September 8th

Gauss' Law – Chapter 24

Review

- Coulomb's law
  - Like charges repel, *F* is away from other charge
  - Unlike charges attract, *F* is toward other charge

$$F = k\frac{|q_1||q_2|}{r^2}$$

- Electric field, *E*, felt by positive test charge, q_0

$$E = \frac{F}{q_0} = k\frac{|q|}{r^2}$$

- Conversely *F* on a charged particle in an *E* field is

$$\vec{F} = q\vec{E}$$

Review

- Gauss' law – form of Coulomb's law
  - q_{enc} is the total charge enclosed by a Gaussian surface

$$\varepsilon_0 \Phi = q_{enc}$$

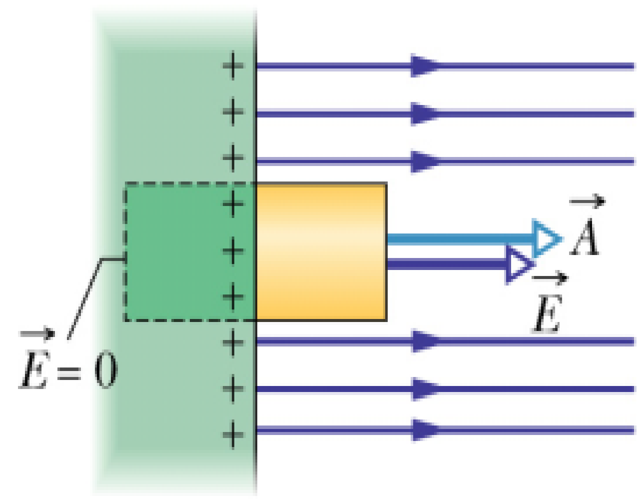
- Flux is proportional to # of E field lines passing through a Gaussian surface

$$\Phi = \oint \vec{E} \bullet d\vec{A}$$

Conductors

- *E* just outside a conductor is proportional to surface charge density at that location

$$E = \frac{Q}{\varepsilon_0 A} = \frac{\sigma}{\varepsilon_0}$$

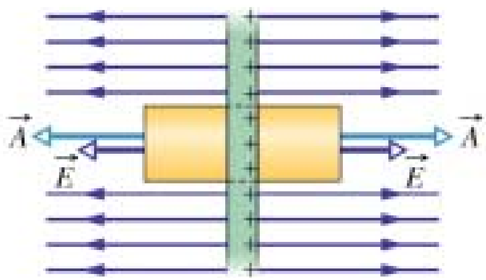


  - If – charge on conductor, *E* toward conductor
  - If + charge on conductor, *E* directed away

Gauss' Law

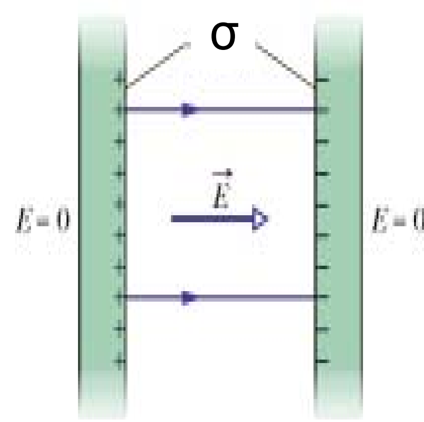
- Non-conducting sheet -
  of charge σ

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



- Parallel conducting sheets –
  of charge σ

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

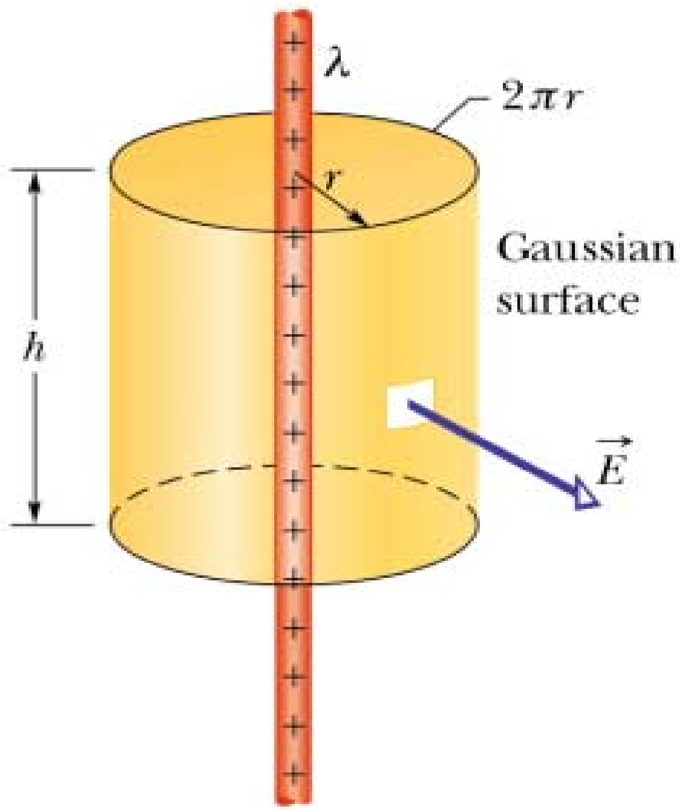


Gauss' Law

- Line of charge -

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

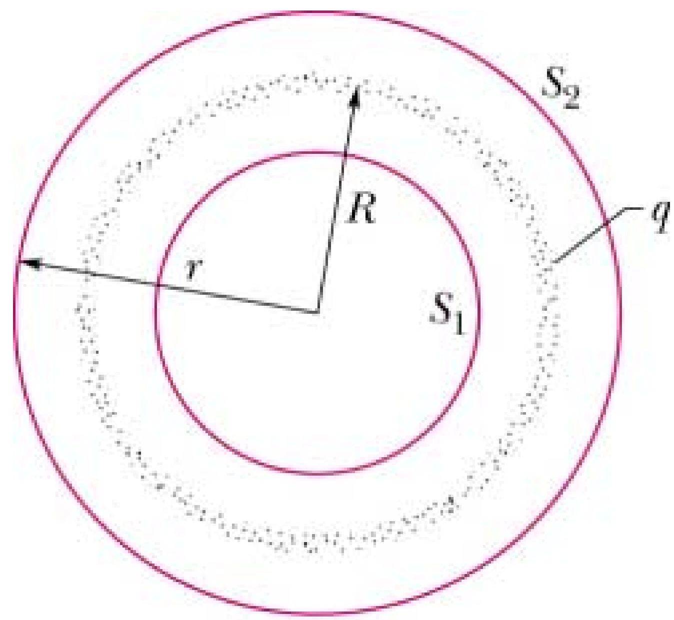
$$\lambda = \frac{Q}{L}$$



Gauss' Law

- Conducting spherical shell -
- Outside shell E is

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



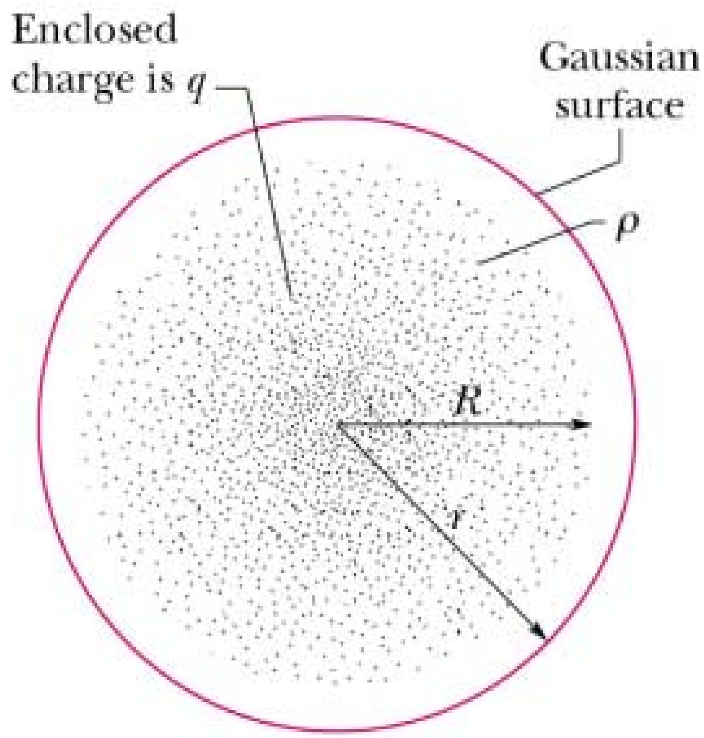
- Inside shell $E = 0$

Gauss' Law

- Non-conducting solid sphere of radius R and total uniform charge q
- Gaussian sphere outside of radius R

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

- Same as shell



(a)

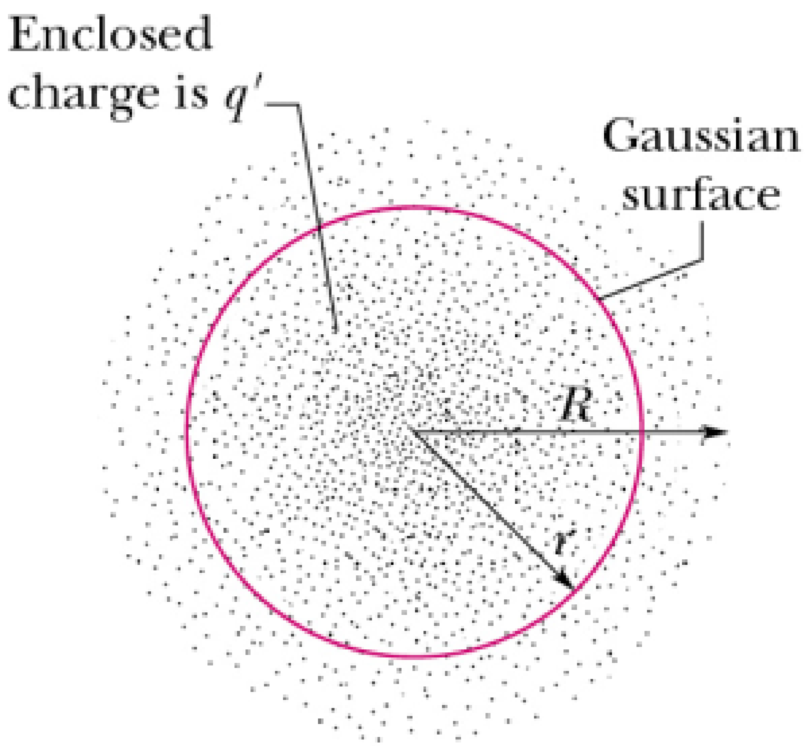
Gauss' Law

- Use Gaussian sphere inside at radius r

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

- Charge is uniform
  - Total q inside radius R is proportional to q' within r

$$\frac{q'}{\frac{4}{3}\pi r^3} = \frac{q}{\frac{4}{3}\pi R^3}$$



(b)

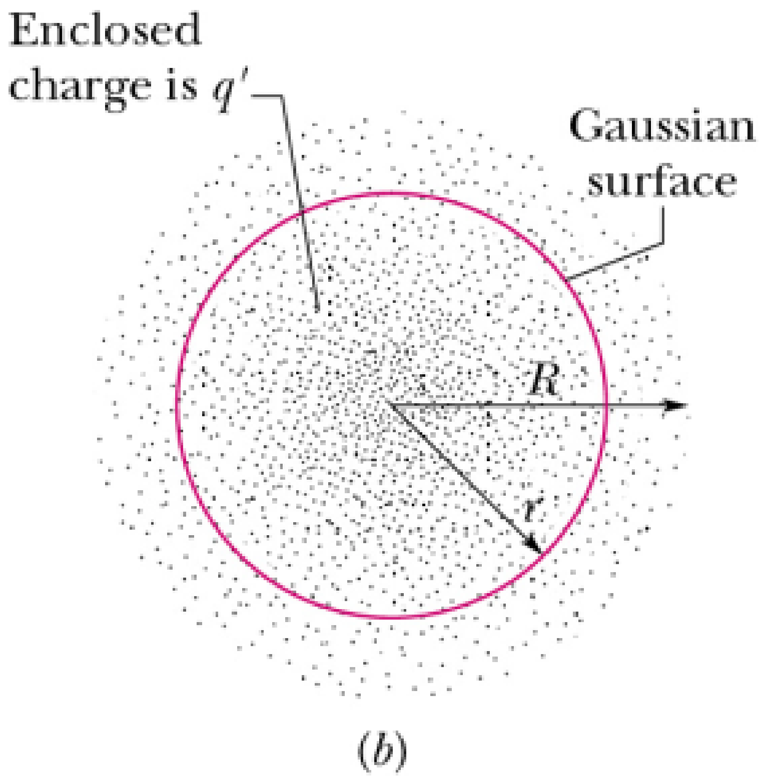
Gauss' Law

- Enclosed charge at r is

$$q' = q\frac{r^3}{R^3}$$

- E field inside non-conducting sphere of uniform charge

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



Review

- For *conductors*
  - Excess charge resides on the surface
  - E field is $\perp$ to surface of conductor
  - ***E* = 0 inside a conductor**