ELECTROSTATICS-01

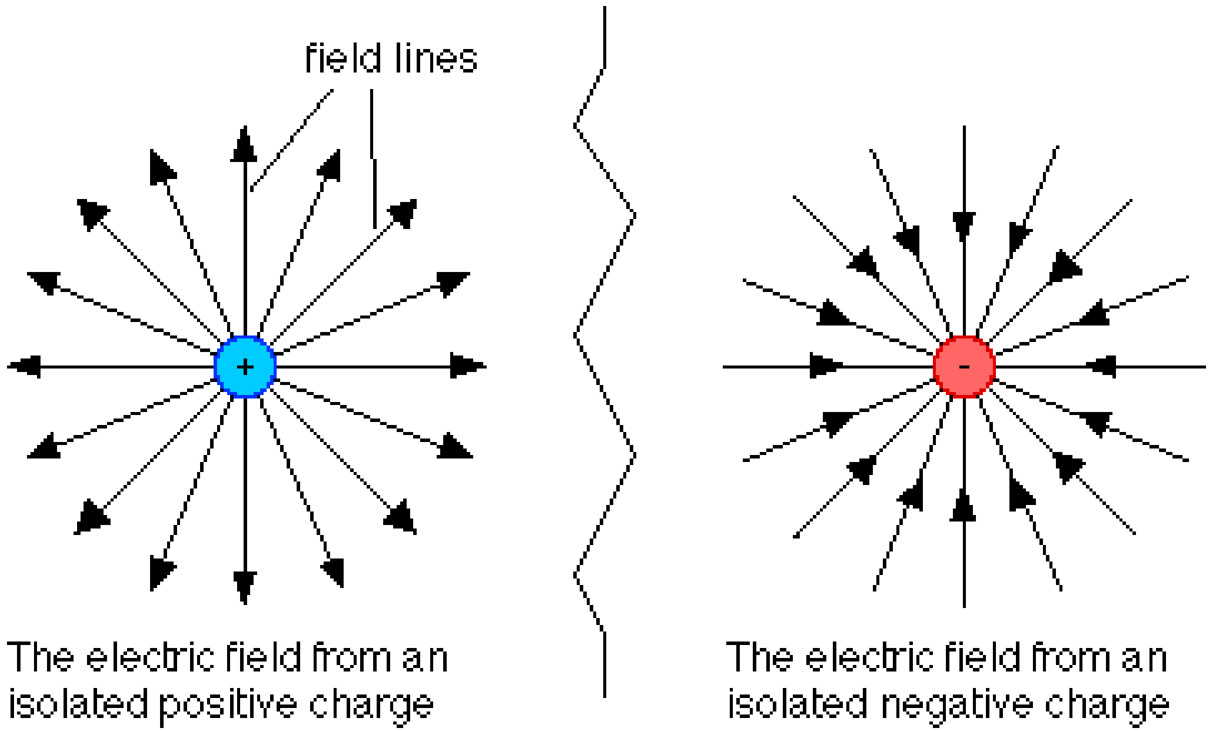
Electric field lines

Integral and differential form of Gauss Law

ELECTRIC FIELD LINES

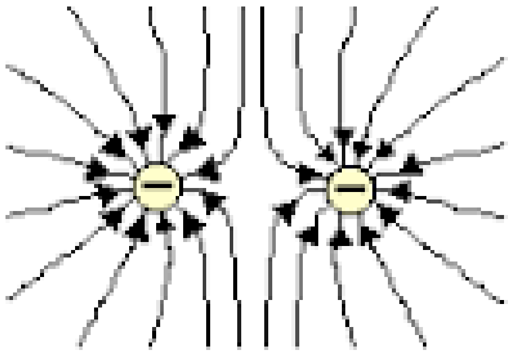
$$E = k\,\frac{q}{r^2}\hat{r}$$

- Electric field varies Inversely with distance squared.
- The magnitude of field is determined by the density of field lines.

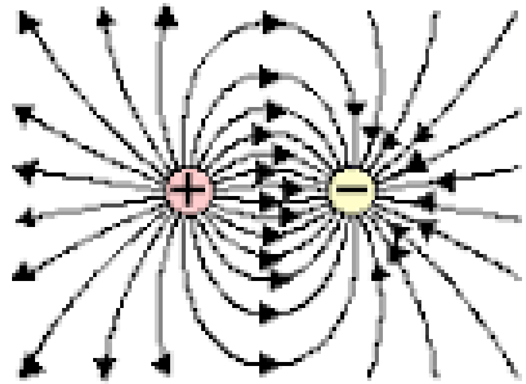


$$\text{Density of lines} = \frac{n}{4\pi r^2}$$

Other Charge Configurations

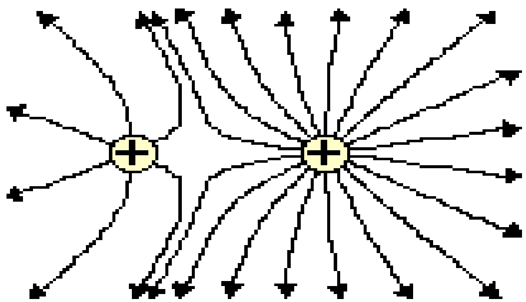


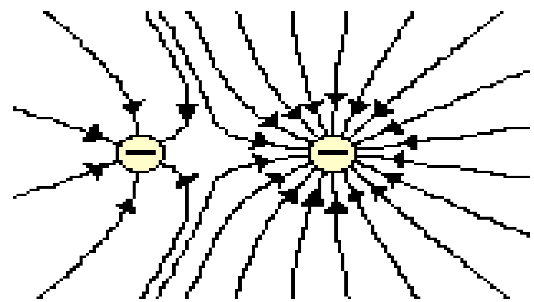
Two Negatively-Charged Objects

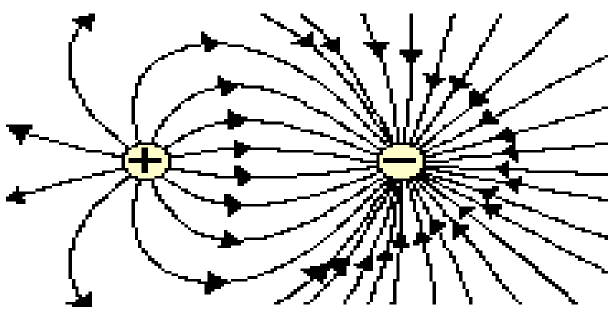


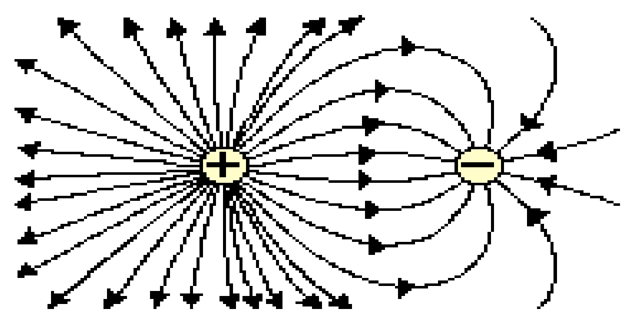
A Positively and a Negatively-Charged Object

Electric Field Line Patterns for Objects with Unequal Amounts of Charge









Properties of Lines of Force

- Field lines starts from positive charge and end at negative charge.
- Tangent of field line represent direction of field at particular point.
- Continuous curves if no conductor is present.
- Lines of force do not cross each other.

Differential equation for Field lines

Tangent represent direction E field

$$\frac{d\vec{r}}{dS} = a\vec{E}(r)$$

$$\frac{dx}{dS} = aE_x \qquad \frac{dy}{dS} = aE_y \qquad \frac{dz}{dS} = aE_z$$

$$\frac{dx}{E_x} = \frac{dy}{E_y} = \frac{dz}{E_z}$$

FLUX AND GAUSS LAW

- Flux is a measure of number of field lines passing through surface S.
- It also measure total charge enclosed inside a closed surface.

$$\phi_E = \oint E.da$$

- For a isolated charge,

$$\oint E.da = \int \frac{1}{4\pi \in_0} \left(\frac{q}{r^2}\hat{r}\right).(r^2 sin\theta d\theta d\emptyset \hat{r})$$

$$= \frac{1}{\in_0} q$$

- For bunch of scattered charges,

$$E = \sum_{i=1}^{n} E_i$$

$$\oint E.da = \oint \sum_{i=1}^{n} E_i\,.da = \frac{1}{\epsilon_0}\sum_{i=1}^{n} q_i$$

$$\oint E.da = \frac{1}{\epsilon_0} q_{enclosed}$$

- This is integral form of Gauss law

$$\oint E.da = \iiint (\nabla.E)d\tau \qquad q = \iiint \rho d\tau$$

$$\iiint (\nabla.E)d\tau = \frac{1}{\epsilon_0}\iiint \rho d\tau$$

$$\nabla.E = \frac{\rho}{\epsilon_0}$$

- This is differential form of Gauss Law