X1.6a **1150**

PHYS-1150(6) (Kaldon-40451) Name ______S O L U T I O N__________

WMU - Fall 2007

Exam 1A - 100,000 points Book Title ____

Rev. 09/26/07 We.4.corr.1

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-6)

FALL 2007

WMU

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

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

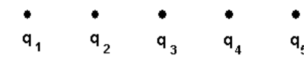
$e = 1.602 \times 10^{-19} \ C$

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!

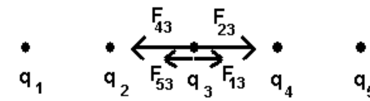
Four or Five to One (50,000 points)

1.) Five identical 15.0 nC (= +15.0 × 10^{-9} C) charges, q_1, q_2, q_3, q_4 and q_5, are equally spaced apart by a distance of 5.00 cm each. Find the total electric force, $\vec{F}_E$, acting on q_3. *If you are clever, you don't have to work so hard.*

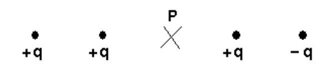


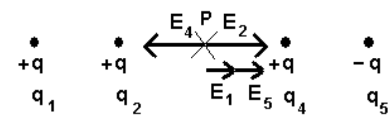
By Symmetry,

$$\vec{F}_{13} + \vec{F}_{53} = 0 \ ; \ \vec{F}_{23} + \vec{F}_{43} = 0$$
$$\vec{F}_E = \vec{F}_{13} + \vec{F}_{53} + \vec{F}_{23} + \vec{F}_{43} = 0$$



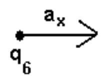
(b) New problem, with four charges of ±15.0 nC as shown. Find the total electric field, $\vec{E}$, at the point P in the center. *Take advantage of all the symmetry and geometry given to simplify the problem if you can. The distances are the same as in (a).*





$$\vec{E}_2 + \vec{E}_4 = 0$$
$$\vec{E}_1 + \vec{E}_5 = 2\vec{E}_1 \ ; \ r = 2(0.0500m) = 0.1000m$$
$$E_1 = \frac{kq_1}{r^2}$$
$$= \frac{(8.988 \times 10^9 \ N \cdot m^2 / C^2)(15.0 \times 10^{-9} C)}{(0.1000m)^2}$$
$$= 13{,}480 N / C$$
$$E_{total} = 2E_1 = 2(13{,}480 N / C) = 26{,}960 N / C$$
$$\vec{E} = 26{,}960 N / C \ @ \ 0° = 26{,}960 N / C \text{ to the right}$$

A single charge $q_6 = -92.5 \times 10^{-9}\ C$ and mass $m = 0.0135\ kg$, accelerates to the right with $a_x = +1.25\ m/s^2$ due to the force from a constant electric field. Find (c) the magnitude of the electric force F_E and (d) the magnitude and direction of the constant electric field vector $\vec{E}$.



(c)
$$\begin{aligned} F_E &= F_x = ma_x \\ &= (0.0135kg)(1.25m/s^2) \\ &= 0.01688N \end{aligned}$$

(d)
$$\begin{aligned} \vec{F}_E &= q\vec{E} \\ F_E &= qE_x \\ E_x &= \frac{F_E}{q} = \frac{0.01688N}{-92.5\times10^{-9}C} \\ &= -182{,}500N/C \\ \vec{E} &= 182{,}500N/C @ 180° = 182{,}500N/C \text{ to the left} \end{aligned}$$

(e) Find the number of electrons *added* or *subtracted* to a neutral object to make q_6.

$$\begin{aligned} q &= \pm Ne \\ N &= -\frac{q}{e} = -\frac{-92.5\times10^{-9}C}{1.602\times10^{-19}C} = +577{,}400{,}000{,}000 \end{aligned}$$

Since the charge is negative, we have to ADD 577,400,000,000 electrons to a neutral object to make q_6

Wet-and-Dry Capacitors (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 $0.0900\ m$ wide by $0.124\ m$ long, with a gap $d = 1.15\ mm$. (a) Calculate the capacitance, C, of this capacitor. $\varepsilon_0 = 8.85\times10^{-12}\ F/m$

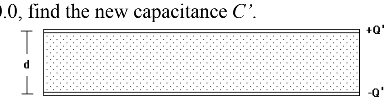
$$\begin{aligned} A &= (0.0900m)(0.124m) = 0.01116m^2 \\ C &= \varepsilon_0 \frac{A}{d} = (8.85\times10^{-12}F/m)\frac{(0.01116m^2)}{(0.00115m)} \\ &= 8.588\times10^{-11}F = 85.88pF \end{aligned}$$

(b) Find the charge $\pm Q$ on the plates and the magnitude of the electric field E with $\Delta V = 555$ volts.

$$\begin{aligned} C &= \frac{Q}{V} \\ Q &= CV = (8.588\times10^{-11}F)(555volts) \\ &= 4.766\times10^{-8}C \end{aligned}$$

$$\begin{aligned} V &= Ed \\ E &= \frac{V}{d} = \frac{555volts}{0.00115m} \\ &= 486{,}600V/m = 4.866\times10^5 N/C \end{aligned}$$

(c) If the capacitor is later filled with pure distilled water, $\kappa = 80.0$, find the new capacitance C'.



$$\begin{aligned} C &= \kappa\varepsilon_0 \frac{A}{d} = (80.0)(8.85\times10^{-12}F/m)\frac{(0.01116m^2)}{(0.00115m)} \\ &= \kappa C_0 = (80.0)(8.588\times10^{-11}F) \\ &= 6.870\times10^{-9}F = 6870pF \end{aligned}$$

Dr. Phil said that the equations for series and parallel capacitors are *extendible*. Consider taking 60 capacitors, each with $C = 621\ pF$. Find the equivalent capacitance when you put these 60 capacitors (d) in series and (e) in parallel. *Do NOT write all sixty-plus terms in the equations.*

(d) SERIES
$$\begin{aligned} C_{eq} &= C_1 + C_2 + \ldots \\ \frac{1}{C_{eq}} &= \frac{1}{C_1} + \frac{1}{C_2} + \ldots = \frac{60}{C_1} \\ C_{eq} &= \frac{C_1}{60} = \frac{621pF}{60} = 10.35pF \end{aligned}$$

(e) PARALLEL
$$\begin{aligned} C_{eq} &= C_1 + C_2 + \ldots \\ &= 60(C_1) = 60(621pF) \\ &= 37{,}260pF \end{aligned}$$