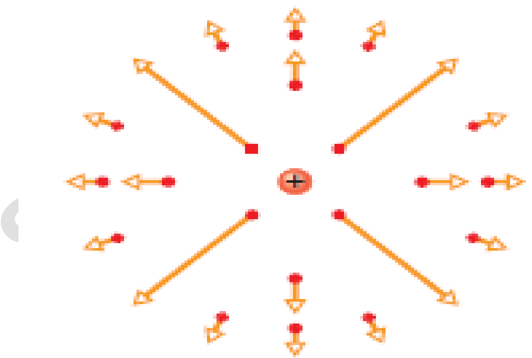
A charged particle sets up an electric field (a vector quantity) in the surrounding space
If a second charged particle is located in that space, an electrostatic force acts on it due to the magnitude and direction of the field at its location.

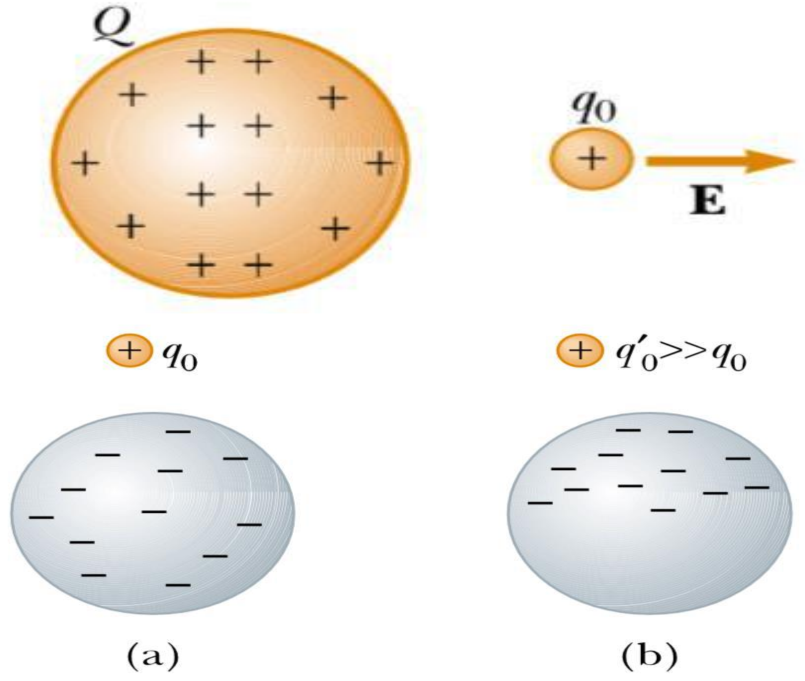
The electric field E at any point is defined in terms of the electrostatic force F that would be exerted on a positive test charge *q* 0 placed there ***E = Fe/ q0***

The vector E has the SI units of newton's per coulomb (N / C)

If the test charge is great enough i.e ***(q'0 >> q0)***

F'e/q'0 ≠ Fe/q0)





Direction of Electric Field and EF due to point charge

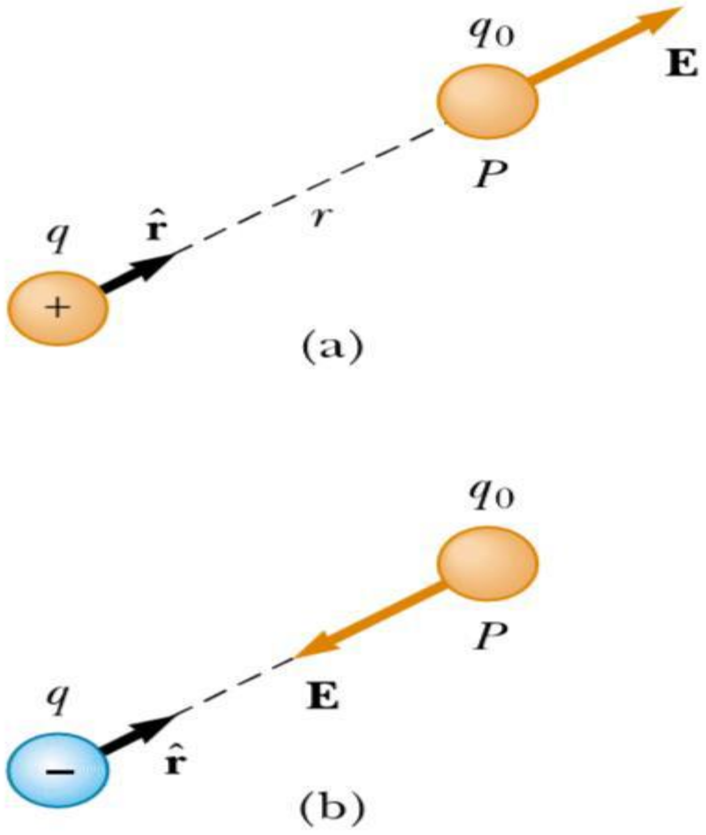
According to Coulomb's law, the force exerted by ***q*** on the test charge is

$$\mathbf{F}_e = k_e \frac{q q_0}{r^2}\,\hat{\mathbf{r}}$$

Electric field at ***P*** is given by $\mathbf{E} = \mathbf{F}_e / q_0$, and the electric field created by ***q*** is

$$\mathbf{E} = k_e \frac{q}{r^2}\,\hat{\mathbf{r}}$$

if ***q*** is positive, the electric field will be directed radially outward. If ***q*** is negative, the field will be directed toward it



Electric field lines extend away from positive charge (where they originate) and toward negative charge (where they terminate).

Electric Field of Forces obey the principle of superposition so

$$\vec{F}_0 = \vec{F}_{01} + \vec{F}_{02} + \cdots + \vec{F}_{0n}.$$

To change over to electric field, we repeatedly use Eq. 22-1 for each of the individual forces:

$$\vec{E} = \frac{\vec{F}_0}{q_0} = \frac{\vec{F}_{01}}{q_0} + \frac{\vec{F}_{02}}{q_0} + \cdots + \frac{\vec{F}_{0n}}{q_0}$$
$$= \vec{E}_1 + \vec{E}_2 + \cdots + \vec{E}_n. \qquad (22\text{-}4)$$

Electric field due to group of charges

At any point P, total electric field due to a group of charges equals the vector sum of the electric fields of the individual charges

$$\mathbf{E} = k_e \sum_i \frac{q_i}{{r_i}^2}\,\hat{\mathbf{r}}_i$$

The Electric Field Due to an Electric Dipole

An electric dipole consists of two particles with charges of equal magnitude *q* but opposite signs, separated by a small distance *d*.

Their electric dipole moment P has magnitude *qd* and points from the negative charge to the positive charge.

$$E = \frac{1}{2\pi\varepsilon_0}\frac{p}{z^3},$$

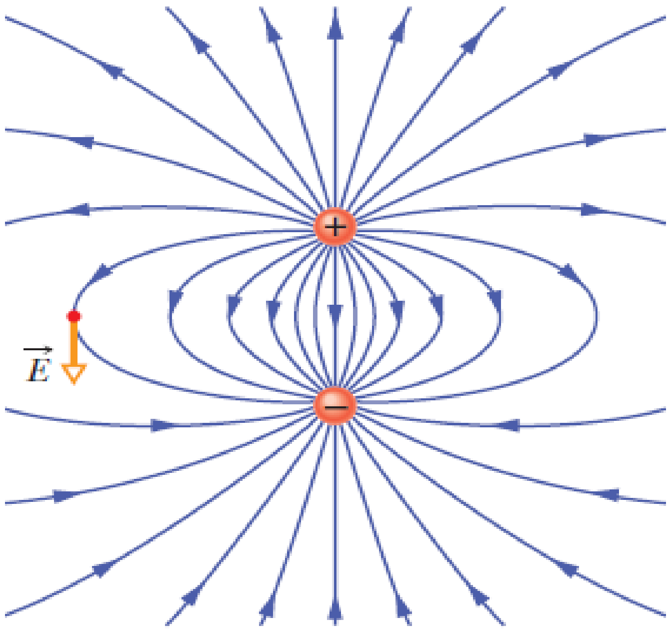


Figure 22-8 The pattern of electric field lines around an electric dipole, with an electric field vector $\vec{E}$ shown at one point (tangent to the field line through that point).

Gauss' Law

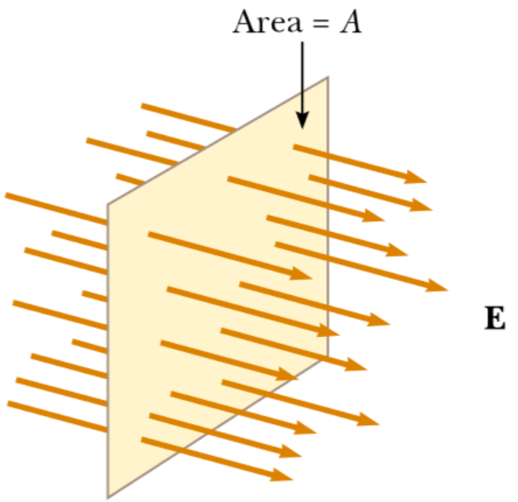
Electric Flux

Electric Flux is the rate of flow of electric field through a given area. Electric flux is proportional to the number of electric field lines going through a surface.

Field lines representing a uniform electric field penetrating a plane of area A, perpendicular to the field.

The electric flux through this area is equal to EA

$$\Phi_E = EA$$



From the SI Units of E and A, we see that Φ_E has unit of newton - meter squared per coulomb $(N \cdot m^2 / C)$

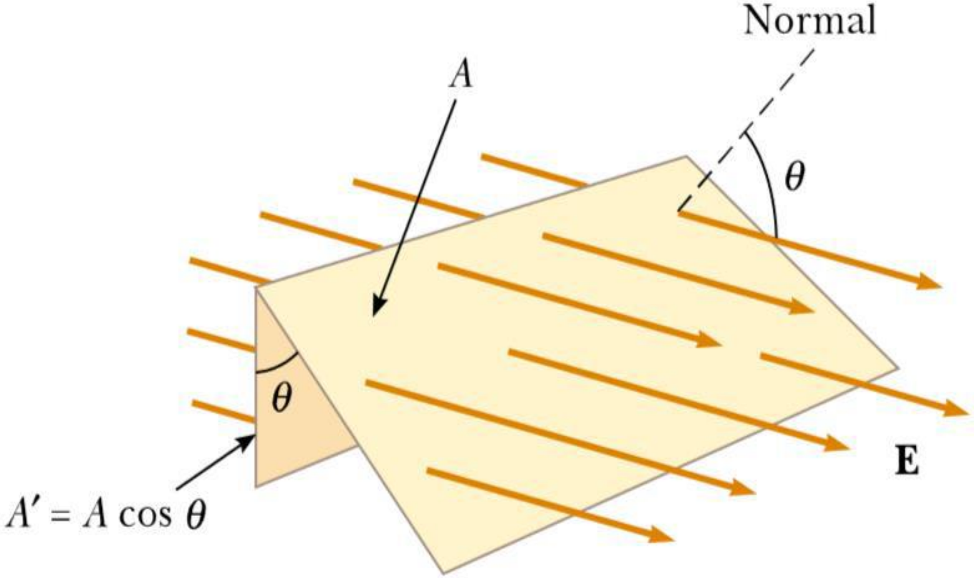
Electric Flux is propotional to the number of electric field lines penetrating some surface.

Maximum and Minimum Electric Flux

Field lines representing a uniform electric field penetrating an area A that is at an angle θ to the field.

It is dot product of EF and Area

$$\Phi_E = EA' = EA\cos\theta$$



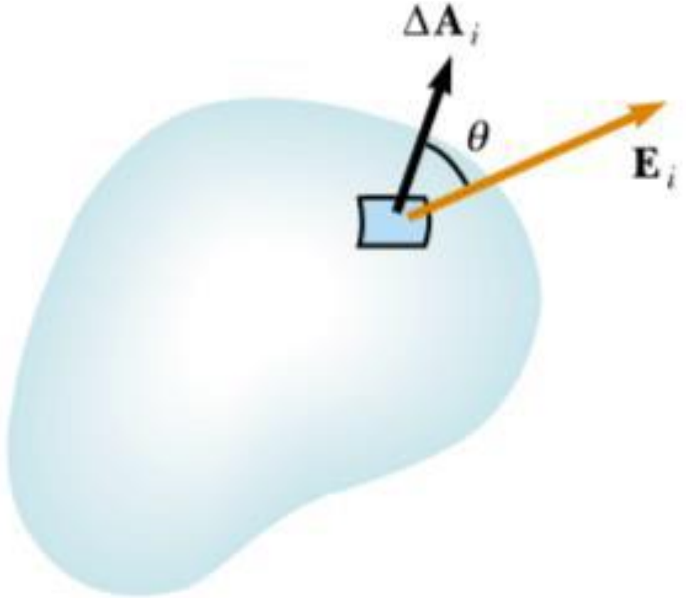
The flux through area element can be

- **Positive**
- **Zero**
- **Negative**

Electric field may vary over a surface.

$$\Delta\Phi_E = E_i\,\Delta A_i \cos\theta = \mathbf{E}_i \cdot \Delta\mathbf{A}_i$$

The electric flux through this small element ΔA is



The general definition of electric flux is

$$\Phi_E = \lim_{\Delta A_i \to 0} \sum \mathbf{E}_i \cdot \Delta\mathbf{A}_i = \int_{\text{surface}} \mathbf{E} \cdot d\mathbf{A}$$

What is the electric flux through a sphere that has a radius of 1.00 m and carries a charge of $+1.00\ \mu\text{C}$ at its center?

$$E = k_e \frac{q}{r^2} = (8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\,\frac{1.00 \times 10^{-6}\ \text{C}}{(1.00\ \text{m})^2}$$

$$= 8.99 \times 10^3\ \text{N/C}$$

The field points radially outward and is therefore everywhere perpendicular to the surface of the sphere. The flux through the sphere (whose surface area $A = 4\pi r^2 = 12.6\ \text{m}^2$) is thus

$$\Phi_E = EA = (8.99 \times 10^3\ \text{N/C})(12.6\ \text{m}^2)$$

$$= \boxed{1.13 \times 10^5\ \text{N}\cdot\text{m}^2/\text{C}}$$