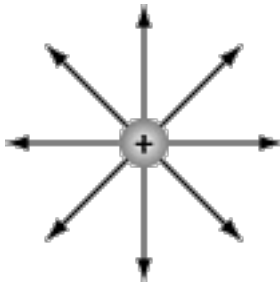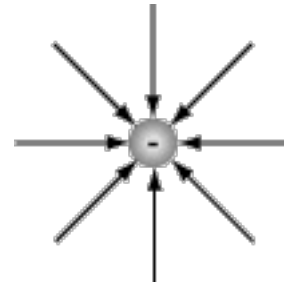# Electric Field Intensity

Every charged object creates an electric field of force in the space around it. Any other charged object in that space will experience a force of attraction or repulsion from the presence of the electric field.

Field Lines around a Positive Charge   **Field Lines around a Negative Charge**

The **electric field intensity**, E, at any point around a charged sphere is defined as the electric force per unit positive charge, and is a vector quantity. The direction is that of the electric force on a positive test charge. The electric field intensity can be defined as:

$$E = \frac{F_E}{q}$$

Where,

E is the electric field intensity in Newtons per Coulomb (N/C)

F_E is the electric force in Newtons (N)

q is the charge of the **test charge** in Coulombs (C)

Note: The electric field due to multiple charges will be the vector sum of the electric field due to each individual charge.

$$\sum \vec{E} = \vec{E_1} + \vec{E_2} + \vec{E_3} + ...$$

Electric Field Intensity and Coulomb's Law

The electric field intensity at any point a distance r from the center of a charged sphere can also be defined in terms of Coulomb's Law:

$$E = \frac{F_E}{q}$$

$$= \frac{\frac{kQq}{r^2}}{q}$$

$$\boxed{E = \frac{kQ}{r^2}}$$

Where,

Q is the charge on the **sphere**

r is the distance from the center of the sphere to the point

Note: In diagrams, the electric field intensity at any point is indicated by the relative distance between adjacent field lines. Where the intensity is strong, the field lines are closer together. More widely spaced field lines indicate a weaker electric field.

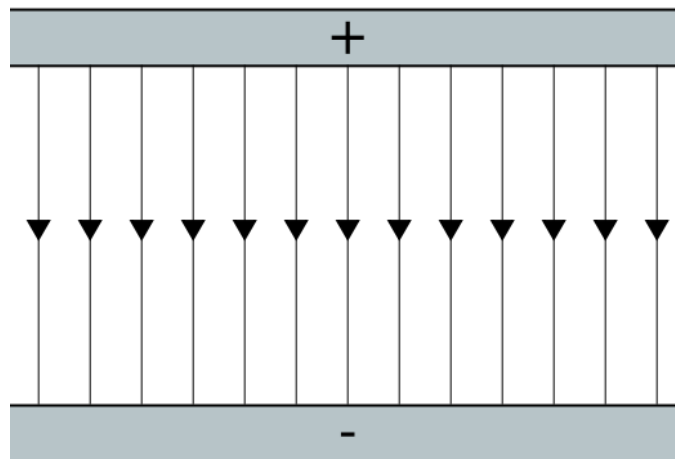### Fields of Some Typical Charge Distributions

Around two Positive Spheres
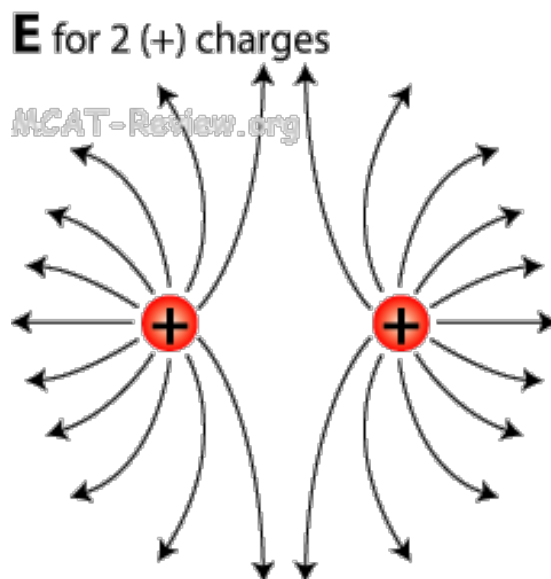
Around two Oppositely Charged Spheres

E for dipole
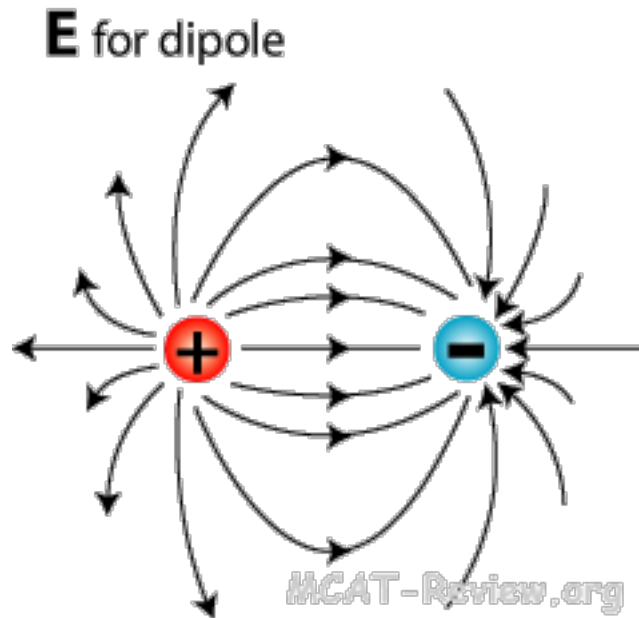
Between two Oppositely Charged Parallel Plates

- The electric field intensity in the region outside the parallel plates is zero (except for a slight bulging of the field near the edges of the plates).

- The electric field intensity is constant everywhere in the space between the parallel plates. The electric field lines are straight, equally spaced, and perpendicular to the parallel plates.

- The magnitude of the electric field intensity at any point between the plates (except the edges) depends only on the magnitude of the charge on each plate. If you double the charge, you double the field intensity.

Example 1

A positive charge of 6.0×10^{-6} C experiences an electric force of 5.2 N, acting to the left. What is the magnitude and direction of the electric field acting on the charge?

Example 2

What is the electric field intensity 0.50 m away from a small sphere with a positive charge of 1.6×10^{-8} C ?

Example 3

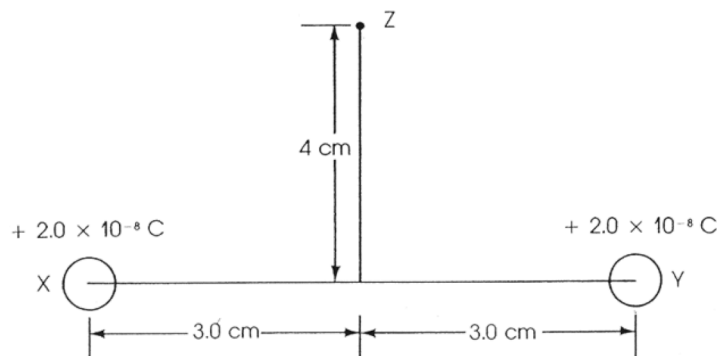Calculate the electric field intensity midway between two negative charges of 3.2×10^{-9} C and 6.4×10^{-9} C that are 30 cm apart.

Example 4

The electric field intensity between the plates of a parallel plate apparatus is $1.5 \times 10^2 \ N/C$. What is the effect on the electric field intensity of

    a. doubling the charge on each plate?

    b. moving the plates 3 times as far apart?

Homework
Field Intensity Worksheet

Field Intensity Worksheet

1. A negative charge of 2.4×10^{-6} C experiences an electric force of magnitude 3.2 N, acting to the left. What is the magnitude and direction of the electric field at that point? (1.3×10^{6} N/C $\left[right\right]$)

2. At a certain point in an electric field, the magnitude of the electric field intensity is 12 N/C. Calculate the magnitude of the electric force exerted on a point charge of 2.5×10^{-7} C, located at this point in the field. (3.0×10^{-6} N)

3. What is the magnitude and direction of the electric field intensity at a point 3.0 m to the right of a positive point charge of 5.4×10^{-4} C? (5.4×10^{5} N/C $\left[right\right]$)

4. What is the magnitude and direction of the electric field at point Z in the diagram below, due to the charged spheres at points X and Y? (2.0×10^{5} N/C $\left[left\right]$)
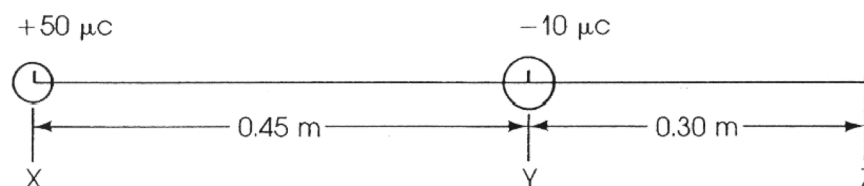
5. Determine the magnitude and direction of the electric field at point Z in the diagram below, due to the charges at points X and Y. (1.2×10^{5} N/C $\left[up\right]$)

6. The electric field strength midway between a pair of oppositely charged parallel plates is 3.0×10^{3} N/C. What is the electric field intensity halfway between this point and the positively charged plate? (3.0×10^{3} N/C)

7. In the parallel plate apparatus in question 6, what would the electric field intensity become, if half the charge were removed from each plate and the separation of the plates was changed from 12 mm to 8 mm? (1.5×10^{3} N/C)