Electric Field

by

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P3.7e Explain why an attractive force results from bringing a charged object near a neutral object.

P3.7f Determine the new electric force on charged objects after they touch and are then separated.

P3.7g Propose a mechanism based on electric forces to explain current flow in an electric circuit.

Items;

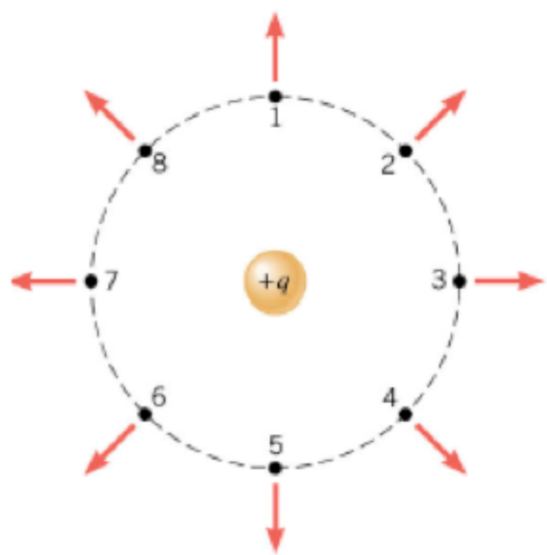
1- Electric Field

2- Electric Field Calculation

3- Electrostatic Force

Electric Field

Every charged object (such as +q in figure (a) below) creates an electric field of force in the space around it. Any other charged object in that field (such as the 8 positive test charges in figure (a) below) will experience a force of electrical attraction or repulsion (the case of figure (a) below). In figure (a) below the red arrows represent the repulsive electrostatic force that is directed outward.



(a)

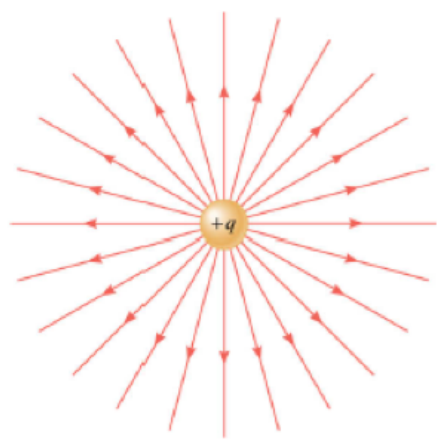
Electric Field Aspects

The electric field can be represented by drawing a series of field lines around the charged object. Field lines:

a- provide a map of the electric force,

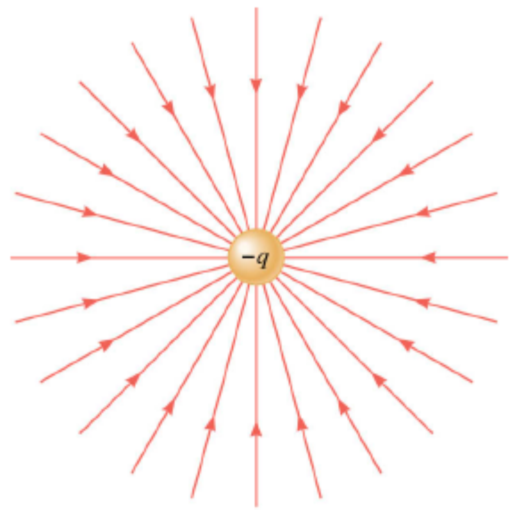
b- show the direction of an electric force,

c- are always directed away from positive charges, (see example below, the positive charge is in the center. The red arrows below represent the electric field lines and are directed outward)



(b)

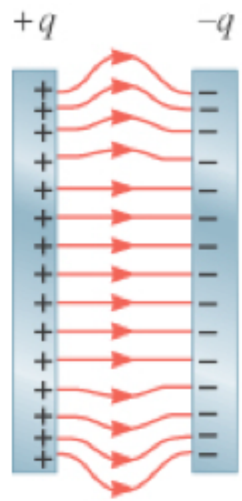
d- are always directed toward negative charges, (see example below, the negative charge is in the center. The red arrows below represent the electric field lines and are directed inward),



d- show the path taken by a small positive test charge when allowed to move freely under the influence of the electric force,

e- indicate the strength of the electric field. The closer the distance between adjacent (besides each other) field lines, the stronger is field.

f- always begin on a positive charge and end on a negative charge and do not stop in mid-space as shown in the figure below.



Electric Field Calculation

The electric field E that exists at a point is the electrostatic force F experienced by a small test charge qo placed at that pint divided by the charge itself.

$$E = F / q_o$$

or

$$F = E \times q_o$$

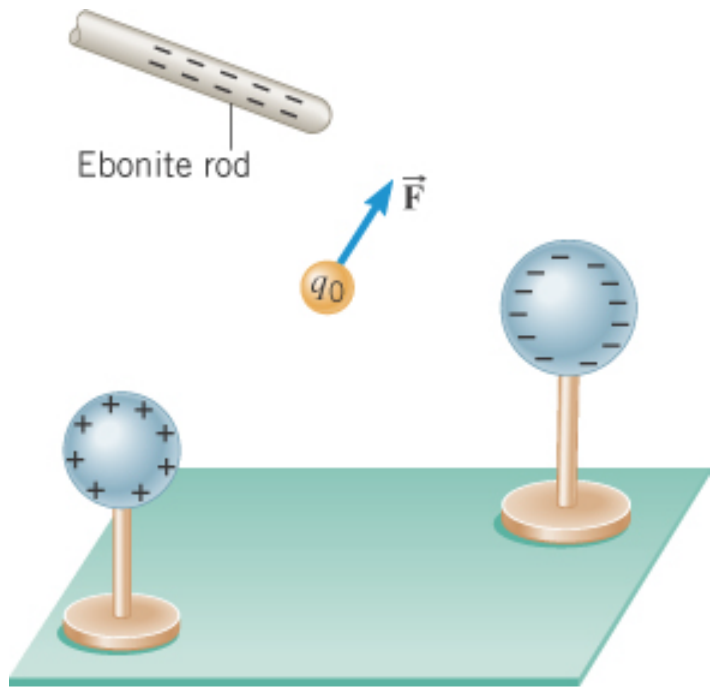
The electric field is a vector, and its direction is the same as the direction of the force F on a positive test charge.

The SI unit of Electric Field is newton per coulomb (N/C)

It is the surrounding charges that create an electric field at a given point.

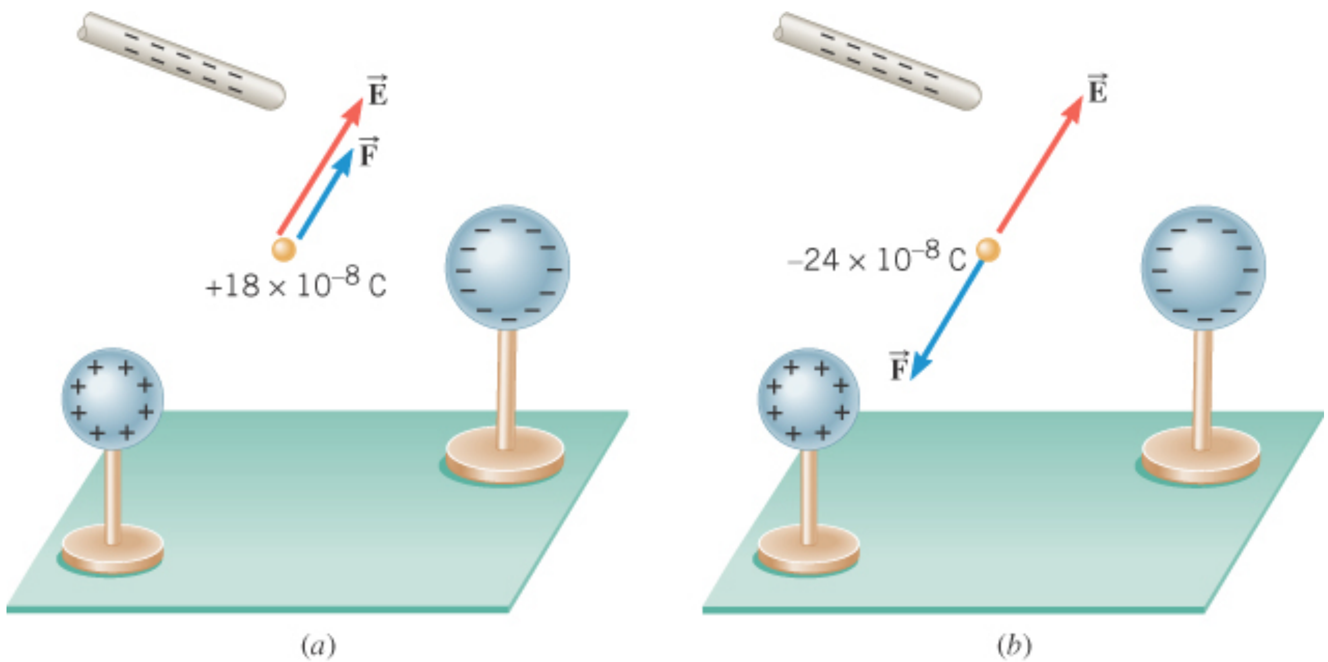
Example 1: *An Electric Field Leads to a Force*

In the figure below, the charges on the two metal spheres and the ebonite rod create an electric field E at the small test charge q_o. This test charge should have a small magnitude so it doesn't affect the other charge. F is the electrostatic force.



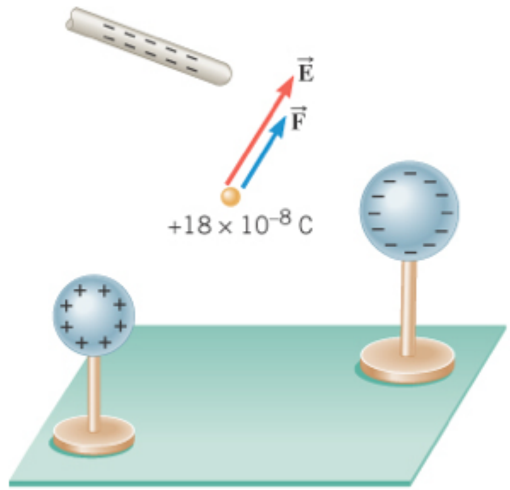
a) The force on a positive charge points in the same direction as E, while

b) the force on the negative charge points opposite to E.



Example 2: Magnitude of the force in the same direction as the field

Determine the magnitude of the force F on the charge q_o (18×10^{-8} C) in the electric field E of magnitude 2.0 N/C.



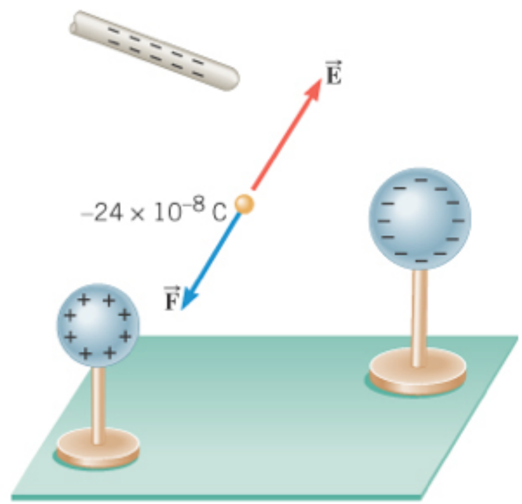
(*a*)

Data Table		
E	q_o	F
2.0 N/C	18×10^{-8} C	?

$$F = E \times q_o = 2.0 \times 18 \times 10^{-8} = 36 \times 10^{-8}\ \text{N}$$

Example 3: *Magnitude of the Force in the Opposite Direction of the Field.*

Determine the magnitude of the force F on the charge q_o (-24×10^{-8} C) in the electric field E of magnitude 2.0 N/C.



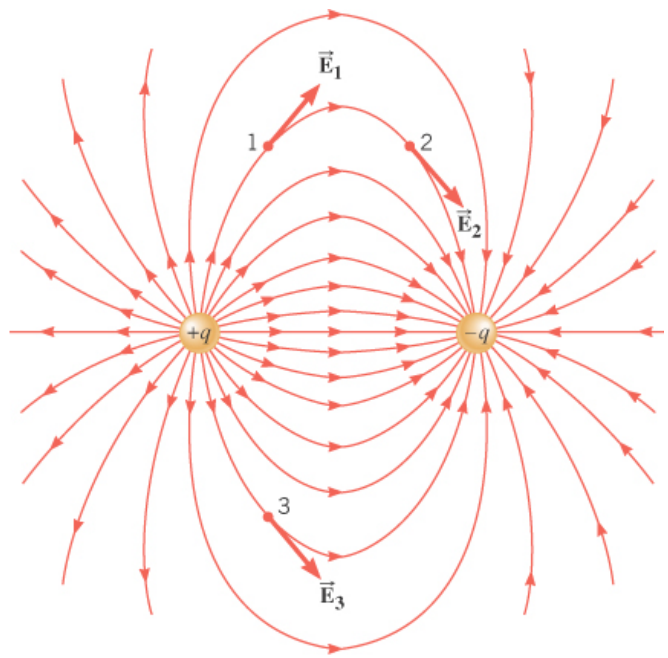
(b)

Data Table		
E	q_o	F
2.0 N/C	-24×10^{-8} C	?

$$F = E \times q_o = 24.0 \times 18 \times 10^{-8} = 48 \times 10^{-8}\ N$$

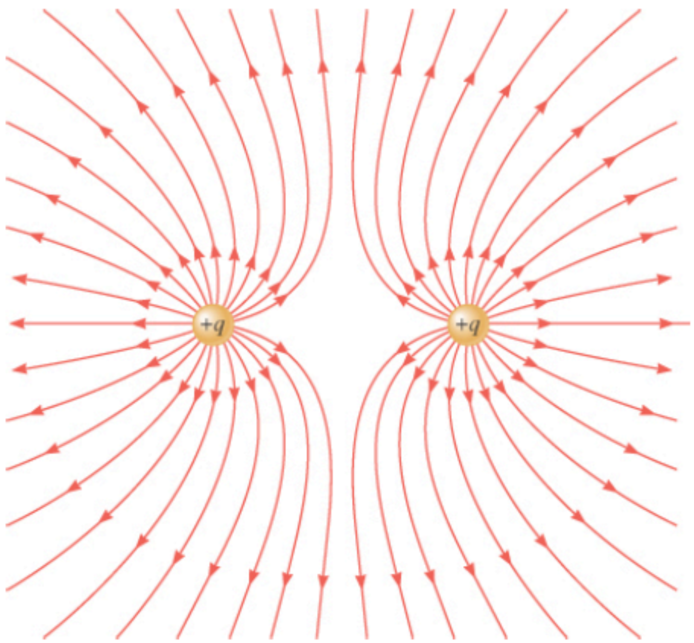
Example 4: *Attractive Electric Field Lines;*

The figure below is a representation of electric field lines in the vicinity of a dipole of two unlike charges +q and -q. The lines are curved and extend from the positive to the negative charge. At any point, such as 1, 2 or 3, the field created by the dipole is tangent to the line through the point.



Example 5: *Repulsive Electric Field Lines;*

The electric field lines are also curved in the vicinity of two identical positive point charges +q. There is an absence of lines in the region between the charges, which means that the electric field is relatively weak between the charges.



References:

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Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current. www.physics.ohio-state.edu/~humanic/*

2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department:"We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

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