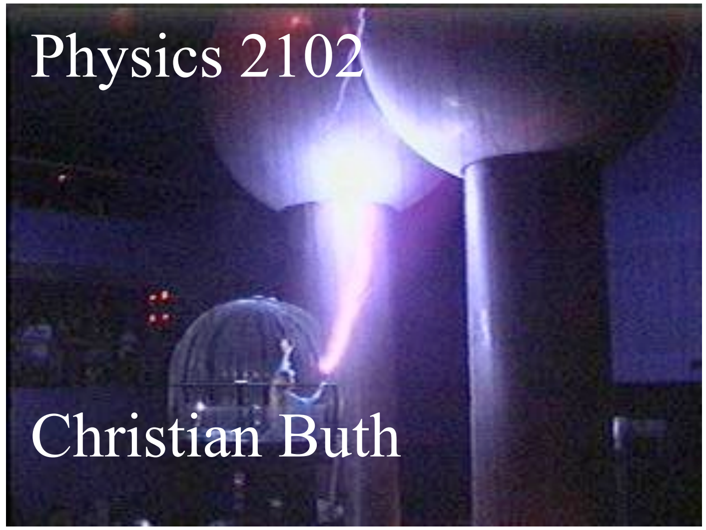
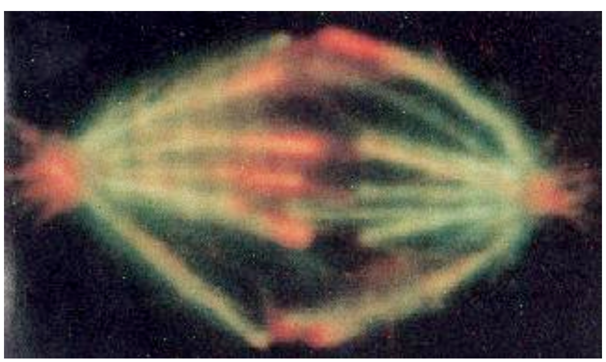


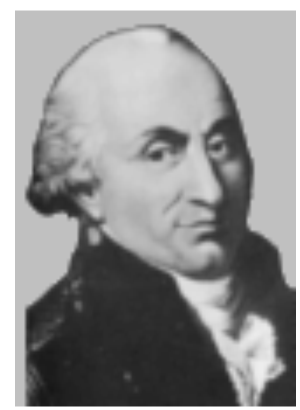
Physics 2102
Lecture 4

Electric Fields 2



Version: 01/21/2009

Charles-Augustin de Coulomb (1736-1806)



Review 1

- New concept **field**: a physical property is associated with every point in space
- **Electric field** $\vec{E} = \dfrac{\vec{F}}{q_0}$
- **Field lines** to visualize the direction and magnitude of an electric field
- Electric field of a point charge: $E=kq/r^2$
- Electric field of a dipole: $E \sim kp/r^3$

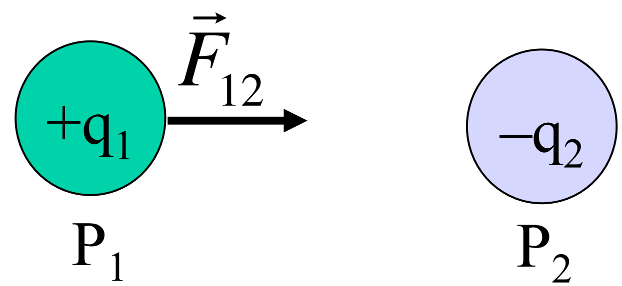
Review 2

Definition of Electric Field:

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

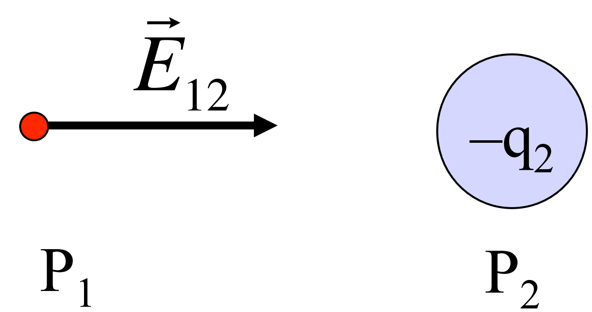
$$|\vec{F}_{12}| = \frac{k\,|q_1||q_2|}{r_{12}^2}$$

E-Force on Charge



$$|\vec{E}_{12}| = \frac{k\,|q_2|}{r_{12}^2}$$

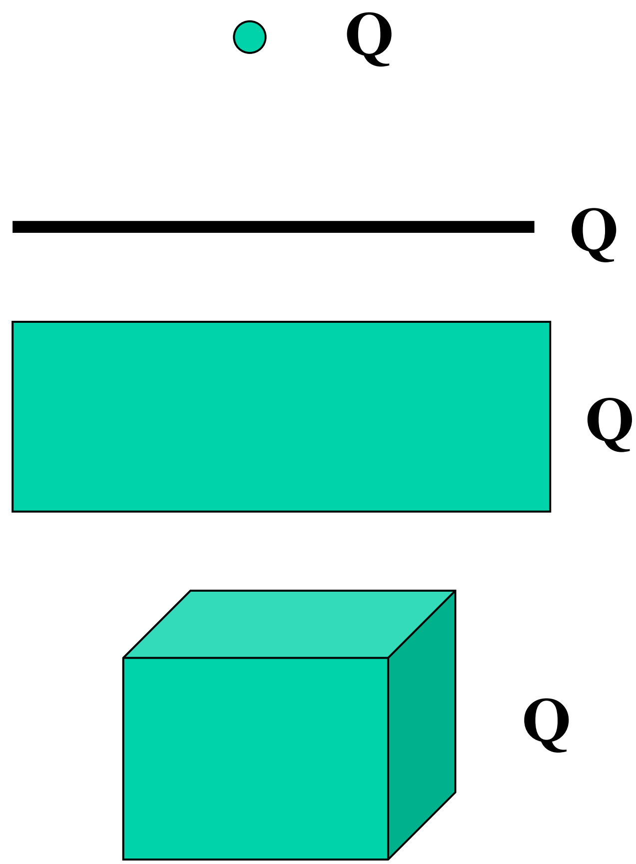
E-Field at Point



Units: F = [N] = [Newton] ; E = [N/C] = [Newton/Coulomb]

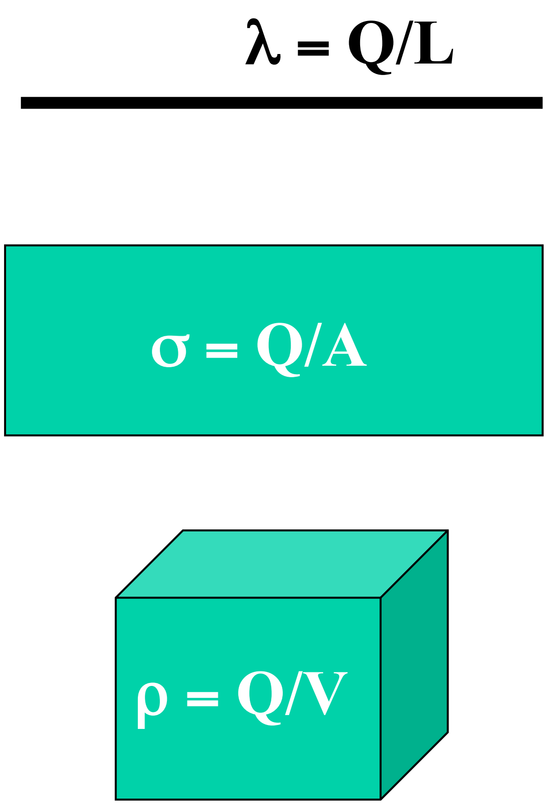
Continuous Charge Distribution

- Thus far, we have only dealt with **discrete, point charges**
- Imagine instead that a charge Q is smeared out over a:
  - Line
  - Area
  - Volume
- How to compute the electric field E?



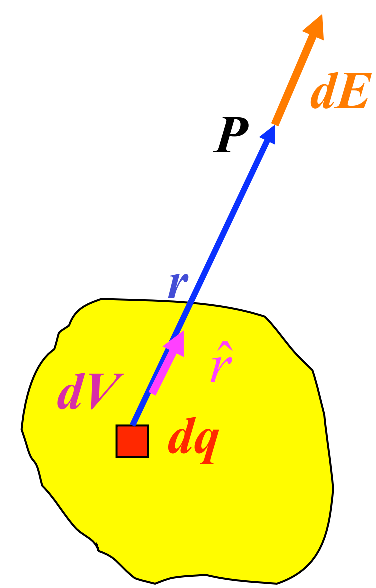
Charge Density

- Useful idea: **charge density**
- Line of charge:
  charge per unit length $= \lambda$
- Sheet of charge:
  charge per unit area $= \sigma$
- Volume of charge:
  charge per unit volume $= \rho$



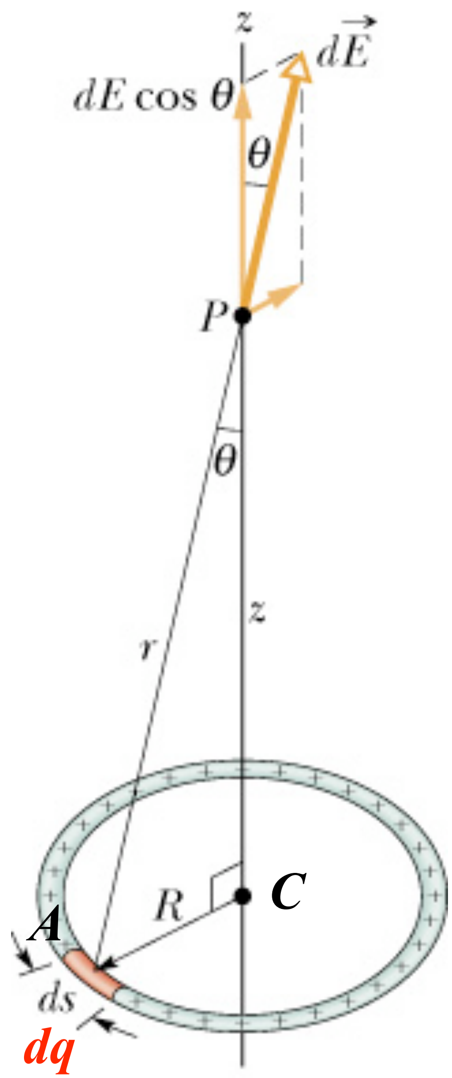
Computing electric field of continuous charge distribution

- Approach: divide the continuous charge distribution into **infinitesimally small elements**
- Treat each element as a **point charge** and compute its electric field
- Sum (**integrate**) over all elements

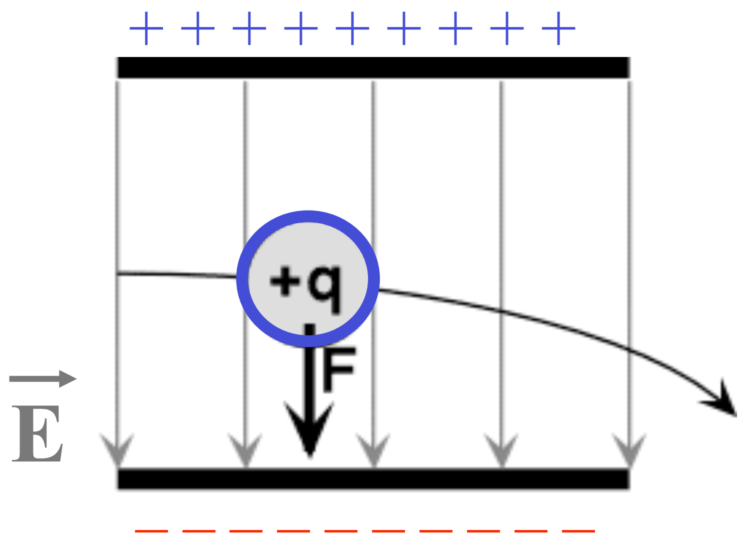


Line of Charge

- **Uniform** line of charge, length $L = 2\pi R$, total charge Q
- Compute explicitly the magnitude of ***E*** **at point P**
- The net field at P is in the **y direction** due to symmetry

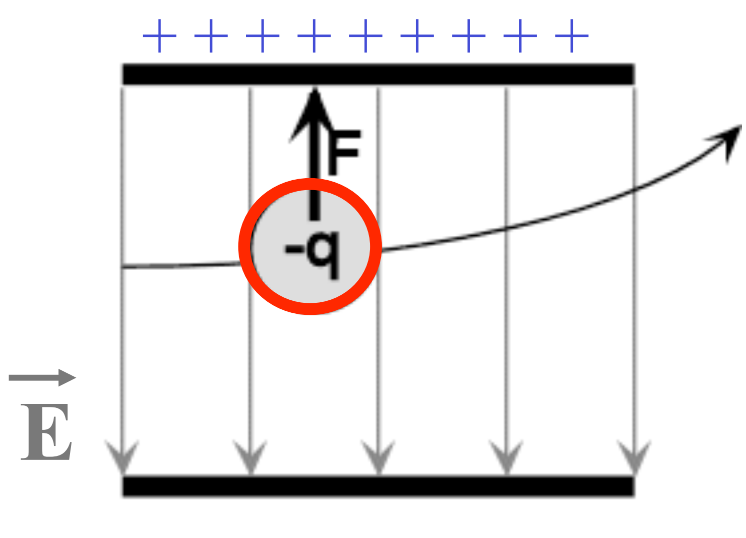


Force on a Charge in Electric Field



Positive Charge
Force in Same
Direction as **E**-Field

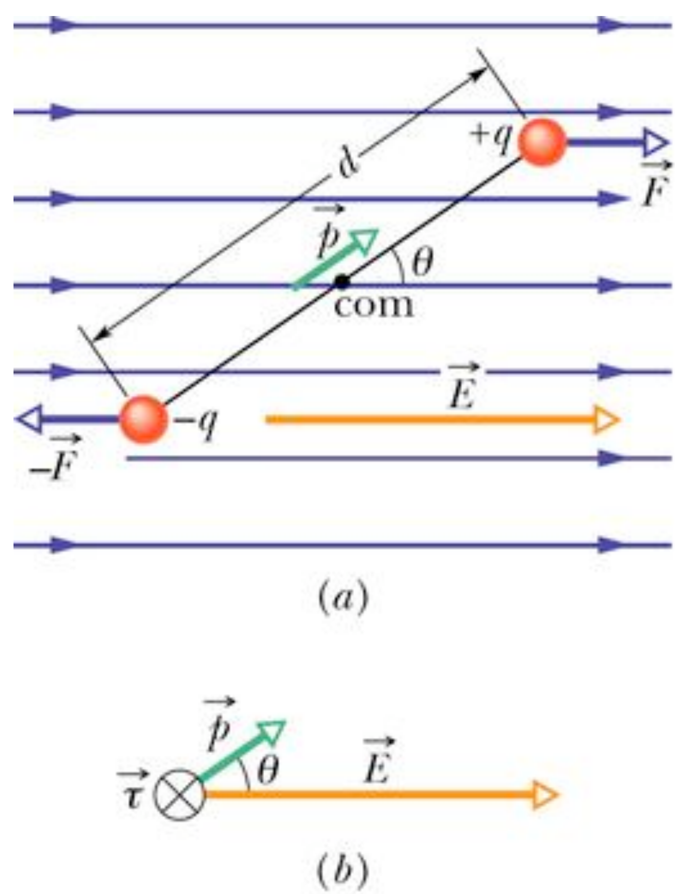
$$\vec{F} = q\,\vec{E}$$



Negative Charge
Force in Opposite
Direction as **E**-Field

Electric Dipole in a Uniform Field

- **Zero net force** on dipole; center of mass stays where it is
- Net **torque**: into page
- The dipole "aligns" itself with the field lines



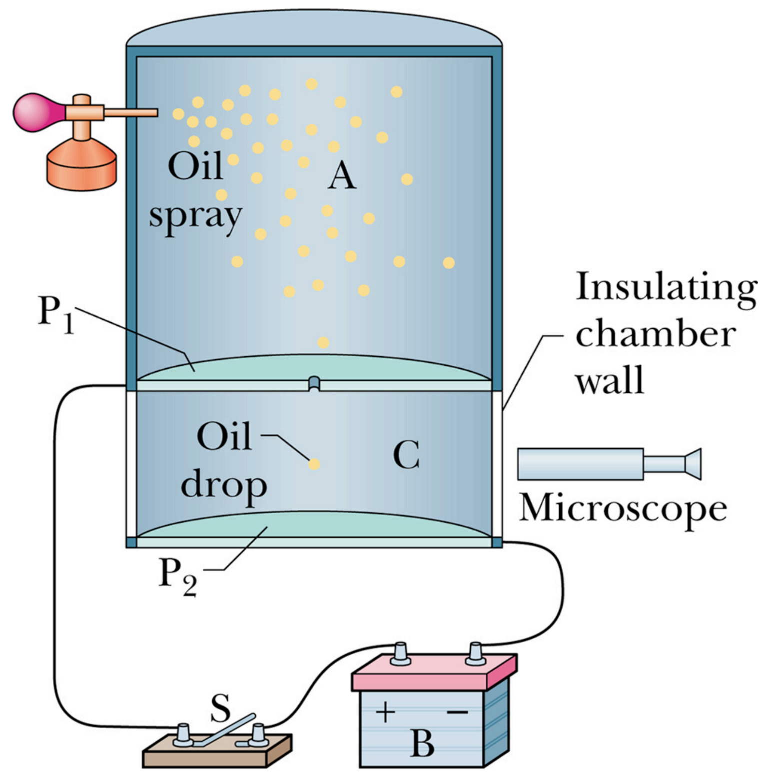
Milliken experiment

- Charge is **quantized**, *i.e.*, $q = n\,e$; measure the **elementary charge** e

- **Downward** electric field in chamber C is switched on/off

- Negatively charged **oil droplets** drift upward/ downward

- **Motion** allows one to determine the charge of droplets



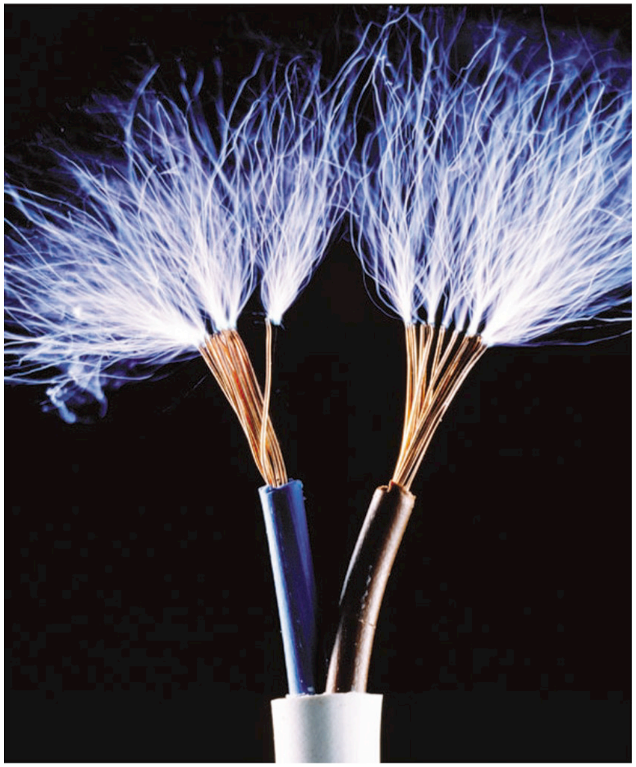
Electrical Breakdown

• If electric field in air exceeds **critical value** then electrical breakdown occurs

• Electrons are **removed** from molecules in the air

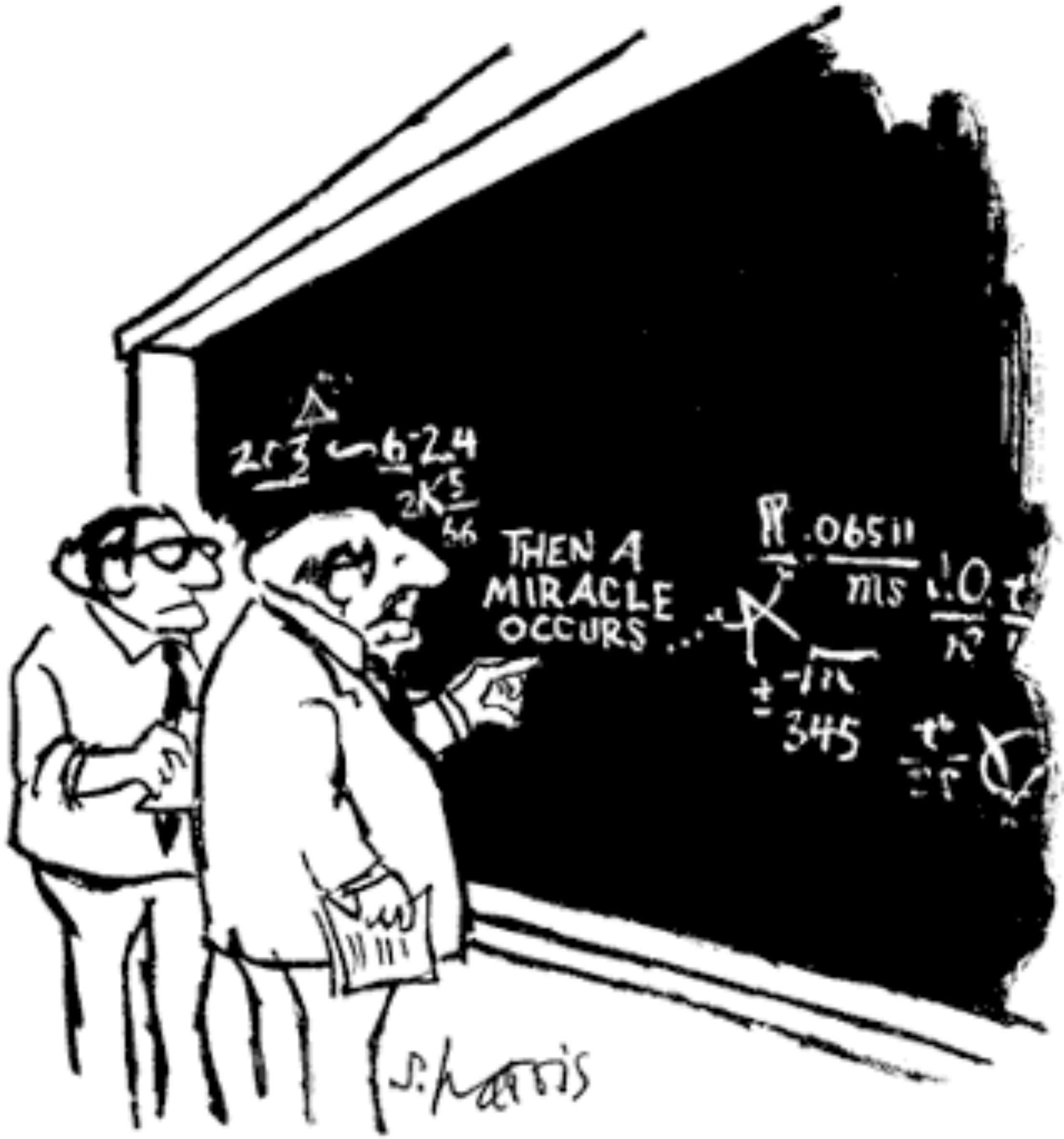
• Electrons move in field and **collide** with other molecules which emit light

• **Air conducts**



Summary

- **Continuous charge distributions** instead of discrete point charges
- Use **calculus** to find electric field from a continuous charge distribution
- For a **known** electric field, determine **force** a on charged particle via $\vec{F} = q\,\vec{E}$
- Electric dipole **aligns along lines** of a uniform electric field
- **Milliken experiment** proves that charge is quantized; yields the magnitude of the **elementary charge**



“I think you should be more explicit here in step two.”