Electricity and Magnetism

Third lecture

Electric field, A point charge in an electric field

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Outline

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1. The Electric Field

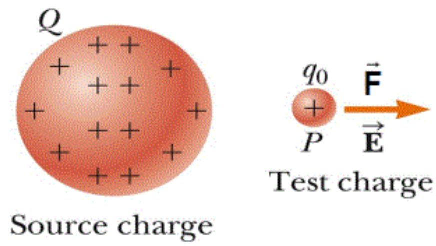
Electric field is defined as the electric force per unit charge, is a vector field because. The direction of the field is taken to be the direction of the force it would exert on a positive test charge.

The electric field vector E at a point in space is defined as the electric force F acting on a positive test charge q_0 placed at that point divided by the test charge:

$$\vec{E} = \frac{\vec{F}}{q_0} \quad \text{(electric field).}$$

The SI units of E are N/C.

The test charge q_0 serves as a detector of the field.



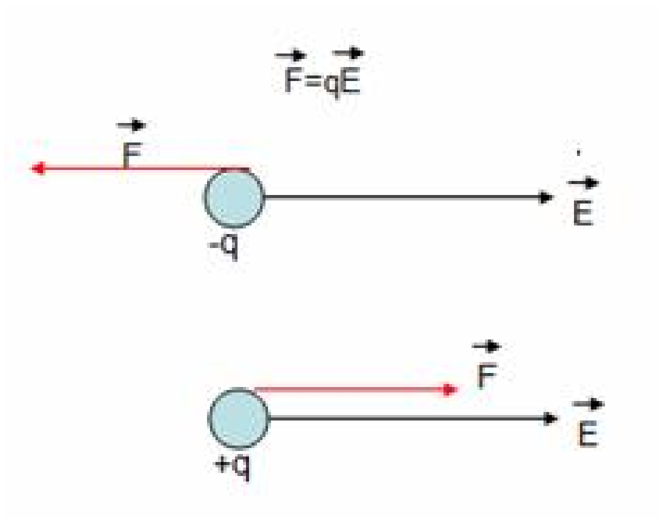
The direction of E is that of the force on a positive test charge.

Relationship between F and E:

$$\vec{F} = q\vec{E}$$

This equation gives us the force on a charged particle placed in an electric field.

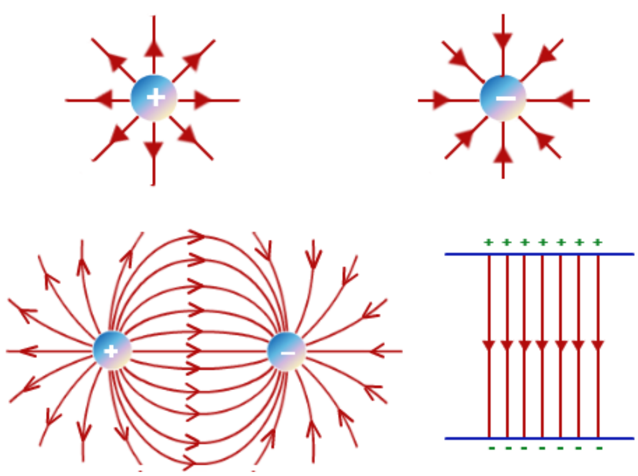
If **test charge, q_0**, is positive, the force and the field are in the same direction.
If **test charge, q_0**, is negative, the force and the field are in opposite directions.



Electric field lines:

Are lines in the space around any given charged particle or object, vectors with different magnitudes and directions.

Electric field lines extend away from positive charge (where they originate) and toward negative charge (where they terminate).



Electric field, vector form according to Coulomb's law, the force exerted by source charge q on the test charge q_o, can be expressed as: where rˆ is a unit vector directed from q toward q_o. The electric field at the position of the test charge is defined by ($E = F / q_o$):

$$\vec{E} = K \frac{q}{r^2} \hat{r}$$

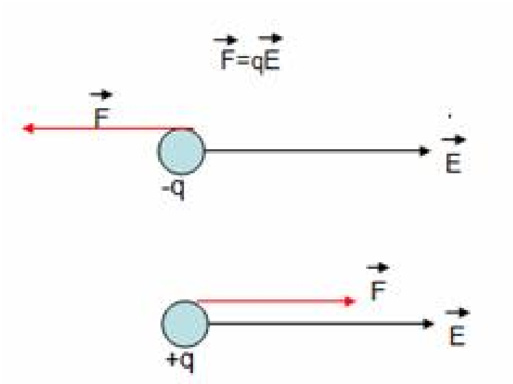
1. *A Point Charge in an Electric Field*

What happens is that an electrostatic force $\vec{F}$ acts on the point charge, as given by:

$$\vec{F} = q\vec{E},$$

in which q is the charge of the point charge (including its sign) and $\vec{E}$ is the electric field.

The electrostatic force $\vec{F}$ acting on a charged particle located in an external electric field $\vec{E}$ has the direction of $\vec{E}$ if the charge q of the particle is positive and has the opposite direction if q is negative.

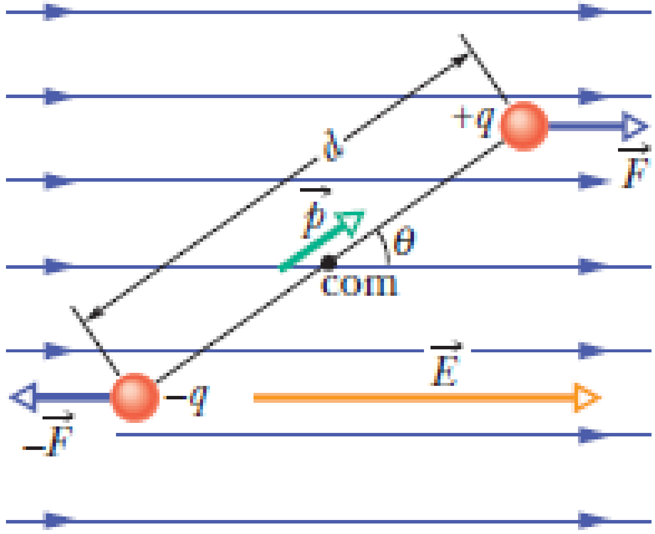


2. A Dipole in an Electric Field

A Dipole is two equal and opposite charges separated by some distance.

What happen when we put a dipole in an electric field?

- Electrostatic forces act on the charged ends of the dipole.
- Because the electric field is uniform, those forces act in opposite directions and with the same magnitude F = qE.
- The net force on the dipole from the field is zero and the center of mass of the dipole does not move.
- A dipole experiences a rotating effect.
- The rotating effect is also called torque on the dipole.



We can write the magnitude of the net torque τ as:

$$\tau = q\,E\,d\,\sin\theta$$

References

Walker, Jearl, Robert Resnick, and David Halliday. Halliday and resnick fundamentals of physics. Wiley, 2014.