E = \frac{V}{d} = \frac{555volts}{0.00115m} = 482{,}600V/m$$

OR

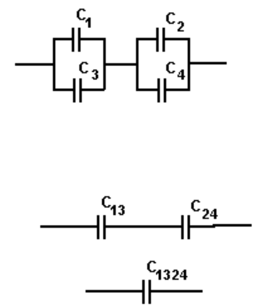
$$\sigma = \frac{Q}{A} = \frac{3.707\times10^{-8}C}{0.008680m^2}$$
$$= 0.000004271C/m^2 = 4.271\times10^{-6}C/m^2$$
$$E = \frac{\sigma}{\varepsilon_0} = \frac{4.271\times10^{-6}C/m^2}{8.85\times10^{-12}F/m} = 482{,}500V/m$$

(d) Sketch the E-field for this capacitor, both in between the plates and include a couple of field lines "at the edges".

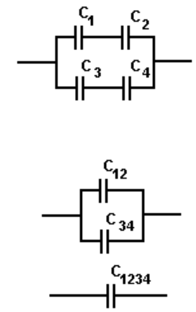


(e) Four of our capacitors are connected together as shown in two configurations, A and B. Find the equivalent capacitance, C_{eq} , of each arrangement. Are they the same? If not, which is bigger, A or B ?

A



B



A

$$C_{eq} = C + C = 2C$$
$$\frac{1}{C_{eq}} = \frac{1}{2C} + \frac{1}{2C} = \frac{2}{2C} = \frac{1}{C}$$
$$C_{eq} = C = 66.80pF$$

B

$$\frac{1}{C_{eq}} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}$$
$$C_{eq} = \frac{C}{2}$$
$$C_{eq} = \frac{C}{2} + \frac{C}{2} = C = 66.80pF$$

A and B are the SAME

(but only because all the capacitors are the same)