Electric Fields

Vocabulary

electric field ($\vec{\varepsilon}$) | electric field lines | electric dipole

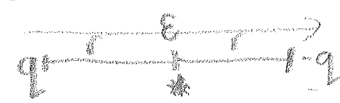
Textbook pp. 334–345

MAIN IDEA: An electric field of force exists in a region of space when a test charge placed at any point in the region has a force exerted upon it. The electric field is a vector denoted by $\vec{\varepsilon}$. A test charge will experience an electric force given by $\vec{F}_E = q\vec{\varepsilon}$. The directions of the electric force and electric field are determined by a positive test charge. For a point charge q_2, the magnitude of the electric field at a distance r from the charge is $\varepsilon = \frac{kq_2}{r^2}$. Electric field lines are continuous lines of force that show the direction of electric force at all points in the electric field around a charge or charges.

STUDY TIP

Using Diagrams
Use a graphic organizer to illustrate connections among concepts.

1. A test charge, q_1 is positive. The electric field points in the same direction as the force that the charge experiences. If the text charge is negative, the electric field points in the opposite direction of the force that the charge experiences.
2. The electric field strength at a distance r from a point charge q is ε. A second point charge equal but opposite in sign to q is placed a distance $2r$ from q. What is the electric field strength halfway between the two charges? Explain your answer.
   (a) 0
   (b) $\frac{\varepsilon}{2}$
   (c) ε
   (d) 2ε



$\varepsilon = \frac{kq}{r^2} + \frac{kq}{r^2} = 2\varepsilon$

3. Four charges equal in magnitude of 12.0 μC are placed on the four corners of a square with side length 0.250 m (**Figure 1**). Determine the electric field experienced by a test charge at the centre of the square. Draw a diagram to help you.

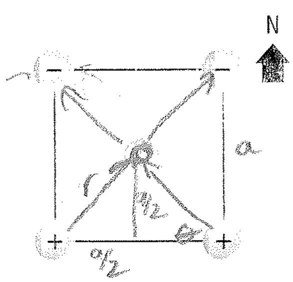


Figure 1

* horizontal components cancel out

$r^2 = (a/2)^2 + (a/2)^2$

$= \frac{2a^2}{4} = \frac{a^2}{2}$

$\theta = 45°$ b/c isosceles.

For one charge:

$\varepsilon = \frac{kq}{r^2}\cos\theta$

$= \frac{(9.0\times10^9\ Nm^2/C^2)(12.0\times10^{-6}\ C)}{(0.250\ m)^2/2}\cos 45°$

$= 2.44\times10^6\ N/C$

For all charges

$\varepsilon = 4\varepsilon = 4(2.44\times10^6\ N/C)$

$\varepsilon = 9.8\times10^6\ N/C$

MAIN IDEA: An electric dipole consists of two equal but opposite charges separated by some small distance. The electric field between two parallel plates of charge is uniform and perpendicular to the plates. The electric field outside the parallel plates is zero. Applications of electric fields include electrostatic precipitators. Some organisms can detect weak electric fields.

4. Draw arrows on the field lines in **Figure 2** to show the direction of the electric field. K/U

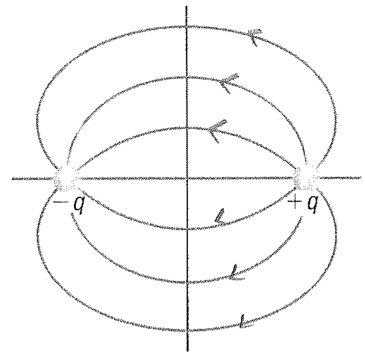


Figure 2

5. The electric field in the atmosphere of Earth
   (a) results from positive ions in the ionosphere
   (b) results from an overall negative charge on Earth's surface
   (c) both (a) and (b)
   (d) is equal to zero K/U

6. List three factors that affect the strength of the electric field between two long parallel plates. K/U

7. Two point charges are arranged as shown in **Figure 3**. The charge on q_1 is 4.5×10^{-6} C while the charge on q_2 is -2.5×10^{-6} C. The distance, r, is 3.5 cm. Calculate the magnitude of the electric field at the origin. T/I

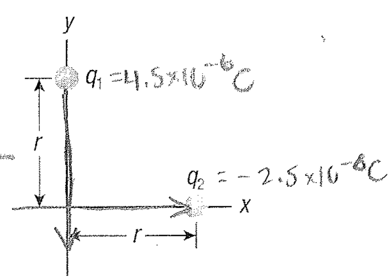


Figure 3

$\varepsilon_1 = \frac{kq_1}{r^2}$

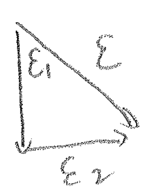
$= \frac{(9.0\times10^9\ Nm^2/C^2)(4.5\times10^{-6}\ C)}{(3.5\times10^{-2}\ m)^2}$

$= 3.31\times10^7\ N/C$

$\varepsilon_2 = \frac{kq_2}{r^2}$

$= \frac{(9.0\times10^9\ Nm^2/C^2)(2.5\times10^{-6}\ C)}{(3.5\times10^{-2}\ m)^2}$

$= 1.84\times10^7\ N/C$



$\varepsilon = \sqrt{\varepsilon_1^2 + \varepsilon_2^2}$

$= \sqrt{(3.31\times10^7\ N/C)^2 + (1.84\times10^7\ N/C)^2}$

$= 3.8\times10^7\ N/C$