# *Physics 111 Homework Solutions Week #3 - Wednesday*

## *Friday, January 17, 2014*

***Chapter 15***

***Questions***

- None

***Multiple-Choice***

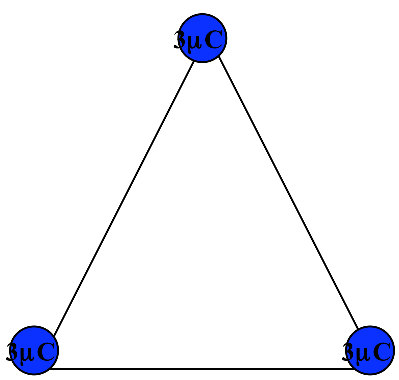
15.8 D

15.9 B

***Problems***

15.1 The equilateral triangle is given as shown. The potential energy is given by the equation $PE_{1,2} = \frac{kQ_1Q_2}{r}$. Substituting the values given, we find the

$$PE_{total} = 3 \times PE_{1,2} = 3 \times \frac{\left(9 \times 10^9 \, \frac{\text{Nm}^2}{\text{C}^2}\right)\left(3 \times 10^{-6}\text{C}\right)^2}{0.05\text{m}} = 4.86\text{J}.$$




15.4 The relation between electric field and electric potential

a. To calculate the potential at any position x, knowing the other position and potential we use the general relation

$$E = -\frac{\Delta V}{\Delta x} \rightarrow 10\,\tfrac{V}{m} = -\frac{\left(V_f - (-15V)\right)}{10m - 0m} \rightarrow V_f = -115V.$$

b. The potential is zero at infinity and also at a distance x given by

$$E = -\frac{\Delta V}{\Delta x} \rightarrow 10\,\tfrac{V}{m} = -\frac{(0-15)V}{x_f - 0m} \rightarrow x = -1.5m.$$

## *Monday, January 20, 2014*

***Chapter 15***

***Questions***

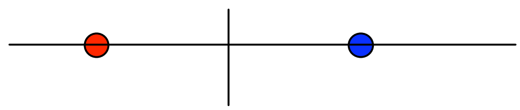
- None

***Multiple-Choice***

15.12 C
15.13 D
15.17 D
15.18 A

***Problems***

15.3 Electric Potential



a. $V = \sum \frac{kQ}{r}$ and since equal and opposite charges are equally distant from the observation point at the origin, the two terms add up to zero – remember these are just + and – numbers, not vectors

b. The electric fields from each charge do not cancel, but both point in the same direction (to the left) since the force from both charges on a positive test charge at the origin is to the left. Adding these up gives $E = 2\frac{kQ}{x^2}$, where Q = 10 μC and x = 0.1 m, so E = 1.8 x $10^7$ N/C, pointing to the left.

c. Since the potential at the origin is V = 0, as it is at infinity (very far away), then there is no change in V for the third charge and therefore no net work is required.

Repeating for two positive charges:

a. $V = \frac{2kQ}{r} = 1.8 \times 10^6 V$;

b. In this case E = 0 since the E fields from each charge point in opposite directions and now cancel;

c. The net work required is QΔV = -18 J or 18J by an external force.

15.12 The capacitance is given by

$C = \frac{\kappa \varepsilon_0 A}{d} = \frac{1 \times 8.85 \times 10^{-12} \frac{C^2}{Nm^2} \times \left( 25mi^2 \times \left( \frac{1600m}{1mi} \right)^2 \right)}{1mi \times \frac{1600m}{1mi}} = 3.54 \times 10^{-7} F$ The charge stored is given by $Q = CV = 3.54 \times 10^{-7} F \times 50 \times 10^6 V = 17.7C$. Finally, the energy stored is given as

$E = \frac{1}{2} CV^2 = \frac{1}{2} \times 3.54 \times 10^{-7} F \times \left( 50 \times 10^6 V \right)^2 = 4.43 \times 10^8 J = 443MJ$

15.17 An air-spaced parallel plate capacitor

a. C = Q/V = 36 μC/12 V = 3 μF

b. The dielectric constant of Pyrex glass is 4.7 (from Table 16.1), so $C = \kappa C_o$ = 14.1 μF

c. Since the capacitance has increased by a factor of 4.7 and V is the same, then Q increases by the same factor to Q = 169 μC.

15.22 The charge that flows due to the sodium ions is

$$Q = \frac{50\text{channels}}{1\mu m^2} \times 100\mu m^2 \times \frac{1000\text{Na}^{+1}\text{ion}}{1\text{channel}} \times \frac{1.6\times10^{-19}C}{\text{Na}^{+1}\text{ion}} = 8.0\times10^{-13}C.$$

The specific capacitance can be related to the capacitance through

$$C = \left(\frac{C}{A}\right)A = \frac{1\times10^{-6}F}{1cm^2\times\left(\frac{1m}{100cm}\right)^2} \times 1000\mu m^2 \times \left(\frac{1m}{1\times10^6\mu m}\right)^2 = 1.0\times10^{-12}F.$$

Therefore the voltage change across the membrane due to the ion flow is given by

$$Q = CV \rightarrow \Delta V = \frac{\Delta Q}{C} - 100mV = \frac{8.0\times10^{-13}C}{1.0\times10^{-12}F} - 100mV = 0.8V - 100mV = 700mV.$$

15.23 The energy in a charged capacitor is given by

$$E = \tfrac{1}{2}CV^2 \rightarrow V = \sqrt{\frac{2E}{C}} = \sqrt{\frac{2\times300J}{30\times10^{-6}F}} = 4470V$$