SPH4U
UNIVERSITY PHYSICS

ELECTRIC, GRAVITATIONAL, & ... FIELDS

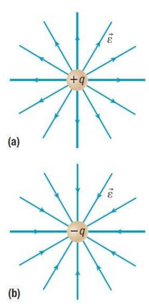
☞ Electric Field Lines
(P.338-345)

Electric Field Lines

*An electric field exists in a region around a charge. The field and its properties can be represented with **electric field lines**. These electric field lines can help us determine the direction of the force on a nearby test charge.*

NOTE!

As was stated earlier, electric fields point away from positive charges (a) and toward negative charges (b). This convention is based on using a positive test charge to determine direction.

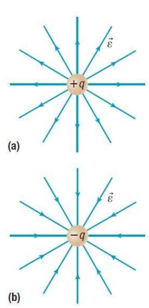


Electric Field Lines

As you may expect, the electric field lines are parallel to ε, and the density of the field lines is proportional to the magnitude of ε. In both parts of the diagram, the field lines are densest near the charges. In both cases, the magnitude of ε increases as the distance to the charge decreases.

NOTE!

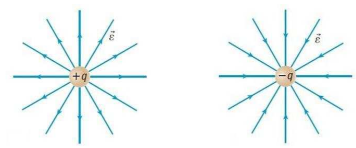
Just as the force between two point charges varies as $1/r^2$, so too does the electric field produced by a point charge. In other words, the electric field obeys an inverse square law.



Electric Field Lines

ELECTRIC FIELD LINES

- continuous lines of force that show the direction of electric force at all points in the electric field (ε) around a charge



RECALL!

The shape of gravitational field lines resemble the electric field lines associated with a negative charge.

Electric Field Lines

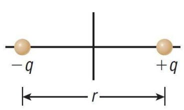
PRACTICE

1. How do two point charges that interact through Coulomb's law "know" about each other? In other words, how does one charge transmit electric force to another charge?

   In terms of the electric field lines, every charge generates (or carries with it) an electric field, through which the electric force is transmitted.

Electric Dipoles

Consider two point charges, with equal but opposite charges, separated by a small distance r. This charge configuration is known as an ***electric dipole***

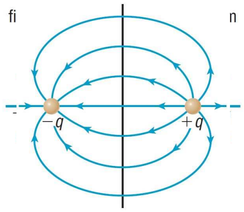


Electric Dipoles

The two charges in an electric dipole give rise to a more complicated electric field than the one associated with a single electric charge. This is because the electric fields around the individual charges interact with each other.

NOTE!

As the fields extend into space, they produce field lines that bend toward the other charge.

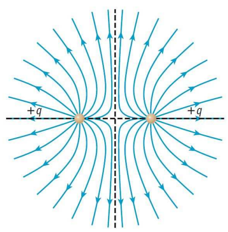


Electric Dipoles

Now consider an arrangement of charges that are equal and alike. In this case, the electric field lines extend outward from both charges. Instead of the field lines merging with each other, the lines from similar charges do not connect at any point.

NOTE!

This electric field pattern would be similar if two negative charges were used. The only difference would be the direction of the field lines.

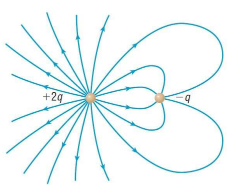


Electric Dipoles

Finally, consider a dipole-like arrangement of two charges that have different magnitudes and signs. In this case, the symmetry of the dipole field is altered.

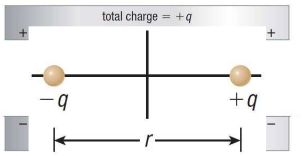
NOTE!

The field-line pattern includes regions near the charges where the density of field lines becomes very high. However, the electric field is still strongest along the line connecting the charges.



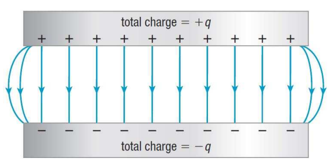
Uniform Electric Fields

Instead of point charges, suppose you have two large conducting plates charged by dry cells. As with the dipole, one plate has a positive charge and the other plate has a negative charge. In both cases, the charge spreads uniformly along each plate.



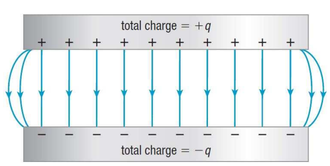
Uniform Electric Fields

Just as the electric field along the line connecting two unlike charges extends straight from the positive to the negative charge, the electric field between the plates of charge extends from the positive plate to the negative plate and is uniform. These field lines are straight, parallel to each other, and perpendicular to the plates.



Uniform Electric Fields

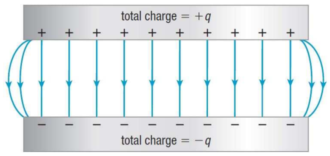
Thus, at any location between the plates, the electric field has the same magnitude and direction – a ***uniform electric field****. Outside the plates, the vector sum of the electric fields from all the individual charges in the two parallel plates yields a value of zero.*



Uniform Electric Fields

NOTE!

As long as the separation between the plates is much smaller than their surface area, the electric field between the plates is uniform. In fact, except near the edges, the magnitude of the electric field depends only on the amount of charge, the area of the plates, and the material between the plates.



Electric Field Lines

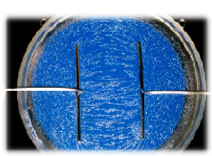
PARALLEL PLATES OF CHARGE

- the electric field (ε) between the plates is:
  - uniform, and
  - perpendicular to the plates
- except near the edges, the magnitude of ε depends only on:
  - the amount of charge on the plates (ε ∝ q)
  - the area of the plates (ε ∝ 1/area)
  - the material between the plates (ε ∝ material)
- outside the plates ε = 0

Electric Field Lines

PRACTICE

2. The electric field intensity at a point M between two oppositely charged parallel plates is "ε". What effect will each of the following changes, considered separately, have on "ε"? <u>Express your answer as a multiplier</u>.
   (a) The distance between the plates is halved.

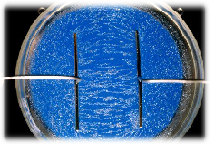


(a) no change

Electric Field Lines

PRACTICE

2. The electric field intensity at a point M between two oppositely charged parallel plates is "ε". What effect will each of the following changes, considered separately, have on "ε"? <u>Express your answer as a multiplier</u>.
   (b) The amount of charge on each plate is tripled.

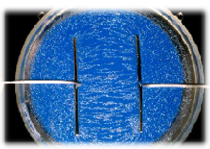


(b) x 3

Electric Field Lines

PRACTICE

2. The electric field intensity at a point M between two oppositely charged parallel plates is "ε". What effect will each of the following changes, considered separately, have on "ε"? <u>Express your answer as a multiplier</u>.
   (c) The area of each plate is halved.



(c) x 2

✔ Check Your Learning

TEXTBOOK
P.345 Q.3,5

WIKI (EGM FIELDS)
✎.... 4U3 - QUIZ#2 (Electric Fields - Part 2)