

Unit two – Electric fields

Defining the electric field

1- Define the electric field.

The electric field is a **property of the space** around a charged object that exerts force on another charged objects.



Note: the electric field is a vector quantity

2- How to determine the electric field at a point around a charged object?

Place a small charged object (Test charge q') at some location. If there is an electric force on it, then there is an electric field at that point.

- *The strength* of the electric field can be calculated by these two equations.

$$E = \frac{F_{on\ q'}}{q'} \quad \longleftrightarrow \quad E = \frac{K \cdot q}{r^2}$$

The strength of an electric field is equal to the force on a positive test charge divided by the strength of the test charge

- ❖ *Note1: The magnitude of the electric field is measured in (N/C)*
- ❖ *Note 2: To find the field from two charges, the fields from the individual charges are added vectorially.*

- *The direction* of the electric field is the direction of the force on a positive test charge

3- What are the characteristics that the test charge should have?

- Positive charged.
- Very small so that it doesn't cause a redistribution of the charges that you are trying to measure.

Applications

- 1- An electric field is measured using a positive test charge of $3.0 \times 10^{-6} \text{ C}$. This test charge experiences a force of 0.12 N at an angle of 15° north of east. What are the magnitude and direction of the electric field strength at the location of the test charge?

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$4.0 \times 10^4 \text{ N/C}$, 15° north of east

- 2- A negative charge of $2.0 \times 10^{-8} \text{ C}$ experiences a force of 0.060 N to the right in an electric field. What are the field's magnitude and direction at that location?

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$3.0 \times 10^6 \text{ N/C}$, to the left

- 3- A positive charge of $3.0 \times 10^{-7} \text{ C}$ is located in a field of 27 N/C directed toward the south. What is the force acting on the charge?

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$8.1 \times 10^{-6} \text{ N}$, to the South

- 4- A pith ball weighting $2.1 \times 10^{-3} \text{ N}$ is placed in a downward electric field of $6.5 \times 10^4 \text{ N/C}$. What charge (magnitude and sign) must be placed on the pith ball so that the electric force acting on it will suspend it against the force of gravity?

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$3.2 \times 10^{-8} \text{ C}$, negative

- 5- You are probing the electric field of a charge of unknown magnitude and sign. You first map the field with a $1.0 \times 10^{-6} \text{ C}$ test charge, then repeat your work with a $2.0 \times 10^{-6} \text{ C}$ test charge.

- A. Would you measure the same forces at the same place with the two test charges? Explain.

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- B. Would you find the same field strengths? Explain.

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6- What is the magnitude of the electric field strength at a position that is 1.2 m from a point charge of $4.2 \times 10^{-6} \text{ C}$?

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$2.6 \times 10^4 \text{ N/C}$

7- The electric field that is 0.25 m from a small sphere is 450 N/C toward the sphere. What is the charge on the sphere?

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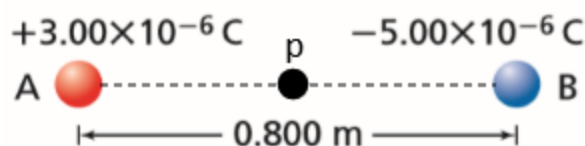
$3.1 \times 10^{-9} \text{ C}$

8- How far from a point charge of $+2.4 \times 10^{-6} \text{ C}$ must a test charge be placed to measure a field of 360 N/C?

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7.7 m

- 9- **Challenge:** What is the electric field at the point "P" which is in the middle between the two charged spheres (A, B) as shown in the next figure?



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$4.5 \times 10^5 \text{ N/C}$, to the right

- 10- How would the electric field strength change in these cases.

A. The test charge is doubled

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B. The charge is tripled.

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C. The distance from the charge is doubled

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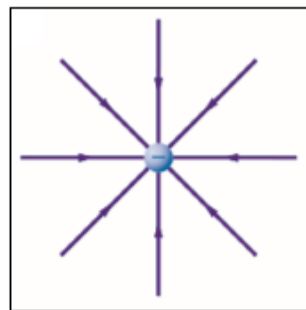
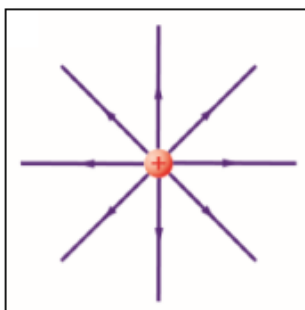
D. The distance from the charge is halved

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E. The charge is halved

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Modeling the electric field



1- What does the electric field line indicate?

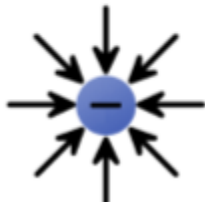
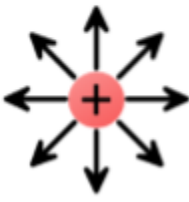
The electric field line indicates the direction of the force due to the electric field on a positive test charge.

2- What do the spaces between the electric field lines indicate?

The strength of the electric field is indicated by the spacing between the lines.

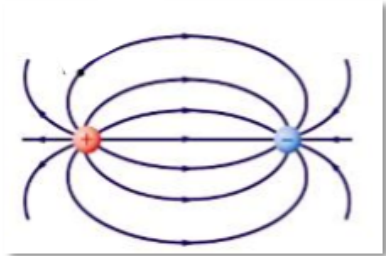
Note: The field is strong where the lines are close together. It is weaker where the lines are spaced farther apart.

3- Compare between the electric field lines of two electric charges are equal in value but one of them is positive and the other is negative.

The negative charge $-q$	The positive charge $+q$
<i>The electric field lines direction is inward the charge</i>	<i>The electric field lines direction is outward the charge</i>
	

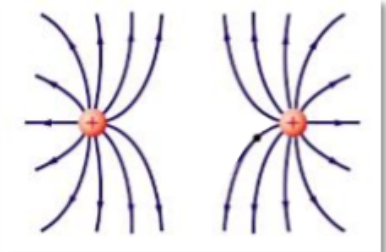
4- **How to draw the electric field lines of two equal and unlike charges?**

- The electric field lines form continuous lines from the positive charge to the negative charge.
- The number of lines drawn for each charge should be equal.

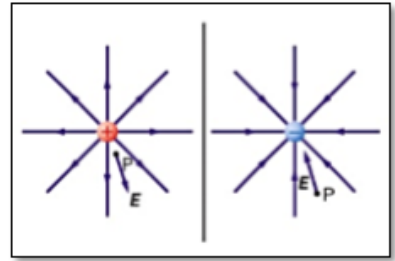
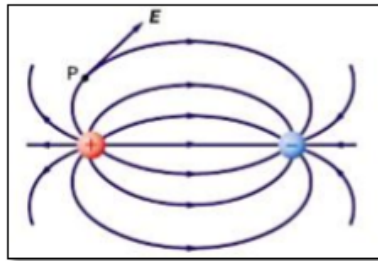
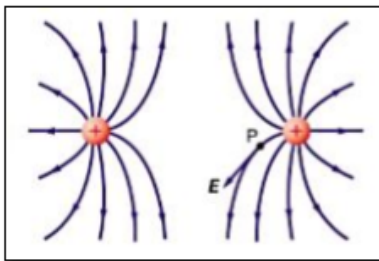


5- **How to draw the electric field lines of two equal and like charges?**

- The electric field lines never connect with each other.
- The number of lines drawn for each charge should be equal.



Note: the direction of the electric field $\vec{E}$ at any point is the tangent drawn to a field line at that point as shown in the next figure.



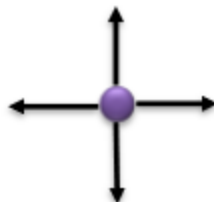
6- **Define Van de Graff generator?**

Van de Graff generator is a device that transfers large amounts of charge from one part of the machine to a metal terminal at the top of the device.



Exercises

1- If we draw the electric field lines of a charged object with charge of $+Q$ as shown in the following figure.



➤ Draw the electric field lines in the following cases:

The electric field lines of charged object with charge of $-Q$	The electric field lines of charged object with charge of $+2Q$
The electric field lines of charged object with charge of $-3Q$	The electric field lines of charged object with charge of $+\frac{1}{2}Q$

2- From the next figure, determine:

A. The type of charge (q_1, q_2).

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B. The value of charge q_1 if $q_2 = 4 \mu\text{C}$

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