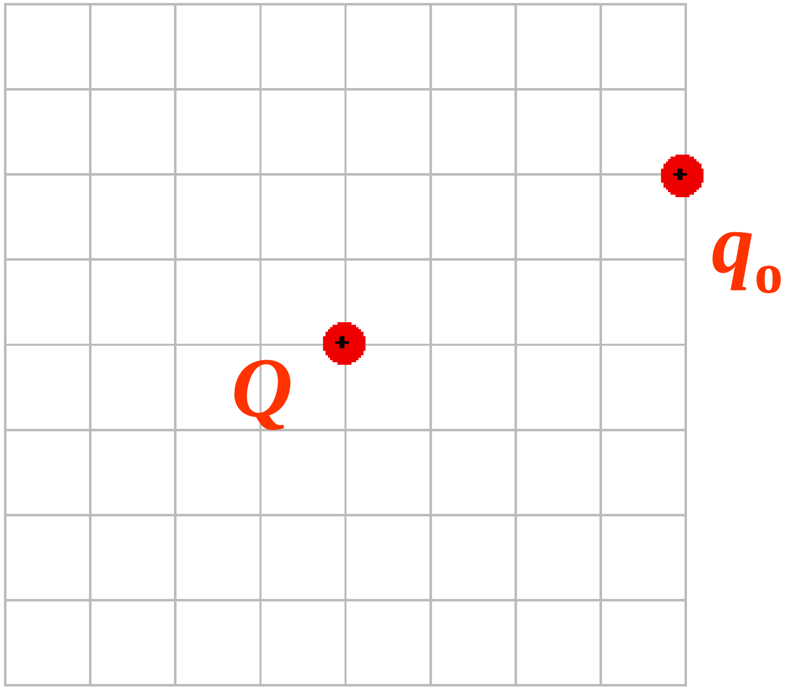
The

Electric

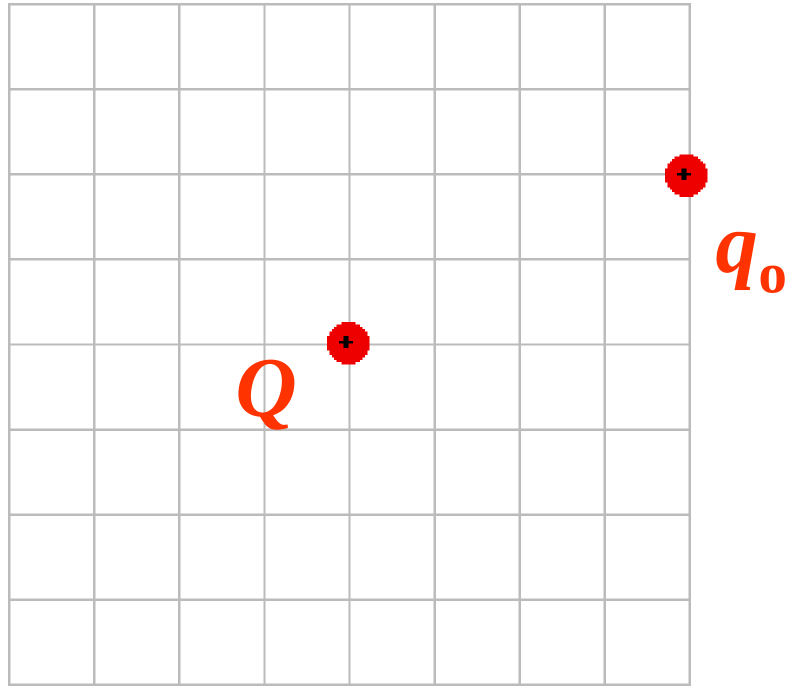
Field

Two point charges are located as shown here.

q_o experiences a force due to Q.

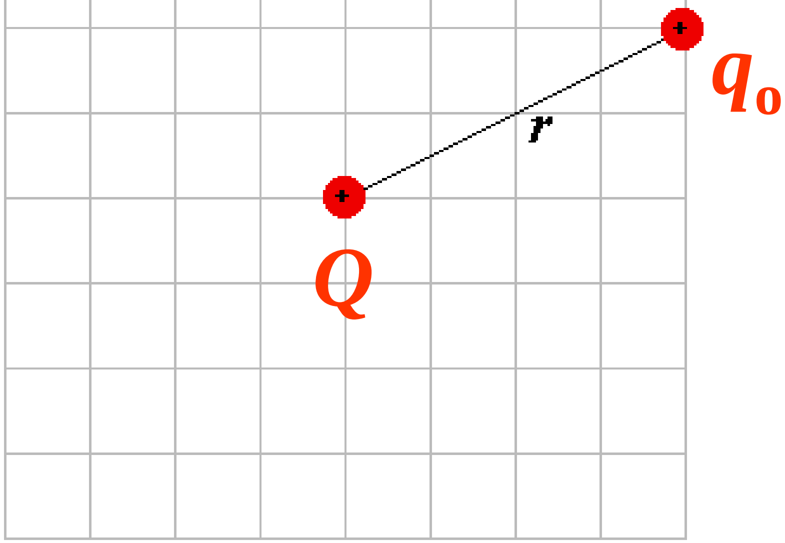


Two point charges are located as shown here. q_o experiences a force due to Q. The force is proportional to the product of the charges, Qq_o



Two point charges are located as shown here. q_o experiences a force due to Q. The force is proportional to the product of the charges, and inversely proportional to the square of the distance between the charges

Qq_o/r^2



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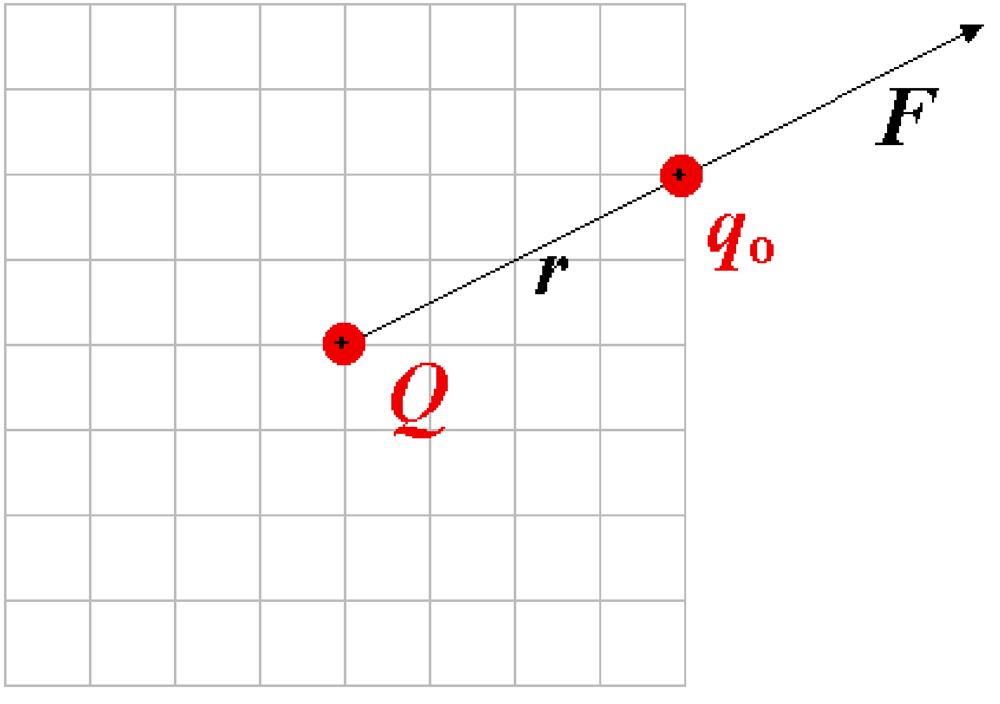
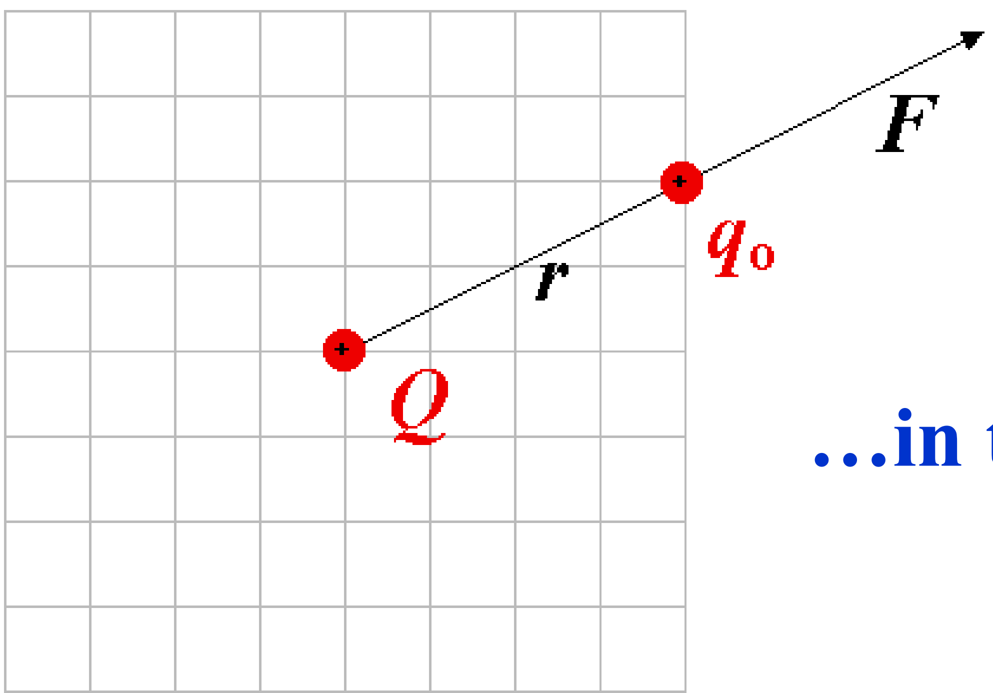


Two point charges are located as shown here. q_o experiences a force due to Q. The force is proportional to the product of the charges, and inversely proportional to the square of the distance between the charges and is directed along the line joining the charges…



$$F = \frac{k_e Q q_o}{r^2}$$

…in the direction shown.

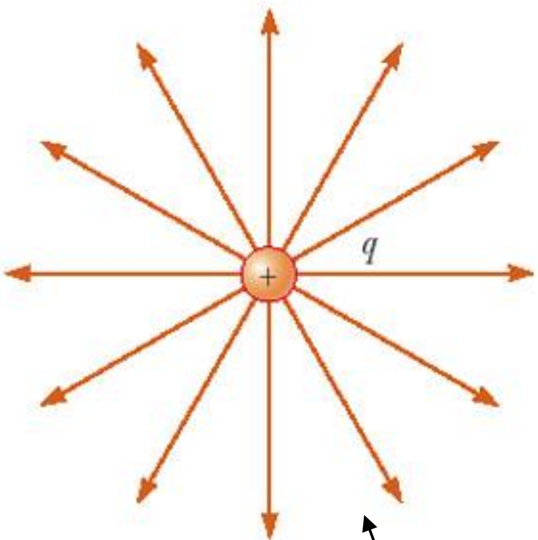
Another viewpoint: **Divide the expression for Coulomb's law by q_o.**

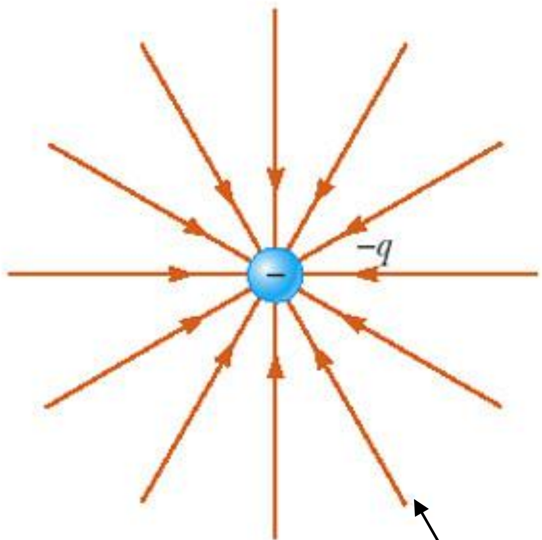
$$\frac{F}{q_o} = k_e \frac{|q|}{r^2}$$

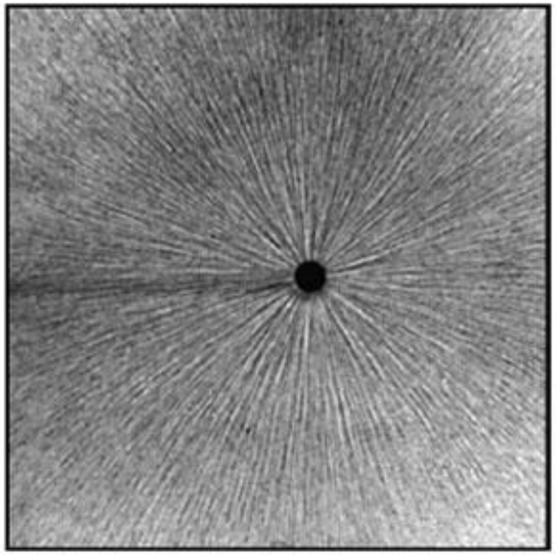
This gives us the magnitude of the force on a "test charge" at a point a distance r from charge q.

This is the <u>ELECTRIC FIELD</u> $\vec{E}$.
The *unit* is N/C.

The electric field is sometimes represented by "*electric field lines*".



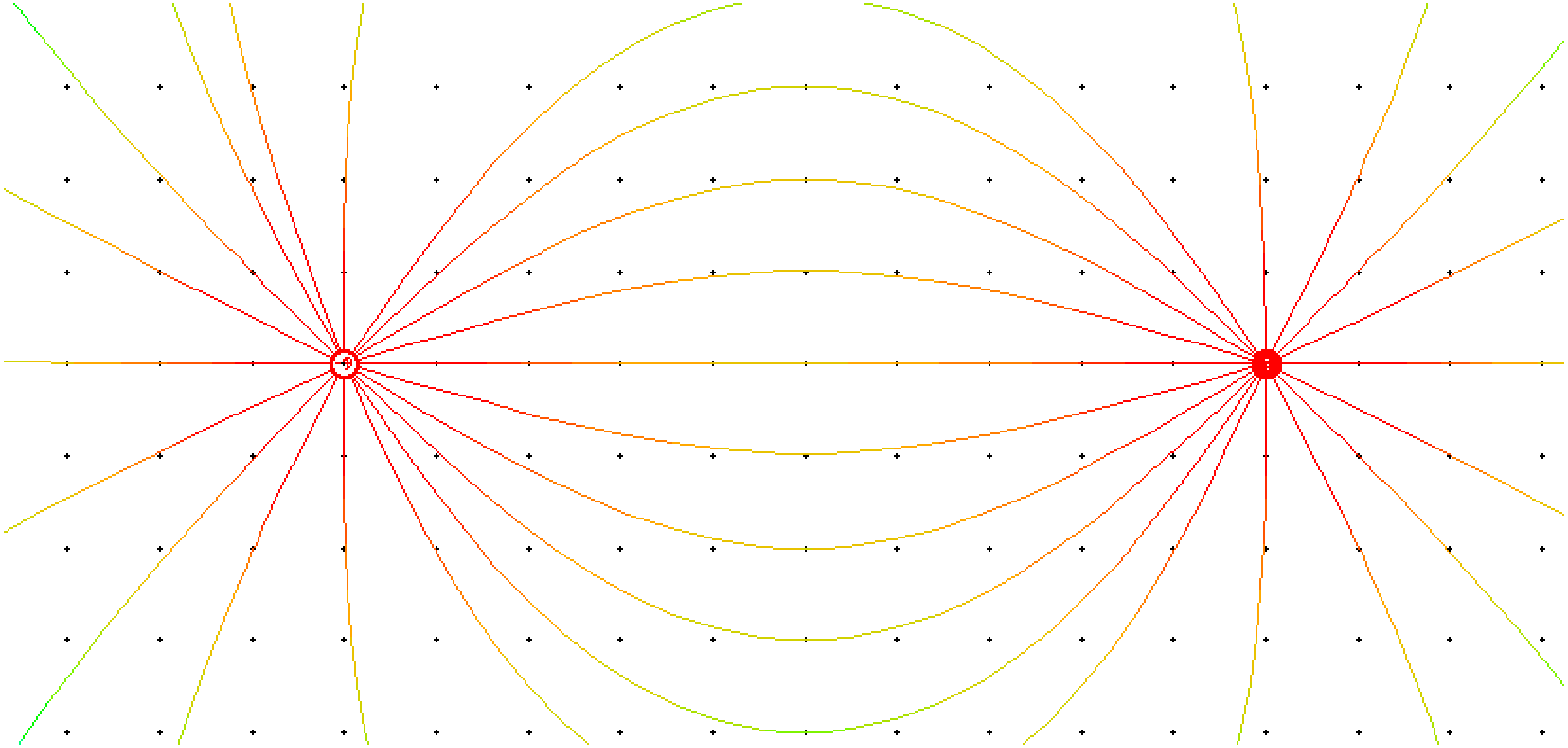




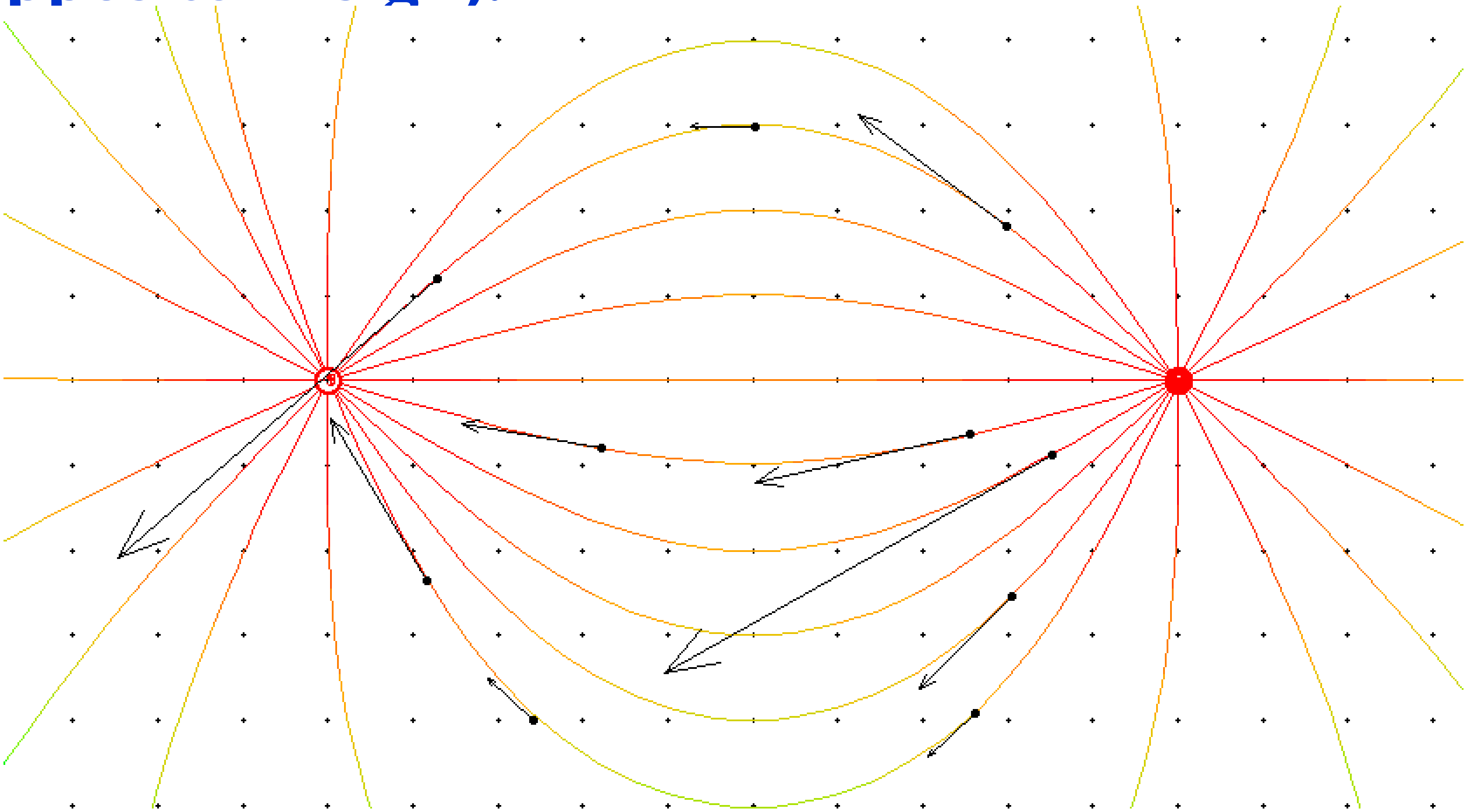
The field lines for a positive point charge are *radially outward*.

The field lines for a negative point charge are *radially inward*.

This is a representation of some of the field lines for a <u>dipole</u> (two charges equal in magnitude, opposite in sign).

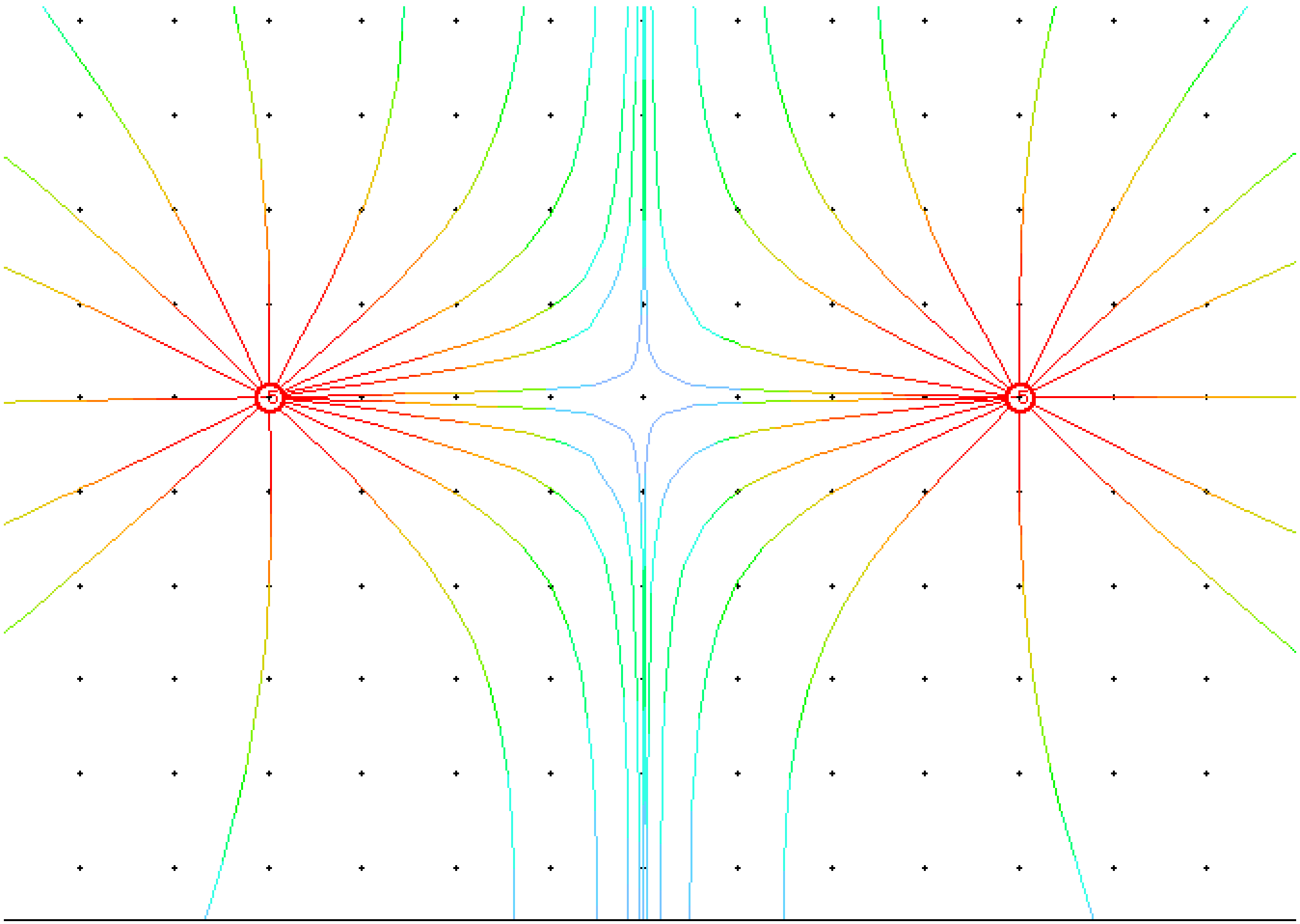


This is a representation of some of the field lines for a dipole (two charges equal in magnitude, opposite in sign).



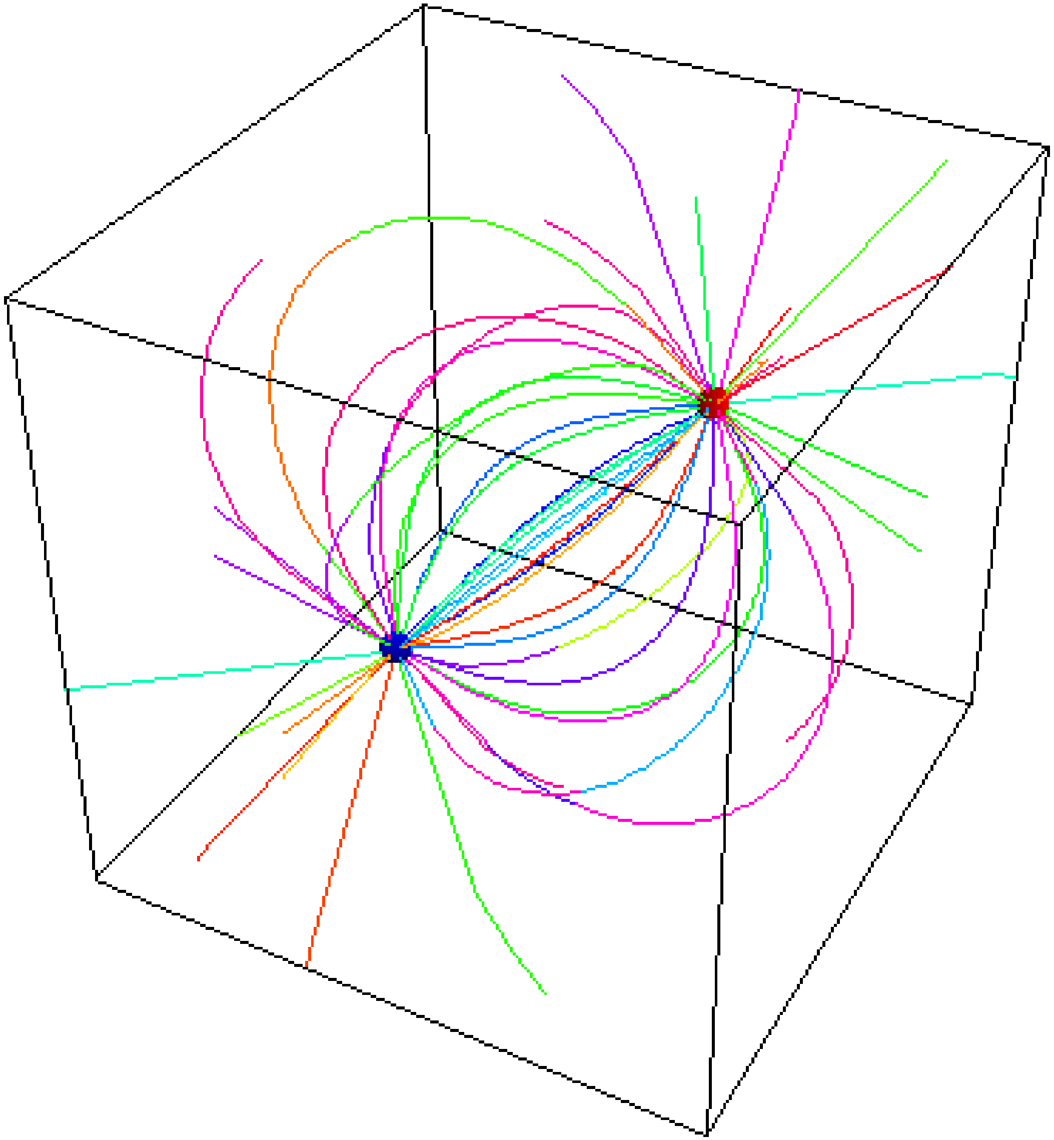
Field vectors (black arrows) are always tangent to field lines.

This represents the field of two equal charges of the same sign.

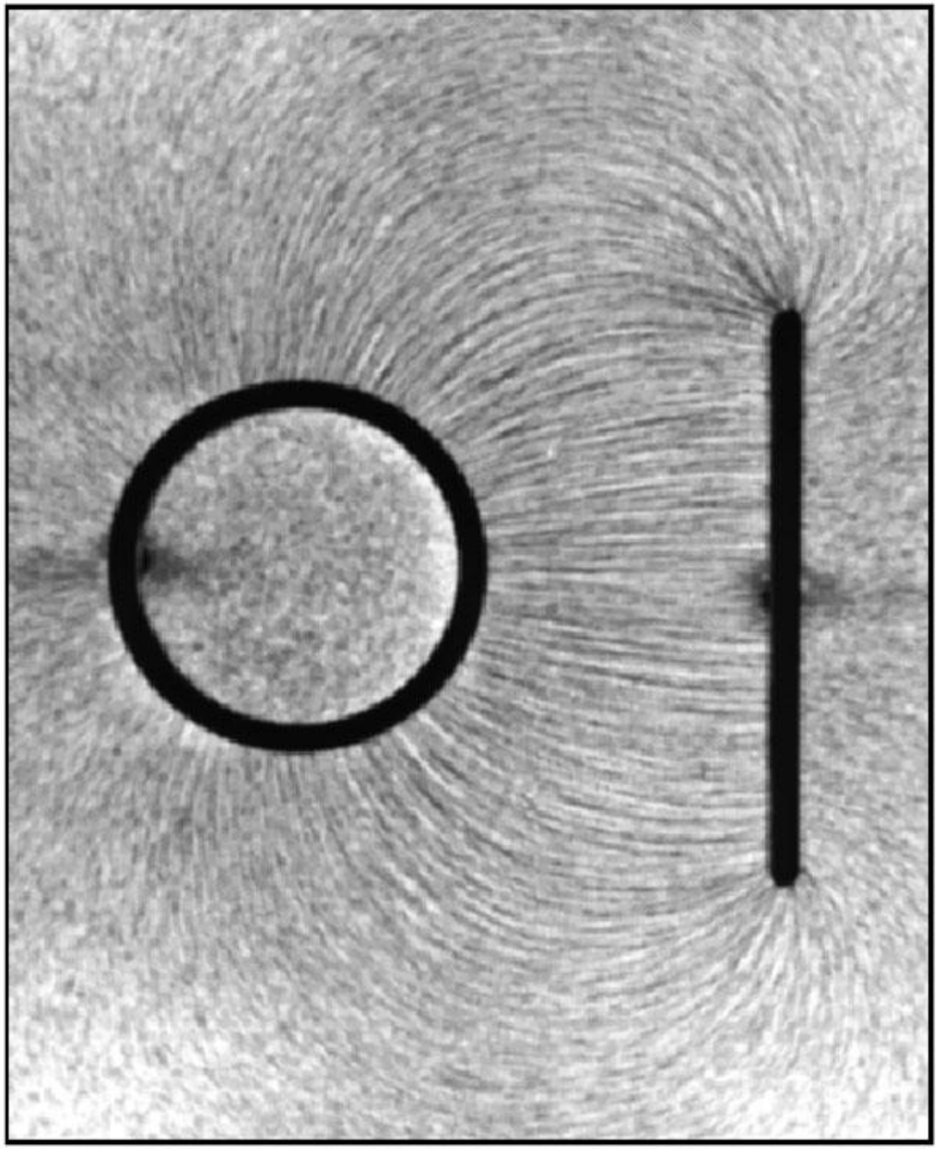


Electric field is tangent to field lines; color indicates magnitude.

Electric fields are really 3-dimensional.



Inside a hollow charged conductor the electric field is zero everywhere.



When no net motion of charge occurs within a conductor, the conductor is said to be in *electrostatic equilibrium*.

An <u>isolated conductor</u> has the following properties:

1. **The electric field is zero everywhere inside the conducting material.**
2. **Any excess charge on an isolated conductor resides entirely on its surface.**
3. **The electric field just outside a charged conductor is perpendicular to the conductor's surface.**
4. **On an irregularly shaped conductor, the charge accumulates at locations where the radius of curvature of the surface is smallest (that is, at sharp points).**

Property 1

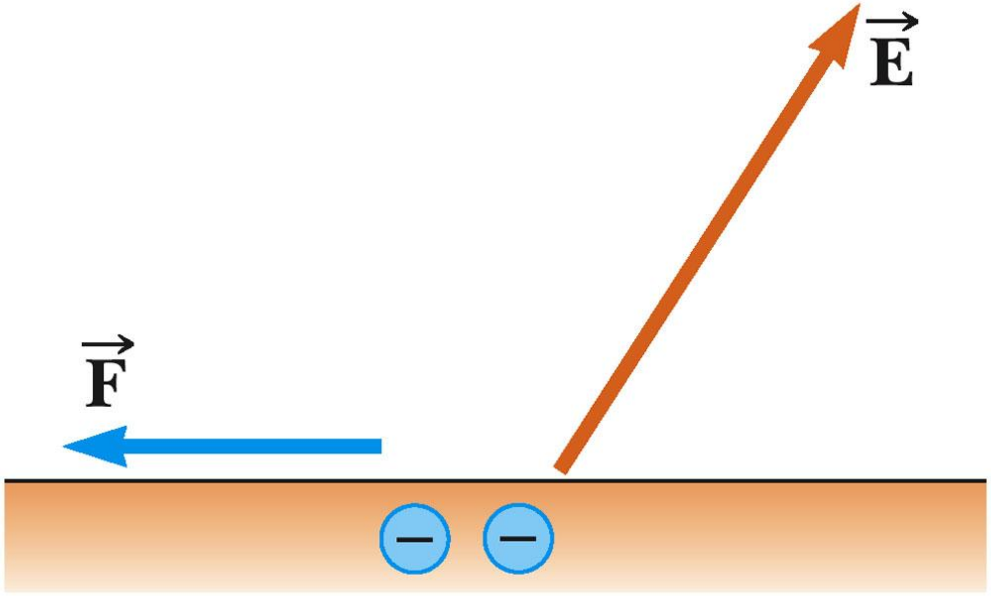
- The electric field is zero everywhere inside the conducting material
  - Consider if this were *not* true
    - If there were an electric field inside the conductor, the free charge there would move and there would be a flow of charge
    - If there were a movement of charge, the conductor would not be in equilibrium

Property 2

- Any excess charge on an isolated conductor resides entirely on its surface
  - A direct result of the $1/r^2$ repulsion between like charges in Coulomb's Law
  - If some excess of charge could be placed inside the conductor, the repulsive forces would push them as far apart as possible, causing them to migrate to the surface

Property 3

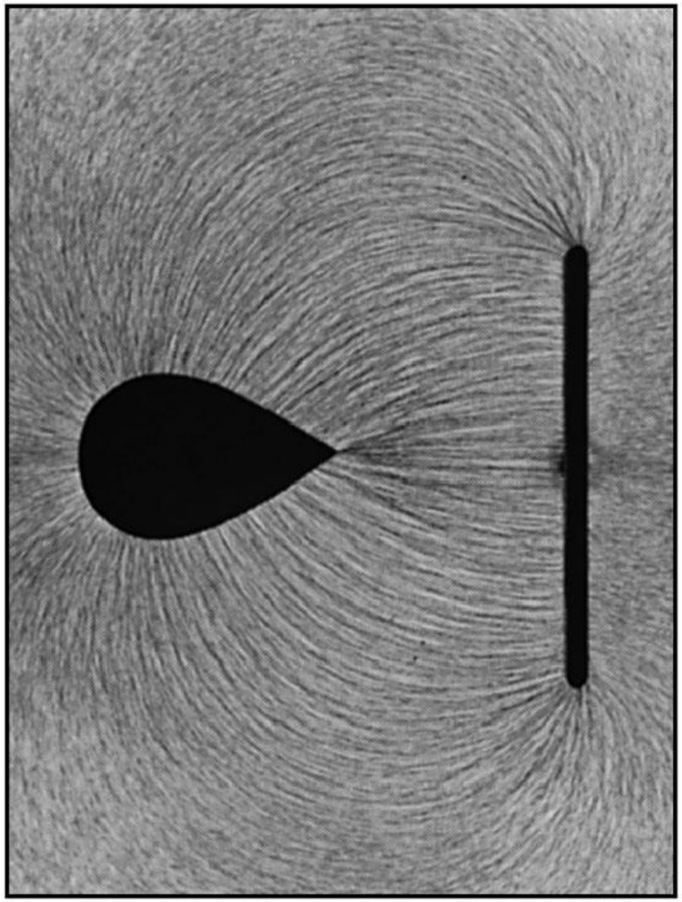
- The electric field just outside a charged conductor is perpendicular to the conductor's surface
  - Consider what would happen it this were not true



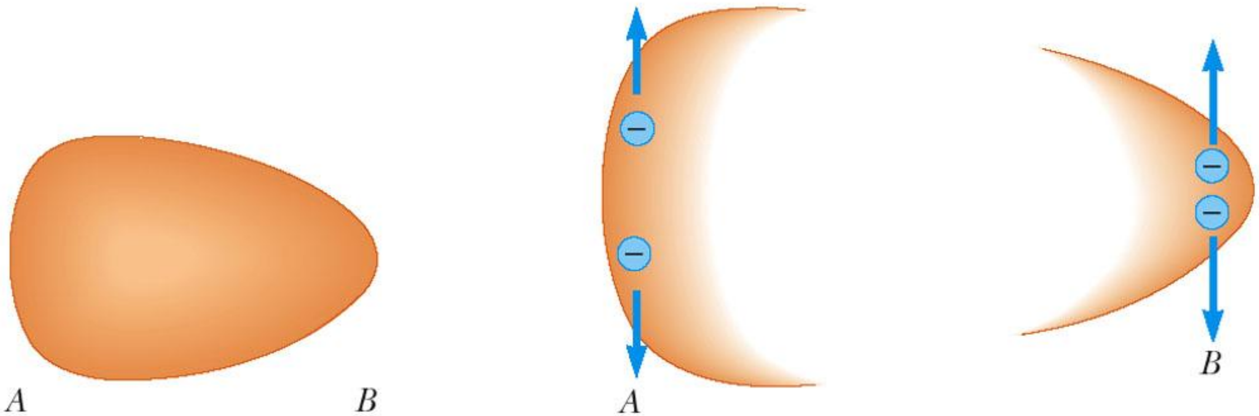
- The component along the surface would cause the charge to move
- It would not be in equilibrium

Property 4

- On an irregularly shaped conductor, the charge accumulates at locations where the radius of curvature of the surface is smallest (that is, at sharp points)



Property 4, cont.



- Any excess charge moves to its surface
- The charges move apart until an equilibrium is achieved
- The amount of charge per unit area is greater at the flat end
- The forces from the charges at the sharp end produce a larger resultant force away from the surface
- Why a lightning rod works