X1.4a **115**

PHYS-115(4) (Kaldon-26364) Name S O L U T I O N

WMU - Spring 2005

Exam 1A - 100,000 points Book Title ______________________

Rev. 02/02/05 We.A5

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-115 (KALDON-4)

SPRING 2005

WMU

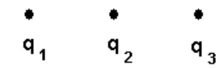
Presidential Inaugurations, State of the Union Speech, Big Winter Storms, and Super Bowl Sunday…

First 115 Physics exam? (with cookies).
Priceless.

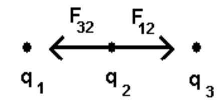
And It's Only Just February!

This Story Has To Have a Point (50,000 points)

1.) Three identical 15.0 nC (= 15.0×10^{-9} C) charges, q_1, q_2 and q_3, are equally spaced apart by a distance of 5.00 cm each. Find the total electric force, $\vec{F}_E$, acting on q_2 in the center.

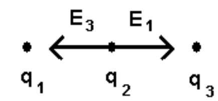


$$\text{By Symmetry, } \vec{F}_E = \vec{F}_{12} + \vec{F}_{32} = 0$$



(b) Find the total electric field, $\vec{E}$, acting on q_2 in the center from the other two charges.

$$\text{By Symmetry, } \vec{E} = \vec{E}_1 + \vec{E}_3 = 0$$



(c) Find the total electric potential V acting on q_2 in the center from the other two charges.

$$d = 5.00cm = 0.0500m$$

$$V = \frac{kq}{r}$$

$$V = V_1 + V_3 = \frac{kq}{d} + \frac{kq}{d} = \frac{2kq}{d}$$

$$= \frac{2\left(8.988 \times 10^9 \ {}^{N \cdot m^2}/_{C^2}\right)\left(15.0 \times 10^{-9} C\right)}{(0.0500m)} = 5393 volts$$

(d) Find the number of electrons *added* or *subtracted* to make q_2.

$$Q = \pm Ne \quad ; \quad q = +Ne$$

$$N = \frac{15.0 \times 10^{-9} C}{1.602 \times 10^{-19} C} = 93{,}630{,}000{,}000 \, electrons \, subtracted$$

(e) An electron is located a long way (1.00 meter to the right) from q_2 in the center from the other two charges. Find the initial magnitude and direction of the electron's acceleration. $m_e = 9.11 \times 10^{-31}\ kg$

$$F_E = \frac{kq_1q_2}{r^2}$$
$$= \frac{\left(8.988\times10^9\ {}^{N\cdot m^2}\!/\!{}_{C^2}\right)(3)\left(15.0\times10^{-9}C\right)\left(1.602\times10^{-19}C\right)}{(1.00m)^2}$$
$$= 6.480\times10^{-17}N$$
$$F_E = ma$$
$$a = \frac{F_E}{m} = \frac{6.480\times10^{-17}N}{9.11\times10^{-31}kg} = 7.113\times10^{13}m/s^2$$

Nonpareil Parallels (50,000 points)

2.) A parallel plate capacitor consists of two metal plates, each *5.00 cm* wide by *10.0 cm* long, with a gap $d = 2.00\ mm$. The space between the plates is filled with silicone oil (dielectric constant $\kappa = 2.50$ and dielectric strength $15.0 \times 10^6\ V/m$). (a) Calculate the capacitance, C, of this capacitor. $\varepsilon_0 = 8.85\times10^{-12}\ F/m$

$$A = (0.0500m)(0.100m) = \left(0.00500m^2\right)$$
$$C = \kappa\varepsilon_0\frac{A}{d} = (2.50)\left(8.85\times10^{-12}F/m\right)\frac{\left(0.00500m^2\right)}{(0.00200m)}$$
$$= 5.531\times10^{-11}F = 55.31pF$$

(b) Show that you can safely charge this capacitor with ΔV = 25,000 volts.

$$\Delta V = Ed$$
$$E = \frac{\Delta V}{d} = \frac{25{,}000volts}{0.00200m}$$
$$= 12{,}500{,}000V/m < 15{,}000{,}000V/m = E_{max}$$

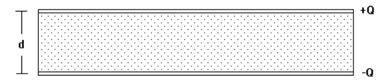
– OR –

$$\Delta V = Ed$$
$$V_{max} = E_{max}d = (15{,}000{,}000V/m)(0.00200m)$$
$$= 30{,}000volts$$
$$So\ldots\ 25{,}000volts < V_{max}$$

(c) Find the charge $\pm Q$ on the plates with ΔV = 25,000 volts. *If you didn't get an answer to (a), use C = 621 pF.*

$$C = \frac{Q}{V}$$
$$Q = CV = \left(5.531\times10^{-11}F\right)(25{,}000volts) = 1.383\times10^{-6}C = 1{,}383{,}000pC$$

(d) Use Gauss' Law to find the magnitude of the electric field between the plates. Because of the dielectric silicone oil between the plates, you'll have to multiply ε_0 by κ in the Gauss' Law equation.



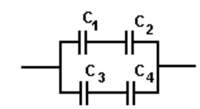
Note: You do NOT get a factor of 2, because E-field is only between the plates, not on the outside.

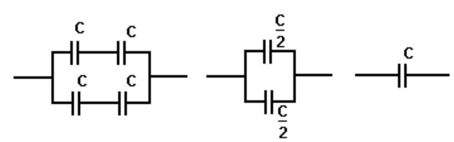
$$\sigma = \frac{Q}{A} = \frac{1.383\times10^{-6}C}{(0.005000m)^2} = 0.0002766C/m^2 = 2.766\times10^{-4}C/m^2$$
$$\Phi_E = EA = \frac{q_{inside}}{\kappa\varepsilon_0} = \frac{\sigma A}{\kappa\varepsilon_0}$$
$$E = \frac{\sigma}{\kappa\varepsilon_0} = \frac{0.0002766C/m^2}{(2.50)\left(8.85\times10^{-12}\ {}^{C^2}\!/\!{}_{N\cdot m^2}\right)} = 12{,}500{,}000N/C$$

This is the SAME answer as in part (b).

(e) Four of our capacitors are connected together as shown. Find the equivalent capacitance, C_{eq}, of this arrangement.

If you didn't get an answer to (a), use C = 621 pF.





$$Series\ \frac{1}{C_{eq}} = \frac{1}{C}+\frac{1}{C} = \frac{2}{C}\ ;\ C_{eq} = \frac{C}{2}$$
$$Parallel\ C_{eq} = \frac{C}{2}+\frac{C}{2} = C$$
$$So\ for\ the\ circuit,\ C_{eq} = C = 55.31pF$$