

Question No. 1 of 10

**Instruction:** (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

<p><b>Question #01</b></p>	<p>Question 1. The center of a balloon with <math>4 \times 10^{11}</math> excess electrons is 30 centimeters away from a similar balloon with an equal excess of electrons. Calculate the repulsive force felt by each balloon.</p> <p>(A) <math>4.1 \times 10^{-4} \text{N}</math>                  (B) <math>4.1 \times 10^{-8} \text{N}</math>                  (C) <math>1.2 \times 10^{-4} \text{N}</math>                  (D) <math>1.3 \times 10^4 \text{N}</math></p>
<p><b>Feedback on Each Answer Choice</b></p>	<p>A. Correct!                  First, change the number of electrons into the correct charge unit of Coulombs. 1 Coulomb = <math>6.25 \times 10^{18}</math> electrons. Then use Coulombs law <math>F = kq_1q_2/d^2</math> to find the force between them. Since both have an excess of electrons, both are negative, thus the force is repulsive.</p> <p>B. Incorrect.                  Remember that the units for k contain meters. Thus, the distance you use must also be in meters. Convert the centimeter measurement into meters.</p> <p>C. Incorrect.                  Don't forget that the distance is squared in the Coulombs law formula.</p> <p>D. Incorrect.                  Since each balloon has an equal negative charge, both of the charges in Coulomb's law are equal. Thus, the charge on one balloon is squared in the formula. Students often double the charge instead of squaring it.</p>
<p><b>Solution</b></p>	<p>First change the number of electrons on each balloon into the correct unit of Coulombs. You need to know that <math>6.25 \times 10^{18}</math> electrons = 1 Coulomb.</p> $4 \times 10^{11} \text{e} \times \frac{1 \text{C}}{6.25 \times 10^{18} \text{e}} = 6.4 \times 10^{-8} \text{C}$ <p>Next, change the radius or distance measurement of 30 centimeters into meters.</p> $30 \text{cm} \times \frac{1 \text{m}}{100 \text{cm}} = .3 \text{m}$ <p>Finally substitute into Coulombs law. Calculate carefully, and notice how the units cancel leaving the correct force unit of Newtons.</p> $F_E = \frac{kq_1q_2}{r^2}$ $F_E = \frac{(9 \times 10^9 \text{Nm}^2/\text{C}^2)(-6.4 \times 10^{-8} \text{C})(-6.4 \times 10^{-8} \text{C})}{(.3 \text{m})^2} = 4.1 \times 10^{-4} \text{N}$ <p>The positive sign indicates that the force is repulsive in this case since both charged balloons were negative.</p>

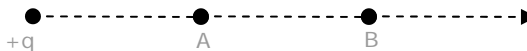
**Question No. 2 of 10**

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**Question #02**

Question 2. The diagram shows an isolated positive charge  $q$ . Point B is twice as far away from  $q$  as point A. The ratio of electric field strength at point A to the electric field strength at point B is:

- (A) 8:1
- (B) 4:1
- (C) 2:1
- (D) 1:1

**Feedback on Each Answer Choice**

A. Incorrect.  
Consider the force acting on the particles. Look at Coulombs law and note the effect of the varying distance.

B. Correct!  
Since electric field depends on the force, and force depends on the distance squared, the closer object has four times the field strength. Examine Coulombs law and note the distance squared in the denominator.

C. Incorrect.  
The force exerted on the points depends on the square of the distance. Thus, it would not be a two to one ratio because of the squared factor.

D. Incorrect.  
The location of an object has an effect on the electric field, and electric force it feels. The ratio would not be one to one.

**Solution**

The electric field strength depends on the amount of force exerted on the point.  $E=F/q$ . The force felt by the point depends on Coulombs law.  $F_E=kq_1q_2/r^2$ . Thus, if the distance is doubled, the force felt, and the electric field strength, is four times less. So the closer point A feels 4 times the electric field of point B. Thus the correct answer choice is (B).

**Question No. 3 of 10**

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**Question #03**

Question 3. Two isolated charges  $+q$  and  $-2q$  are 2 cm apart. If  $F$  is the magnitude of the force acting on charge  $-2q$ , what is the magnitude and direction of the force acting on charge  $+q$ ?

- (A)  $\frac{1}{2} F$  toward charge  $-2q$
- (B)  $\frac{1}{2} F$  away from charge  $-2q$
- (C)  $F$  toward charge  $-2q$
- (D)  $F$  away from charge  $-2q$

**Feedback on Each Answer Choice**

A. Incorrect.  
The force that is exerted on one charge will be equal in magnitude to the force exerted on the other charge. This concept can be taken from Newton's third law.

B. Incorrect.  
The force that is exerted on one charge will be equal in magnitude to the force exerted on the other charge. This concept can be taken from Newton's third law.

C. Correct!  
The force on each charge is equal in magnitude,  $F$ . Newton's third law says there is an equal and opposite reaction force for every force. Since the two charges are opposite in sign, the force is attractive. Thus, the force acts toward charge  $-2q$ .

D. Incorrect.  
The forces would repel the charges, pushing them away from each other, if they were of similar charges. In this case, they are of opposite charges.

**Solution**

The force on each charge is equal in magnitude,  $F$ . Newton's third law says there is an equal and opposite reaction force for every force. Since the two charges are opposite in sign, the force is attractive. The positive charge will be attracted to the negative charge. Also, the negative charge will be equally attracted to the positive charge. Thus, the force acts toward charge  $-2q$ .

**Question No. 4 of 10**

**Instruction:** (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

**Question #04**

Question 4. A single electron is placed in an electric field 100 N/C and points to the right. What is the magnitude and direction of the force exerted on this lonely electron?

- (A) 100N to the right
- (B) 100N to the left
- (C)  $1.6 \times 10^{-17} \text{N}$  to the left
- (D)  $1.6 \times 10^{-17} \text{N}$  to the right

**Feedback on Each Answer Choice**

A. Incorrect.  
Don't forget to change the one electron into an appropriate number of Coulombs.  $1 \text{ C} = 6.25 \times 10^{18}$  electrons.

B. Incorrect.  
Don't forget to change the one electron into an appropriate number of Coulombs.  $1 \text{ C} = 6.25 \times 10^{18}$  electrons.

C. Correct!  
First, change the single electron into the correct number of Coulombs.  $1 \text{ C} = 6.25 \times 10^{18}$  electrons. Then, use the electric field strength formula,  $E = F/q$  to find the force on that electron. Rearrange the formula to give  $F = E q$ . Finally, to determine the direction of that force, remember that the electric field points in the direction that a positive charge would move. Thus, our electron moves in the opposite direction to the field. It moves to the left.

D. Incorrect.  
Don't forget that the electric field points in the direction that a positive test charge would move. Therefore, our electron would move in the opposite direction.

**Solution**

First change the single electron into an appropriate number of Coulombs.

$$1e \times \frac{1\text{C}}{6.25 \times 10^{18} e} = 1.6 \times 10^{-19} \text{C}$$

Then, use the electric field formula to find the force on the electron.

$$E = \frac{F}{q} \quad F = Eq$$

$$F = (1.6 \times 10^{-19} \text{C})(100 \text{N/C}) = 1.6 \times 10^{-17} \text{N}$$

Notice that the unit of Coulombs cancels leaving the correct unit of Newtons.

This number represents only the magnitude, or size, of the force. To find the direction, remember that the electric field points in the direction that a positive charge would move. Thus, our negative electron would move in the opposite direction to the electric field. The electron moves to the left.

### Question No. 5 of 10

**Instruction:** (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

**Question #05**

Question 5. Calculate the electric potential of point A as pictured.

- (A)  $2.3 \times 10^{-6} \text{V}$
- (B) 77V
- (C) 380V
- (D) -160V



**Feedback on Each Answer Choice**

- A. Incorrect.  
Be sure to use the correct formula for electric potential.  $V = kq/r$  Don't confuse this relationship with Coulombs law.  $FE = kq_1q_2/r^2$
- B. Incorrect.  
For each contribution to the sum of the electric potential, use the distance that point A is away from each charge. For one term use  $.5\text{m}$ , for the other term use  $.2\text{m}$ . The total distance is not needed here.
- C. Incorrect.  
Don't forget to incorporate the signs of the charges. Since one of the charges is negative, the sign carries through in the electric potential calculation.
- D. Correct!  
Find the overall electric potential by summing the electric potential from each of the two charges pictures.  $V = kq/r$  Since there are two charges, in this case  $V = kq_1/r_1 + kq_2/r_2$  The radius or distance needed is the distance from point to each of the charges. Although electric potential isn't a vector, be sure to include the signs of the charges.

**Solution**

Find the overall electric potential by summing the electric potential from each of the two charges pictures.  $V = kq/r$  Since there are two charges in this case, the formula expands to:

$$V = k \frac{q_1}{r_1} + k \frac{q_2}{r_2}$$

The radius or distance needed is the distance from point to each of the charges. Although electric potential isn't a vector, be sure to include the signs of the charges.

$$V = (9 \times 10^9 \text{Nm}^2/\text{C}^2) \frac{6 \times 10^{-9} \text{C}}{.5\text{m}} + (9 \times 10^9 \text{Nm}^2/\text{C}^2) \frac{-6 \times 10^{-9} \text{C}}{.2\text{m}}$$

$$v = 108\text{V} - 270\text{V} = -162\text{V}$$

Notice how the units cancel, leaving  $\text{Nm}/\text{C}$ . Since a  $\text{Nm}$  equals one Joule, and a Joule/Coulomb equals a volt, this is the correct unit.

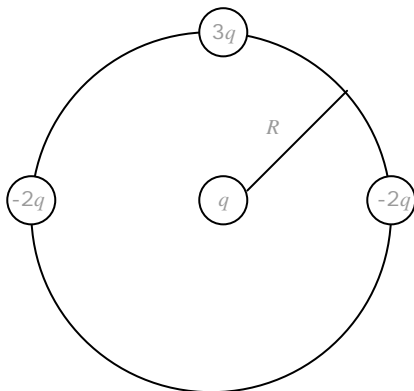
You may notice that the electric potential is negative due to the closer proximity of the negative charge. If point A had been equidistant between the equal and opposite charges, the electric potential would be zero.

**Question No. 6 of 10**

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**Question #06**

Question 6. Three point charges are distributed around a circle of radius  $R$ . What is the magnitude of the net force on the charge at the center of the circle?



- (A) 0
- (B)  $2kq^2/R^2$
- (C)  $3kq^2/R^2$
- (D)  $4kq^2/R^2$

**Feedback on Each Answer Choice**

A. Incorrect.  
Although the forces from point charges of  $-2q$  cancel, there is a contribution from the point charge of  $3q$ .

B. Incorrect.  
The forces from point charges of magnitude  $2q$  cancel.

C. Correct!  
This is the contribution from the point charge of  $3q$ , as according to the electrostatic force law.

D. Incorrect.  
The forces from point charges of magnitude  $2q$  cancel.

**Solution**

Find the net force by summing the forces from each of the charges pictured. The charge in the center is simultaneously attracted to the charge on the left and the charge on the right; the net force in the  $x$ -direction (from left to right) is therefore given by

$$F_x = k \frac{q(-2q)}{R^2} - k \frac{q(-2q)}{R^2} = 0$$

so the force in the  $x$ -direction is zero.

On the other hand, the force in the  $y$ -direction (from bottom to top) is given by:

$$F = k \frac{q(3q)}{R^2} = \frac{3kq^2}{R^2}$$

thus the answer choice (C) is correct.

**Question No. 7 of 10**

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**Question #07**

Question 7. A charge of  $3.0 \mu\text{C}$  is located  $1.0 \text{ m}$  away from a charge of  $1.0 \mu\text{C}$ . At what point along the line is joining the charges does the electric field equal zero?

- (A) 25 cm from the  $1.0 \mu\text{C}$  charge
- (B) 33 cm from the  $1.0 \mu\text{C}$  charge
- (C) 37 cm from the  $1.0 \mu\text{C}$  charge
- (D) 50 cm from the  $1.0 \mu\text{C}$  charge

**Feedback on Each Answer Choice**

A. Incorrect.  
This value is too small.

B. Incorrect.  
Although the ratio of the charges is 1:3, the distances will not be in the same ratio because electric field is proportional to the square of distance.

C. Correct!  
Set the electric fields from each of the charges equal to each other at a point  $x \text{ m}$  away from the  $1 \mu\text{C}$  charge. Then solve a quadratic equation to solve for the position  $x$ . See the solution below.

D. Incorrect.  
The electric fields from the two point charges will not be zero at this point.

**Solution**

Find the electric field by summing the electric fields from each of the charges. The charge in the center is simultaneously attracted to the charge on the left and the charge on the right; the net force in the  $x$ -direction (from left to right) is therefore given by

$$E = k \frac{q}{x^2} - k \frac{3q}{(1-x)^2} = 0$$

The preceding equation is equivalent to the following equation (after factors of  $kq$  are taken out)::

$$x^2 = \frac{(1-x)^2}{3}$$

Solve the preceding equation as follows:

$$3x^2 = 1 - 2x + x^2$$

$$2x^2 + 2x - 1 = 0$$

Using the quadratic equation, we obtain:

$$x = \frac{-2 \pm \sqrt{4+8}}{4} = -\frac{1}{2} \pm \frac{\sqrt{12}}{4} = -\frac{1}{2} \pm \frac{\sqrt{3}}{2}$$

Discard the negative answer, as this is unphysical. Thus the correct answer is  $-0.5 + 0.866 = 0.37 \text{ m} = 37 \text{ cm}$ . So (C) is the correct answer.

**Question No. 8 of 10**

**Instruction:** (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

**Question #08**

Question 8. If a charge of 1.0 nC is located 1.0 nm away from a charge of 2.0 nC, what is the potential energy of the system?

- (A) 18 J
- (B) 9.0 GJ
- (C) 18.0 GJ
- (D) none of the above

**Feedback on Each Answer Choice**

A. Correct!  
Use  $U = kq_1q_2/r$  to find the potential energy. See the solution below.

B. Incorrect.  
This value is what the electric potential due to the 1.0 nC charge at a distance 1.0 nm would be in GV. Multiply this value by the charge of the 2.0 nC charge.

C. Incorrect.  
The electric potential does not obey a  $1/r^2$  relationship.

D. Incorrect.  
The electric fields from the two point charges will not be zero at this point.

**Solution**

Find the electric potential at 1.0 nm distance from the 1.0 nC charge:

$$V = (9.0 \times 10^9 \text{ N} \cdot \text{C}^{-2} \cdot \text{m}^2) \frac{1.0 \times 10^{-9} \text{ C}}{1.0 \times 10^{-9} \text{ m}} = 9.0 \times 10^9 \text{ V}$$

The potential energy is found by multiplying the 2.0 nC charge by the previously calculated electric potential:

$$U = (2.0 \times 10^{-9} \text{ C}) \times (9.0 \times 10^9 \text{ V}) = 18 \text{ J}$$

So (B) is the correct answer.



**Question No. 9 of 10**

**Instruction:** (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

**Question #09**

Question 9. An oil drop of mass  $10^{-9}$  g and charge  $10^{-12}$  C is falling between two conducting plates which produce a potential difference of 10 V. The electric field is equal to the electric potential divided by the distance.  $E=V/d$  What is the acceleration of the oil drop?

- (A)  $0.1 \text{ m/s}^2$
- (B)  $10 \text{ m/s}^2$
- (C)  $100 \text{ m/s}^2$
- (D)  $1000 \text{ m/s}^2$

**Feedback on Each Answer Choice**

A. Incorrect.  
Remember to convert the mass from g to kg.

B. Incorrect.  
Remember to divide by the distance between the two plates.

C. Correct.  
Use the definition for E field strength. Set this equal to  $F=ma$ . Solve for a.

D. Incorrect.  
Remember the rules for dividing with powers of 10.

**Solution**

The electric field,  $E$ , is related to the voltage difference,  $V$ , and the distance between the plates,  $d$ :

$$E = \frac{V}{d}$$

To find the acceleration, the force,  $F$ , is needed to be found from  $E$ , which was previously calculated, and the charge of drop,  $q$ :

$$F = qE = \frac{qV}{d}$$

The acceleration,  $a$ , can be found by dividing  $F$  by the mass of the drop,  $m$ .

$$a = \frac{F}{m} = \frac{qV}{dm}$$

As the last step, plug in the quantities' numerical values:

$$a = \frac{(10^{-12} \text{ C}) \times (10 \text{ V})}{(0.1 \text{ m}) \times (10^{-12} \text{ kg})} = 100 \text{ m/s}^2$$

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**Question #10**

Question 10. Consider a uniformly charged ring with total charge 1.0 nC and of radius 4.0 cm. At a point on the axis of the ring, but 3.0 cm above the center of the ring, what is the potential?

- (A) 180 V
- (B) 230 V
- (C) 300 V
- (D) none of the above

**Feedback on Each Answer Choice**

A. Correct!  
Use the definition of the potential, using 5.0 cm as the distance. See the solution below.

B. Incorrect.  
Do not divide by 4.0 cm as the distance; the height above the center above the ring plays a role.

C. Incorrect.  
Include the radius of the ring in your calculation.

D. Incorrect.  
One of the answer choices above is correct.

**Solution**

Consider a contribution from a piece of charge  $\Delta Q$  along the ring to the potential,

$$\Delta V = \frac{k\Delta Q}{\sqrt{R^2 + z^2}}$$

where the radius of the ring is  $R$ , and the height above the center of the ring is  $z$ . Summing over all pieces of charge  $\Delta Q$  to get the total charge of the ring, where  $\Sigma \Delta Q = Q$ , we obtain the final result for  $V = \Sigma \Delta V$ ,

$$V = \frac{kQ}{\sqrt{R^2 + z^2}}$$

As a last step, substitute the numerical values given in the problem statement:

$$V = \frac{(9.0 \times 10^9) \times (1.0 \times 10^{-9} \text{ C})}{\sqrt{0.04^2 + 0.03^2} \text{ m}} = \frac{9.0}{5 \times 10^{-2} \text{ m}} = 180 \text{ V}$$

Thus (A) is the correct answer choice.