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← PHYS-2B, section 34945, Spring 2020

INSTRUCTOR
John Walkup
California State University
Fresno

Review Up To Ohm's Law (Homework)

Current Score

QUESTION	1	2	3	4	5	6	7	8	9	10	11	12
POINTS	0/3 ✗	4/4 ✓	2/2 ✓	0/3 ✗	–/2	4/4 ✓	4/4 ✓	–/4	1/1 ✓	–/4	2/2 ✓	2/2 ✓

TOTAL SCORE

19/35 54.3%

Due Date Past Due

SAT, FEB 29, 2020
11:59 PM PST

Request Extension

Assignment Submission & Scoring

Assignment Submission

For this assignment, you submit answers by question parts. The number of submissions remaining for each question part only changes if you submit or change the answer.

Assignment Scoring

Your last submission is used for your score.

The due date for this assignment has passed.

Your work can be viewed below, but no changes can be made.

Important! Before you view the answer key, decide whether or not you plan to request an extension. Your Instructor may not grant you an extension if you have viewed the answer key. Automatic extensions are not granted if you have viewed the answer key.

Request Extension

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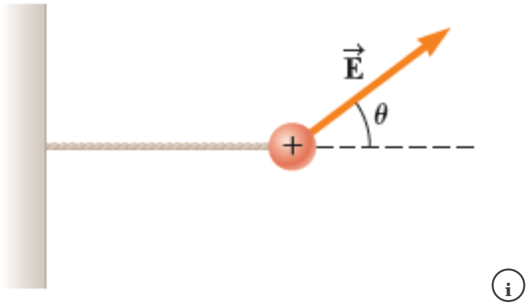
1. 0/3 points Previous Answers **SERCP11 15.3.P.022.**

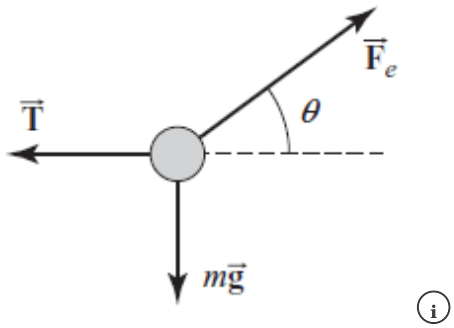
My Notes Ask Your Teacher

A small sphere of charge q = +67 μC and mass m = 5.7 g is attached to a light string and placed in a uniform electric field $\vec{\mathbf{E}}$ that makes an angle θ = 30° with the horizontal. The opposite end of the string is attached to a wall and the sphere is in static equilibrium when the string is horizontal as in the figure shown below.



(a) Construct a free body diagram for the sphere. (Submit a file with a maximum size of 1 MB.)

Key:



This answer has not been graded yet.

(b) Find the magnitude of the electric field.

1350 ✗ 1670

Your response differs from the correct answer by more than 10%. Double check your calculations. N/C

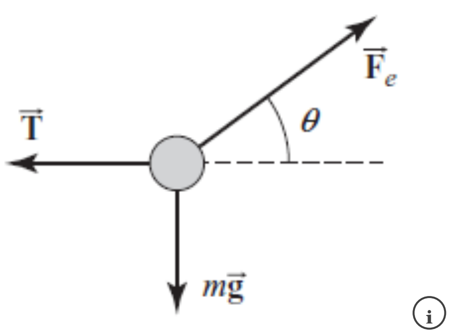
(c) Find the tension in the string. (Enter the magnitude of the tension in the string.)

.0741 ✗ 0.0968

Your response differs from the correct answer by more than 10%. Double check your calculations. N

Solution or Explanation

(a)



(b) $\sum F_y = 0 \Rightarrow F_e \sin(\theta) - mg = 0$ or $F_e = \dfrac{mg}{\sin(\theta)}$

Since $F_e = qE$, this gives

$$E = \frac{mg}{q\sin(\theta)} = \frac{(5.70 \times 10^{-3}\text{ kg})(9.8\text{ m/s}^2)}{(67.0 \times 10^{-6}\text{ C})\sin(30°)} = 1.67 \times 10^3\text{ N/C}$$

(c) $\sum F_x = 0 \Rightarrow F_e \cos(\theta) - T = 0$ or $T = F_e \cos(\theta) = \left(\dfrac{mg}{\sin(\theta)}\right)\cos(\theta) = \dfrac{mg}{\tan(\theta)}$

and $T = \dfrac{(5.70 \times 10^{-3}\text{ kg})(9.8\text{ m/s}^2)}{\tan(30°)} = 9.68 \times 10^{-2}\text{ N}$

Need Help? Read It

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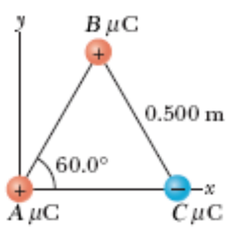
2. 4/4 points Previous Answers **SERCP11 15.3.P.024.**

My Notes Ask Your Teacher



(a) Three point charges, $A = 1.85$ μC, $B = 6.75$ μC, and $C = -4.05$ μC, are located at the corners of an equilateral triangle as in the figure above. Find the magnitude and direction of the electric field at the position of the 1.85 μC charge.

magnitude 2.12e5 ✓ 2.12e+05 N/C

direction 83.4 ✓ 83.4 ° below the $+x$-axis

(b) How would the electric field at that point be affected if the charge there were doubled?

- ○ The magnitude of the field would be halved.
- ● The field would be unchanged.
- ○ The magnitude of the field would double.
- ○ The magnitude of the field would quadruple.

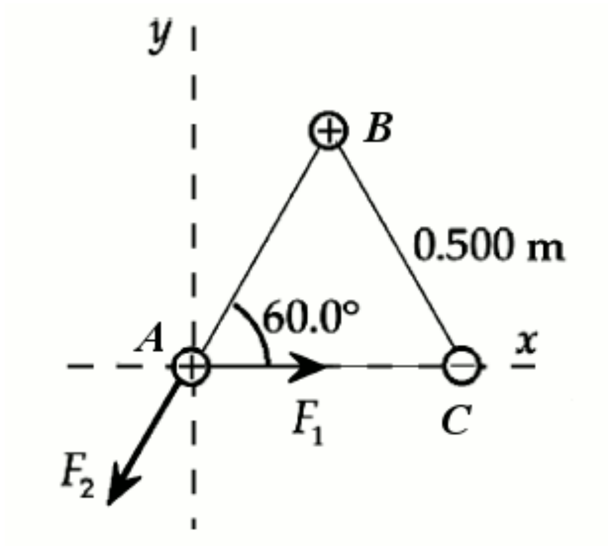
✓

Would the magnitude of the electric force be affected?

- (selected) Yes
- No

Solution or Explanation

(a) Please see the sketch below.



$$F_1 = \frac{(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)(1.85 \times 10^{-6}\ \text{C})(4.05 \times 10^{-6}\ \text{C})}{(0.500\ \text{m})^2}$$

or

$F_1 = 0.269$ N

$$F_2 = \frac{(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)(1.85 \times 10^{-6}\ \text{C})(6.75 \times 10^{-6}\ \text{C})}{(0.500\ \text{m})^2}$$

or

$F_2 = 0.449$ N

The components of the resultant force acting on the 1.85 μC charge are:

$$F_x = F_1 - F_2 \cos(60.0°) = 0.269\ \text{N} - (0.449\ \text{N}) \cos(60.0°) = 0.0449\ \text{N}$$

and

$$F_y = -F_2 \sin(60.0°) = -(0.449\ \text{N}) \sin(60.0°) = -0.389\ \text{N}$$

The magnitude and direction of this resultant force are

$$F = \sqrt{F_x{}^2 + F_y{}^2} = \sqrt{(0.0449\ \text{N})^2 + (-0.389\ \text{N})^2} = 0.391\ \text{N}$$

at $\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{-0.389\text{ N}}{0.0449\text{ N}}\right) = -83.4°$
or 83.4° below the +*x*-axis.

Since the electric field at a location is defined as the force per unit charge experienced by a test charge placed in that location, the electric field at the origin in the charge configuration is

$$\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}}{q_0} = \frac{0.391\text{ N}}{1.85 \times 10^{-6}\text{ C}} \text{ at } -83.4° = 2.12 \times 10^{5}\text{ N/C at } 83.4° \text{ below the } +x\text{-axis}$$

(b) The electric force experienced by the charge at the origin is directly proportional to the magnitude of that charge. Thus, doubling the magnitude of this charge would double the magnitude of the electric force. However, the electric field is the force per unit charge and the field would be unchanged if the charge was doubled. This is easily seen in the calculation of part (a) above. Doubling the magnitude of the charge at the origin would double both the numerator and the denominator of the ratio $\vec{\mathbf{F}}/q_0$, but the value of the ratio (i.e., the electric field) would be unchanged.

Need Help? Read It

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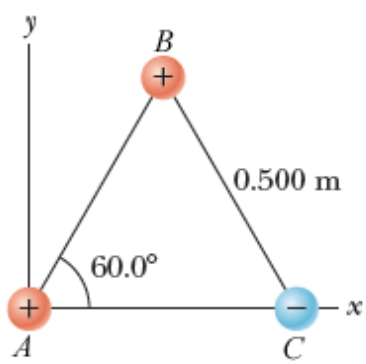
3. 2/2 points Previous Answers **SERCP11 15.2.OP.013.**

My Notes Ask Your Teacher

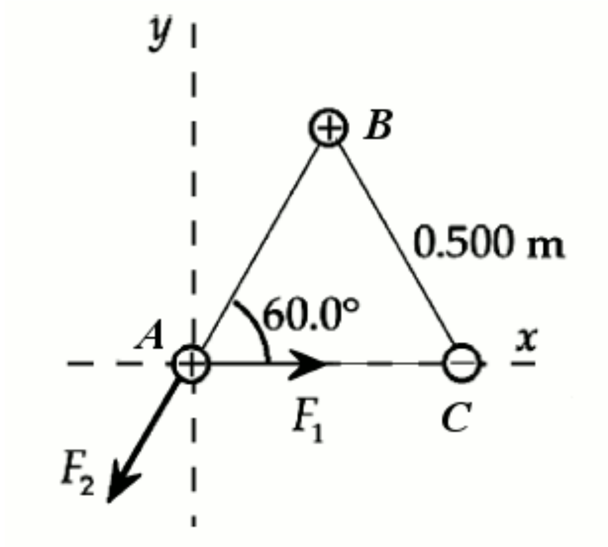
The figure below shows three small, charged beads at the corners of an equilateral triangle. Bead *A* has a charge of 1.20 μC; *B* has a charge of 5.70 μC; and *C* has a charge of −5.02 μC. Each side of the triangle is 0.500 m long. What are the magnitude and direction of the net electric force on A? (Enter the magnitude in N and the direction in degrees below the +*x*-axis.)



magnitude	2.33e-1	0.233	N
direction	66.2	66.3	° below the +*x*-axis

Solution or Explanation

Please see the sketch below.



$$F_1 = \frac{(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)(1.20 \times 10^{-6}\ \text{C})(5.02 \times 10^{-6}\ \text{C})}{(0.500\ \text{m})^2}$$

or

$$F_1 = 0.217\ \text{N}$$

$$F_2 = \frac{(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)(1.20 \times 10^{-6}\ \text{C})(5.70 \times 10^{-6}\ \text{C})}{(0.500\ \text{m})^2}$$

or

$$F_2 = 0.246\ \text{N}.$$

The components of the resultant force acting on the 1.20 μC charge are

$$F_x = F_1 - F_2 \cos(60.0°) = 0.217\ \text{N} - (0.246\ \text{N}) \cos(60.0°) = 0.0936\ \text{N}$$

and

$$F_y = -F_2 \sin(60.0°) = -(0.246\ \text{N}) \sin(60.0°) = -0.213\ \text{N}.$$

The magnitude and direction of this resultant force are

$$F = \sqrt{F_x^{\ 2} + F_y^{\ 2}} = \sqrt{(0.0936\ \text{N})^2 + (-0.213\ \text{N})^2} = 0.233\ \text{N}$$

at

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{-0.213\ \text{N}}{0.0936\ \text{N}}\right) = -66.3°$$

or 66.3° below the +x-axis.

Need Help? Read It

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4. 0/3 points Previous Answers **SERCP11 16.3.P.025.**

My Notes Ask Your Teacher

Calculate the speed (in m/s) of an electron and a proton with a kinetic energy of 1.75 electron volt (eV). (The electron and proton masses are $m_e = 9.11 \times 10^{-31}$ kg and $m_p = 1.67 \times 10^{-27}$ kg. Boltzmann's constant is $k_B = 1.38 \times 10^{-23}$ J/K.)

HINT

(a) an electron

7.84e-26 ✗ 7.85e+05 m/s

(b) a proton

(No Response) 18300 m/s

(c) Calculate the average translational kinetic energy in eV of a 3.25×10^2 K ideal gas particle. (Recall from Topic 10 that $\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_BT$.)

(No Response) 0.042 eV

Solution or Explanation

Note: We are displaying rounded intermediate values for practical purposes. However, the calculations are made using the unrounded values.

Use the conversion factor 1 eV = 1.60×10^{-19} C · V to find the kinetic energy in joules.

$$KE = (1.75\text{ eV})\left(\frac{1.60 \times 10^{-19}\text{ J}}{1\text{ eV}}\right) = 2.80 \times 10^{-19}\text{ J}$$

(a) Solve for the electron's speed from the definition of kinetic energy.

$$KE = \frac{1}{2}m_e v_e^2 \rightarrow v_e = \sqrt{\frac{2(KE)}{m_e}} = \sqrt{\frac{2(2.80 \times 10^{-19}\text{ J})}{9.11 \times 10^{-31}\text{ kg}}} = 7.85 \times 10^5\text{ m/s}$$

(b) Follow the same steps to find the proton's speed.

$$KE = \frac{1}{2}m_p{v_p}^2 \rightarrow v_p = \sqrt{\frac{2(KE)}{m_p}} = \sqrt{\frac{2(2.80 \times 10^{-19}\text{ J})}{1.67 \times 10^{-27}\text{ kg}}} = 1.83 \times 10^{4}\text{ m/s}$$

(c) Use $KE_{\text{av}} = \frac{1}{2}m\overline{v^2} = \frac{3}{2}k_{\text{B}}T$ to find the average translational kinetic energy in joules.

$$KE_{\text{av}} = \frac{3}{2}k_{\text{B}}T = \frac{3}{2}(1.38 \times 10^{-23}\text{ J/K})(325\text{ K})$$
$$= 6.73 \times 10^{-21}\text{ J}$$

Convert to eV to find the following.

$$KE_{\text{av}} = (6.73 \times 10^{-21}\text{ J})\left(\frac{1\text{ eV}}{1.60 \times 10^{-19}\text{ J}}\right) = 0.0420\text{ eV}$$

Need Help? Read It Watch It

5. –/2 points **SERCP11 16.3.P.028.** My Notes Ask Your Teacher

In the classical model of a hydrogen atom, an electron orbits a proton with a kinetic energy of +13.6 eV and an electric potential energy of −27.2 eV.

HINT

(a) Use the kinetic energy to calculate the classical orbital speed (in m/s).

(No Response) 2.19e+06 m/s

(b) Use the electric potential energy to calculate the classical orbital radius (in m).

(No Response) 5.29e-11 m

Solution or Explanation

Note: We are displaying rounded intermediate values for practical purposes. However, the calculations are made using the unrounded values.

Use 1 eV = 1.60×10^{-19} J to convert the given energies to joules.

$$KE_e = (13.6 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV}) = 2.18 \times 10^{-18} \text{ J}$$

and

$$PE_e = (-27.2 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV}) = -4.36 \times 10^{-18} \text{ J}$$

(a) Use the definition of kinetic energy to find the electron's speed.

$$KE = \frac{1}{2}mv^2 \rightarrow v_e = \sqrt{\frac{2(KE_e)}{m_e}} = \sqrt{\frac{2(2.18 \times 10^{-18} \text{ J})}{9.11 \times 10^{-31} \text{ kg}}} = 2.19 \times 10^6 \text{ m/s}$$

(b) Use the potential energy of a pair of charges to solve for the orbital radius r.

$$PE = k_e \frac{q_e q_p}{r}$$

$$r_e = -k_e \frac{e^2}{PE_e} = -(8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{(1.60 \times 10^{-19} \text{ C})^2}{-4.36 \times 10^{-18} \text{ J}}$$
$$= 5.29 \times 10^{-11} \text{ m}$$

Need Help? Read It Watch It

6. 4/4 points Previous Answers **SERCP11 16.CQ.001.**

My Notes Ask Your Teacher

A proton is released from rest in a uniform electric field. Determine whether the following quantities increase, decrease, or remain unchanged as the proton moves.

HINT

(a) the electric potential at the proton's location

- increases
- decreases (selected)
- remains unchanged

(b) the proton's associated electric potential energy

- increases
- decreases (selected)
- remains unchanged

Don't confuse the two terms *electric potential* and *electric potential energy*. They represent different physical quantities, related by $\Delta V = \frac{\Delta PE}{q}$: electric potential is a measure of the change in electric potential energy *per unit charge*. As ΔV increases, potential energy can either increase (for $q > 0$) or decrease (for $q < 0$).

(c) its kinetic energy

- increases (selected)
- decreases
- remains unchanged

(d) its total energy

- increases
- decreases
- remains unchanged

Solution or Explanation

(a) The electric potential at the proton's location decreases. By conservation of energy, $e\Delta V + \Delta KE = 0$ where ΔV is the change in electric potential and ΔKE is the change in kinetic energy. As the proton moves, it gains speed and kinetic energy so that $\Delta KE > 0$. To conserve energy as KE increases, $e\Delta V$ must decrease. Because $e > 0$, $\Delta V < 0$ so that the electric potential decreases.

(b) The proton's associated electric potential energy decreases. The change in the proton's electric potential energy is $\Delta PE = e\Delta V$. As in (a), $\Delta V < 0$ so $\Delta PE < 0$.

(c) Its kinetic energy increases. The proton starts from rest and gains speed as it moves so that $\Delta KE > 0$.

(d) Its total energy remains unchanged. By conservation of energy, the system's total energy is unchanged as the proton moves.

Need Help? Read It

7. 4/4 points Previous Answers **SERCP11 16.CQ.002.**

My Notes Ask Your Teacher

An electron is released from rest in a uniform electric field. Determine whether the following quantities increase, decrease, or remain unchanged as the electron moves.

HINT

(a) the electric potential at the electron's location

- increases (selected, correct)
- decreases
- remains unchanged

(b) the electron's associated electric potential energy

- increases
- decreases (selected, correct)
- remains unchanged

Don't confuse the two terms *electric potential* and *electric potential energy*. They represent different physical quantities, related by $\Delta V = \frac{\Delta PE}{q}$: electric potential is a measure of the change in electric potential energy *per unit charge*. As ΔV increases, potential energy can either increase (for $q > 0$) or decrease (for $q < 0$).

(c) its kinetic energy

- increases (selected, correct)
- decreases
- remains unchanged

(d) its total energy

- increases
- decreases
- remains unchanged (selected, correct)

Solution or Explanation

(a) The electric potential at the electron's location increases. By conservation of energy, $-e\Delta V + \Delta KE = 0$ where ΔV is the change in electric potential and ΔKE is the change in kinetic energy. As the electron moves, it gains speed and kinetic energy so that $\Delta KE > 0$. To conserve energy as KE increases, $-e\Delta V$ must decrease so that $\Delta V > 0$.

(b) The electron's associated electric potential energy decreases. The change in the electron's electric potential energy is $\Delta PE = -e\Delta V$. As in (a), $\Delta V > 0$ so $\Delta PE < 0$.

(c) Its kinetic energy increases. The electron starts from rest and gains speed as it moves so that $\Delta KE > 0$.

(d) Its total energy remains unchanged. By conservation of energy, the system's total energy is unchanged as the electron moves.

Need Help? Read It

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8. –/4 points SERCP11 16.CQ.003. My Notes Ask Your Teacher

The figure below shows equipotential contours in the region of space surrounding two charged conductors.

24.0 V

16.0 V

48.0 V

56.0 V

72.0 V

32.0 V

40.0 V

Find the work W_{AB} in electron volts done by the electric force on an electron that moves from point A to point B. Similarly, find W_{AC}, W_{AD}, and W_{AE}. (Assume the electron starts and stops at rest. Enter your answers in eV.)

HINT

(a) W_{AB}

(No Response) 0 eV

(b) W_{AC}

(No Response) 40 eV

(c) W_{AD}

(No Response) 72 eV

(d) W_{AE}

(No Response) 72 eV

Solution or Explanation

The work done on the particle is $W = -q\Delta V$ where q is the charge and ΔV is the potential difference in volts. Here, the particle is an electron so that $q = -e$ and $W = +e\Delta V$. Because $q = -1e$, the work in units of eV done on an electron is $W = +(1 \text{ electron charge})\Delta V = +\Delta V$ eV.

(a) The surface of a conductor is an equipotential so $W_{AB} = -q\Delta V = 0$ eV.

(b) $W_{AC} = +\Delta V_{AC}$ eV $= +(V_C - V_A)$ eV $= 40.0$ eV

(c) $W_{AD} = +\Delta V_{AD}$ eV $= +(V_D - V_A)$ eV $= 72.0$ eV

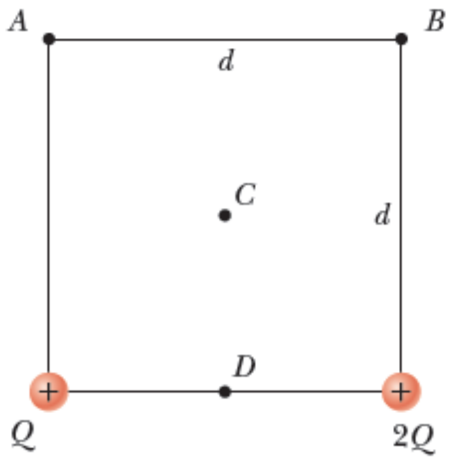
(d) The electric potential is a constant everywhere inside a conductor and equal to the same value at the surface, so $V_E = V_D$ and $W_{AE} = +\Delta V_{AE}$ eV $= +(V_E - V_A)$ eV $= 72.0$ eV

Need Help? Read It

9. 1/1 points Previous Answers **SERCP11 16.CQ.013.**

My Notes Ask Your Teacher

Rank the electric potentials at the four points shown in the figure below from largest to smallest. (Use only ">" or "=" symbols. Do not include any parentheses around the letters or symbols.)



D>C>B>A ✓ D>C>B>A

Need Help? Read It

10. –/4 points SERCP11 16.1.P.001. My Notes Ask Your Teacher

A uniform electric field of magnitude 371 N/C pointing in the positive x-direction acts on an electron, which is initially at rest. The electron has moved 3.50 cm.

(a) What is the work done by the field on the electron?

(No Response) 2.08e-18 J

(b) What is the change in potential energy associated with the electron?

(No Response) -2.08e-18 J

(c) What is the velocity of the electron?

magnitude (No Response) 2.14e+06 m/s

direction (No Response) -x

Solution or Explanation

(a) Because the electron has a negative charge, it experiences a force in the direction opposite to the field and, when released from rest, will move in the negative x-direction. The work done on the electron by the field is

$$W = F_x(\Delta x) = (qE_x)\Delta x = (-1.60 \times 10^{-19}\ \text{C})(371\ \text{N/C})(-3.50 \times 10^{-2}\ \text{m})$$
$$= 2.08 \times 10^{-18}\ \text{J}$$

(b) The change in the electric potential energy is the negative of the work done on the particle by the field. Thus,

$$\Delta PE = -W = -2.08 \times 10^{-18}\ \text{J}$$

(c) Since the Coulomb force is a conservative force, conservation of energy gives

$$\Delta KE + \Delta PE = 0,$$

or

$$KE_f = \frac{1}{2}m_e v_f^2 = KE_i - \Delta PE = 0 - \Delta PE,$$

and

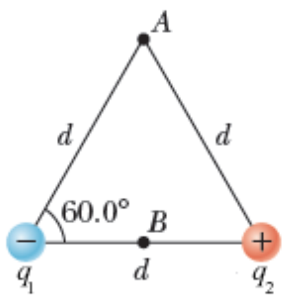
$$v_f = \sqrt{\frac{-2(\Delta PE)}{m_e}} = \sqrt{\frac{-2(-2.08 \times 10^{-18}\ \text{J})}{9.11 \times 10^{-31}\ \text{kg}}} = 2.14 \times 10^6\ \text{m/s in the } -x\text{-direction}$$

Need Help? Read It

11. 2/2 points Previous Answers **SERCP11 16.2.OP.012.**

My Notes Ask Your Teacher

The figure below shows two charged particles separated by a distance of d = 3.00 cm. The charges are q_1 = −20.0 nC and q_2 = 25.5 nC. Point B is at the midpoint between the two charges, and point A is at the peak of an equilateral triangle, with each side of length d, as shown. (Assume the zero of electric potential is at infinity.)



(a) What is the electric potential (in kV) at point A?

1.65 ✔ 1.65 kV

(b) What is the electric potential (in kV) at point B?

3.30 ✔ 3.3 kV

Solution or Explanation

Note: We are displaying rounded intermediate values for practical purposes. However, the calculations are made using the unrounded values.

(a) The electric potential at a point in space, due to a charged particle, is given by

$$V = \frac{k_e q}{r}$$

where q is the charge and r is the distance from the charge to the point. The total potential is the sum of the potential due to each charge. Therefore, at point A,

$$V_A = \frac{k_e q_1}{r_1} + \frac{k_e q_2}{r_2}$$

Note the distance from A to each charge is the same, so $r_1 = r_2 = d$. Therefore,

$$V_A = \frac{k_e q_1}{d} + \frac{k_e q_2}{d} = \frac{k_e}{d}(q_1 + q_2).$$

Substituting values gives

$$V_A = \frac{8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2}{0.0300 \text{ m}}(-20.0 \times 10^{-9} \text{ C} + 25.5 \times 10^{-9} \text{ C}) = 1,650 \text{ V, or}$$

$$V_A = 1.65 \text{ kV}.$$

(b) The potential at B is found in the same way. Note the distance from B to each charge is now $\frac{d}{2}$.

$$V_B = \frac{k_e q_1}{\left(\frac{d}{2}\right)} + \frac{k_e q_2}{\left(\frac{d}{2}\right)} = \frac{2k_e}{d}(q_1 + q_2)$$

Note this turns out to be 2 times the potential V_A, so,

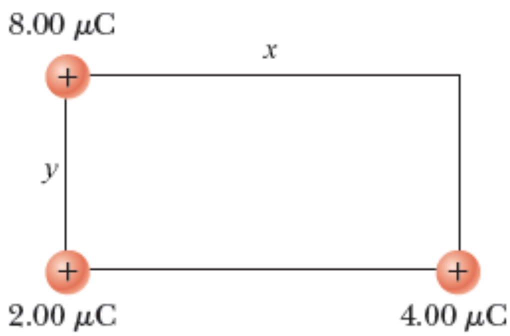
$$V_B = 2V_A = 2(1.65 \text{ kV}) = 3.30 \text{ kV}.$$

Need Help? Read It

12. 2/2 points Previous Answers **SERCP11 16.2.P.013.**

My Notes Ask Your Teacher

Consider the following figure.



(a) Find the electric potential, taking zero at infinity, at the upper right corner (the corner without a charge) of the rectangle in the figure. (Let x = 5.40 cm and y = 2.90 cm.)

2.87e6 ✔ 2.87e+06 V

(b) Repeat if the 2.00-μC charge is replaced with a charge of −2.00 μC.

2.28e6 ✔ 2.28e+06 V

Solution or Explanation

(a) Calling the 2.00 μC charge q_3,

$$V = \sum_i \frac{k_e q_i}{r_i} = k_e\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{\sqrt{r_1^{\,2} + r_2^{\,2}}}\right)$$

$$= \left(8.99 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2}\right)\left(\frac{8.00 \times 10^{-6}\ \text{C}}{5.40 \times 10^{-2}\ \text{m}} + \frac{4.00 \times 10^{-6}\ \text{C}}{2.90 \times 10^{-2}\ \text{m}} + \frac{2.00 \times 10^{-6}\ \text{C}}{\sqrt{(5.40 \times 10^{-2})^2 + (2.90 \times 10^{-2})^2}\ \text{m}}\right)$$

$$V = 2.87 \times 10^6\ \text{V}$$

(b) Replacing 2.00×10^{-6} C by -2.00×10^{-6} C in part (a) yields

$$V = 2.28 \times 10^6\ \text{V}$$

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