Electric Field Lines

We've already defined the electric field mathematically by the equation **E** = **F**/q. However, how do we visualize the E-field since we cannot see it physically? One way to visualize the electric is to use ***Electric-Field Line***.

The rules for drawing E-field lines are summarized below:

1. Electric field lines begin on positive charges (or at infinity) and end on negative charges (or at infinity).
2. The lines are drawn uniformly spaced entering or leaving an isolated point charge.
3. The number of lines leaving a positive charge or entering a negative charge is proportional to the magnitude of the charge.
4. The density of the lines (the number of lines per unit area perpendicular to the lines) at any point is proportional to the magnitude of the field at that point.
5. At large distances from a system of charges with a net charge, the field lines are equally spaced and radial, as if they came from a single point charge equal to the net charge of the system.
6. Field lines do not cross. (If two field lines crossed, that would indicate two directions for $\vec{E}$ at the point of intersection.)

RULES FOR DRAWING ELECTRIC FIELD LINES

One problem with the electric-field line model is that we draw a finite number of lines for a charge. Thus, it appears that the **E**-field may exist in certain directions only. This is not true! The field lines are continuous at every point around the charge. The density of the lines only represents the strength of the **E**- field!

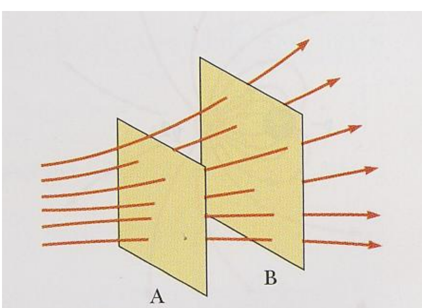
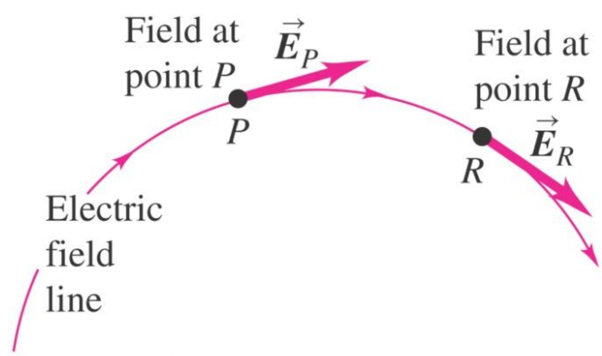
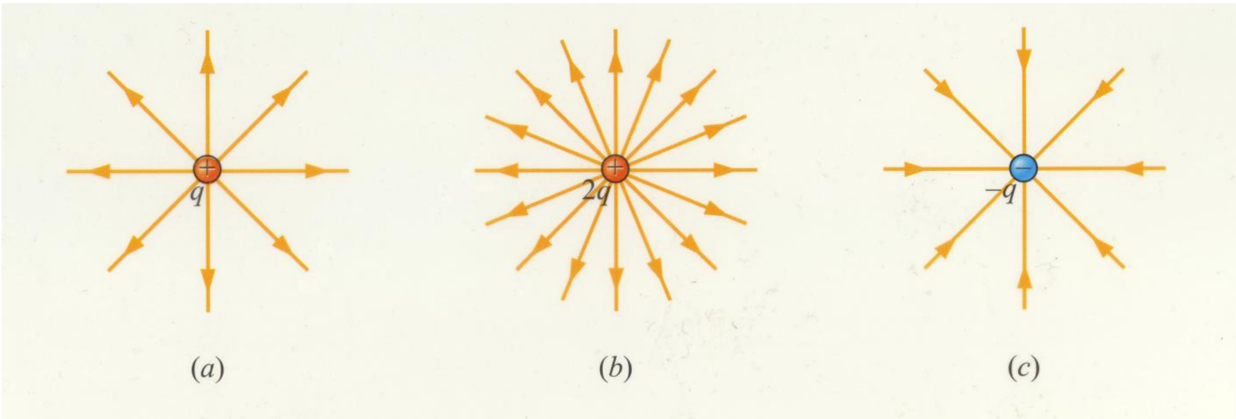
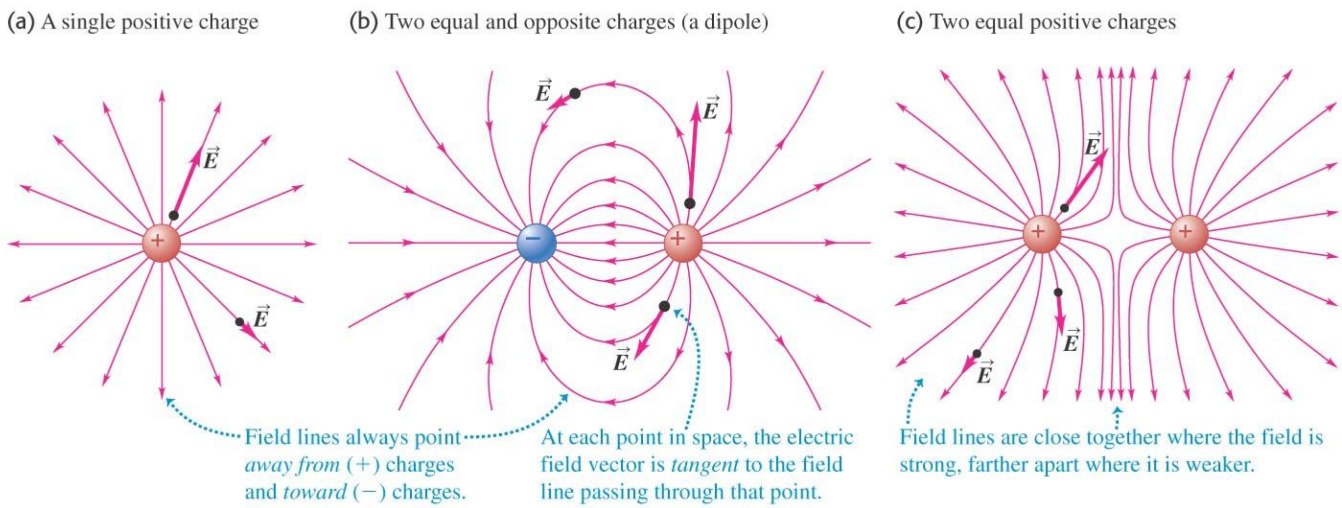
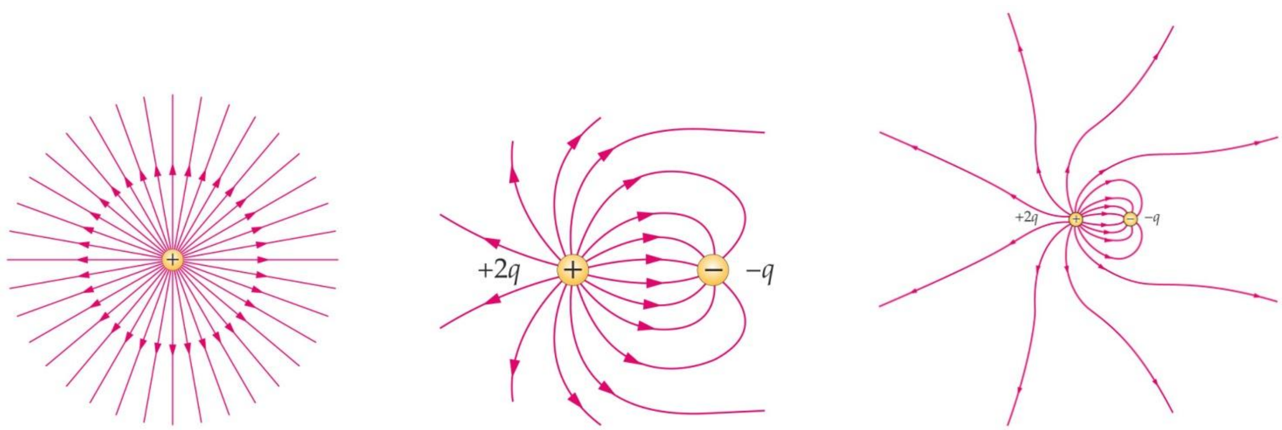


Figure 23.20 Electric field lines penetrating two surfaces. The magnitude of the field is greater on surface A than on surface B.









In the middle figure note that only half of the lines leaving the positive charge enter the negative charge. The remaining half terminate on a negative charge assumed to be located at infinity.

Since the **E**-field vector is tangent to the **E**-field lines at any given point, a charge *q* will experience a force **F** = *q***E** in same direction of the **E**-field vector. Thus, the electric force **F**=*q***E** and the acceleration of the chare are both tangent to the **E**-field lines. In general, the direction of motion of a charged particle is not the same as the **E**-field.

Electric Dipoles

DEF: *An electric dipole consists of two point charges of equal magnitude but opposite sign held at a fixed distance apart.*

Many different system can be described as electric dipoles. Some of these systems include antennas and polarized molecules. A good example of a polarized molecule is H_20 (water). The bonding of the H and O atom cause a slight separation of charge that make H_20 a polar molecule with a permanent electric dipole. The electric dipoles of polar molecules play a very important role in their properties.

Microwave ovens take advantage of the polar nature of the water molecule. Microwaves ovens generate a rapidly changing E-field that causes the polar molecule to swing back and forth, absorbing energy from the field in the process. During such process the molecules collide with each other and the energy they absorb from the E-field is converted to internal energy, which in turn increases the temperature of the food.

Two questions:

1. What force and torque does an Electric Dipole experience in an external E-field?
2. What E-field does an Electric Dipole produce itself?