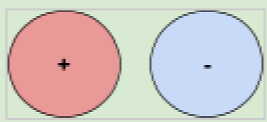
Lab: AP Review Sheets	**AP Physics C**
Chapter 5 | Electric Forces and Fields	Michael Munder

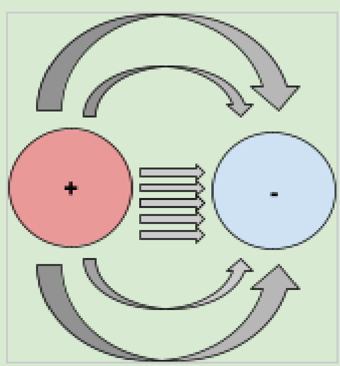
Background | What to Expect

Electric charges and fields are a fundamental concept in the AP Physics curriculum. In short, it describes how charged objects interact with one another.

There are two types of charges - Positive and negative



Like charges repel each other, while opposite charges attract. An electric field is what represents the effect a charge has on the space around it, influencing other charges within that space. The strength and direction of electric fields are crucial for understanding how forces act between charged objects, which is essential in both theoretical and practical applications such as electronics and electromagnetism.



Major Topics | Vocabulary | Formulae

Major Topics:

1. Electric Charges and Coulomb's Law
    - Charging by conduction and induction.
    - Grounding and its effects.
2. Electric Fields and Charge Distribution
    - Field due to point charges and continuous charge distributions.
    - Motion of a charge in an electric field.

Vocabulary:

- Conduction: Transfer of charge through direct contact.
- Induction: Charging an object without direct contact.
- Grounding: Neutralizing a charged object by connecting it to the earth.
- Coulomb's Law: Describes the force between two point charges.
- Electric Field (E): A vector field around charges influencing other charges.
- Point Charge: An idealized model of a charged object treated as having no size.

Formulae:

- **Coulomb's Law:**

  $F = k * (q1 * q2) / r^2$

  Where:

  F = Force between the charges

  k = Coulomb's constant =8.99×109 Nm2/C2

  q1, q2 = Charges

  r = Distance between the charges

- **Electric Field by a Point Charge:**

  $E = k * q / r^2$

  Where:

  E = Electric field

  q = Charge

  r = Distance from the charge

- **Continuous Charge Distribution:**

  $E' = \int (k * dq / r^2)$

  $\lambda = q / L \rightarrow dq = \lambda * dL$

  $\sigma = q / A \rightarrow dq = \sigma * dA$

  $\rho = q / V \rightarrow dq = \rho * dV$

- **Determining Acceleration of a Charge in an Electric Field:**

  $E = F / q$, $F = qE$, $F_{net} = ma$, $a = (qE) / m$

  Where:

  a = Acceleration

  m = Mass of the charge

  q = Charge

  E = Electric field strength

FRQs (3)

FRQ #1

Imagine two objects: one has a charge of +3.0μC and is fixed in place, while another, with a charge of −2.0μC, sits 5.0 cm to the east.

(a) Calculate the force experienced by the −2.0μC charge in terms of its magnitude and direction.

Solution - To find the force, we use Coulomb's Law: F = k * (q1 * q2) / r^2

In This Case:

k=8.99×10^9Nm2/C2

q1=+3.0×10^−6C

q2=−2.0×10^−6C

r=0.05m.

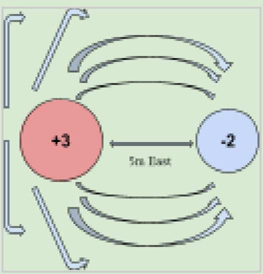
F = 8.99 * 10^9 * (3.0 * 10^-6 * 2.0 * 10^-6) / (0.05)^2

F = 21576 N

(b) Now, replace the −2.0μC charge with a −1.0μC charge. Describe how the force on this new charge compares to the force on the original −2.0μC charge, without performing detailed calculations.

Solution: Now that the charge is −1.0μC, the force magnitude is half of what it was with the −2.0μC charge because the force depends linearly on the product of the charges. So, reducing one charge by half reduces the force by half.

(c) Draw a diagram showing the electric field lines around the +3.0μC charge. Mark the direction of the field at various points around the charge.



The lines should start at the positive charge and point outward, indicating that the field moves away from the charge. Label the direction on the lines with arrows to show that they radiate outward

FRQ #2

A long, straight wire carries a uniform linear charge density of λ=−1.0μC/m and is placed along the x-axis. A small point charge of +3.0μC is located 1.0 m directly above the center of a 2.0 m segment of this wire.

(a) Calculate the electric field at the point where the +3.0μC charge is located due to the 2.0 m segment of the wire.

Solution:

- $\lambda=-1.0\times10{-6}$ C/m (linear charge density)
- z=1.0m (height above the wire)
- L=2.0m (length of the wire segment)
- x=0 (position directly above the center of the segment)
- $\varepsilon 0=8.85\times10{-12}$ F/m (permittivity of free space)

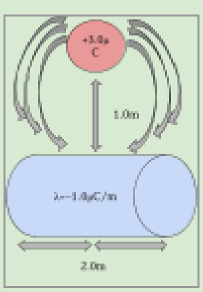
Plug in the values to simplify and The result shows the magnitude and direction (downward towards the wire) of the electric field.

(b) How does the electric field change if the point charge is moved to 0.5 m above the wire?

Solution:

As the point charge moves closer to the wire, the magnitude of the electric field increases. This is because the electric field strength varies inversely with the distance from the charge source, as shown in the denominator of the electric field equation.

(c) Draw a diagram showing the wire, the point charge, and the direction of the electric field.



Draw a horizontal line representing the wire along the x-axis. Place a dot above the center of this line at 1.0 m, representing the point charge. Draw arrows pointing downward from the point charge towards the wire, indicating the direction of the electric field.

FRQ #3

A small particle with a charge of−1.0μC and a mass of 2.0×10^−3 kg is released from rest in a uniform electric field. The electric field has a strength of 5.0×10^3 N/C and is directed vertically upward.

(a) Calculate the acceleration of the charged particle.

Solution

The force exerted by the electric field on the charge is calculated using the equation F=qE:

F = (-1.0 * 10^-6 C) * (5.0 * 10^3 N/C)

= -5.0 * 10^-3 N

Using Newton's Second Law F=ma, solve for acceleration:

a = F / m = (-5.0 * 10^-3 N) / (2.0 * 10^-3 kg)

= -2.5 m/s^2

The negative sign indicates that the acceleration is downward, opposite the electric field direction.

(b) Describe the motion of the particle after release.

Solution:

The particle will accelerate downward due to the downward force exerted by the upward electric field on the negatively charged particle. The motion is uniformly accelerated, similar to free fall but in an electric field.

(c) Draw a simple diagram of the situation, including the direction of the electric field and the motion of the particle.