University of Anbar
College of Engineering
Dept. of Electrical Engineering

Electric physics II

Application of the Gauss' law

By

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Application of the Gauss' law:

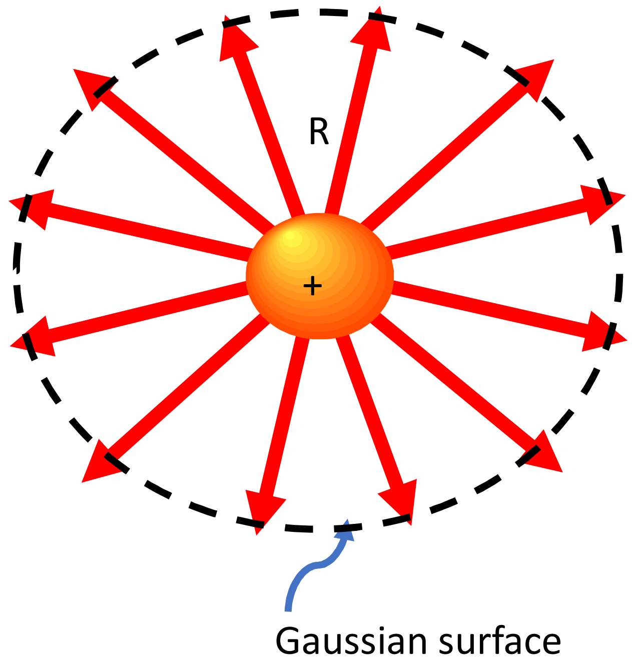
1.Electric field due to infinite point of charge

$$\Phi = \oint E.dA = \frac{Q_{in}}{\varepsilon_0}$$

$$E\oint dA \cos 0 = \frac{Q_{in}}{\varepsilon_0}$$

$$E \times 4\pi R^2 = \frac{Q_{in}}{\varepsilon_0}$$

$$E = \frac{Q_{in}}{4\pi R^2 \varepsilon_0} = \frac{KQ_{in}}{R^2}$$



Application of the Gauss' law:

2.Electric field due to infinite line of charge

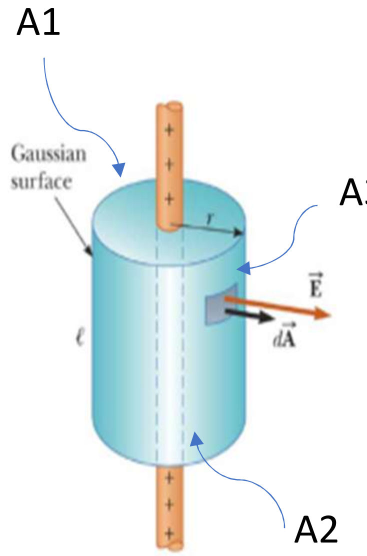
$\oint E.dA = \frac{Q_{in}}{\varepsilon_0}$

$= \oint_1 E.dA + \oint_2 E.dA + \oint_3 E.dA \qquad = \frac{Q_{in}}{\varepsilon_0}$

$E \oint dA \cos 0 = \frac{\lambda l}{\varepsilon_0}$

$E . 2\pi r\, l \quad = \frac{\lambda l}{\varepsilon_0}$ where the area of cylindrical surface is $2\pi r\, l$

E= $\frac{\lambda}{2\pi r \varepsilon_0}$



$\lambda = \frac{Q}{l}$

Linear charge density

Application of the Gauss' law:

3.Nonconducting sheet (surface of charge)

$\oint E.dA = \frac{Q_{in}}{\varepsilon_0}$

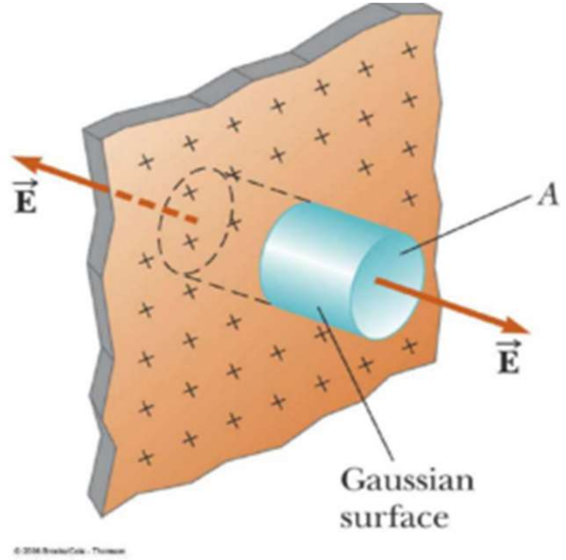
$= \oint_1 \ E.dA + \oint_2 \ E.dA + \oint_3 \ E.dA \qquad = \frac{Q_{in}}{\varepsilon_0}$

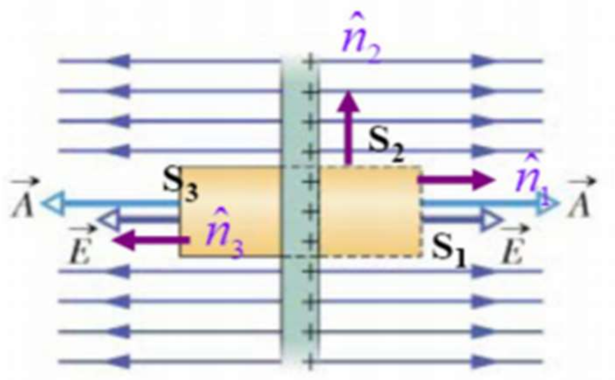
E.A + E.A = $\frac{\sigma A}{\varepsilon_0}$

2A.E= $\frac{\sigma A}{\varepsilon_0}$

E= $\frac{\sigma}{2\varepsilon_0}$

$\sigma = \frac{Q}{A}$(C/m^2) the surface charge density)





Application of the Gauss' law:

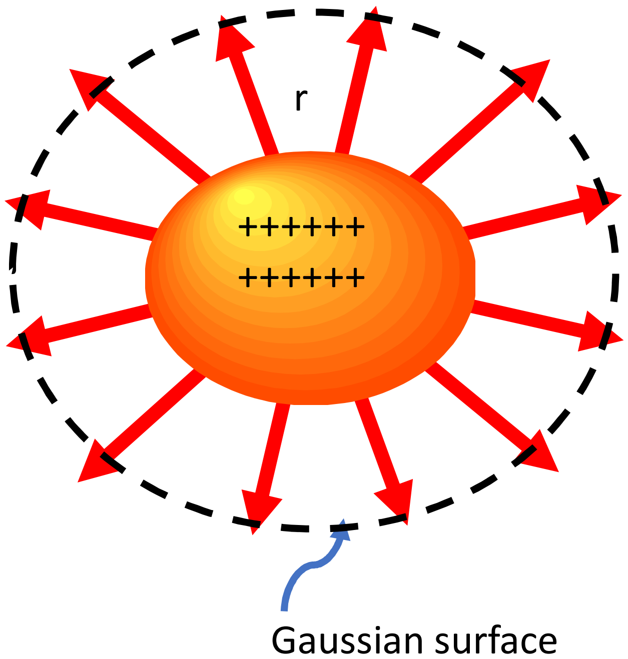
4.Solid nonconducting sphere

a)The electric field outside the sphere

$$\oint E.dA = \frac{Q_{in}}{\varepsilon_0}$$

$$E \times 4\pi r^2 = \frac{Q_{in}}{\varepsilon_0}$$

$$E = \frac{Q_{in}}{4\pi r^2 \varepsilon_0}$$



$\rho = \frac{Q}{V}$ (c/m^3)(the volume charge density)

Application of the Gauss' law:

Solid nonconducting sphere

b)The electric field inside the sphere(r<R)

$$\oint E.dA = \frac{Q_{in}}{\varepsilon_0}$$

$$E \times 4\pi r^2 = \frac{Q_{in}}{\varepsilon_0}$$

$$E = \frac{Q'}{4\pi r^2 \varepsilon_0}$$

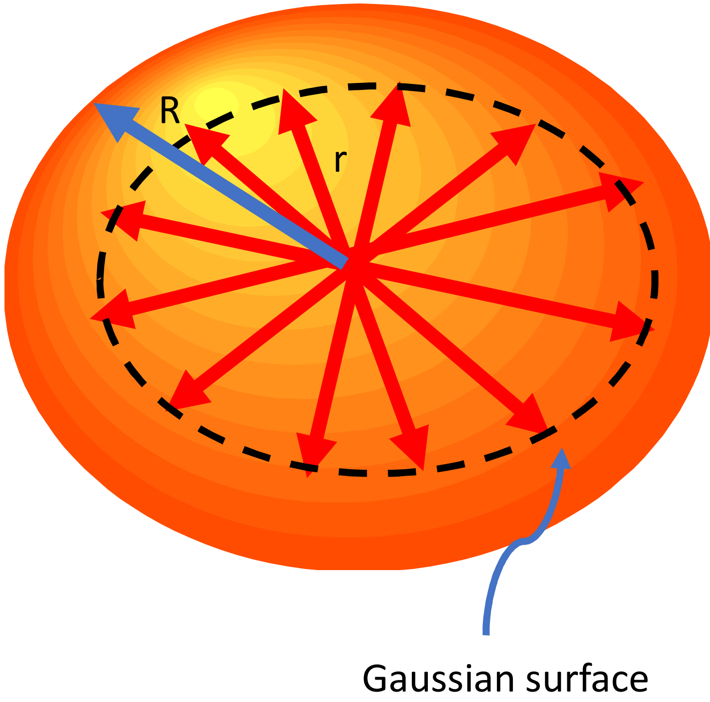
$$E = \frac{Q'}{4\pi r^2 \varepsilon_0}$$

$$E = \frac{KQ\,r}{R^3}$$

$$\rho = \frac{Q}{V} = \frac{Q'}{V}$$

$$\frac{Q}{{}^4/_3\pi R^3} = \frac{Q'}{{}^4/_3\pi r^3}$$

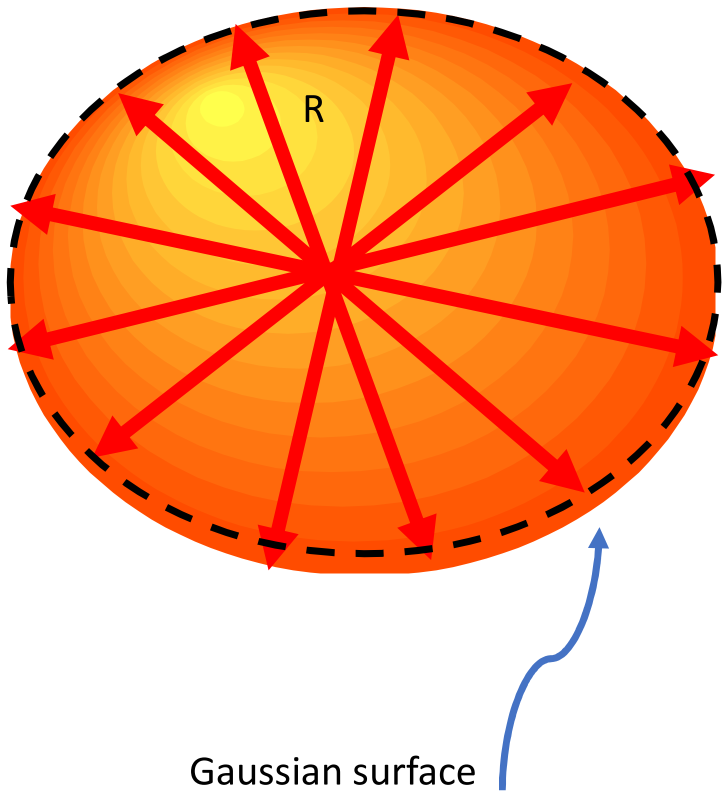
$$Q' = \frac{Qr^3}{R^3}$$



Application of the Gauss' law:

c)The electric field on the surface of the sphere(the radius is R)

$$E = \frac{Q\ R}{4\pi R^3 \varepsilon_0} = \frac{Q}{4\pi R^2 \varepsilon_0}$$



Application of the Gauss' law:

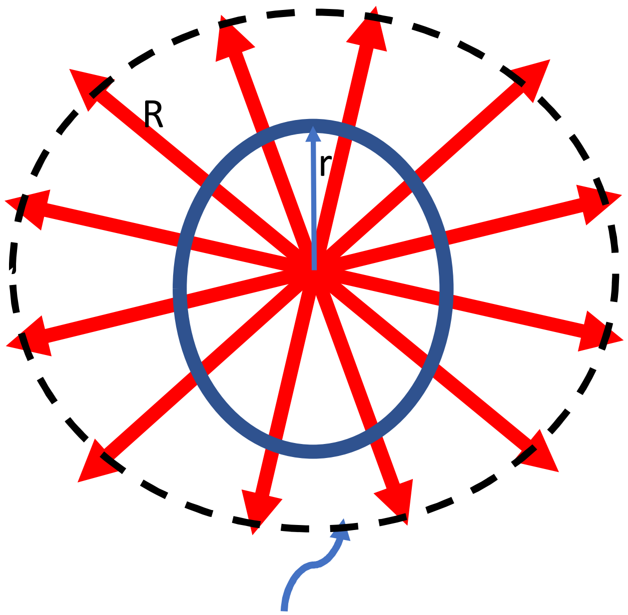
- 5) conducting sphere and thin shell
- A) r>R

$$\Phi = \oint E.dA = \frac{Q}{\varepsilon_0}$$

$$E\oint dA\, cos0 = \frac{Q}{\varepsilon_0}$$

$$E \times 4\pi R^2 = \frac{Q}{\varepsilon_0}$$

$$E = \frac{Q_{in}}{4\pi R^2 \varepsilon_0} = \frac{KQ}{R^2}$$



b) r<R

$$E \times 4\pi R^2 = \frac{Q}{\varepsilon_0} = 0$$ (there is no charge in side the conductor)

Application of the Gauss' law:

6)Thick conducting shell

- E outside

$$\oint E.dA = \frac{Q}{\varepsilon_0}$$

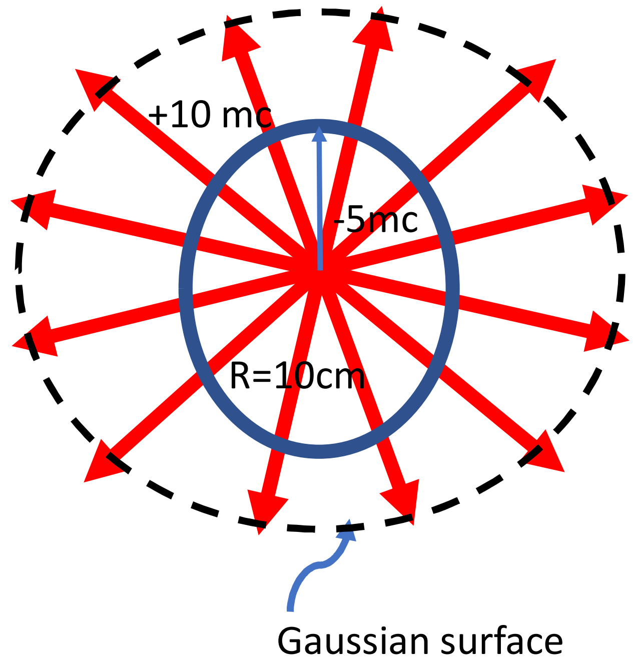
$$E \times 4\pi R^2 = \frac{Q}{\varepsilon_0}$$

$$E \times 4\pi R^2 = \frac{(+10-5)\times 10^{-6}}{\varepsilon_0}$$

$$E = \frac{5\times 10^{-6}}{4\pi R^2 \varepsilon_0}$$

.E inside

$$E \times 4\pi R^2 = \frac{-5\times 10^{-6}}{\varepsilon_0}$$



Application of the Gauss' law:

- Find E when r>5?

$$E \times 4\pi R^2 = \frac{-5\times10^{-6}}{\varepsilon_0}$$

- Find E when 5<r<3?

  E=0

- Find E when r<3?

  E=0 (there is no charge inside the shell)