Chapter 22
ELECTRIC FIELD

Introduction: The presence of an electric charge produces a force on all other charges present. The electric force produces action-at-a-distance; the charged objects can influence each other without touching. Suppose two charges, q_1 and q_2, are initially at rest. Coulomb's law allows us to calculate the force exerted by charge q_2 on charge q_1 (see Figure 23.1). At a certain moment charge q_2 is moved closer to charge q_1. As a result we expect an increase of the force exerted by q_2 on q_1. However, this change can not occur instantaneous (no signal can propagate faster than the speed of light). The charges exert a force on one another by means of disturbances that they generate in the space surrounding them. These disturbances are called electric fields. Each electrically charged object generates an electric field which permeates the space around it, and exerts pushes or pulls whenever it comes in contact with other charged objects.

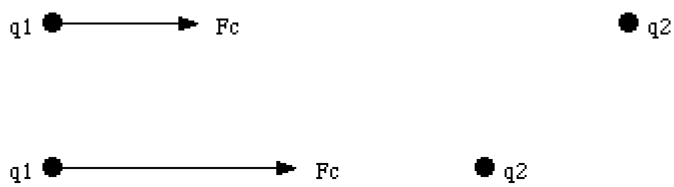


Figure 23.1. Electric force between two electric charges.

To calculate the electric field ***E***, it is often convenient to make use of a fictitious charge called a **test charge** q_o . This charge is similar to a real charge except in one respect: The test charge is defined to exert no force on other charges. It therefore does not disturb the charges in the vicinity. In practical situations, a test charge can be approximated by a charge of nearly negligible magnitude. The test charge will feel an electric force *F*. The electric field at the location of the point charge is defined as the force *F* divided by the charge q_o :

$$\boldsymbol{E} = \lim_{q_o \to 0} \frac{\boldsymbol{F}}{q_o} = k \frac{q_o Q}{q_o r^2} \boldsymbol{r} = k \frac{Q}{r^2} \boldsymbol{r}$$

The definition of the electric field shows that the electric field is a vector field: the electric field at each point has a magnitude and a direction. The direction of the electric field is the direction in which a positive charge placed at that position will move. In this chapter the calculation of the electric field generated by various charge distributions will be discussed.

Observations:

1. Dimensions are force per charge, so units are N/C. Later we will tend to use units V/m, after the unit of volts is introduced.
2. The bold-faced quantities above indicate vectors. The electric field is a vector field, since force is a vector quantity. You already know numerous scalar fields, quantities which vary over space; some examples are temperature and pressure. Vector fields are an extension of the field concept to vector quantities.

The effect of introducing the positive test charge q_o must be minimized, therefore the limiting case is considered. Superposition of forces leads to superposition of the electric field contributions of a group of point charges.

The field approach may be summarized as follows:

1. Charge Q sets up an electric field in space around it.
2. The resulting field exerts a force on q_0 which depends only on the position and magnitude of q_o .

The field plays an intermediate role.

$$\underset{Q}{\text{charge}} \xrightarrow[\text{produces}]{} \text{field} \xrightarrow[\text{interact with}]{} \underset{q_o}{\text{charge}}$$

This approach separates the situation into two parts:

1. Calculate the electric field created by given charge distribution. .
2. Calculate the force exerted on charge placed in the field.

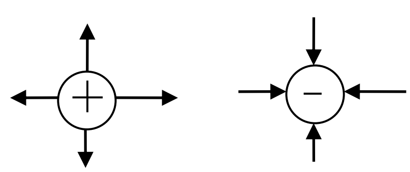
Note that there *is* a constraint: Introducing q_o must NOT change the positions of the charges responsible for the fields.

Graphical Representation of the Electric Field:

Electric field lines (also known as lines of force) are constructed with the following rules:

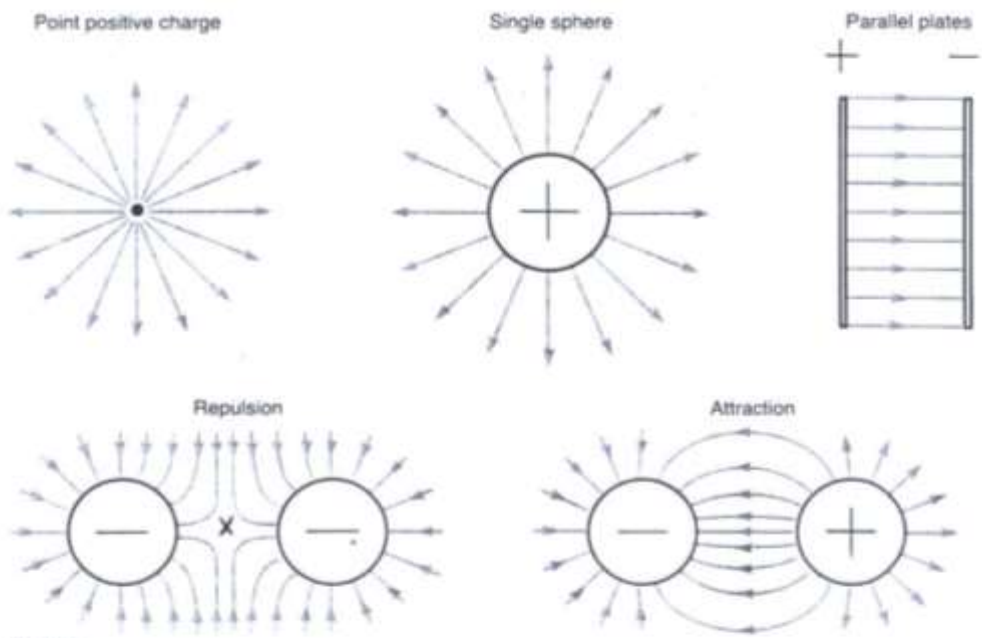
1. The tangent to the field line at any point gives the direction of the electric field there.
2. Lines of force are drawn to that the "number of lines/unit area" is proportional to the magnitude of the electric field. If close together, the field is strong there, weaker where further apart.

The following observations can be made about field lines:



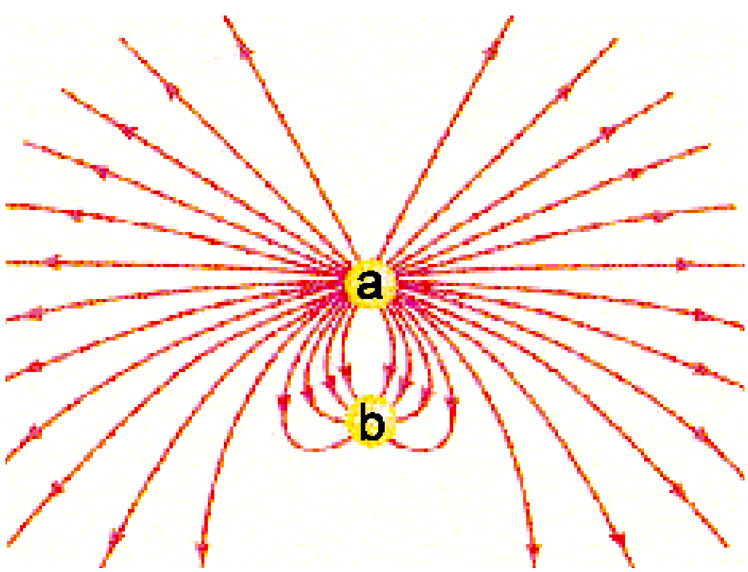
1. The direction of the electric field at a point is the same as the direction of the force experienced by a positive test charge placed at that point.
2. Electric field lines can be used to sketch electric field.
3. Field lines come out of positive charges (because a positive charge repels a positive test charge).

4. Field lines come into negative charges (because they attract the positive test charge).
5. Field lines originate on positive charges and terminate on negative charges, without crossing between each other.
6. The density of field lines in any region is proportional to the strength of the electric field in that region.
7. **x** is called the neutral point, that is the electric field is zero.



Example

1. What are the relative magnitudes of the charges?
2. What are the signs of the charges?



1- $\dfrac{|Q_a|}{|Q_b|} = \dfrac{32}{8} = 4$

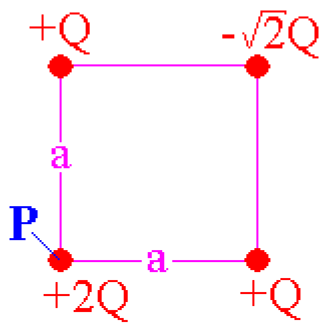
2- a is positive charge, b is negative charge.

The electric field: (E, [E] = (N/C)) at a point P in the space is defined as *the electric force **F** that acts on a **small positive test charge**, q_o , placed at that point divided by the magnitude of the test charge*, i.e.

$$\boldsymbol{E}_i = \frac{\boldsymbol{F}_i}{q_o} = k\,\frac{q_o q_i}{q_o r_i^2}\hat{\boldsymbol{r}} = k\,\frac{q_i}{r_i^2}\hat{\boldsymbol{r}} \quad \Rightarrow \quad \boldsymbol{E} = \sum_i \boldsymbol{E}_i = k\sum_i \frac{q_i}{r_i^2}\hat{\boldsymbol{r}}$$

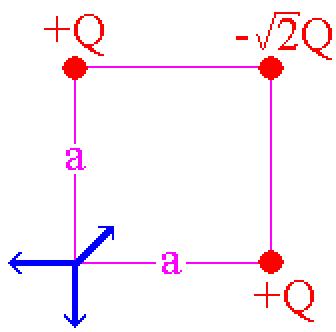
where $\boldsymbol{r}_i$ is a vector directed from the charge, q_i, to the point in question.

Example: What is the **direction** of **E** experienced by the charge at point P?



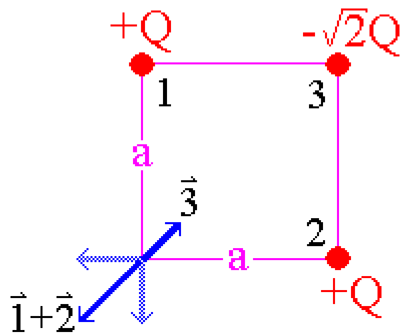
Solution:

Since we have been asked about the electric field experienced by the +2Q charge, it may be treated as the positive test charge. The directions of the electric field contributions from the other three charges are indicated below:



Note that the magnitudes of the contributions from 1 and 2 are the same since charges 1 and 2 are the same. A direction has been assigned to the contribution from charge 3 [diagonally inward] but its magnitude relative to the others is not known until we evaluate it.

Recognizing that the resultant of the contributions from 1 and 2 points diagonally outward, as shown below, the solution to this question reduces to a determination of the relative magnitude of the contribution from charge 3 to the resultant of the contributions from 1 and 2.



The relationship for the electric field of a point charge:

$\boldsymbol{E} = k\,\dfrac{Q}{r^2}\hat{r}$ Thus the magnitude of the contribution from 1 (and 2) is

$$|\boldsymbol{E}_1| = |\boldsymbol{E}_2| = k\,\frac{Q}{a^2}$$

and the resultant is

$$|\boldsymbol{E}_1 + \boldsymbol{E}_2| = k\sqrt{2}\,\frac{Q}{a^2}$$

The magnitude of the contribution from 3 is

$$|\boldsymbol{E}_3| = k\,\frac{\left(\sqrt{2}Q\right)}{\left(\sqrt{2}a\right)^2} = k\,\frac{\sqrt{2}Q}{2a^2}$$

which is one-half that from 1 and 2 combined, so the relative contributions shown in the previous figure are correct and the direction of **E** from all three contributions points diagonally outward (225 degrees or southwest).

For a continuous charge distribution, the electric field is given by

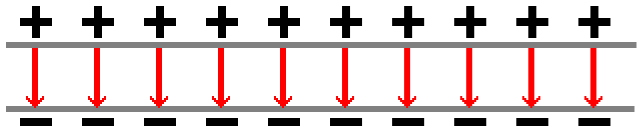
$$\boldsymbol{E} = k\sum_i \frac{q_i}{r_i^2}\boldsymbol{r}_i = k\int \frac{dq}{r^2}\boldsymbol{r}$$

and dq could be calculated using the charge density as follows:

$$\overbrace{\begin{array}{ccc} \text{Volume} & \text{Surface} & \text{Linear} \\ \rho = \dfrac{dq}{dV} & \sigma = \dfrac{dq}{dA} & \lambda = \dfrac{dq}{dl} \end{array}}^{\text{charge density}}$$

The Uniform Electric Field

An important field for our consideration is the ***uniform electric field***, a field that has the same magnitude and direction at all points. An infinite sheet of charge will be used to create the uniform **E**. This may be realized to a good approximation in the lab by hooking a battery to two isolated parallel metal plates so that they become oppositely charged.



An electron injected into the region between the plates will experience a force given by

$$\mathbf{F} = -e\,\mathbf{E}.$$

The resulting acceleration can be found from Newton's second law. In the region between the plates, the electron will experience a constant acceleration and the resulting parabolic trajectory.

The control of electrons by so-called deflection plates is the principle behind the operation of the cathode-ray tube used in oscilloscopes and many televisions and computer monitors.

Motion of charged particle in a uniform electric field: A charged particle of mass m and charge q moving in an electric field E has acceleration

$$\boldsymbol{a} = \frac{q}{m}\boldsymbol{E}$$

If the electric field is uniform, the acceleration is constant and the motion of the charge is similar to that of a projectile moving in a uniform gravitational field.

Ex: A proton enters a region of a uniform electric field $\boldsymbol{E} = 80\,\hat{i}\,\dfrac{\text{N}}{\text{C}}$ with an initial velocity of $\boldsymbol{v}_i = 80\,\hat{j}\,\dfrac{\text{m}}{\text{s}}$. What is the speed of the proton 2.0×10^{-6} s after entering this region?

Ans:

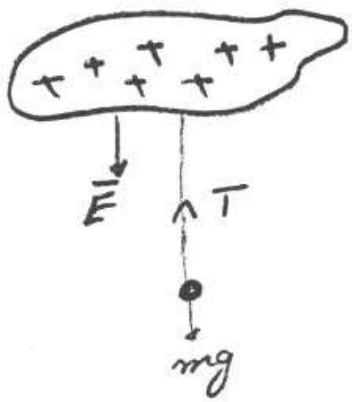
$$v_x = v_{ix} + at = 0 + \frac{qE}{m_p}t = \frac{\left(1.6\times10^{-19}\right)\times 80}{1.6\times10^{-27}}\left(2.0\times10^{-6}\right) = \underline{1.5\times10^{4}\ \text{m/s}},$$

$$v_y = v_{iy} + gt = 2.0\times10^{4} + 9.8\times2.0\times10^{-6} = \underline{2.0\times10^{4}\ \text{m/s}},$$

$$|\boldsymbol{v}| = \sqrt{v_x^2 + v_y^2} = \underline{2.5\times10^{4}\ \text{m/s}}$$

Ex: A tiny, 0.6-g ball carries a charge of magnitude 8.0×10^{-6} C. It is suspended by a light thread in a downward electric field of intensity 300 N/C. What is the tension in the thread if the charge on the ball is (a) positive (b) negative?

Ans:



(a) Positive charge:

$$T = F_q + mg = 8\times10^{-6}\times300 + 0.6\times10^{-3}\times9.8 = \underline{8.3\times10^{-3}\ \text{N}}$$

(b) Negative charge

$$T = F_q + mg = -8\times10^{-6}\times300 + 0.6\times10^{-3}\times9.8 = \underline{3.5\times10^{-3}\ \text{N}}$$

Chapter23 Electric Fields

23-3 Electric Field Lines

Which one of the following statements is CORRECT?

(a) Electric charge is not quantized.
(b) Electric field lines are closer together when the electric field is weak, and are far apart when the electric field is strong.
(c) Halfway between two point charges of equal magnitude and opposite sign, the net electric field is zero.
(d) In a solid conductor, electrons do not move freely.
(e)@ The direction of an electric field does not change whether a positive or negative test charge
is used in calculating the electric field.

The strength of the electric field shown in Figure 3

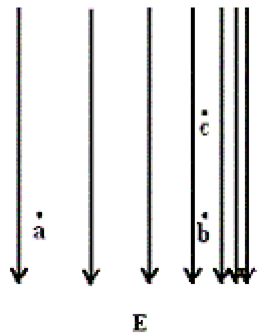


Figure 3

(a)@ increases as we go from point a to point b.
(b) increases as we go from point c to point b.
(c) increases as we go from point b to point a.
(d) is the same at points a, b and c.
(e) increases as we go from point b to point c.

A 32 micro-C charge is positioned on the x-axis at x = 4.0 cm. Where should a -18 micro-C charge be placed (on the x-axis) so that the net electric field at the origin is zero?

(a) 1 cm
(b) 4 cm
(c) 5 cm
(d)@ 3 cm
(e) 7 cm

A point charge of 4.0 nano-C is located at a point having coordinates (30.0 cm, 40.0 cm). At what point will the electric field be 72 N/C and pointing in the negative y-direction?

(a) (10.0, -89.9) cm
(b) (30.0, 49.9) cm
(c)@ (30.0, -30.7) cm
(d) (30.0, 70.7) cm
(e) (30.0, -49.9) cm

A 40 micro-C charge is positioned on the x axis at x = 4.0 cm. In order to produce a net electric field of zero at the origin, where, on the x-axis, should a -60 micro-C charge be placed?

(a) 5.7 cm
(b)@ 4.9 cm
(c) -6.0 cm
(d) -5.3 cm
(e) 6.0 cm

Four charges are placed on the circumference of a circle of radius 1.0 m and centered at the origin as shown in Figure 2. What is the magnitude and direction of the electric field at the origin (0,0)?

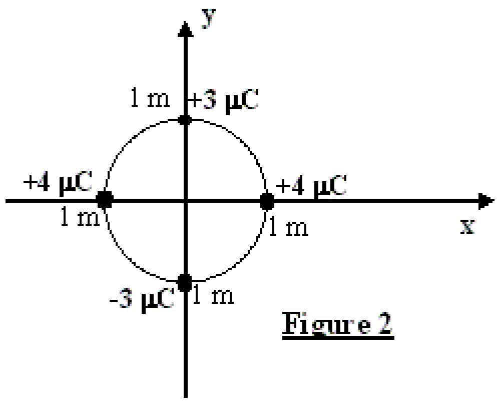


Figure 2

(a) 72000 N/C along the positive x-axis
(b)@ 54000 N/C along the negative y-axis
(c) 54000 N/C along the positive y-axis
(d) Zero
(e) 72000 N/C along the negative x-axis

Four electric charges are arranged so that the total electric field at the origin is zero. Which configuration in figure (1) would achieve this?

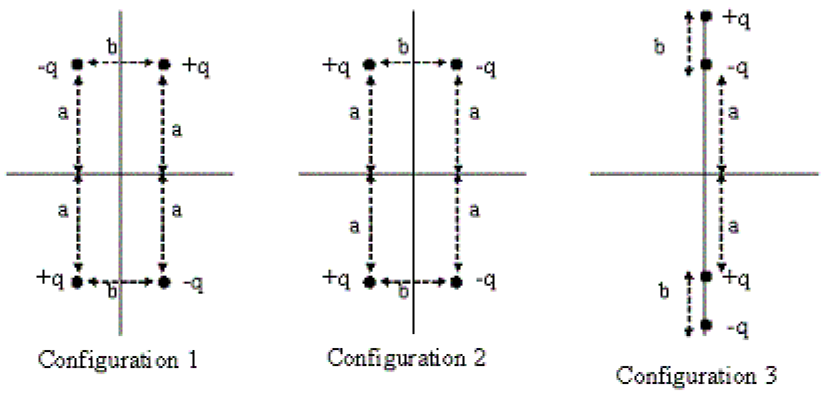


Figure 1

(a) All configurations.
(b)@ Configuration 1.
(c) Neither configuration.
(d) Configuration 3.
(e) Configurations 1 and 2.

A charged particle has a mass of 2.0×10(-4) kg. If it is held stationary by a downward 300 N/C electric field, the charge of the particle is:

(a) - 1.5×10(-6) C.
(b)@ - 6.5×10(-6) C.

(c) 6.5×10(-6) C.
(d) 1.5×10(-6) C.
(e) - 3.0×10(-6) C.

Two uniformly charged, concentric and hollow, spheres have radii r and 1.5 d. The charge of the inner sphere is q/2 and that on the outer sphere is 3 q/2. Find the electric field at a distance 2.0 d from the center of the spheres.

(a)@ $0.5k\,\frac{q}{d^2}$.

(b) $0.25k\,\frac{q}{d^2}$.

(c) $0.35k\,\frac{q}{d^2}$.

(d) Zero.

(e) $0.13k\,\frac{q}{d^2}$.

For the arrangement of charges shown in figure (1), the electric field at the point P is:

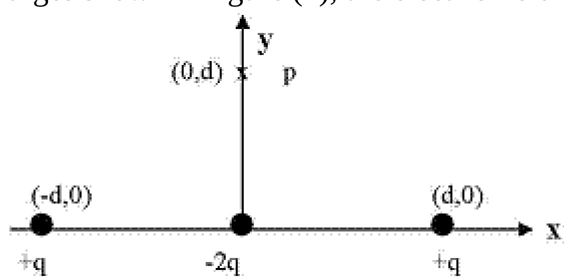


Figure 1

(a) Zero.

(b) $k\,\frac{q}{d^2}$ in the positive y-direction.

(c) $2k\,\frac{q}{d^2}$ in the negative y-direction.

(d) $2k\,\frac{q}{d^2}$ in the positive y-direction.

(e)@ $k\,\frac{q}{d^2}$ in the negative y-direction.

In figure (4), what is the magnitude of the electric field at point P due to the four point charges shown?

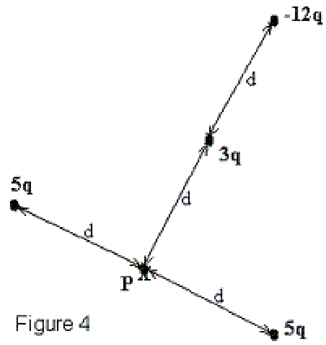


Figure 4

(a) $q\sqrt{2}$ N/C.
(b) $90q$ N/C.
(c)@ zero
(d) $5\,q$ N/C.
(e) $12q$ N/C.

Four point charges are placed at the corners of a square as shown in figure 2. What is the magnitude of the electric field at the center of the square ?

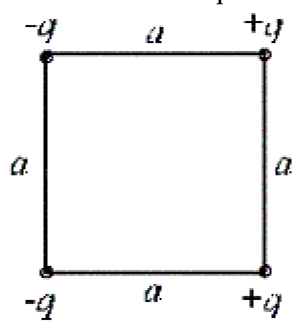


Figure 2

(a) zero
(b)@ $5.66\times k\times q/(a^2)$
(c) $1.41\times k\times q/(a^2)$
(d) $22.6\times k\times q/(a^2)$
(e) $2.83\times k\times q/(a^2)$

A charge of - 4.0 micro-Coulomb is located at the origin, and a charge of - 5.0 micro-C is located along the y-axis at y = 2.0 m. At what point on the y-axis is the electric field zero?

(a) + 3.2 m
(b) - 0.94 m
(c) + 1.1 m
(d)@ + 0.94 m
(e) - 1.1 m

Two point charges are located as shown in figure 1. q1 = +1 micro-Coulomb and q2 = -1 micro-Coulomb. Find the magnitude of the electric field at point P.

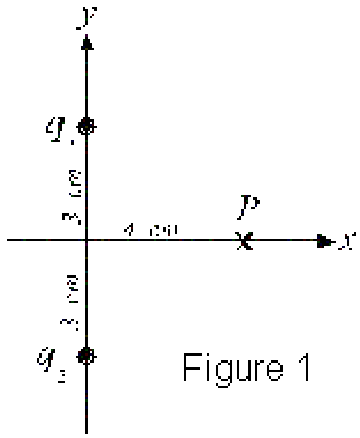


Figure 1

(a) 5.04×10^{6} N/C
(b) 5.76×10^{6} N/C
(c)@ 4.32×10^{6} N/C
(d) zero
(e) 3.60×10^{6} N/C

In figure (4), what is the magnitude of the electric field at point P, center of the equilateral triangle? [take d = 2 m, q = 10**(-9) C]

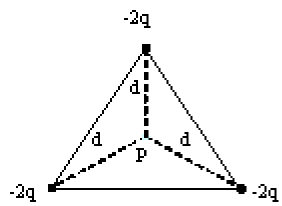


Figure (4)

(a) 22 N/C.
(b) 18 N/C.
(c)@ Zero.
(d) 9 N/C.
(e) 11 N/C.

In figure 4, a 0.3 g metallic ball hangs from an insulating string in a vertical electric field of 4000 N/C directed upward as shown. If the tension in the string is 0.005 N, then the charge on the ball is:

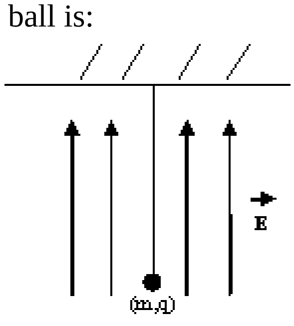


Figure 4

At equilibrium:

$$T + qE = mg \Rightarrow 0.005 + q(400) = 0.3\times10^{-3}\times 9.8$$

Solve for $q \Rightarrow q = \underline{-0.52\ \mu\text{C}}$

(a) 0.73 micro-C

(b) -0.73 micro-C
(c) 0.52 micro-C
(d)@ -0.52 micro-C
(e) -1.3 micro-C

In figure 5, four charges are placed on the circumference of a circle of diameter 2 m. If an electron is placed at the center of the circle, then the electron will [Take Q = 60 micro-C, q = 20 micro-C]

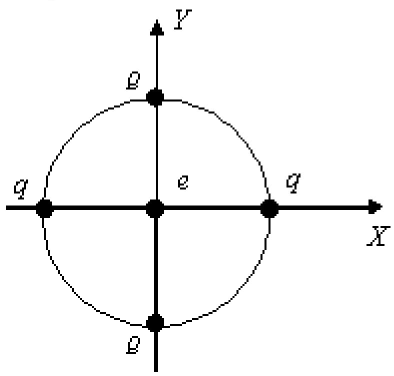


Figure 5

At the center: $\vec{E} = 0 \Rightarrow \vec{F} = 0$
So, the electron stays at the center.

(a) move to the left.
(b) move to the right.
(c) move downward.
(d)@ stay at the center.
(e) move upward.

At which point can the electric field due to the two charges shown in figure 6 be zero?

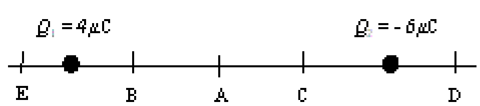


Figure 6

(a) point D.
(b) point C.
(c) point A.
(d) point B.
(e)@ point E.

The electric field 20 mm from a certain point charge has a magnitude |E|. The magnitude of the electric field 10 mm from the point charge is

(a)@ 4.0×|E|.
(b) 6.0×|E|.
(c) 2.0×|E|.
(d) 1.5×|E|.
(e) zero.

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Question 1 0.47-53%

A charge of +20.0 micro-Coulomb is located at the origin and a charge of +15.0 micro-Coulomb is located at x = +10.0 cm. At what point on the x-axis, other than infinity, is the electric field zero?

(a) x = -5.36 cm
(b)@ x = +5.36 cm
(c) x = +4.64 cm
(d) x = -74.6 cm
(e) x = +74.6 cm

A +40-micro-Coulomb charge is positioned on the x axis at x = +4.0 cm. To produce a net electric field of zero at the origin, where should a -60 micro-Coulomb charge be placed?
(a)@ x=+4.9 cm
(b) x=+6.0 cm
(c) x=-6.0 cm
(d) x=+5.7 cm
(e) x=-5.3 cm

The electric field produced by a +3.0 C charge at a point 1000 m to the left of the charge is

(a) 3.0×104 N/C toward the left.
(b) 1.7×107 N/C toward the left.
(c) 2.7×104 N/C toward the right.
(d)@ 2.7×104 N/C toward the left.
(e) 3.0×104 N/C toward the right.

Three charges +2.00×10(-8) C, +2.00×10(-8) C, and -4.00×10(-8) C are respectively arranged at the corners F, G, and H of a right-angle triangle as shown in figure 2. Find the magnitude and direction of the resultant electric field at point P due to the three charges.

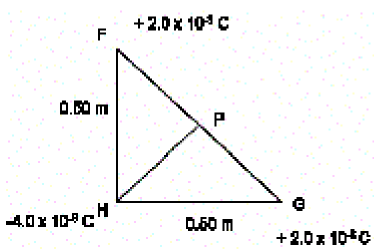

Figure 2

(a) 2.88×103 N/C away from H.
(b)@ 2.88×103 N/C towards H.
(c) 5.37×103 N/C away from H.
(d) 5.37×103 N/C towards H.
(e) 1.09×105 N/C towards F.

In figure 9, a small ball of mass m=2.0 g is hanging from a fixed point by a non-conducting string of length 1.00 m. The ball carries a charge q=25.0×10(-9) C. The mass of the string is negligible. An electric field E with magnitude E=2.0×10^5 N/C, in the positive x-direction, causes the ball to be in an equilibrium position with an angle Theta. Find the angle Theta. [Take g = 9.80 m/s^2].

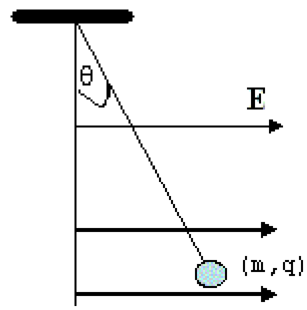

Figure 9

(a) 7.1 degrees.
(b)@ 14.3 degrees.
(c) 75.7 degrees.
(d) 10.0 degrees.
(e) 0.2 degrees.

23-8	A Point Charge in an Electric field

A particle (m =1.0×10^{-2} g, q = -4.0 micro-C) is moving with a velocity of 20 m/s in the positive x-direction. If the particle enters a uniform electric field of 20 N/C in the positive x-direction, what is the particle's speed after 5.0 s?

(a) 30 m/s , in negative x-direction.
(b) 50 m/s , in negative x-direction.
(c) 30 m/s , in positive x-direction.
(d) 20 m/s , in positive x-direction.
(e)@ 20 m/s , in negative x-direction.

An electron enters a region of a uniform electric field directed along the positive x-axis and of magnitude 5 kN/C. The initial velocity of the electron is 10^4 km/s in the positive x direction. What is the speed of the electron 1.5 nano-seconds after entering this region?

(a) 2.1×10^3 km/s
(b) 1.1×10^3 km/s
(c) 2.4×10^4 km/s
(d)@ 8.7×10^3 km/s
(e) 1.1×10^4 km/s

An electron starts from point P (at t = 0) with an initial velocity v_o =(8.6×10^5)i m/s in an electric field E =(4.1×10^3)i N/C. Find the time it takes the electron to return to point P. (i is the unit vector along the positive x-axis.)

(a)@ 2.4×10(-9) sec
(b) 1.2×10(-9) sec
(c) 1.19×10(-8) sec

(d) 2.4×10(-8) sec
(e) 3.5×10(-9) sec

A proton enters a region of uniform electric field (E = 80 N/C) with an initial velocity of 20 km/s directed perpendicularly to the electric field. What is the speed of the proton 2.0 micro-seconds after entering this region?

(a)@ 25 km/s
(b) 35 km/s
(c) 42 km/s
(d) 4.7 km/s
(e) 15 km/s

An electron, traveling with initial velocity 10^5 i m/s, enters a region of a uniform electric field given by E = 4.0×103 i N/C. Determine the time it takes for the electron to come to rest momentarily. (i is a unit vector in the positive x-direction)

(a) It does not come to rest because time would then be negative.
(b) 4.0×10(-10) s.
(c)@ 1.4×10(-10) s.
(d) 2.0×10(-10) s.
(e) t=0, i.e. it immediately turns to the negative x-direction.

A proton is shot out along the +x-axis from the origin with a speed of 1.0×106 m/s. In this region a uniform electric field of 2500 N/C exits in the negative x-direction. Find the distance traveled by the proton before it momentarily comes to rest.

(a) 8.9 m.
(b) 1.0 m.
(c) 4.2 m.
(d)@ 2.1 m.
(e) 2.9 m.

A uniform electric field exists in a region between two oppositely charged plates. An electron, released from rest from the negative plate, strikes the other plate with a speed of 1.2×10^6 m/s, 15 nanoseconds after its release. What is the distance between the plates?

(a) 2.0 cm
(b)@ 0.90 cm
(c) 1.4 cm
(d) 1.7 cm
(e) 1.1 cm

An electron with an initial velocity of 3.5×10^5 i (m/s) enters a region in which the electric field is 400 i (N/C). What is the speed of the electron two nano-seconds after it enters the electric field ? (i is a unit vector in the x direction)

(a) 3.5×10^5 m/s
(b) 2.8×10^5 m/s
(c) 4.9×10^5 m/s
(d)@ 2.1×10^5 m/s
(e) 5.6×10^5 m/s

A particle of mass 5.0 g and charge 40 mili-C moves in a region of space where the electric field is uniform and given by **E** = -5.5 **i** (N/C). If the velocity of the particle at t = 0 is given by **v** = 50 **j** (m/s), find the speed of the particle at t = 2 s. [**i**, and **j** are the unit vectors in the directions of x, and y respectively].

$$v_y = v_{0y} = 50 \text{ m/s},$$

$$\mathrm{v_x} = v_{ox} + at = 0 + \frac{qe}{m}t = 0 + \frac{40\times10^{-3}\times5.5}{5\times10^{-3}}(2) = 88 \text{ m/s}$$

$$v = \sqrt{v_x^2 + v_y^2} = \underline{101 \text{ m/s}}$$

(a) 150 m/s.
(b)@ 101 m/s.
(c) 65 m/s.
(d) 34 m/s.
(e) 85 m/s.

Two particles of the same mass carrying charges +3Q and -2Q are shot into a region that contains a uniform electric field as in figure 2. The particles have the same initial velocities in the + x direction. The direction of the electric field is as shown. What will be the resulting paths for the particles?

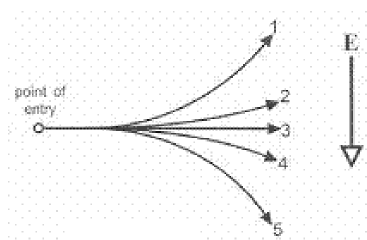

FIGURE 2

(a)@ path 5 for +3Q and path 2 for -2Q
(b) path 2 for +3Q and path 5 for -2Q
(c) path 1 for +3Q and path 4 for -2Q
(d) path 3 for +3Q and path 2 for -2Q
(e) path 4 for +3Q and path 3 for -2Q

Two 1.0 g spheres are charged equally and placed 2.0 cm apart. When released, each one begins to accelerate at 225 m/s**2. What is the magnitude of the charge on each sphere?

(a)@ 1.0×10(-7) C.
(b) 8.0×10(-9) C.
(c) 2.0×10(-7) C.
(d) 3.0×10(-7) C.
(e) 0.5×10(-14) C.

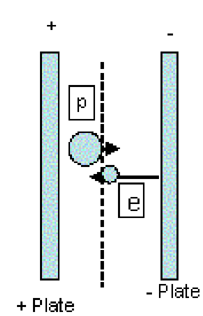

Figure 3

A uniform electric field is set up between two large charged plates, see Figure 3. An electron is released from the negatively charged plate, and at the same time, a proton is released from the positively charged plate. They cross each other at a distance of 5.00*10(-6) m from the positively charged plate. If only the field due to the charged plates is considered, find the distance between the two plates. [Take the ratio mass of the electron : mass of the proton = 1 : 1833]

(a) 2.34 mm.
(b) 11.3 mm.
(c) 14.6 mm.
(d) 7.77 mm.
(e)@ 9.19 mm.

An electron is moving along the positive x-axis with a constant speed of 1.5×108 m/s. When it is at a point +500 m from the origin, an electric field of magnitude 2.0×103 N/C and directed along the positive x-axis is switched on. How far will the electron reach in the field before stopping momentarily?

(a) 511 m.
(b) 468 m.
(c) 502 m.
(d) 551 m.
(e)@ 532 m.

23-9 A Dipole in an Electric field

An electric dipole consists of a positive charge of magnitude 6.0×10(-6) C at the origin and a negative charge of magnitude 6.0×10(-6) C on the x-axis at x = 3.0×10(-3) m. Its dipole moment is:

(a) 1.8×10(-8) C.m, in the positive x direction.
(b)@ 1.8×10(-8) C.m, in the negative x direction.
(c) 1.8×10(-8) C.m, perpendicular to the x-axis.
(d) 3.6×10(-8) C.m, in the negative x direction.
(e) Zero because the net charge is Zero.

Which of the following statements is WRONG:

(a)@ A shell of uniform charge density exerts a constant force on a charge inside it.
(b) Electric field lines extend away from a positive charge.
(c) Electric field can exert a torque on an electric dipole.
(d) A shell of uniform charge density exerts a constant force on a charge outside it.
(e) The magnitude of the charge on a positive ion is an integer multiple of the electron charge.

An electric dipole consists of charges +2e and -2e separated by 0.78×10(-9) m. It is in an electric field of strength 3.0×106 N/C. Calculate the magnitude of the torque on the dipole when the dipole is perpendicular to the field. [e is the magnitude of the charge on the electron.]

(a) 6.5×10^{-22} N.m.
(b) 8.5×10^{-22} N.m.
(c) 3.5×10^{-22} N.m.
(d)@ 7.5×10^{-22} N.m.
(e) 0 N.m.

An electric dipole consists of two opposite charges, each of magnitude 5.0×10(-19) C, separated by a distance of 1.00×10(-9) m. The dipole is placed in an electric field of strength 2.45×10^{5} N/C. Calculate the magnitude of the torque exerted on the dipole when the dipole moment is perpendicular to the electric field.

(a)@ 1.2×10^{-22} N.m.
(b) 3.5×10^{-22} N.m.
(c) -2.0×10^{-22} N.m.
(d) 2.0×10^{-22} N.m.
(e) -5.2×10^{-19} N.m.

Which statement is false:

(a) The electric dipole consists of two charges of the same magnitude but opposite sign.
(b)@ Electric field lines extend away from negative charge and toward positive charge.
(c) The principle of superposition applies to electric fields as well as to electrostatic forces.
(d) When an electric dipole is placed in a uniform electric field, the net force on the dipole is zero.
(e) Electric fields are vector fields.

An electric dipole has a dipole moment of magnitude 2.0×10^{-9} C.m. The dipole is placed in an external electric field whose strength is 300 N/C, with its dipole moment initially perpendicular to the field. The electric field rotates the dipole until it is aligned parallel to the field. How much work is done by the electric field ?

(a) -12×10(-7) J
(b) +12×10(-7) J
(c) zero
(d) -6.0×10(-7) J
(e)@ +6.0×10(-7) J

Which one of the following statements is WRONG?

(a) Electric field lines form a vector field.
(b) The principle of superposition applies to electric fields as well as electrostatic forces.

(c)@ Electric field lines extend away from negative charges and toward positive charges.
(d) The electric dipole consists of two charges having the same magnitude but opposite sign.
(e) When an electric dipole is placed in a uniform external electric field, the net force on it is zero.

A proton is located at the origin and an electron is located on the y axis at y = +1.0 mm. What is the electric dipole moment of these two particles? (i and j are the unit vectors in the x and y directions, respectively)

(a) -1.6×10(-22)i (C.m)
(b) +1.6×10(-22)i (C.m)
(c) +1.6×10(-22)j (C.m)
(d) zero
(e)@ -1.6×10(-22)j (C.m)

A point charge (q= -10.0 micro-C) is at the center of a metallic sphere that has a radius of 20.0 cm. The electric field 0.500 m away from the center of the sphere is found to be -432 kV/m. What is the charge density on the metallic sphere?

(a) 400 micro-C/m^2
(b) 4.00 C/m^2
(c) -4.00 C/m^2
(d)@ -4.00 micro- C/m^2
(e) 4.00 micro- C/m^2.
