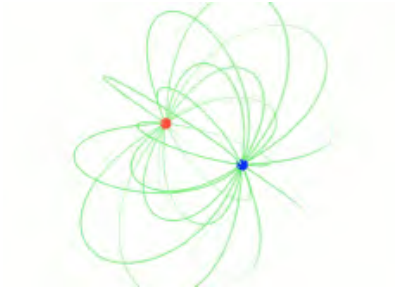
Physics for Scientists & Engineers 2

Spring Semester 2005

Lecture 4



The Electric Field

- For the past three days we have been discussing the force between two charges that we not moving with respect to each other
- Suppose one charge were moving, how would the second charge know that the first charge had moved?
- What if there were other charges, how would one charge know about the extra charges?
- To deal with these situations, we introduce the concept of a field

The Electric Field (2)

- A field is an abstract concept that we can use to describe forces
- The electric field is defined at any point in space as the force of the electric field on a positive point charge
- If we place a positive point charge in an electric field, there will be a vector force on that charge in the direction of the electric field
  - The magnitude of the force is given by the strength of the electric field

Definition of Electric Field

- We define the electric field in terms of the force it exerts on a positive point charge

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

- The unit of the electric field are N/C (newtons per coulomb)
- We can then write

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

- We see that the electric force is parallel to the electric field and is proportional to the charge
  - The force on a negative charge will be in the opposite direction

Superposition of Electric Fields

- Suppose we have many charges
- The electric field at any point in space will have contributions from all the charges
- The electric field at any point in space is the superposition of of the electric field from n charges is

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + ... + \vec{E}_n$$

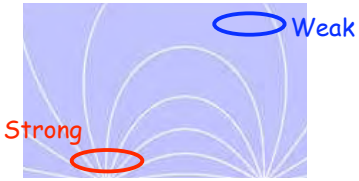
- Note that the superposition applies to each component of the field

Electric Field Lines

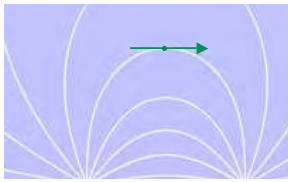
- We can represent the electric field graphically by drawing lines that represent the vector force exerted on a positive test charge
- Electric field lines will originate on positive charges and terminate on negative charges
- Electric fields exist in three dimensions, but we often show a two-dimension representation
- Electric field lines do not cross
- The electric force at a given point in space is tangent to the electric field lines

Properties of Field Lines

- The strength of the electric field is represented by the density of electric field lines

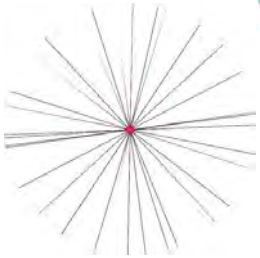


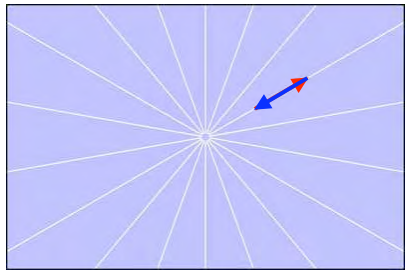
- The direction of the electric field is tangent to the electric field lines



Field Lines from a Point Charge

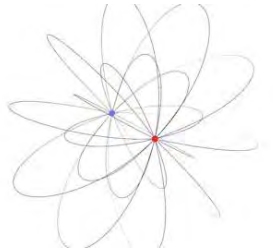
- The electric field lines from a point charge extend out radially
- For a positive point charge, the field lines point outward
  - Terminate at infinity
- For a negative charge, the field lines point inward
  - Originate at infinity

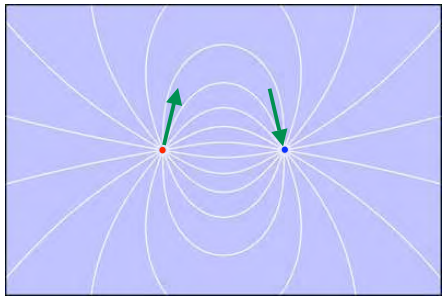




Electric Field Lines for Two Point Charges

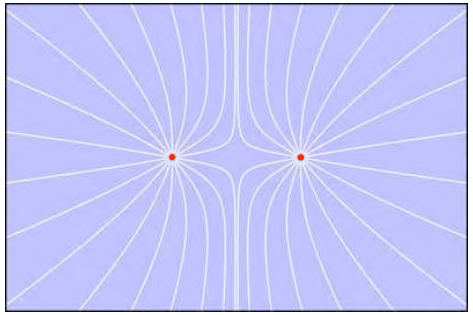
- We can use the superposition principle to calculate the electric field from two point charges
- Let's start with one positive charge and one negative charge
- The field lines will originate from the positive charge and terminate on the negative charge





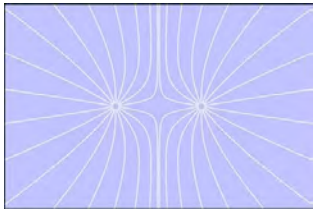
Electric Field Lines from Identical Point Charges

- Now let's look at the electric field from two identical point charges
- For two positive charges, the field lines originate on the positive charges and terminate at infinity
- For two negative charges, the field lines terminate on the negative charges and originate at infinity



General Observations about Field Lines

- If the field lines connect, we have an attractive force
  - You can imagine the charges pulling on each other
- If the field lines seem to spread out, we have a repulsive force
  - You can imagine the charges pushing each other apart



- Field lines always originate on positive charge and terminate on negative charge
- Field lines never cross
- http://lectureonline.cl.msu.edu/~mmp/kap18/RR447app.htm

Example - Force from Field Lines

- What are the magnitudes (high, medium, low) and the direction of the electric force for the following four cases:

1) +q at a)
2) +q at b)
3) -q at c)
4) -q at d)