Week 8

Detailed learning goals

By completing this topic, you should be able to:

- Explain electric charge, and describe how the two types of charge interact with each other and with neutral objects
- Explain the law of conservation of charge
- Define and explain conductor and insulator
- Describe methods for charging an object
- Explain what happens to an electrical force as you move farther from the source
- Define and explain charge polarisation
- Explain Coulomb's law in terms of how the electrostatic force changes with the distance between two objects
- Calculate the electrostatic force between two charged point forces, such as electrons or protons
- Describe a force field and calculate the strength of an electric field due to a point charge
- Calculate the force exerted on a test charge by an electric field
- Explain the relationship between electrical force on a test charge and electrical field strength

Prescribed readings for SLE123 content

Please read the following sections from Giambattista Physics (5th ed.). New York: McGraw-Hill:

- Section 16.1 Electric Charge.
- Section 16.2 Electric Conductors and Insulators.
- Section 16.3 Coulomb's Law.
- Section 16.4 - The Electric Field.

Practice questions:

8.1 An uncharged metal sphere, A, is on an insulated base. A second sphere, B, of the same shape, size and material carrying a charge $+Q$ is brought *into contact* with sphere A.
(a) Describe what happens to charges on spheres A and B as they are brought into contact.
(b) If we now remove sphere B and place it far away, what is the charge on sphere A?
(c) How is this charge (if any) distributed?

Answer: (a) Electrons will move from sphere A to sphere B so that the excess charge $+Q$ is spread evenly over both spheres. (b) $+ \frac{1}{2} Q$. (c) Evenly over the surface of sphere A

8.2 An uncharged metal sphere, A, is on an insulated base. A second sphere, B, of the same shape, size and material carrying a charge $+Q$ is brought *close to*, *but not touching*, sphere A.
(a) Describe what happens to the charges on spheres A and B as they are brought close together *but not touching*.
(b) If we now remove sphere B, what is the charge on sphere A?
(c) How is this charge (if any) distributed?

Answer: (a) Sphere A becomes polarized with the side nearer sphere B becoming negatively charged and the far side becoming positively charged. (b) $Q = 0$ C (c) no charge to distribute

8.3 A positively charged metal sphere, sphere A, is held close to *but not touching* an identical uncharged sphere, sphere B. Sphere A is now removed. After sphere A has been removed Sphere B is touched to an initially uncharged sphere, sphere C. What is the sign of the charge (if any) on sphere C after it has been touched to sphere B?

Answer: There is no charge on sphere C (nor is there a charge on sphere B).

8.4 A $+3\times10^{-6}$ coulomb charge is placed 5 centimetres due west from a $+2\times10^{-6}$ coulomb charge.
(a) What is the force the +2 μC charge exerts on the +3 μC charge?
(b) What is the force the +3 μC charge exerts on the +2 μC charge?

Answer: (a) 21.6N West (b) 21.6N East

8.5 Two charges, one +4 C and the other +2 C, are separated by some distance $R0$. If we increase the distance between the charges by a factor of 5, what happens to the magnitude of the force on the +2 C charge?

Answer: $F = 1/25\ F0$

8.6 Two charges, QA and QB, are separated by a distance x. If we double the distance between the charges and triple the magnitude of charge A, what happens to the magnitude of the force that charge A exerts on charge B? What happens to the magnitude of the force that charge B exerts on charge A?

Answer: $F = 3/4\ F0$ for both charges

8.7 A small charged particle of mass 9×10^{-6} kg and charge of magnitude -3×10^{-6} C is placed in a chamber in which there is a uniform electric field. If the charge accelerates due north at a rate of 250ms^{-2} what is the magnitude and direction of the electric field inside the chamber? (ignore gravitational forces)

Answer: $E = 750\ \text{N C}^{-1}$ due south

8.8 Answer the following:
(a) What is the magnitude and direction of the electric field 10m away from a +0.1mC charge?
(b) What is the magnitude and direction of the electrostatic force on a +1.5mC charge placed at this point (10m from the charge in (a))?
(c) What is the magnitude and direction of the electrostatic force on a −3.5mC charge placed at this point (10m from the charge in (a))?

Answer: (a) $E = 9000 \text{NC}^{-1}$ pointing away from the charge (b) $F = 13.5$N away from the original charge (c) $F = 31.5$ N towards the original charge