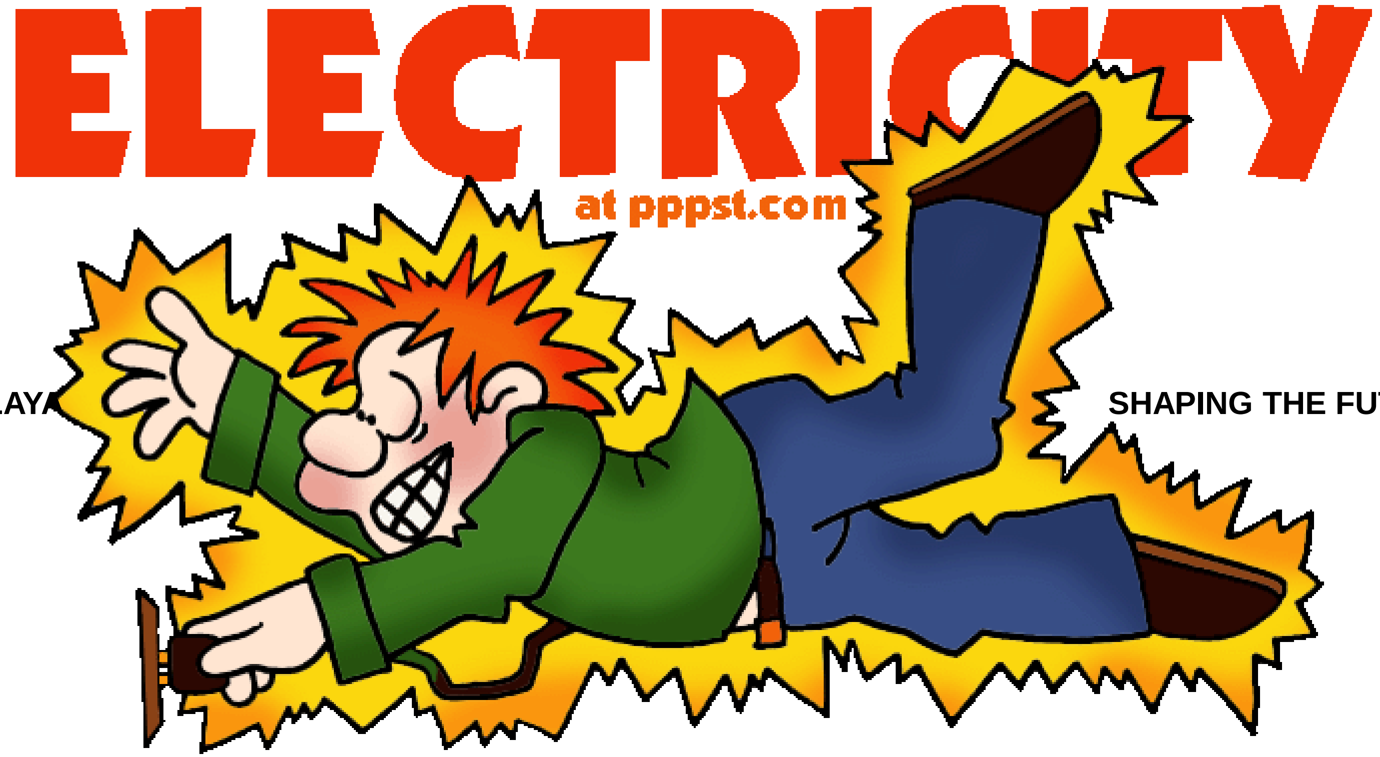
ATUL VIDYALAYA

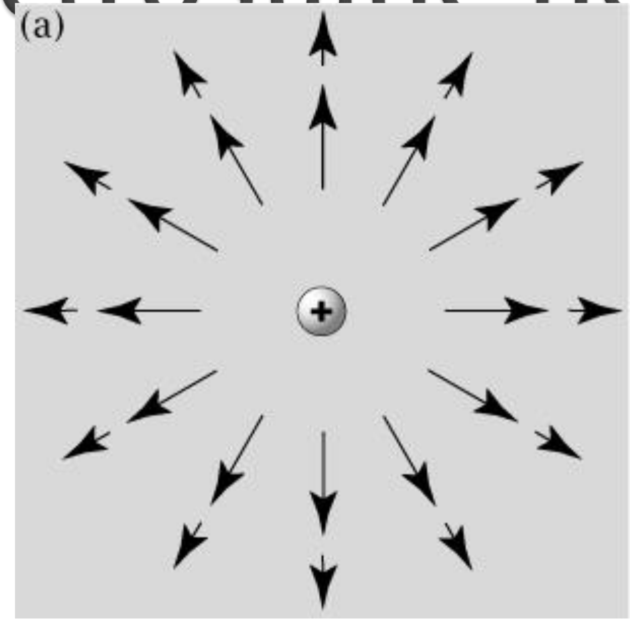


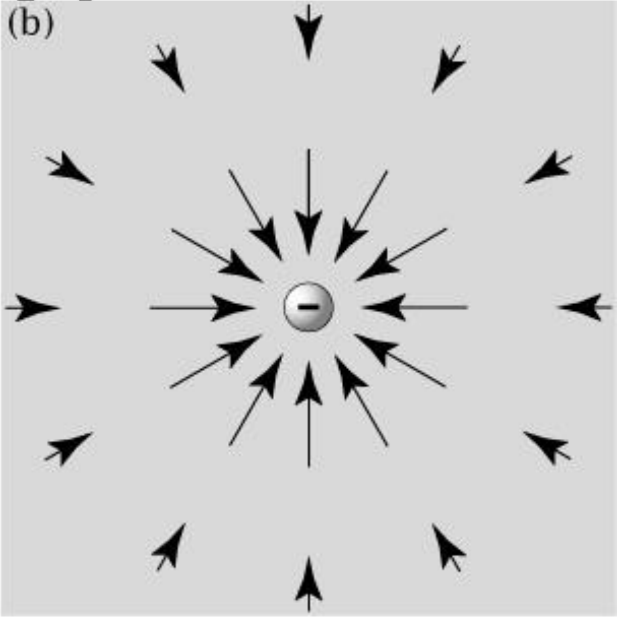
SHAPING THE FUTURE

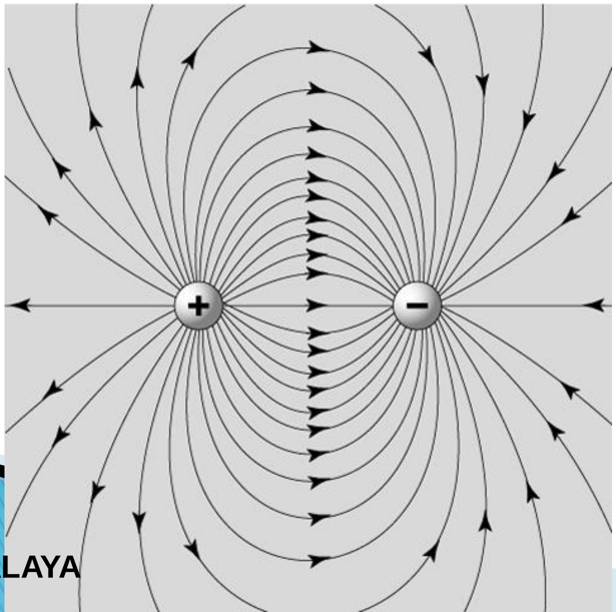
Electrostatics

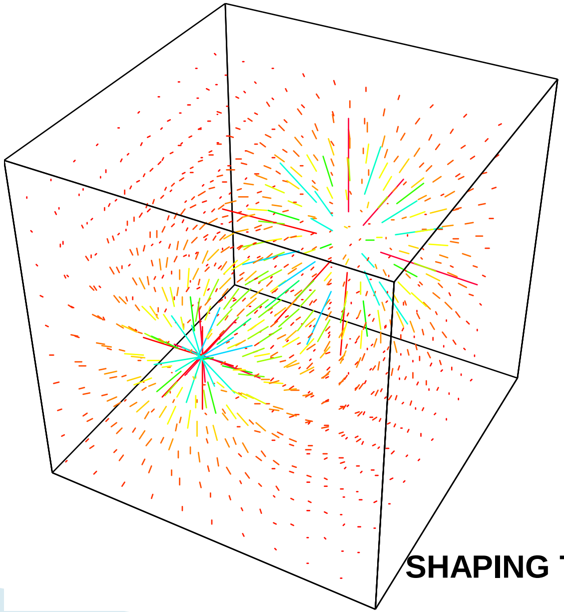
Nay, electrophun!!!

Electrostatic fields









Electric field flux

- Flux: the amount of "stuff" passing through surface
  - Concentration
  - Fluid flow
  - Electric field
- Fluxes arise from
  - Sources: positive charges
  - Sinks: negative charges
- Electric field flux: integral of electric displacement over a surface

$$\Phi = \int_{\partial\Omega} \underbrace{D\mathbf{E}}(\mathbf{s}) \cdot d\mathbf{s}$$

Boundary surface of volume Ω

Electric displacement

Jacobian; points in surface normal direction

Field flux: point charge in a sphere

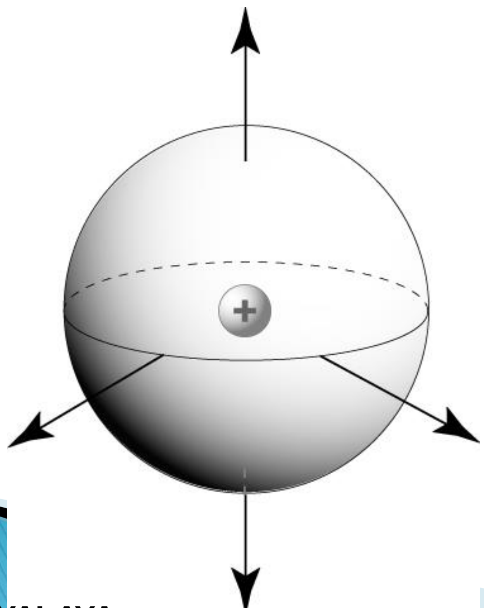
- Point charge has spherically-symmetric field
- Field is constant on sphere surface
- Flux is independent of sphere diameter

$$\Phi = \int_0^{\pi}\int_0^{2\pi} DE(r)\, r^2 \sin\theta\, d\theta\, d\psi$$

$$= DE(r)\, 4\pi r^2$$

$$= D\frac{q}{4\pi\varepsilon_0 D r^2} 4\pi r^2$$

$$= \frac{q}{\varepsilon_0}$$



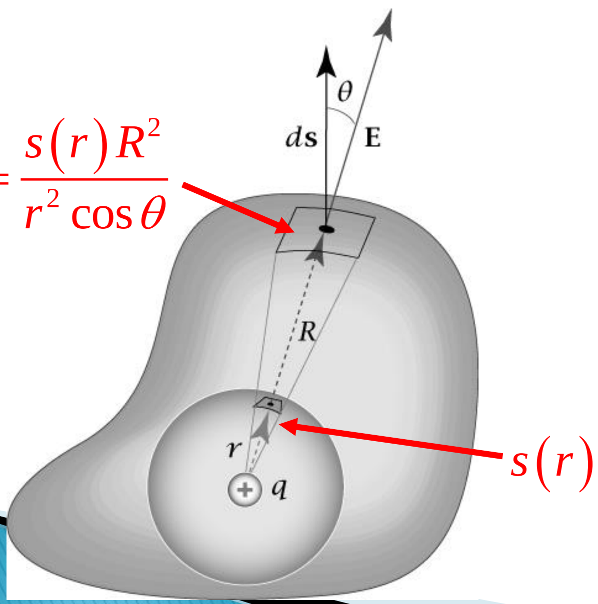
Field flux: point charge in a balloon

- Consider another "outer" surface that surrounds an "inner" sphere
- The outer surface can have any shape
- The fluxes through any (arbitrarily small) portion of the outer and inner surfaces can be calculated
- These surface portions can be related
- The fluxes through the two surfaces are the same!

$$\Phi_{\text{in}}[s] = DE(r)s(r) = \frac{qs(r)}{4\pi\varepsilon_0 r^2}$$

$$\Phi_{\text{out}}[S] = DE(R)S(R)\cos\theta = \frac{qS(R)\cos\theta}{4\pi\varepsilon_0 R^2}$$

$$S(R) = \frac{s(r)R^2}{r^2\cos\theta}$$



$$\frac{\Phi_{\text{out}}[S]}{\Phi_{\text{in}}[s]} = \frac{\dfrac{qS(R)\cos\theta}{4\pi\varepsilon_0 R^2}}{\dfrac{qs(r)}{4\pi\varepsilon_0 r^2}} = \frac{S(R)}{s(r)}\frac{r^2}{R^2}\cos\theta = \frac{\dfrac{s(r)R^2}{r^2\cos\theta}}{s(r)}\frac{r^2}{R^2}\cos\theta = 1$$

Gauss' law

- The integral of field flux through a closed, simple surface is equal to the total charge inside the surface
- This is true for *both* homogeneous and inhomogeneous dielectric media
- This generalizes to other charge distributions

$$\Phi = \oiint_{\partial\Omega} D\mathbf{E}(\mathbf{s}) \cdot d\mathbf{s}$$

$$= \oiint_{\partial\Omega} D\left(\sum_i \mathbf{E}_i(\mathbf{s})\right) \cdot d\mathbf{s}$$

$$= \sum_i \oiint_{\partial\Omega} D\mathbf{E}_i(\mathbf{s}) \cdot d\mathbf{s}$$

$$= \frac{1}{\varepsilon_0} \sum_i q_i$$

$$\Phi = \oiint_{\partial\Omega} D\mathbf{E}(\mathbf{s}) \cdot d\mathbf{s}$$

$$= \frac{1}{\varepsilon_0} \int_{\Omega} \rho(\mathbf{x})\, d\mathbf{x}$$