

Physics 111 Homework Solutions Week #1 - Friday

Tuesday, January 7, 2014

Chapter 14

Questions

- 14.1 We have an initial charge of $+15 e^-$ and when we remove 20 protons, the charge decreases to $-5 e^-$. Then removing $5 e^-$ makes the system neutral with a charge of $0 e^-$.
- 14.2 Since both the charge and mass has to be conserved we have ${}_{81}^{127}X \rightarrow {}_{-1}^0e + {}_{82}^{127}Y$. Thus there are 82 protons in the nucleus (we converted a neutron from the original nucleus into a proton) and $127 - 82 = 45$ neutrons in the nucleus.

Multiple-Choice

- 14.9 C

Problems

1.

The number of e^- is given by :

$$\frac{1e^-}{1.6 \times 10^{-19} C} \times 1C = 6.25 \times 10^{18} e^-.$$

The mass of these e^- is given by :

$$\frac{9.11 \times 10^{-31} \text{kg}}{e^-} \times 6.25 \times 10^{18} e^- = 5.69 \times 10^{-12} \text{kg}.$$

2.

The number of e^- is roughly given by :

$$\frac{1}{2} \left[\frac{M_{\text{Earth}}}{2M_{\text{proton}}} \right] = 9 \times 10^{50} e^-.$$

Wednesday, January 8, 2014

Chapter 14

Questions

- 14.3 If an equal magnitude charge is placed at the midpoint between two other charges (whether those charges are positive or negative) the charge at the midpoint is in stable equilibrium since the forces on this charge are equal in magnitude and oppositely directed. If the two charges are positive and the third charge is also positive and is displaced slightly to one side along the line jointing the two positive charges the third charge will oscillate back and forth exactly as a mass on a spring. If the third charge has an opposite sign and the charge is displaced to one side it will continue to move toward the charge to which it was displaced. If all charges are positive and the midpoint charge is displaced off of the line perpendicular to the line the displaced

charge will move away to infinity. If the midpoint charge is of opposite charge and is displaced off of the line perpendicular to the line the displaced charge will oscillate about the line joining the two charges exactly like a mass on a spring.

14.4 Coulomb's Law

- Of the distance between the charges is doubled the force decreases by a factor of 4.
- If the charge of one is halved the force decreases by a factor of 2.
- If the sign of both charges were changed nothing happens to the magnitude or direction of the force.
- If the sign of one of the charges were changed nothing happens to the magnitude but the direction of the force reverses.
- If the distance between the charges are doubled and one of the charges is halved then the force decreases by a factor of 8.

Multiple-Choice

14.2 B

Problems

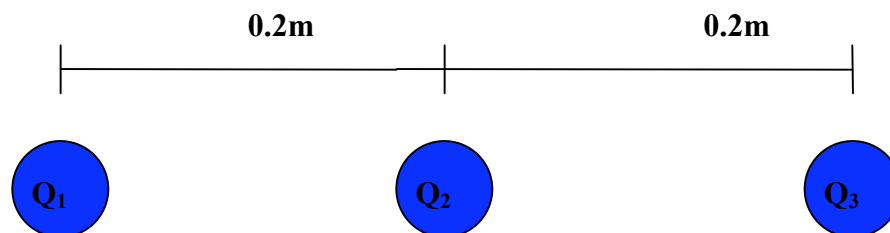
14.3 We equate the weight of a proton to the electrostatic force. We have

$$m_p g = \frac{ke^2}{r^2} \rightarrow r = \sqrt{\frac{ke^2}{m_p g}} = \sqrt{\frac{9 \times 10^9 \frac{Nm^2}{C^2} \times (1.6 \times 10^{-19} C)^2}{1.67 \times 10^{-27} kg \times 9.8 \frac{m}{s^2}}} = 0.12m$$

14.5 The centripetal force is given by Coulomb's Law and we have

$$\frac{ke^2}{r^2} = m_e \frac{v^2}{r} \rightarrow v = \sqrt{\frac{ke^2}{m_e r}} = \sqrt{\frac{9 \times 10^9 \frac{Nm^2}{C^2} \times (1.6 \times 10^{-19} C)^2}{9.11 \times 10^{-31} kg \times 0.53 \times 10^{-10} m}} = 2.2 \times 10^6 \frac{m}{s}$$

14.9. The forces on each charge are the vector sum of all of the forces on a charge due to the other charges separately. The magnitudes of the forces are given by Coulomb's law and the directions are obtained from the diagram.

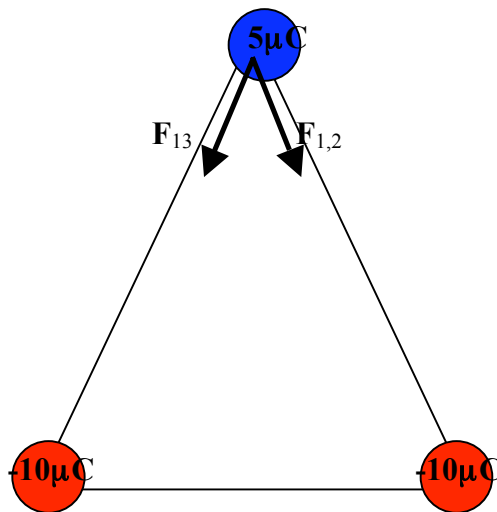


$$\begin{aligned}\vec{F}_{net,1} &= \vec{F}_{1,2} + \vec{F}_{1,3} = \left(-k \frac{Q_1 Q_2}{r_{1,2}^2} - k \frac{Q_1 Q_3}{r_{1,3}^2} \right) \hat{i} \\ &= -\left(9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2} \right) \left(2 \times 10^{-6} \text{C} \right) \left(\frac{1}{(0.2\text{m})^2} + \frac{1}{(0.4\text{m})^2} \right) \hat{i} \\ &= -1.13\text{N} \hat{i}\end{aligned}$$

$$\begin{aligned}\vec{F}_{net,2} &= \vec{F}_{2,1} + \vec{F}_{2,3} = \left(-k \frac{Q_2 Q_1}{r_{2,1}^2} + k \frac{Q_2 Q_3}{r_{2,3}^2} \right) \hat{i} \\ &= \left(9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2} \right) \left(2 \times 10^{-6} \text{C} \right) \left(+\frac{1}{(0.2\text{m})^2} - \frac{1}{(0.2\text{m})^2} \right) \hat{i} \\ &= 0\text{N} \hat{i}\end{aligned}$$

$$\begin{aligned}\vec{F}_{net,3} &= \vec{F}_{3,1} + \vec{F}_{3,2} = \left(+k \frac{Q_3 Q_1}{r_{3,1}^2} + k \frac{Q_3 Q_2}{r_{3,2}^2} \right) \hat{i} \\ &= +\left(9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2} \right) \left(2 \times 10^{-6} \text{C} \right) \left(\frac{1}{(0.4\text{m})^2} + \frac{1}{(0.2\text{m})^2} \right) \hat{i} \\ &= +1.13\text{N} \hat{i}\end{aligned}$$

14.10



To calculate the net force we break of the forces into their respective x- and y-components. For the net force in the x-direction we find:

$$F_{Net,x} = F_{1,2} \cos 60 - F_{1,3} \cos 60 = 0, \text{ since } |F_{1,2}| = |F_{1,3}|.$$

For the net force in the y-direction we find:

$$F_{Net,y} = -F_{1,2} \sin 60 - F_{1,3} \sin 60 = -2 \left(9 \times 10^9 \frac{Nm^2}{C^2} \right) \frac{(5 \times 10^9 C)(10 \times 10^9 C) \sqrt{3}}{(0.5m)^2} \frac{1}{2}$$
$$= -3.12N.$$

Therefore the net force is 3.12N in the -y-direction.

Note: The charges can be cycled to different corners of the triangle. The magnitude of the net force will be the same but the direction will change.