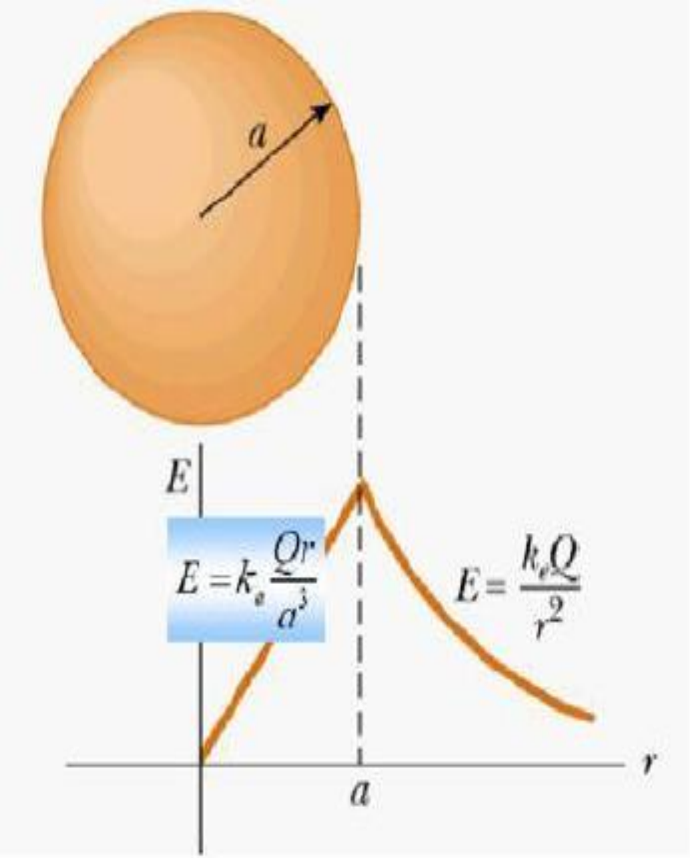
Physics (II)
Section 5

Electric Field Configuration

The magnitude of the electric field at

a point inside and outside the sphere.



- $E = K_e \frac{Q_r}{a^3}$, $r < a$ (Inside)
- $E = K_e \frac{Q}{r^2}$, $r > a$ (Outside)
- By butting r =a from given the two equations
- so the electric field at the surface is

$$E_s = K_e \frac{Q}{a^2} \;, r = a \qquad at\ the\ surface$$

Ex) A solid sphere of radius 40 cm has a total positive charge of 26 μC uniformly distributed throughout its volume. Calculate the magnitude of the electric field (a) 0 cm (b) 10cm (c) 40 cm (d) 60 cm from the center of the sphere

- Solution:

$$a)E = K_e \frac{Q}{a^3} \mathrm{r} = 0$$

$$b)E = K_e \frac{Q}{a^3} r = \frac{(8.99 \times 10^9)(26\times 10^{-6})(0.100)}{(0.400)^3} = 365.218\ KN/C$$

$$c)E = K_e \frac{Q}{r^2} = \frac{(8.99 \times 10^9)(26\times 10^{-6})}{(0.400)^2} = 1.46\ \ MN/C$$

$$d)E = K_e \frac{Q}{r^2} = \frac{(8.99 \times 10^9)(26\times 10^{-6})}{(0.600)^2} = 649.277\ KN/C$$

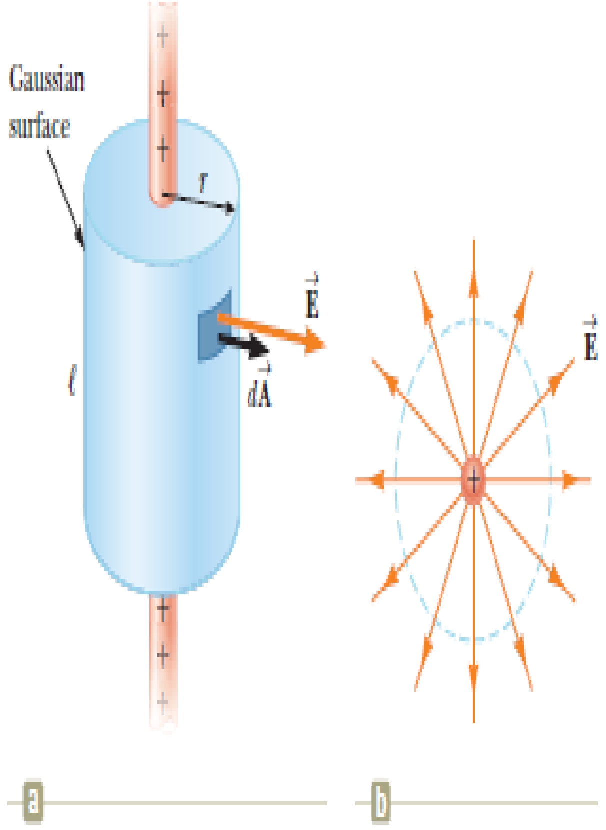
The direction for each electric field is radially outward

A Cylindrically Symmetric Charge Distribution

The electric field a distance *r* from a line of positive charge of infinite length and constant charge per unit length λ (Fig. 24.12a).

We construct a Gaussian surface in the form of a cylinder of radius r , length L and coaxial with charged line.

$$E = \frac{\lambda}{2\pi\varepsilon r} = 2k\frac{\lambda}{r}$$



Ex) A uniformly charged, strait filament 7 m in length has a total positive charge of 2 μC . An uncharged cardboard cylinder 2 cm in length 10 cm in radius surround the filament at its center with the filament as the axis of the cylinder by using approximations, find (a) the electric field at the surface and (b) the total electric flux through the cylinder

(a) $$E = \frac{2k_e\lambda}{r} = \frac{2\left(8.99\times10^9\ \mathrm{N\cdot m^2/C^2}\right)\left[\left(2.00\times10^{-6}\ \mathrm{C}\right)/7.00\ \mathrm{m}\right]}{0.100\ \mathrm{m}}$$

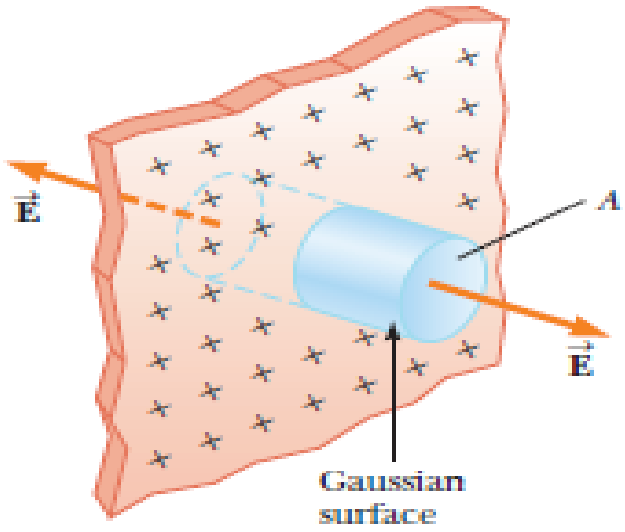
$$E = \boxed{51.4\ \mathrm{kN/C},\ \text{radially outward}}$$

(b) $$\Phi_E = EA\cos\theta = E(2\pi r\ell)\cos 0°$$

$$\Phi_E = \left(5.14\times10^4\ \mathrm{N/C}\right)2\pi(0.100\ \mathrm{m})(0.0200\ \mathrm{m})(1.00) = \boxed{646\ \mathrm{N\cdot m^2/C}}$$

The electric field due to an infinite plane of positive charge with uniform surface charge density . $E = \frac{\sigma}{2\varepsilon}$

- $\boldsymbol{E = \frac{\sigma}{2\varepsilon}}$



Electric Potential and Potential Difference

- The work done on a point charge q_o immersed in an electric field to move it for an infinitesimal displacement $\vec{ds}$ is

$$\boldsymbol{W = \vec{F} \, . \, \overrightarrow{ds} = q \, .\vec{E} \, . \, \overrightarrow{ds}}$$

The Work is done by the field

$$\boldsymbol{dU = -W = -q \, \vec{E} \, . \, \overrightarrow{ds}}$$

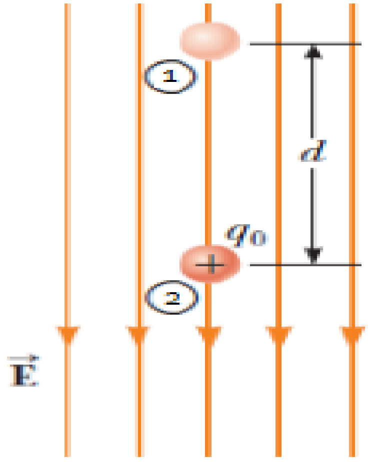
- For a finite displacement of the charge from point ① to point ②, the change in

potential energy of the system $\Delta U = U② - U①$ is:

$$\Delta U = -q \int_1^2 \vec{E} \, . \, \overrightarrow{ds}$$

Potential Difference in a Uniform Electric Field

- $\Delta V = \dfrac{\Delta U}{q}$
- $V_2 - V_1 = \Delta V$
- $\Delta V = -\int_1^2 E.ds = -\int_1^2 E.d\cos(0) = -\int_1^2 E.ds = -E\int_1^2 ds$
- $\Delta V = -E.d$



❖ $\Delta V = -\int_1^2 \vec{E}.\overrightarrow{ds} = \overrightarrow{-E}\int_1^2 \overrightarrow{ds} = -\vec{E}.\vec{s}$

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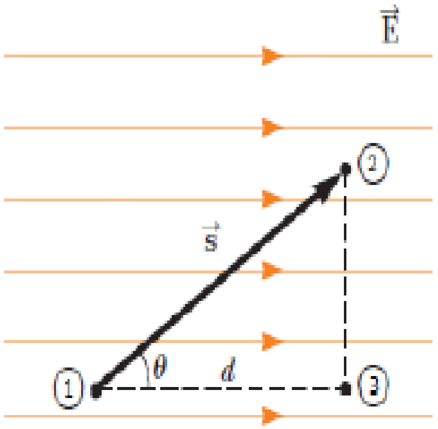

➢ $\Delta U = q\Delta V$

➢ $\Delta U = q\Delta V = -q\vec{E}.\vec{s} = -qE.d$

Ex) A proton is released from rest at point A in a uniform electric field that has a magnitude of 8.0×10^4 V/m (Fig. 25.6). The proton undergoes a displacement of magnitude d= *0.5* m to point B in the direction of **E**

.A) Find the change in electric potential between A and B of the proton after completing the displacement

B) Find the change in potential energy of the proton field system for this displacement

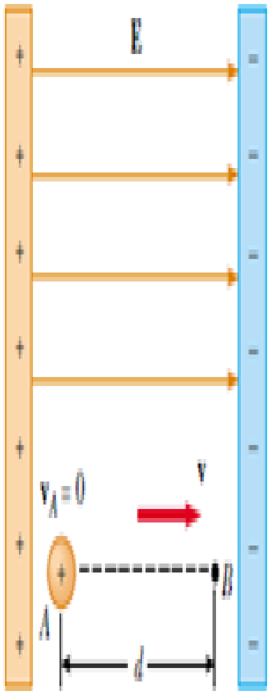

Figure 25.6 (Example 25.2) A proton accelerates from A to B in the direction of the electric field.

A) Find the change in electric potential between A and B
of the proton after completing the displacement

$\Delta v = -\ E\ .\ d = -(8 \times 10^4).\ (0.5)\ = -4.0 \text{ x } 10^4$ V

B) Find the change in potential energy of the proton field system for
this displacement

- $\Delta\ U = q\Delta v$
- $\Delta\ U = (1.6 \times 10^{-19}\ \ x\ (-4.0\ 10^4)$

$= -\ 6.4 \text{ x} 10^{-15}$ J

MCQ:

1) A total charge of $6.3X10^{-8}$ C is distributed uniformly throughout 2.7 cm radius sphere. The volume charge density is :

- a) 3.7×10^{-7} C/m^2
  b) 6.9×10^{-6} C/m^3
  c) 7.6×10^{-4} C/m^3
  d) 7.6×10^{-4} C/m^2

Ans: C