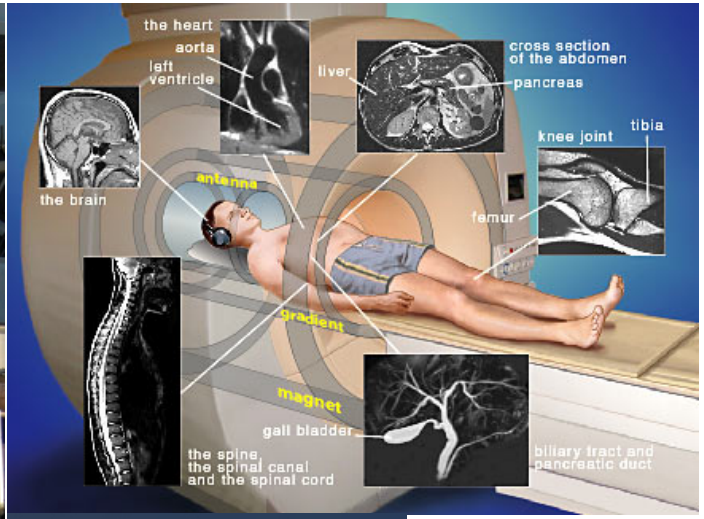
Physics 2049, General Physics B

Prof. Stephen Hill, Course Leader

An Introduction to Electricity, Magnetism and Optics



Prof. H-K. Ng

Prof. O. Vafek

Prof. S. Tabor

Physics 2049C: This Week and Next

- No labs this week or next; they start in week 3.
- First LON-CAPA assignment due Thursday!!
  - You will prepare for this in tomorrow's recitation
  - Very strict deadline of 11:59:59 pm on due date
  - See syllabus and LON-CAPA for subsequent deadlines
- First Mini-Exam next Thursday (Sep. 8th)
- Today:

  Intro to Electricity and Magnetism

  Start Ch. 20 – Electric charge and force
- Thursday:

  Cont… electric field and Coulomb's law

PHY2048 - What causes acceleration?

Linguistic arguments:

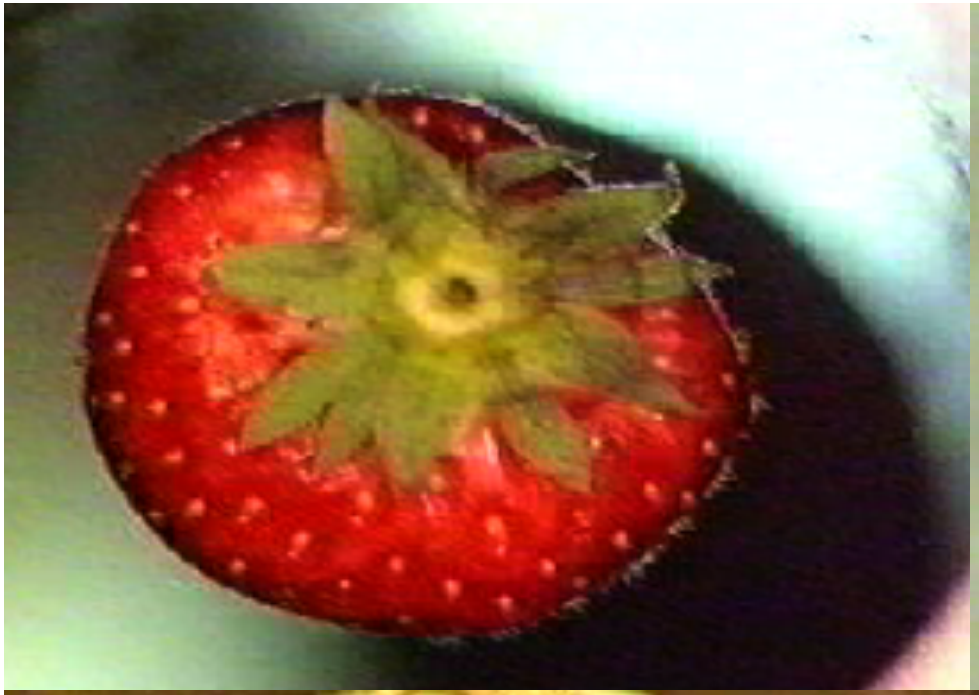
- Some sort of interaction - loosely speaking, a push or a pull on an object.
- We call this a **force**, which can be said to act on a body.
- Examples of forces:

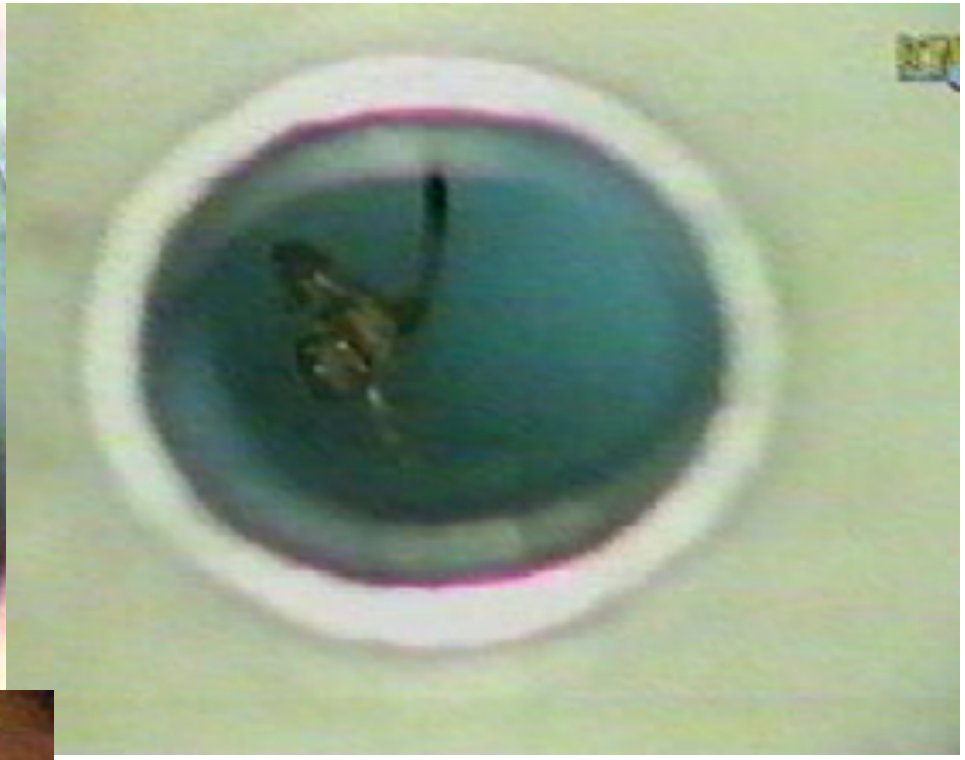
→ Normal or "contact force"

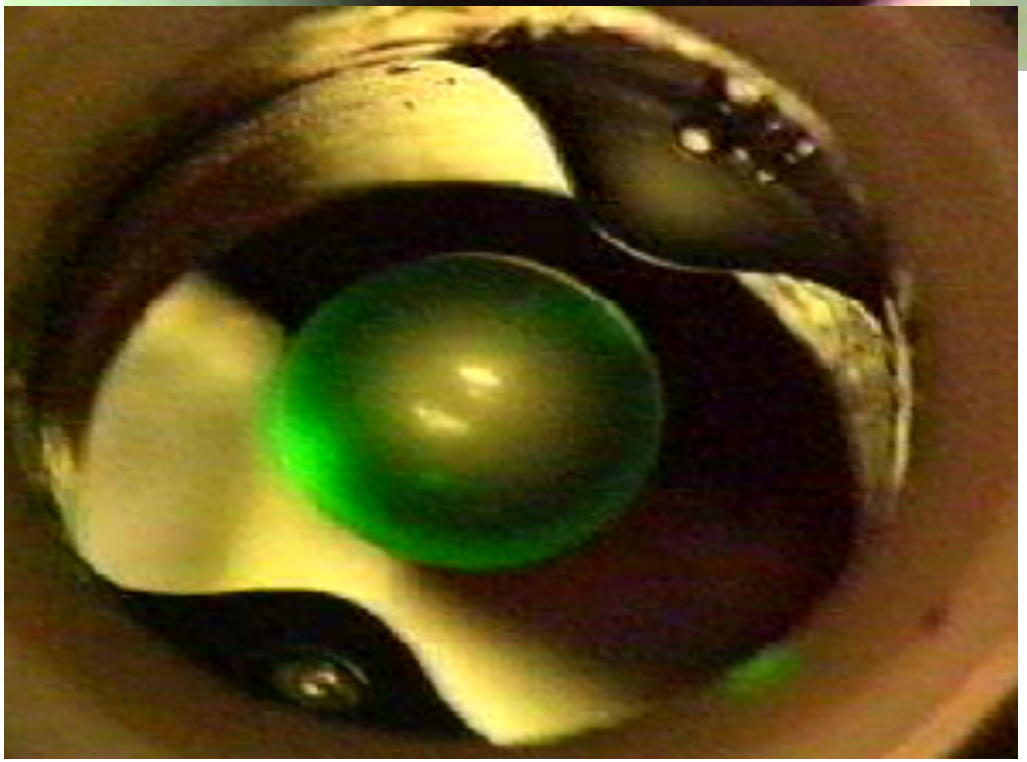
Gravitational force

Electromagnetic force

Weak and strong nuclear forces



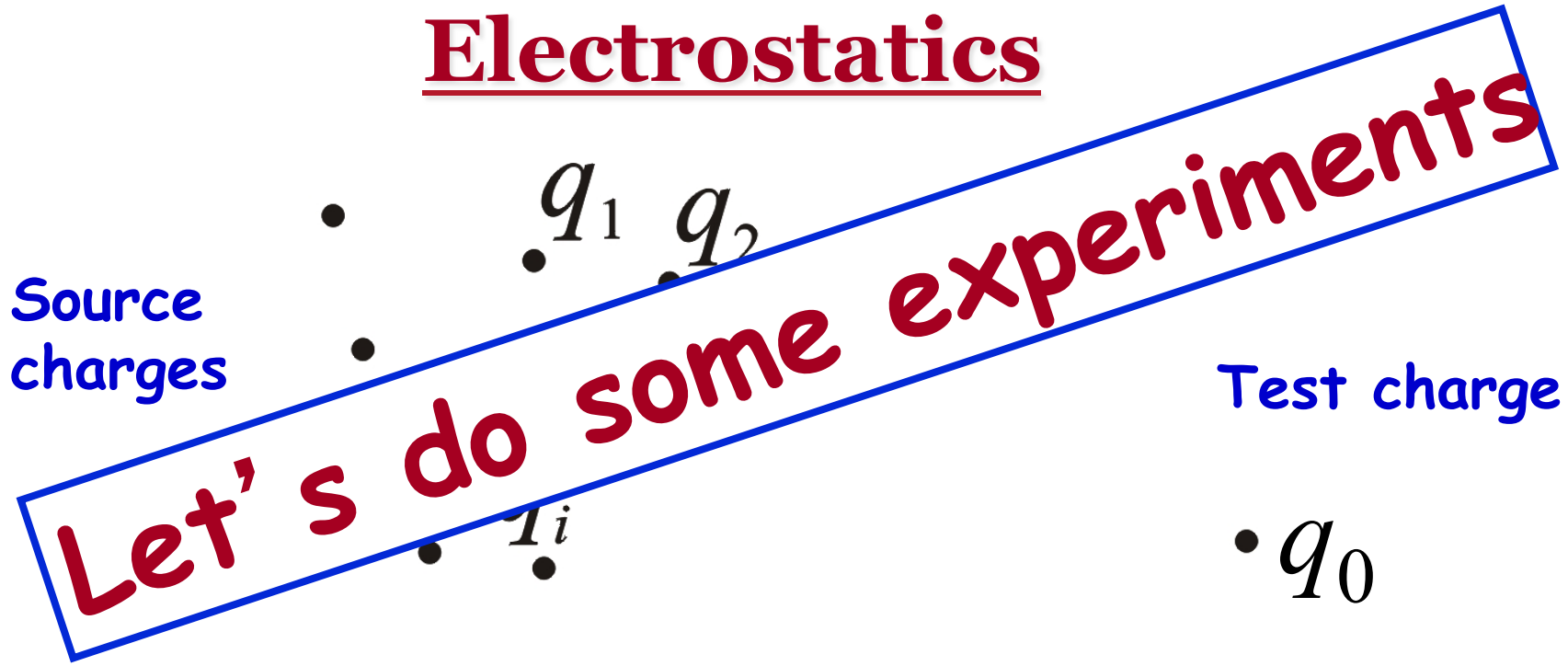




We'd better be more scientific about this...

The main subject of this course

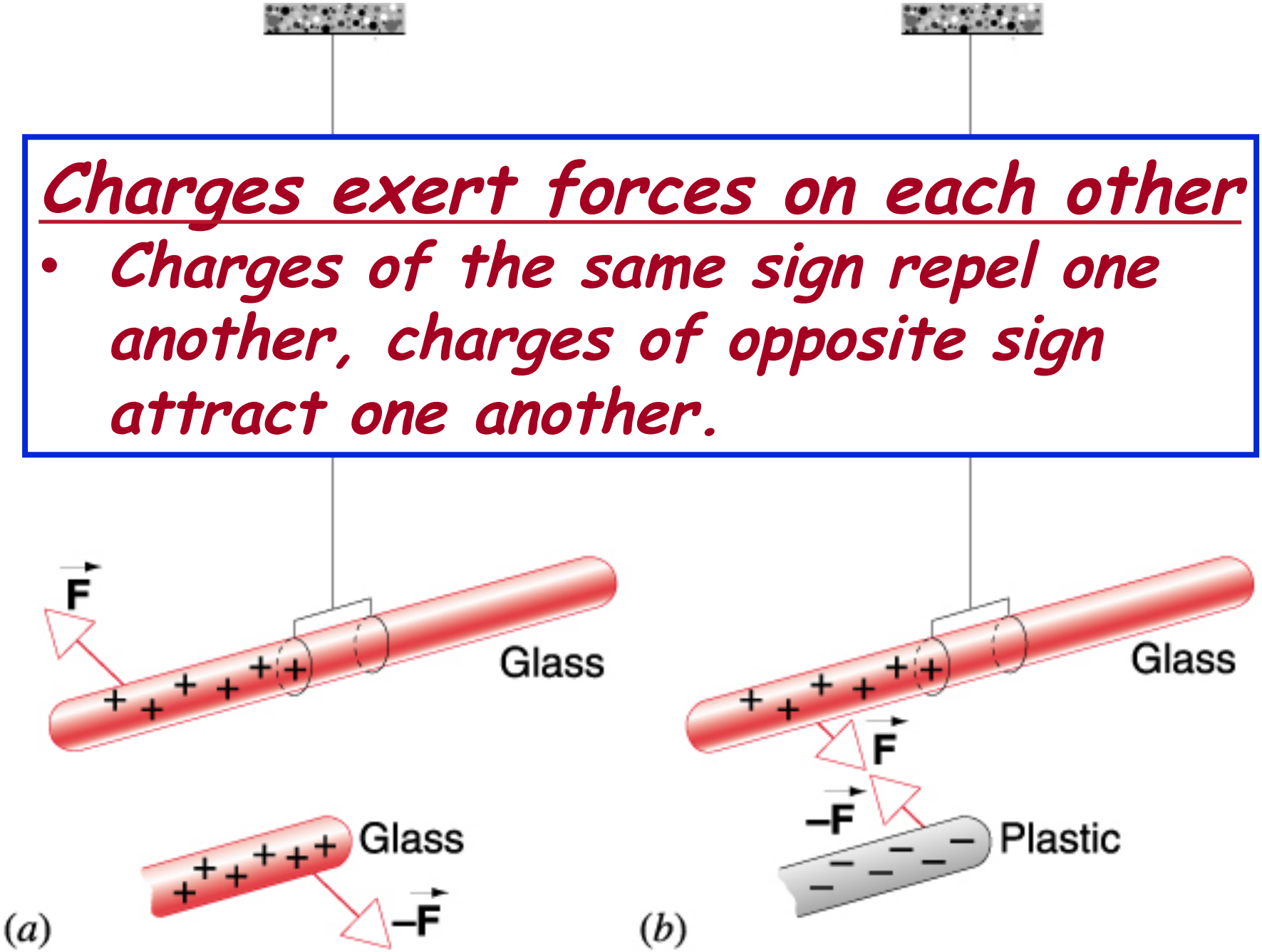
Electrostatics



- **What is the force on q_0?**
- **How much energy would I have to supply to move q_0 a distance r?**

Charges exert forces on each other

- Charges of the same sign repel one another, charges of opposite sign attract one another.



25.02

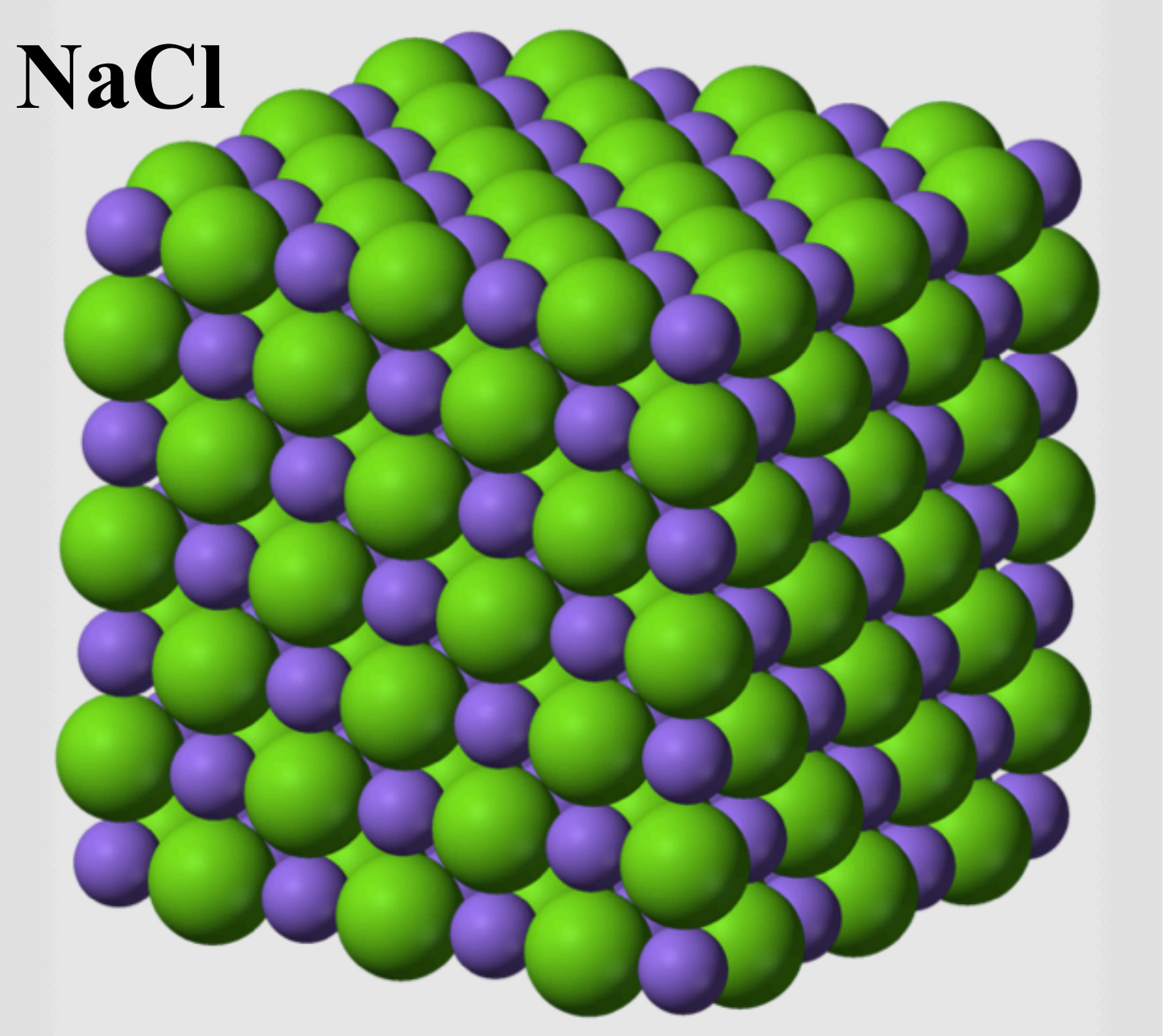
What is charge?

- Charge is measured in Coulombs (C)
  - Fundamental unit.
  - Definition based on forces between current carrying wires (current = Ampères, or C/s), i.e. chapter 26.
- Charge is discrete
  - Thompson discovered the electron in 1896. He found that charge was carried by elementary particles with the same charge to mass ratio.
  - The elementary charge of the electron was not measured until 1909 (Millikan).
  - Both experiments earned Nobel prizes.

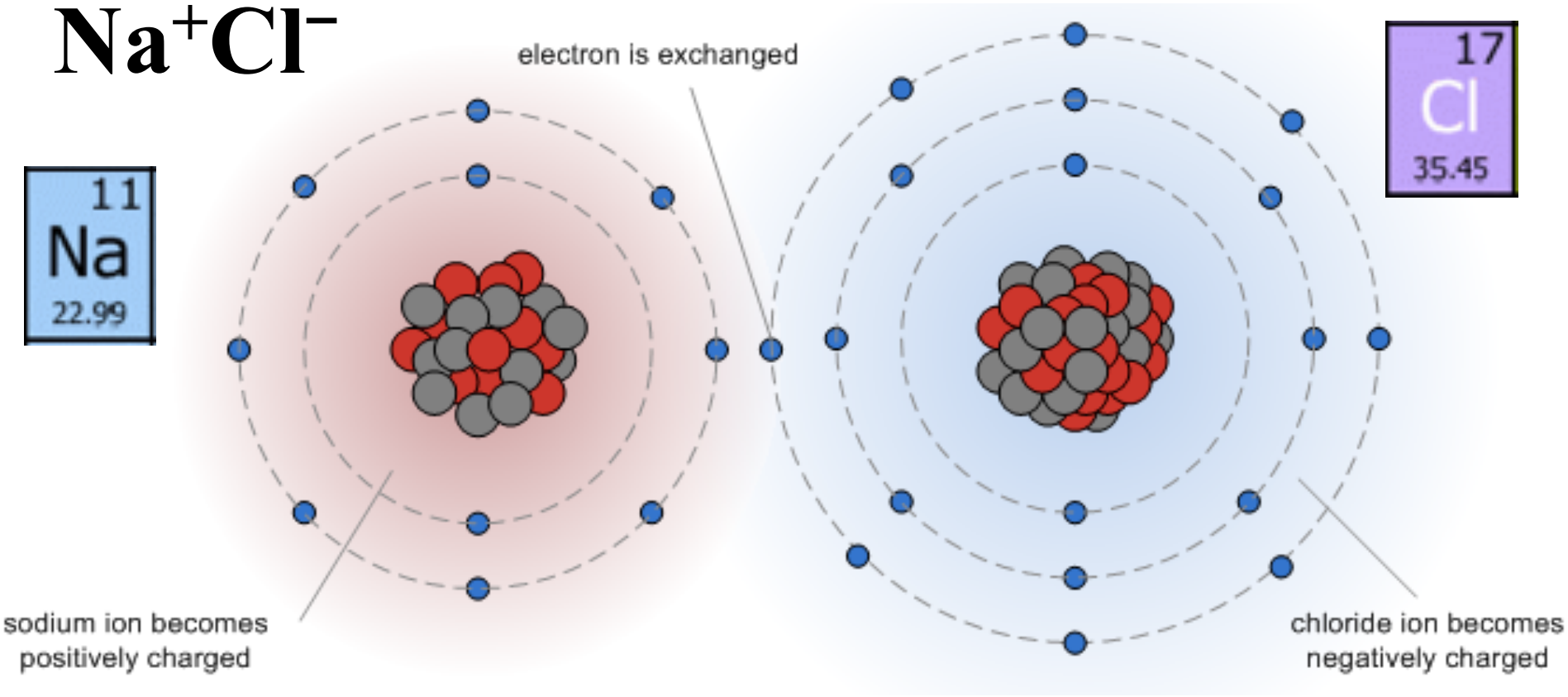
Charge on an electron:	$e = 1.6 \times 10^{-19}$ Coulombs
1 Coulomb of charge:	6.24×10^{18} electrons
1 Ampère (= 1 C/s)	6.24×10^{18} electrons/second

Charge is discrete: $q = ne$ $n = \pm 1, \pm 2, \pm 3, \ldots$

Matter – solids, liquids and gases

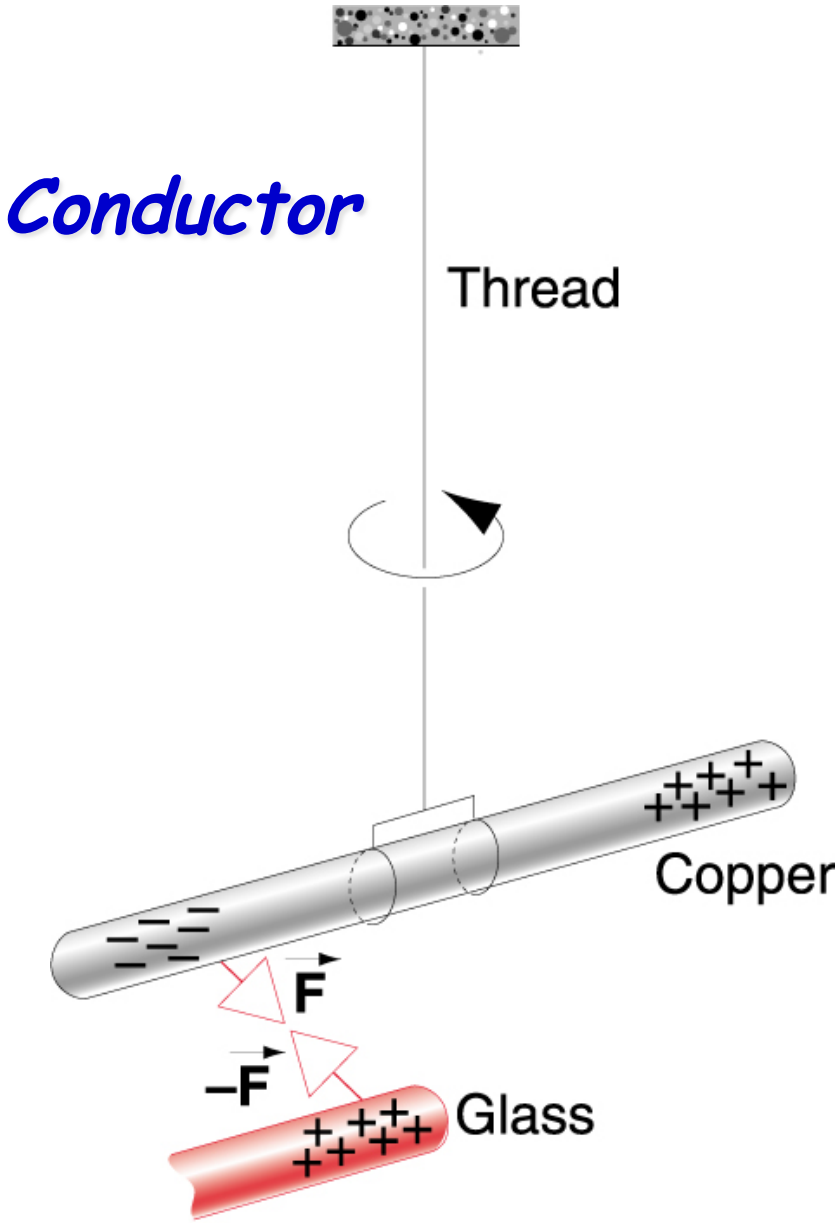


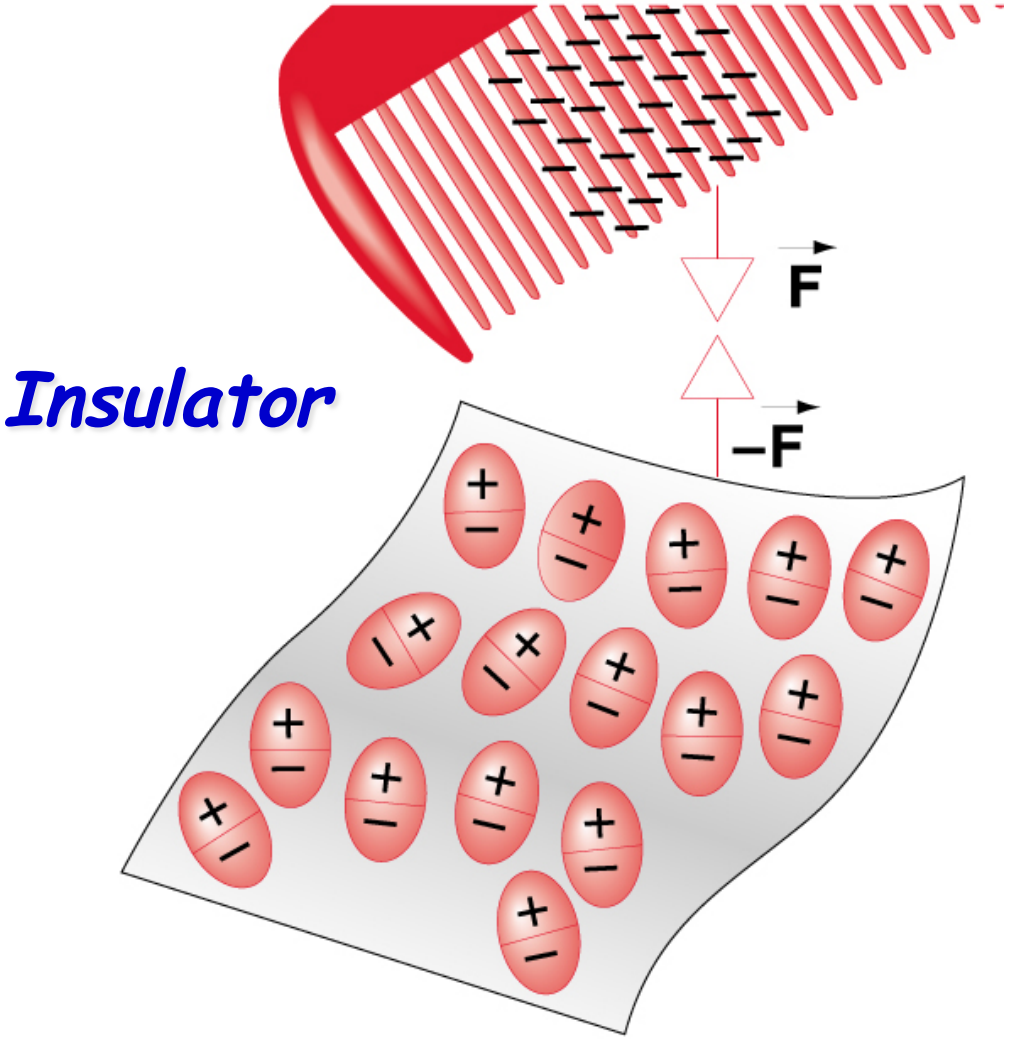
Matter – solids, liquids and gases



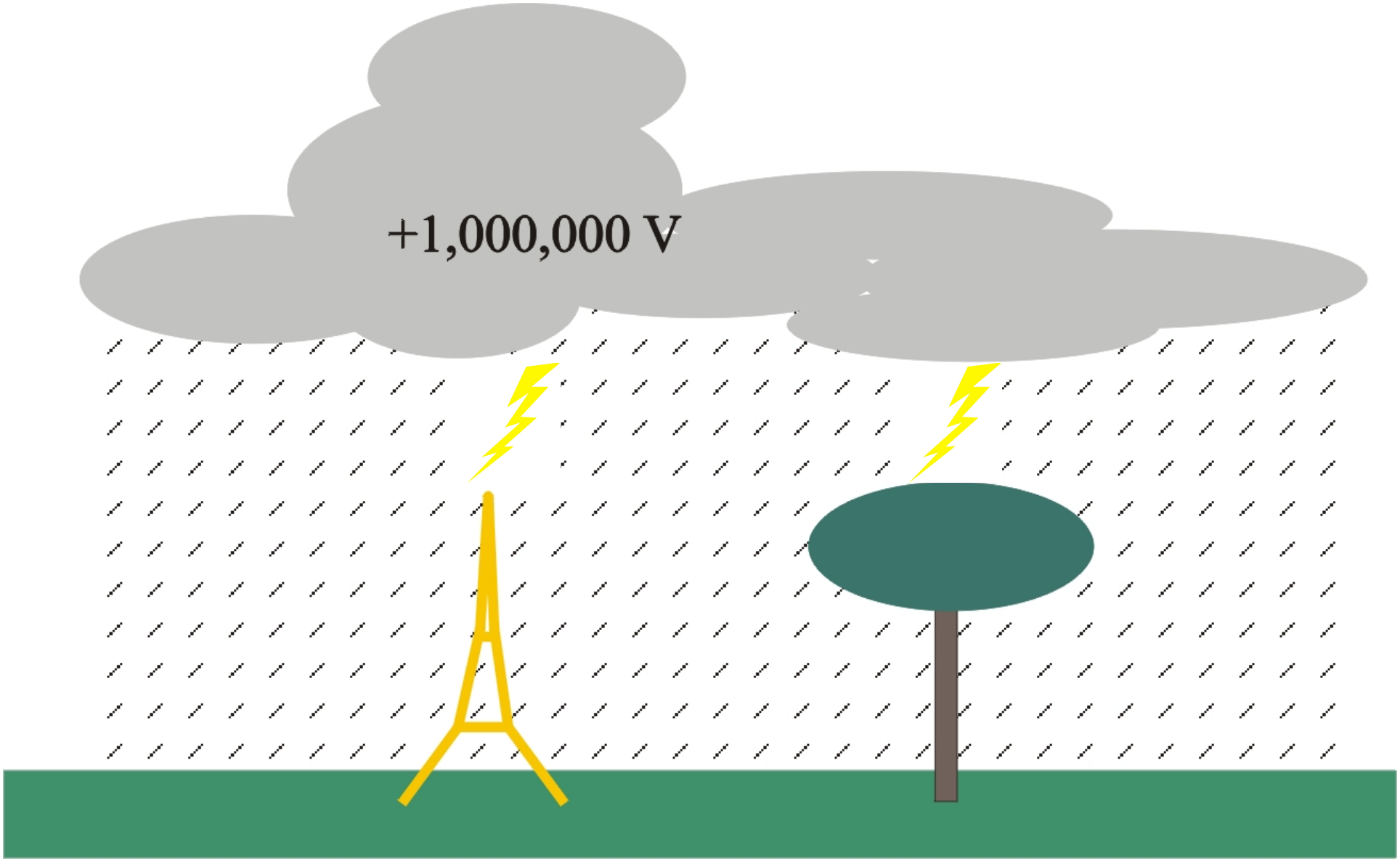
- Proton: charge = $+1.6 \times 10^{-19}$ Coulombs
- Neutron: charge = 0 (neutral)
- Electron: charge = -1.6×10^{-19} Coulombs

Static electricity through charging





Electrical discharge



History Lesson

600BC **Greek philosophers**
First references to magnetism and electric charge

1175-1600 **Alexander Neckem, Petrus Peregrinus, William Gilbert**
References to and explanation for the compass

1747 **Benjamin Franklin (and William Watson)**
Discovers that there are two kinds of charge

1780s **Charles Augustine de Coulomb**
Discovers law of forces between charges – birth of electrostatics

1825 **André-Marie Ampère**
Discovers law of forces between currents – birth of magnetostatics

1720 **Hans Christian Oersted**
Discovers that electric currents influence compass needles

1831 **Michael Faraday**
Discovers law of electromagnetic induction – birth of electrodynamics

1873 **James Clerk Maxwell**
Publishes *A Treatise on Electricity and Magnetism*

1887 **Henrich Hertz**
Confirms that light is an electromagnetic wave

1905 **Albert Einstein***
Formulates special theory of relativity

1909 **Robert Millikan***
Measurement of elementary unit of charge

***Nobel prize**

PHY3101 – next semester

At the end of the 19th century, A. A. Michelson (very famous physicist) stated that *"all of the grand underlying physical principles had been firmly established."*

Then came two revolutions:

- Relativity

  concepts of space and time change at large relative velocities

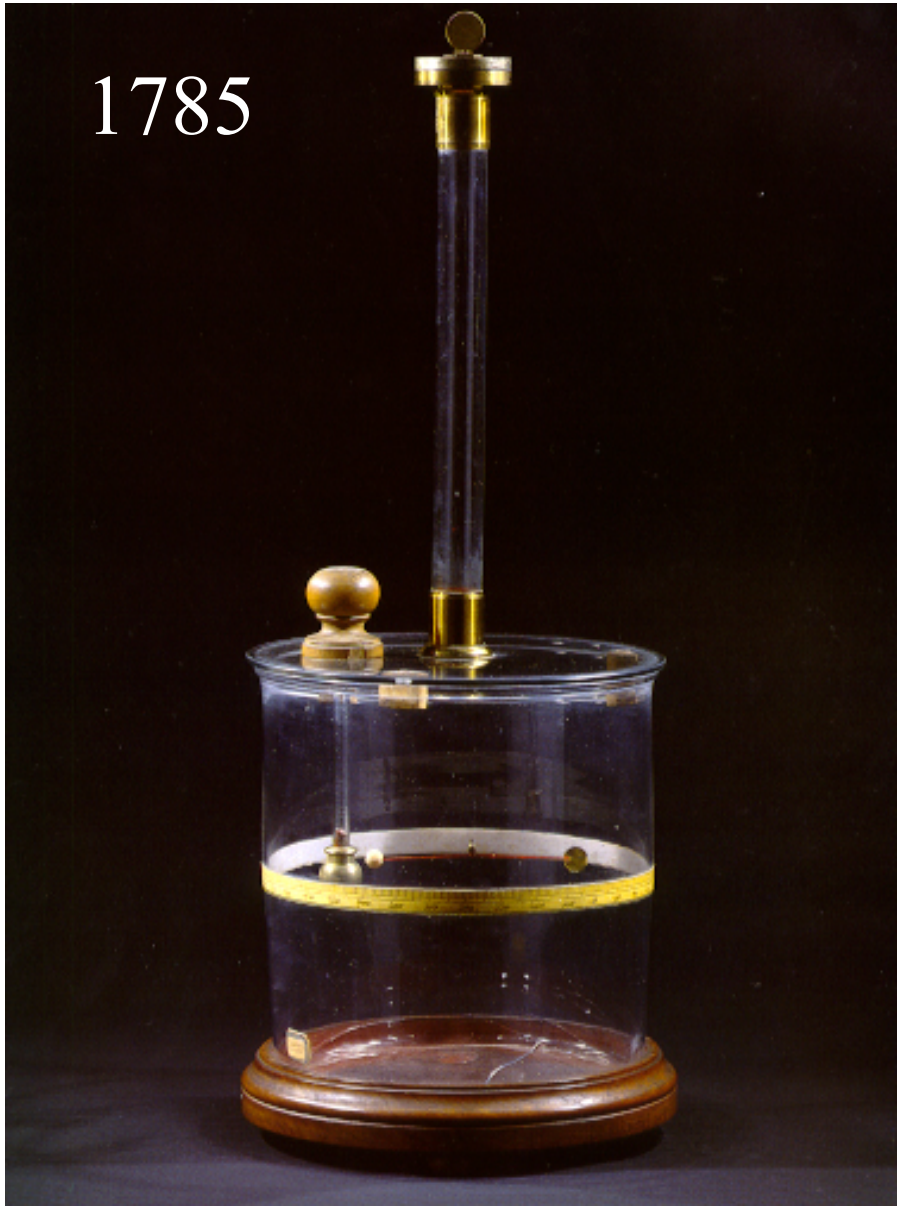
- Quantum mechanics

  concept of matter changes on small length scales

- Classical laws of mechanics break down in these limits, and much remains to be discovered

Coulomb's Law

Coulomb's torsional balance



$$F \propto \frac{|q_1||q_2|}{r^2}, \quad \text{or} \quad F = k\frac{|q_1||q_2|}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_o} = 8.99\times10^9\ \mathrm{N\cdot m^2/C^2}$$

$$\varepsilon_o = 8.85418781762 \times 10^{-12}\ \mathrm{C^2/N\cdot m^2}$$

$$\varepsilon_o = \frac{1}{\left(4\pi\times10^{-7}\ \mathrm{N\cdot s^2/C^2}\right)\times c^2}$$

c = speed of light in vacuum
= 299792458 m/s