KEY

First Name:______________________________ Last Name:______________________________

LO58-06 – Worksheet – Electric Fields

$\vec{E} = \frac{\vec{F_e}}{q_{test}}$ $|\vec{E}| = \frac{kq_{source}}{r^2}$ $|\vec{F_e}| = \frac{kq_1q_2}{r^2}$

Textbook Questions

Pg 548 #1: An ion with a charge of 1.60×10^{-19} C is placed in an electric field produced by another larger charge. If the magnitude of the field at this position is 1.00×10^{3} N/C, calculate the magnitude of the electrostatic force on the ion.

$q = 1.60\times10^{-19}$ C

$|\vec{E}| = 1.00\times10^{3}$ N/C

$F_e = ?$

$E = \frac{F_e}{q_{test}}$

$1.00\times10^{3}\ N/C = \frac{F_e}{1.60\times10^{-19} C}$

$|\vec{F_e}| = 1.60\times10^{-16} N$

Pg 548 #2: The magnitude of the electrostatic force on a small charged sphere is 3.42×10^{-18} N when the sphere is at a position where the magnitude of the electric field due to another larger charge is 5.34 N/C. What is the magnitude of the charge on the small charged sphere?

$F_e = 3.42\times10^{-18}$ N

$|\vec{E}| = 5.34$ N/C

$q = ?$

$|\vec{E}| = \frac{|\vec{F_e}|}{q_{test}}$

$5.34\ N/C = \frac{3.42\times10^{-18} N}{q_{test}}$

$q_{test}(5.34) = 3.42\times10^{-18}$

$q_{test} = 6.42\times10^{-19} C$

Pg 549 #1: The electric field at a position 2.00 cm from a charge is 40.0 N/C directed away from the charge. Determine the charge producing the electric field.

$|\vec{E}| = 40.0$ N/C

$r = 0.02$ m

$q = ?$

$|\vec{E}| = \frac{kq_{source}}{r^2}$

$40.0 = \frac{(8.99\times10^{9})\,q_{source}}{(0.02)^2}$

$q_{source} = 1.7798\times10^{-12} C$

KEY

Pg 549 #2: An electron has a charge of -1.60×10^{-19}C. At what distance from the electron would the magnitude of the electric field be 5.14×10^{11} N/C?

$q_{source} = 1.60 \times 10^{-19}$ C

$|\vec{E}| = 5.14 \times 10^{11}$ N/C

$r = ?$

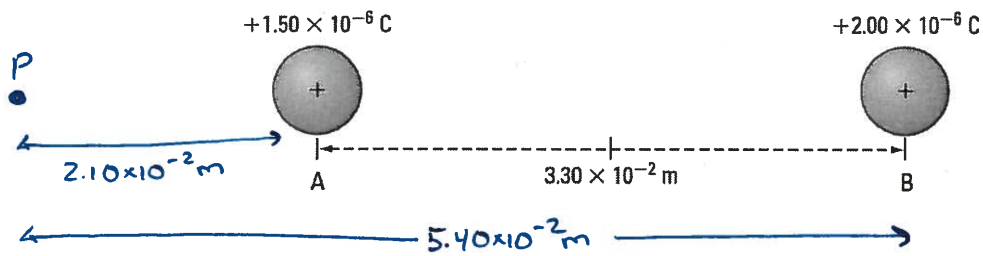
$$|\vec{E}| = \frac{kq}{r^2}$$

$$5.14 \times 10^{11} = \frac{(8.99 \times 10^9)(1.60 \times 10^{-19})}{r^2}$$

$$r^2 = 2.798 \times 10^{-21}$$

$$r = 5.29 \times 10^{-11} \text{ m}$$

Pg 550 #1: Calculate the net electric field at a point 2.10×10^{-2} m to the left of the 1.50×10^{-6} C charge in the figure below.



$$|\vec{E}_{qA}| = \frac{kq_A}{r^2} = \frac{(8.99 \times 10^9)(1.5 \times 10^{-6})}{(2.10 \times 10^{-2})^2} = 3.0578 \times 10^7 \text{ N/C [left]}$$

$$|\vec{E}_{qB}| = \frac{kq_B}{r^2} = \frac{(8.99 \times 10^9)(2.00 \times 10^{-6})}{(5.40 \times 10^{-2})^2} = 6.1659 \times 10^6 \text{ N/C [left]}$$

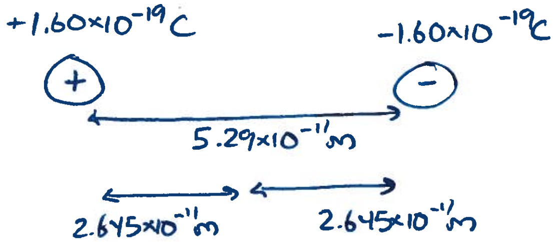
$$\vec{E}_{net} = \vec{E}_{qA} + \vec{E}_{qB}$$

$$= 3.0578 \times 10^7 \text{ N/C [left]} + 6.1659 \times 10^6 \text{ N/C [left]}$$

$$= 3.6744 \times 10^7 \text{ N/C [left]}$$

KEY

Pg 550 #2: An electron an a proton are 5.29 x 10^{-11} m apart in a hydrogen atom. Determine the net electric field at a point midway between the two charges.



$$|\vec{E}_{q+}| = \frac{kq_+}{r^2} = \frac{(8.99\times10^{9})(1.60\times10^{-19})}{(2.645\times10^{-11})^2} = 2.056\times10^{12}\ N/C\ [\text{right}]$$

$$|\vec{E}_{q-}| = 2.056\times10^{12}\ N/C\ [\text{right}]$$

Pg 553 #7ab: Given a small sphere with a positive charge of 4.50 x 10^{-6} C, determine

a. The magnitude and direction of the electric field at a point 0.300 m to the right of the charge.
b. The magnitude and direction of the electric force acting on a positive charge of 2.00 x 10^{-8} C placed at the point in (a).

(A) $q = 4.50\times10^{-6}C$
$r = 0.300m$

$$|\vec{E}| = \frac{kq}{r^2} = \frac{(8.99\times10^{9})(4.50\times10^{-6})}{(0.3)^2} = 449{,}500\ N/C$$

Field lines go out of positive charge.

(B) $|\vec{E}| = \frac{|\vec{F}|}{q_{test}}$ $\quad 449{,}500 = \frac{F}{2.00\times10^{-8}}$ $\quad \vec{F} = 8.99\times10^{-3} N\ [\text{right}]$

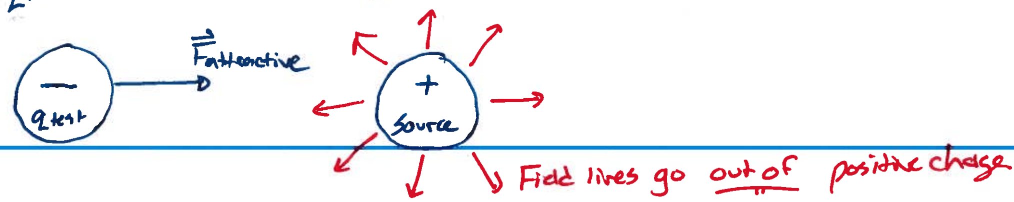
Positive charge pushed in same direction of field.

KEY

Pg 553 #8: A small test sphere with a negative charge of 2.50 µC experiences an electrostatic attractive force of magnitude 5.10 x 10^{-2} N when it is placed at a point 0.0400 m from another larger charged sphere. Calculate

a. The magnitude and direction of the electric field at this point.
b. The magnitude and the sign of charge on the larger charged sphere.

Ⓐ $|\vec{E}| = \frac{|\vec{F}|}{q_{test}}$ $\qquad |\vec{E}| = \frac{5.10\times10^{-2}}{2.5\times10^{-6}} = 20{,}400$ N/C [away from larger sphere]



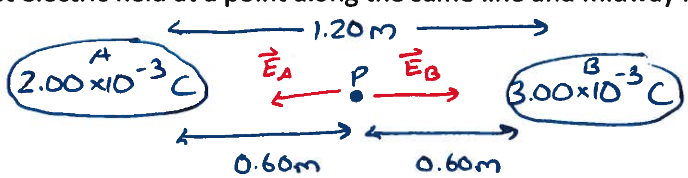
Ⓑ $F = \frac{kq_1q_2}{r^2}$ or $\frac{kq_{source}}{r^2}$

$$5.10\times10^{-2} = \frac{(8.99\times10^9)(2.5\times10^{-6})\,q_{source}}{(0.04)^2}$$

$q_{source} = +\,3.63\times10^{-9}$ C

Pg 553 #9a: A negative charge of 3.00 mC is 1.20 m to the right of another negative charge of 2.00 mC. Calculate

a. The net electric field at a point along the same line and midway between the two charges.



$$|\vec{E}_A| = \frac{kq_A}{r^2} = \frac{(8.99\times10^9)(2.00\times10^{-3})}{(0.6)^2} = 4.994\times10^7 \text{ N/C [left]}$$

$$|\vec{E}_B| = \frac{kq_B}{r^2} = \frac{(8.99\times10^9)(3.00\times10^{-3})}{(0.6)^2} = 7.492\times10^7 \text{ N/C [right]}$$

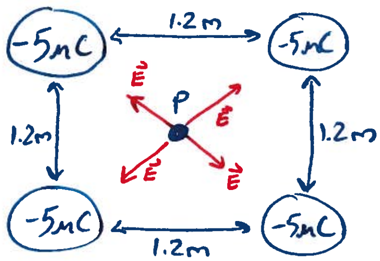
$$\vec{E}_{net} = \vec{E}_A + \vec{E}_B$$

$= -4.994\times10^7$ N/C [right] $+ 7.492\times10^7$ N/C [right]

$= 2.497\times10^7$ N/C [right]

KEY

Pg 553 #10: Four similarly charged spheres of -5.00 µC are placed at the corners of a square with sides of 1.20 m. Determine the electric field at the point of intersection of the two diagonals of the square.



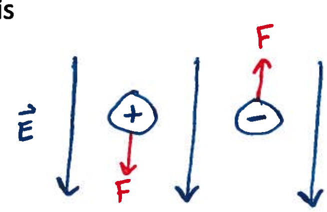
All vectors cancel out.

$\vec{E}_{net} = 0\ N/C.$

Diploma Worksheet Questions – Electric Fields (Basic Definitions)

Q143: If a positively charged test body is placed in an electric field that is directed downward, the direction of the force on the test body is

a. Up
b. Down
c. Left
d. Right



Electric field direction is the direction that a positive test charge would experience a force.

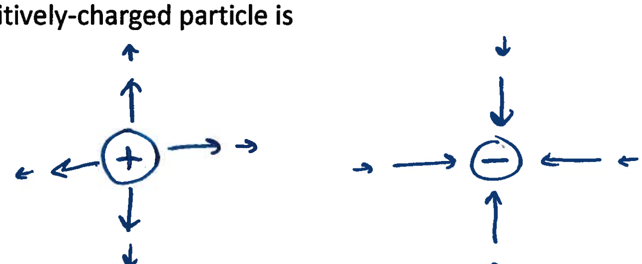
Q145: The direction assigned to an electric field vector is the same direction of the force exerted by the field on a

a. Positive test charge
b. Negative test charge
c. Flow of positive charge
d. Flow of negative charge

See above explanation.

Q147: The direction of the electric field near a positively-charged particle is

a. Counter-clockwise around the charge
b. Clockwise around the charge
c. Inward toward the particle
d. Outward from the particle



Q148: A unit for electric field strength is

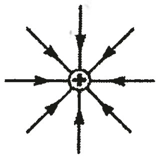
a. V
b. N/C
c. J/C
d. N/(C*m)

Key

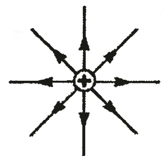
Diploma Worksheet Questions – Electric Fields (Diagrams)

Q153: Which diagram would represent the electric field surrounding a positive charge?

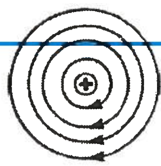
A.



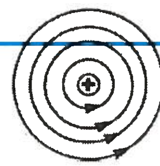
B.



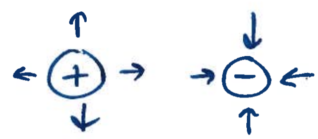
C.



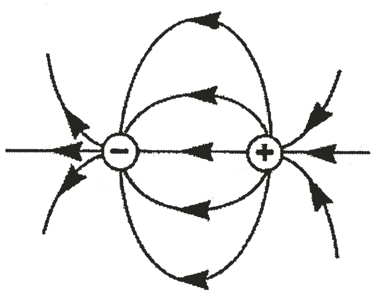
D.



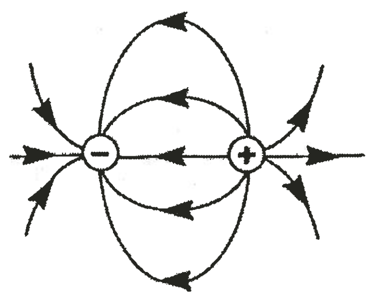
Q153: The diagram that best represents the electric field around two oppositely charged spheres is



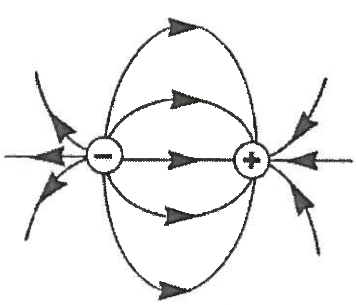
A.



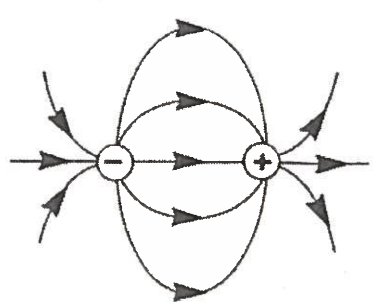
B.



C.



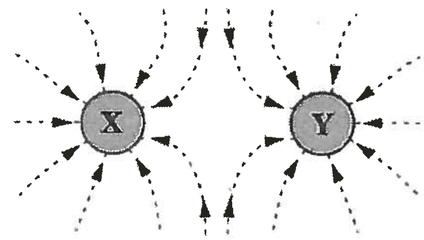
D.



Key

Use the following information to answer Q157:

Electric Field Lines Near Two Charged Spheres



Q157: The types of charge present on X and Y are, respectively,

a. Negative and negative
b. Negative and positive
c. Positive and negative
d. Positive and positive

$\vec{E}$-field lines go into a negative charge and out of a positive charge.

Diploma Worksheet Questions – Electric Fields (in 1-Dimension)

Q159: A 4.0×10^{-6} C charge with a mass of 3.0 g experiences a force of 8.0 N while under the influence of an electric field. What is the intensity of the electric field (assuming there are negligible gravitational forces)?

a. 2.0×10^{6} N/C
b. 4.8×10^{6} N/C
c. 6.0×10^{6} N/C
d. 1.6×10^{7} N/C

$$|\vec{E}| = \frac{\vec{F}}{q_{test}}$$

$$|\vec{E}| = \frac{8.0}{4.0\times10^{-6}} = 2.0\times10^{6}\ N/C$$

KEY

Q160: Two charged objects, each with a mass of 2.0 x 10^{-9} kg, accelerate in an electric field with a strength of 4.0 x 10^{6} N/C. If the acceleration of one object is -3.2 x 10^{-3} m/s^2 and the acceleration of the other object is -1.92 x 10^{-3} m/s^2, the charges differ by

a. 8e
b. 6e
c. 4e
d. 2e

$|\vec{E}| = \frac{|\vec{F}|}{q} \Rightarrow |\vec{F}| = q|\vec{E}|$ and $F = ma$

so $\boxed{q|\vec{E}| = ma}$

Also, $1e = 1.60 \times 10^{-19}$ C

Object A

$q(4.0\times10^{6}) = (2.0\times10^{-9})(3.2\times10^{-3})$

$q = 1.60\times10^{-18}$ C

$q = 10e$

Object B

$q(4.0\times10^{6}) = (2.0\times10^{-9})(1.92\times10^{-3})$

$q = 9.6\times10^{-19}$ C

$q = 6e$

Difference of 4e

Q166: A point charge of magnitude 6.9 x 10^{-5} C produces an electric field of 1.0 x 10^{3} N/C at point P. The distance from P to the charge is

a. 4.3 x 10^{-2} m
b. 2.1 x 10^{-1} m
c. 2.5 x 10^{1} m
d. 6.2 x 10^{2} m

$|\vec{E}| = \frac{kq_{source}}{r^2}$

$1.0\times10^{3} = \frac{(8.99\times10^{9})(6.9\times10^{-5})}{r^2}$

$r^2 = 620.31$

$r = 24.9$ m

$r \approx 2.5\times10^{1}$ m

Q168: The magnitude of an electric field at a distance *x* from a point charge *Q* is 8.3 x 10^{-4} N/C. If the distance is increased to *3x* and the charge is reduced to *Q/4*, then the magnitude of the electric field will be

a. 1.9 x 10^{-3} N/C
b. 3.7 x 10^{-4} N/C
c. 6.9 x 10^{-5} N/C
d. 2.3 x 10^{-5} N/C

$|\vec{E}_{original}| = \frac{kq}{r^2} = 8.3\times10^{-4}$ N/C

$|\vec{E}_{new}| = \frac{k(\frac{1}{4}q)}{(3r)^2} = \frac{\frac{1}{4}kq}{9r^2} = \frac{1}{36}\left(\frac{kq}{r^2}\right)$

$= \frac{1}{36}(8.3\times10^{-4})$

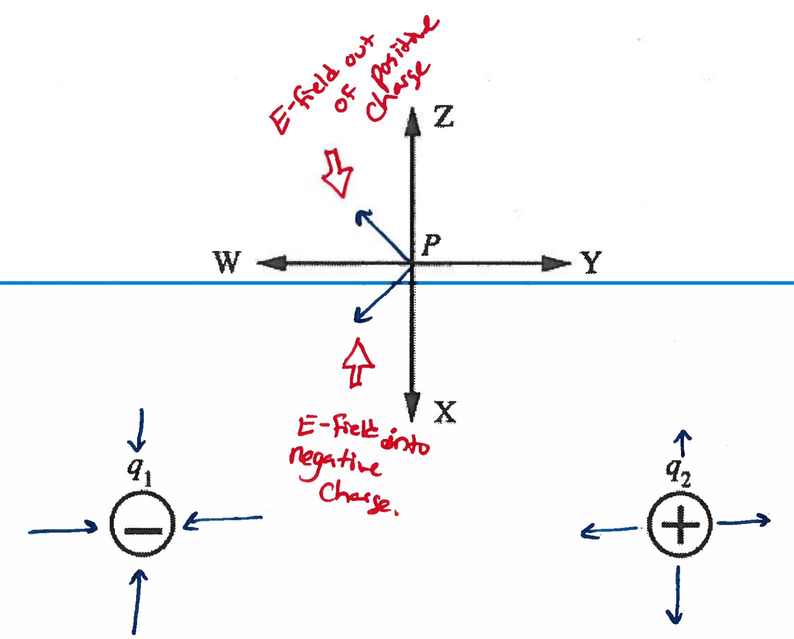
$= 2.3\times10^{-5}$ N/C

KEY

Diploma Worksheet Questions – Electric Fields (in 2-DImensions)

Use the following information to answer Q169:

Electric Field from Two Point Charges



In the diagram, q_1 and q_2 are charges of equal magnitude but opposite sign. Point P is equidistant from q_1 and q_2.

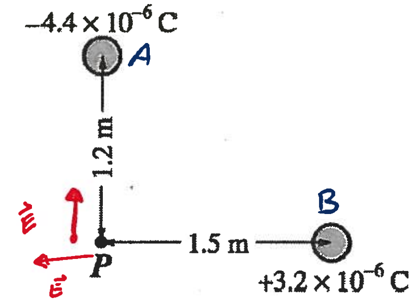
Q170: The direction of the net electric field at point *P* is the same as direction

a. W
b. X
c. Y
d. Z

KEY

Use the following information to answer Q173 – Q174:

Two point charges and point P are located as shown below.



Q173: At point P, the direction of the net electric field due to the two point charges is

A.


B.


C.

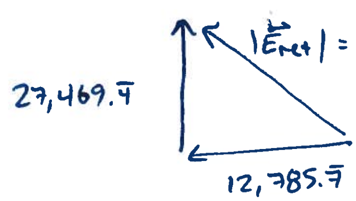

D.


Q174: At point P, the magnitude of the net electric field due to the two point charges is

a. 1.5×10^4 N/C
b. 3.0×10^4 N/C
c. 4.0×10^4 N/C
d. 5.2×10^4 N/C

$|\vec{E}_A| = \frac{kq_A}{r^2} = \frac{(8.99 \times 10^9)(4.4 \times 10^{-6})}{(1.2)^2} = 27{,}469.\bar{4}$ N/C [up]

$|\vec{E}_B| = \frac{kq_B}{r^2} = \frac{(8.99 \times 10^9)(3.2 \times 10^{-6})}{(1.5)^2} = 12{,}785.\bar{7}$ N/C [left]



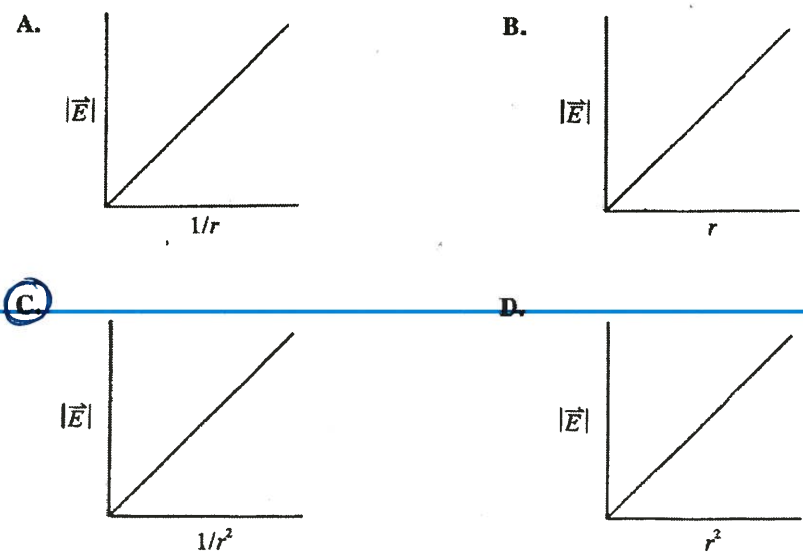
$|\vec{E}_{net}| = 30{,}299$ N/C

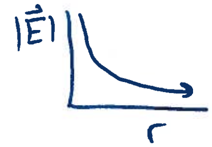
$\simeq 3.0 \times 10^4$ N/C

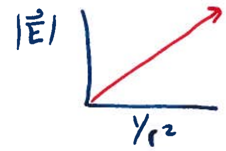
■ KEY ■

Diploma Worksheet Questions – Electric Fields (Graphing)

Q175: Which graph represents the electric field strength $|\vec{E}|$ as a function of the distance r from a point charge?





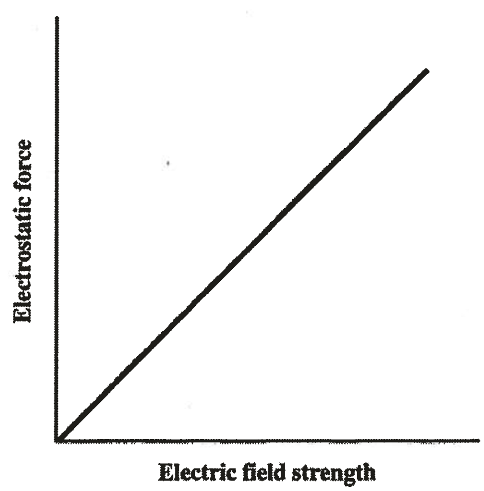


$|\vec{E}| = (kq)\frac{1}{r^2} + 0$

$y = (m)\ x + b$

Use the following information to answer Q177:

Force as a Function of Electric Field Strength



Q177: The slope of the graph represents

a. Coulomb's Law
b. The distance between two parallel charged plates
c. The magnitude of the charge on a particle in an electric field
d. The potential difference between two points in an electric field

$|\vec{E}| = \frac{|\vec{F}|}{q}$

$|\vec{F}| = q|\vec{E}| + 0$

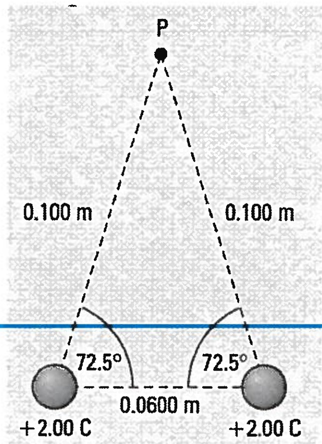
$y = m(x) + b$

so slope = charge

KEY

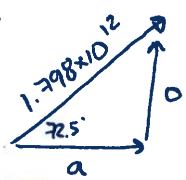
Challenge Questions

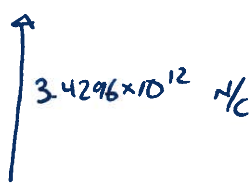
Pg 551 #1: Calculate the net electric field at point P, which is 0.100 m from two similar spheres with positive charges of 2.00 C and separated by a distance of 0.0600 m, as shown in the figure below.



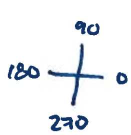
$$|\vec{E}_A| = \frac{kq_A}{r^2} = \frac{(8.99\times10^9)(2.00)}{(0.1)^2} = 1.798\times10^{12}\ N/C$$

$$|\vec{E}_B| = 1.798\times10^{12}\ N/C$$

	x-comp $- \longleftrightarrow +$	y-comp $+ \updownarrow -$
$\vec{E}_A$ 	$\cos\theta = \frac{a}{h}$ $E_{Ax} = +5.4067\times10^{11}\ N/C$	$\sin\theta = \frac{o}{h}$ $E_{Ay} = +1.7148\times10^{12}\ N/C$
$\vec{E}_B$ 	$E_{Bx} = -5.4067\times10^{11}\ N/C$	$E_{By} = +1.7148\times10^{12}\ N/C$
	$E_{net\,x} = 0\ N/C$	$E_{net\,y} = 3.4296\times10^{12}\ N/C$



$$\vec{E}_{net} = 3.4296\times10^{12}\ N/C\ [90°]$$

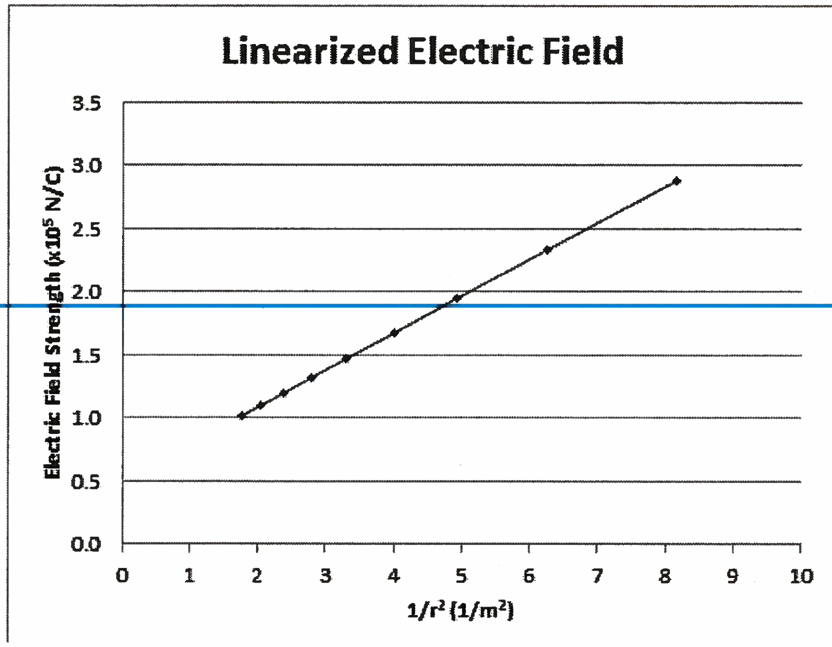


KEY

Use the following information to answer Q1:

The strength of an electric field is measured at various distances from a negatively charged sphere, and graphed below.

r	1/r^2	E (x10^5)
0.350	8.163	2.885
0.400	6.250	2.326
0.450	4.938	1.943
0.500	4.000	1.669
0.550	3.306	1.466
0.600	2.778	1.312
0.650	2.367	1.192
0.700	2.041	1.096
0.750	1.778	1.019



Q1: The negatively charged sphere has a charge of ***a.bc*** x 10^{-d} C, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

3	2	5	6

$$|\vec{E}| = (kq)\frac{1}{r^2} + 0$$
$$y = (m)\,x + b$$

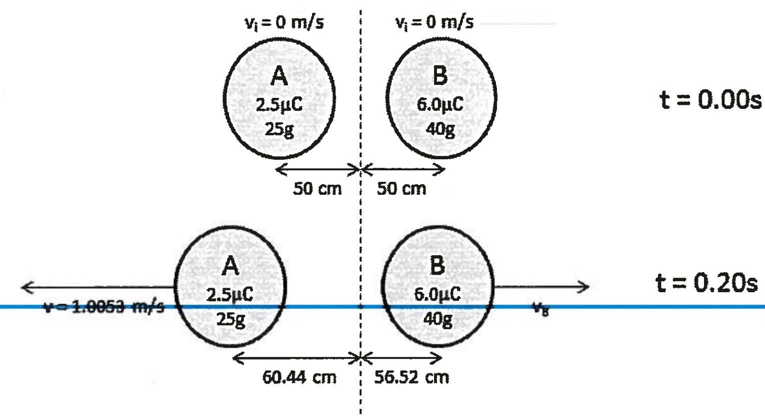
$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(2.885\times10^5)-(1.019\times10^5)}{8.163 - 1.778} = 29{,}244.7454973$$

$$m = kq$$
$$29{,}244.7454973 = (8.99\times10^9)\,q$$
$$q = 3.25\times10^{-6}\ C$$

KEY

Use the following information to answer Q2-Q5:

Two positively charged spheres are held 1.00m apart. Once released, both charges electrostatically repel from each other, per the diagram below.



Q2: The instantaneous acceleration of *Object A*, the moment it is released, is

a. 5.39×10^{-3} m/s^2
b. 2.16×10^{-2} m/s^2
c. 5.39 m/s^2
d. 2.16×10^{1} m/s^2

$$F = \frac{kq_Aq_B}{r^2} = \frac{(8.99\times10^{9})(2.5\times10^{-6})(6.0\times10^{-6})}{(1.0)^2}$$

$$F = 0.13485 N$$

$$a = \frac{F_{net}}{m} = \frac{0.13485}{0.025} = 5.394 \text{ m/s}^2$$

Q3: What is the impulse experienced by *Object A* within the first 0.20 seconds?

a. 2.35×10^{-2} Ns
b. 2.51×10^{-2} Ns
c. 2.70×10^{-2} Ns
d. 2.87×10^{-2} Ns

$F\Delta t = m\Delta v$

Keep in mind that Force will change (decrease) as we increase our distance... and we don't know what F_{avg} is. So look at Δp instead.

$$F\Delta t = (0.025)(1.0053)$$

$$F\Delta t = 0.0251325 \text{ Ns}$$

$$\approx 2.51\times10^{-2} \text{ Ns}$$

KEY

Q4: What is the speed of *Object B* at exactly 0.20 seconds is ***a.bc*** x 10^{-d} m/s, where ***a, b, c,*** and ***d*** are ____, ____, ____, and ____.

*(Record your **four digit** answer in the Numerical Response boxes below)*

6	2	8	1

Isolated system (no external forces... just internal repulsion).

$$P_i = P_f$$

$$0 = m_A v_A + m_B v_B \qquad - \longleftrightarrow +$$

$$0 = (0.025)(-1.0053) + (0.040)v_B$$

$$v_B = 0.6283125 \text{ m/s}$$

$$= 6.28 \times 10^{-1} \text{ m/s}$$

Q5: The electrostatic force between *Object A* and *Object B*, measured at exactly 0.20s, is ***a.bc*** x 10^{-d} N, where ***a, b, c,*** and ***d*** are ____, ____, ____, and ____.

*(Record your **four digit** answer in the Numerical Response boxes below)*

9	8	6	2

$$F = \frac{k q_A q_B}{r^2} = \frac{(8.99\times10^{9})(2.5\times10^{-6})(6.0\times10^{-6})}{(1.1696)^2} = 9.86\times10^{-2} \text{ N}$$