

Homework 5

Due Mon, Jan 29, 2007

Reading Assignment: Make sure you have read all of Chapter 18 (Sections 18.1 thru 18.8 and 18.11) and Chapter 19, sections 19.1 thru 19.3.

Instructions: Answer all of the questions below. Circle the letter of your answer for the multiple-choice problems. Show your work or reasoning for **all numerical problems**.

1. A droplet of ink in an industrial ink-jet printer carries a charge of $1.6 \times 10^{-10} \text{ C}$ and is pushed onto paper by a force of $3.2 \times 10^{-4} \text{ N}$. Find the strength of the electric field to produce this force.

Answer: $2.0 \times 10^6 \text{ N/C}$

$$F = |q|E = (1.6 \times 10^{-10} \text{ C}) E = (3.2 \times 10^{-4} \text{ N})$$

$$E = \frac{3.2 \times 10^{-4} \text{ N}}{1.6 \times 10^{-10} \text{ C}} = 2.0 \times 10^6 \frac{\text{N}}{\text{C}}$$

2. What is the force of gravity on an electron (i.e. what is the weight)? If an electron is in an electric field of $E = 10000 \text{ N/C}$ (a relatively small field), what is the magnitude of the electric force? Which is bigger?

Answer: $W = 8.93 \times 10^{-30} \text{ N}$ $F_E = 1.60 \times 10^{-15} \text{ N}$ ← Much bigger.

$$W = mg = (9.11 \times 10^{-31} \text{ kg}) (9.81 \text{ m/s}^2) = 8.93 \times 10^{-30} \text{ N}$$

$$F_E = |q|E = (1.60 \times 10^{-19} \text{ C}) (10000 \text{ N/C}) = 1.60 \times 10^{-15} \text{ N}$$

3. A charge of $q = +7.50 \mu\text{C}$ is located in an electric field. The components of the field are $E_x = 6.00 \times 10^3 \text{ N/C}$ and $E_y = 8.00 \times 10^3 \text{ N/C}$. (a) What are the components of the force of the charge? (b) What is the magnitude of the force on the charge? (c) What is the angle that the force makes with the $+x$ -axis?

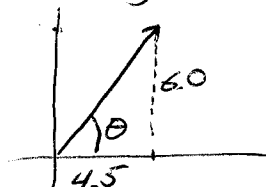
Answer: (a) $F_x = 4.50 \times 10^{-2} \text{ N}$ $F_y = 6.00 \times 10^{-2} \text{ N}$
 (b) $F = 7.5 \times 10^{-2} \text{ N}$ (c) $\theta = 53.1^\circ$

$$F_x = qE_x = (7.5 \times 10^{-6} \text{ C}) (6.0 \times 10^3 \text{ N/C}) = 4.50 \times 10^{-2} \text{ N}$$

$$F_y = qE_y = (7.5 \times 10^{-6} \text{ C}) (8.0 \times 10^3 \text{ N/C}) = 6.00 \times 10^{-2} \text{ N}$$

$$F = \sqrt{F_x^2 + F_y^2} = \sqrt{(4.50 \times 10^{-2} \text{ N})^2 + (6.00 \times 10^{-2} \text{ N})^2} = 7.5 \times 10^{-2} \text{ N}$$

$$\theta = \tan^{-1}\left(\frac{6}{4.5}\right) = 53.1^\circ \text{ looks ok}$$



4. A surface completely surrounds a collection of charges. Find the electric flux through this surface if the collection consists of (a) a single $+3.5 \times 10^{-6} \text{ C}$ charge, (b) a single $-2.3 \times 10^{-6} \text{ C}$ charge, and (c) both of the charges in (a) and (b). (Gauss's Law is all about the relationship between the electric flux and the enclosed charge, even if you can't necessarily use $E \cdot A$.)

Answer: (a) $\frac{3.95 \times 10^5 \text{ Nm}^2/\text{C}}{1.36 \times 10^5 \text{ Nm}^2/\text{C}}$ (b) $\frac{-2.60 \times 10^5 \text{ Nm}^2/\text{C}}{1.36 \times 10^5 \text{ Nm}^2/\text{C}}$

a)

$$\frac{\Phi_E}{\epsilon_0} = \frac{q_{\text{enc}}}{\epsilon_0} = \frac{3.5 \times 10^{-6} \text{ C}}{8.85 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}} = 3.95 \times 10^5 \frac{\text{Nm}^2}{\text{C}}$$

b)

$$\frac{\Phi_E}{\epsilon_0} = \frac{q_{\text{enc}}}{\epsilon_0} = \frac{-2.3 \times 10^{-6} \text{ C}}{8.85 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}} = -2.60 \times 10^5 \frac{\text{Nm}^2}{\text{C}}$$

c)

$$\frac{\Phi_E}{\epsilon_0} = \frac{q_{\text{enc}}}{\epsilon_0} = \frac{3.5 \times 10^{-6} \text{ C} - 2.3 \times 10^{-6} \text{ C}}{8.85 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}} = 1.36 \times 10^5 \frac{\text{Nm}^2}{\text{C}}$$

5. A metal sphere has a charge of $+8.0 \mu\text{C}$. What could you do to neutralize the charge? (Show your work.)

(a) Add 8.0×10^{-6} electrons.

(b) Take away 5×10^{13} electrons.

(c) Take away 5×10^{19} electrons.

(d) Add 5×10^{13} electrons.

$$N = \frac{q}{e} = \frac{8.0 \times 10^{-6} \text{ C}}{1.6 \times 10^{-19} \text{ C}} = 5 \times 10^{13}$$

6. The force of repulsion of two like charges is 3.5 N. What will the force be if the distance between the charges is increased to 5 times its original value? (Explain your reasoning or show your work.)

(a) 0.14 N

(b) 0.7 N

(c) 3.5 N

(d) 17.5 N

(e) 87.5 N

$$\frac{1}{25} F = k \frac{q_1 q_2}{(5R)^2}$$

$$F_{\text{new}} = \frac{3.5 \text{ N}}{25} = 0.14 \text{ N}$$

Had to divide both sides by 25

7. A surface completely surrounds a $+2.0 \times 10^{-6} \text{ C}$ charge. Find the electric flux through the surface if the surface is (a) a sphere with a radius of 0.50 m, and (b) a cube with edges that are 0.25 m long.

Answer: (a) $\frac{2.26 \times 10^5 \text{ Nm}^2/\text{C}}{2.26 \times 10^5 \text{ Nm}^2/\text{C}}$ (b) $\frac{2.26 \times 10^5 \text{ Nm}^2/\text{C}}{2.26 \times 10^5 \text{ Nm}^2/\text{C}}$

a)

$$\frac{\Phi_E}{\epsilon_0} = \frac{q_{\text{enc}}}{\epsilon_0} = \frac{2 \times 10^{-6} \text{ C}}{8.85 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}} = 2.26 \times 10^5 \frac{\text{Nm}^2}{\text{C}}$$

b) Same as (a) because q_{enc} is the same.