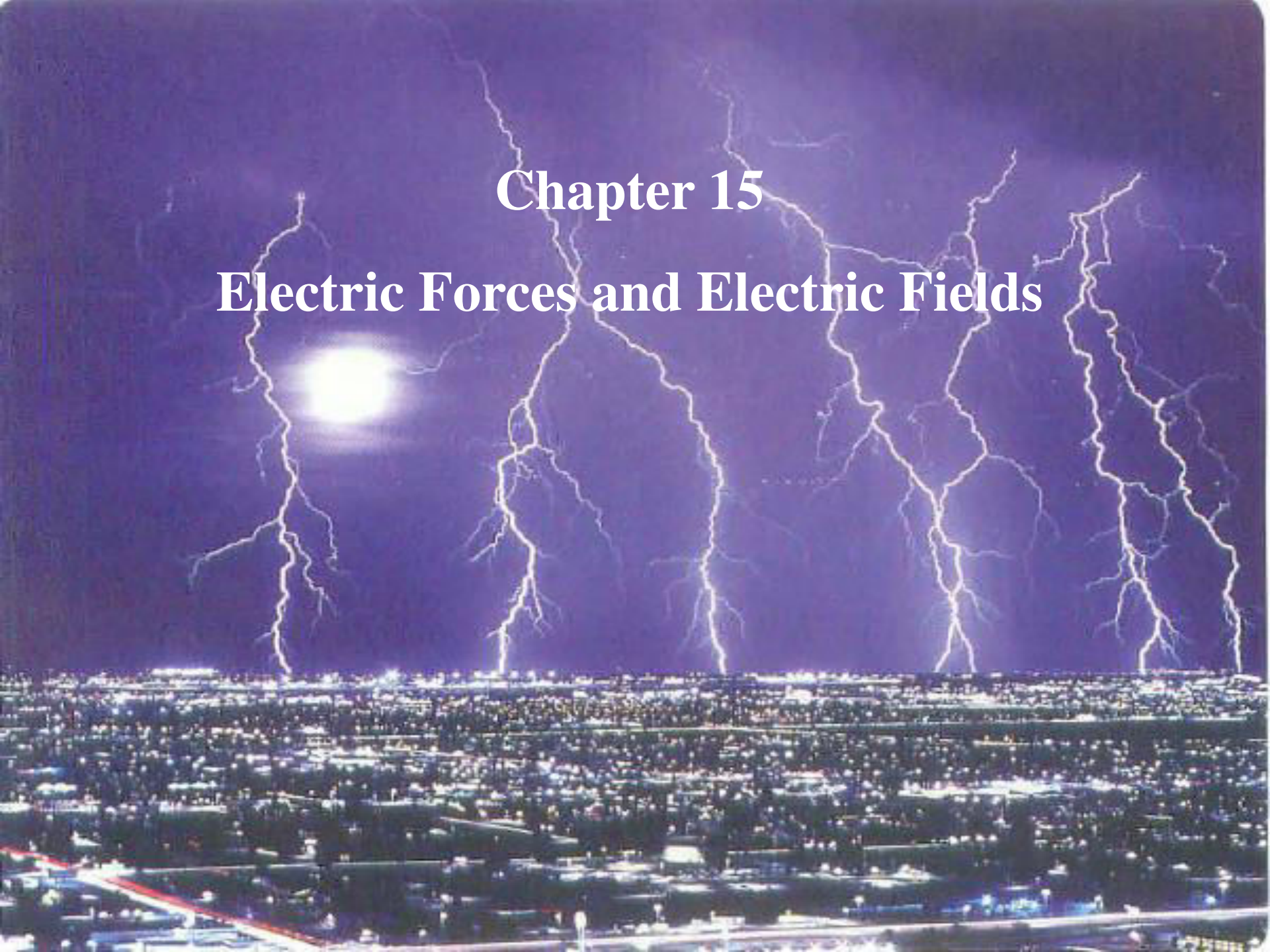


Chapter 15

Electric Forces and Electric Fields

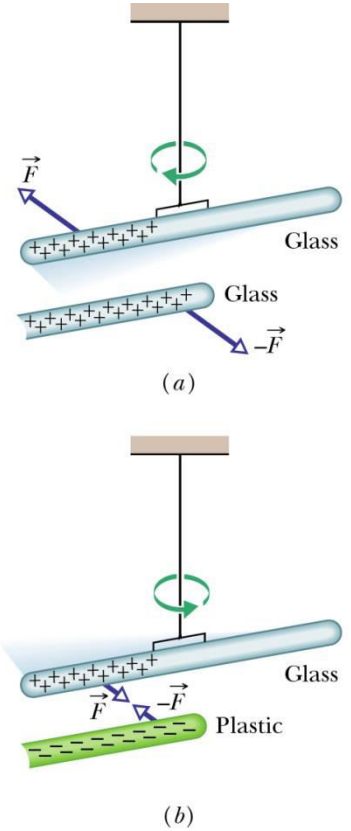
OUTLINE

15.1 Properties of electric charges

15.2 Insulators and Conductors

15.3 Coulombs Law

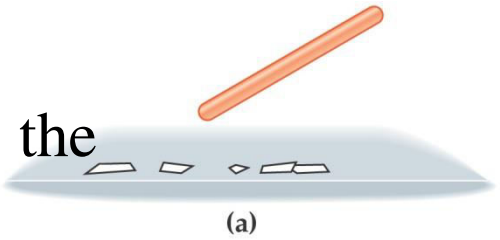
BENJAMIN FRANKLIN
(1706–1790)



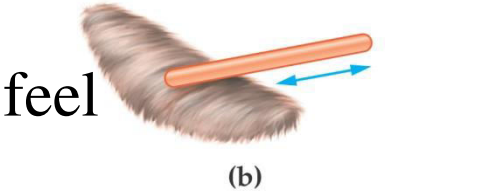
15.1 Properties of electric charges

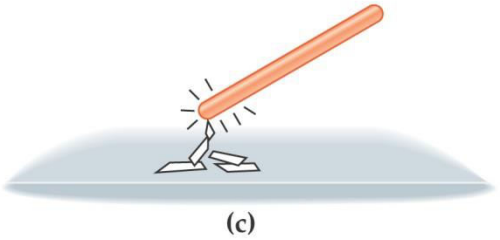
The effects of electric charge were first observed as static electricity:

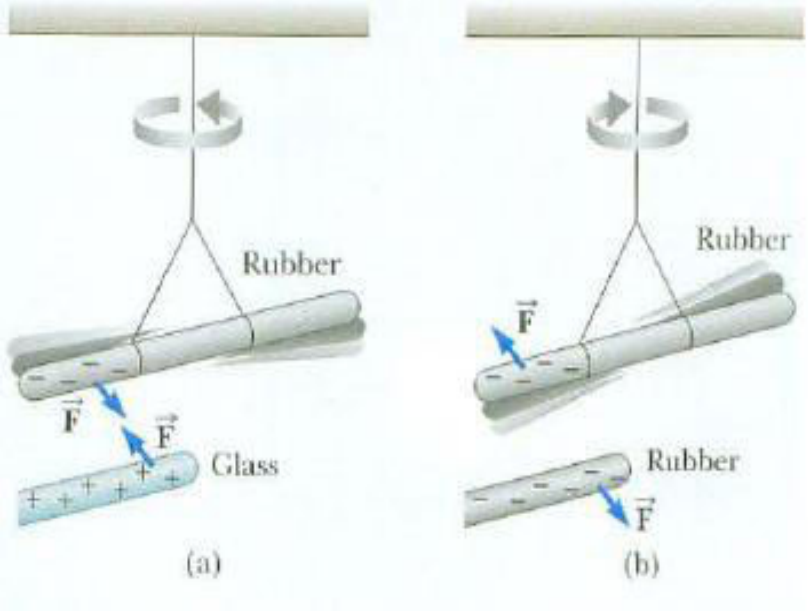
After combing your hair, the comb may acquire the capability to attract pieces of paper.



When you rub your shoes on a wool rug, you may feel "zapped" when touching the door knob.



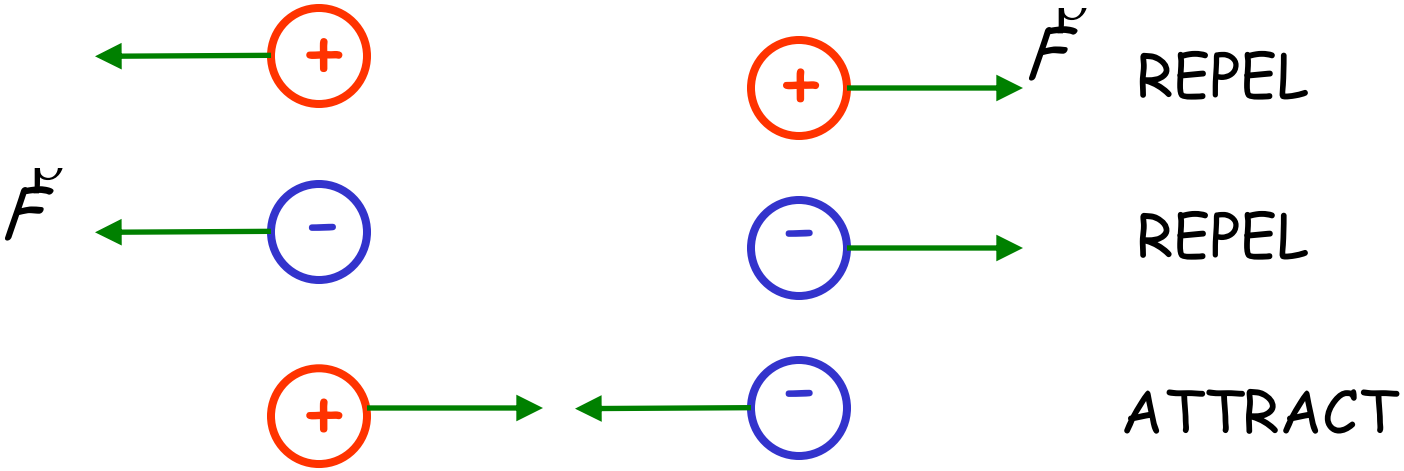




Franklin found that there are two kinds of electric charge Positive and negative

Electric Charge

- A scalar quantity
- Comes in "positive" and "negative"
- Most objects are electrically neutral; they have equal numbers of negative and positive charges (net charge is 0).
- An object becomes charged by adding or removing electrons.



Units: coulomb, C

and also "smallest unit of charge", $e \approx +1.602 \times 10^{-19}\ C$

Electric Charge

- Charge often appears in nature in units of "e":

eg:	Particle	Charge
	electron	-e
	proton	+e

Net charge is a conserved quantity: that is,
the **algebraic sum of positive and negative charges is constant**…
charge **is not created but transferred from one object to another**

The charge is quantized ±e, ±2e,…., There is no a fraction of Electron charge ±0.23e

15.2 Insulators and Conductors

Insulators: charges do NOT move
eg: glass, rubber, paper

- can be charged by rubbing, but charges do not move (only the rubbed area are charged)

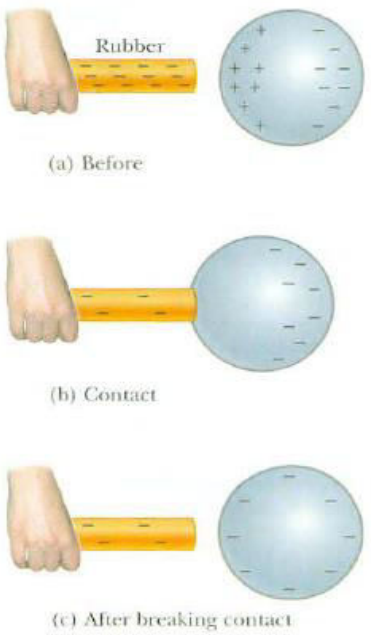
Conductors: charges move freely
eg: metals, some liquids

Semiconductors: electrical properties between insulators and conductors
eg: silicon, germanium

Electrostatic Charging

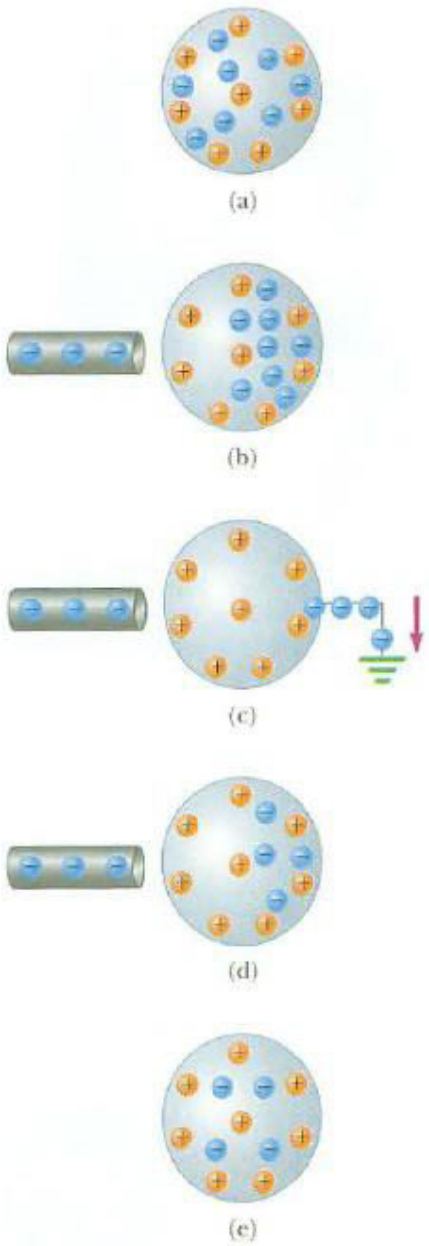
- There are two ways to charge an object
  - Conduction
  - Induction
- Charging by conduction
  - We can charge an object by connecting a source of charge directly to the object and then disconnecting the source of charge.
  - The sphere having the same charge of the rubber rod.

There must be contact…



Charging by Induction

- We can also charge an object without physically connecting to it
  - First we charge a rod negatively
  - Then we ground the object to be charged
    - Connecting the object to the Earth provides an effectively infinite sink for charge
  - We bring the charged rod close to the object but do not touch it
  - We remove the ground connection and move the rod away
  - The object will be charged by induction



No contact with the object inducting the charge

15.3 Coulomb's Law

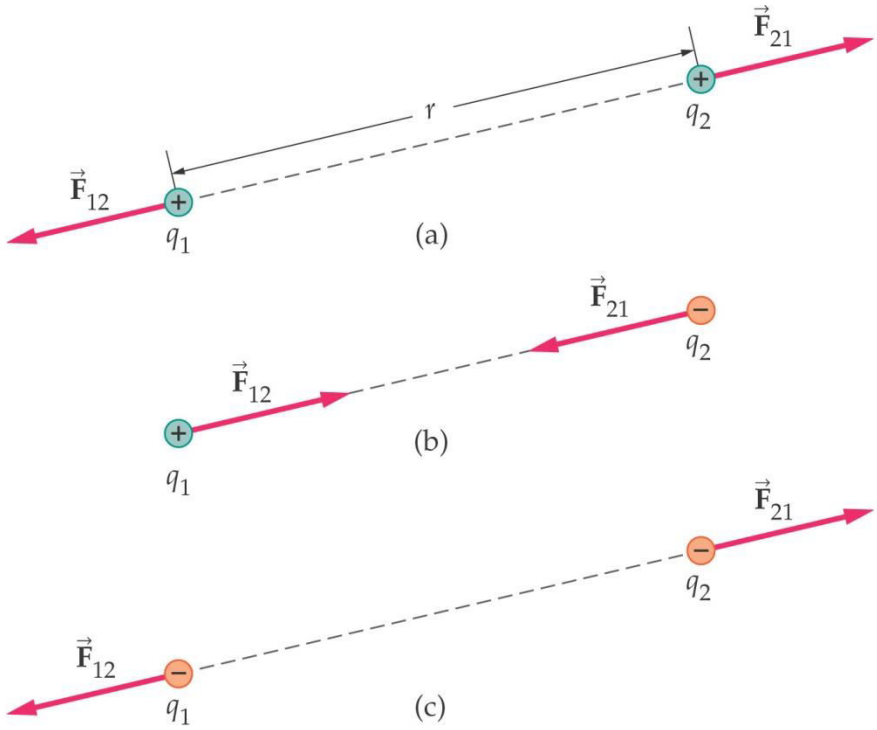
Coulomb's law gives the force between two point charges:

$$F = k\frac{|q_1||q_2|}{r^2} \qquad k = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$$

SI unit: newton, N

Action-reaction forces

CHARLES COULOMB
(1736–1806)

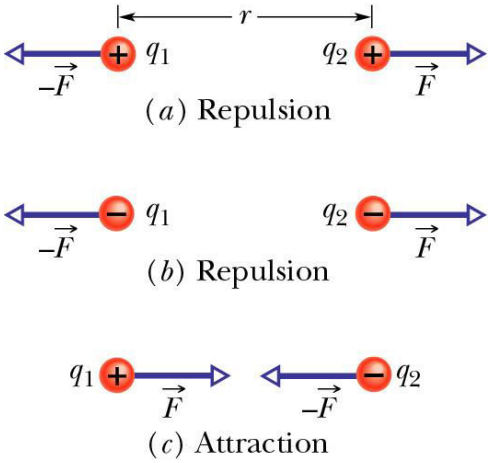


The force is along the line connecting the charges, and is attractive if the charges are opposite, and repulsive if the charges are like.

15.3 Coulomb's Law

- Double one of the charges
  force doubles
- Change sign of one of the charges
  force changes direction
- Change sign of *both* charges
  force stays the same
- Double the distance between
  charges force four times weaker
- Double both charges
  force four times stronger

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



Coulomb force is similar to the gravitational force, Charges takes places of masses, both forces are $1/r^2$ dependence.

15.3 Coulomb's Law

TABLE 15.1

Charge and Mass of the Electron, Proton, and Neutron

Particle	Charge (C)	Mass (kg)
Electron	-1.60×10^{-19}	9.11×10^{-31}
Proton	$+1.60 \times 10^{-19}$	1.67×10^{-27}
Neutron	0	1.67×10^{-27}

Do you know that a rubber or glass rod is charged by friction, Have a net charge of the order of 10^{-6}C (1μC).

Q: How many protons to create a total charge of 1 C.

Ex.15.1

The electron and proton of hydrogen atom are separated (on the average) by a distance of about 5.3×10^{-11} (a) Find the magnitudes of the electric force and the gravitational force that each particle exerts on the other, and the ratio of the electric force F_e the gravitational force F_g (b) Compute the accelcration caused by the electric force of the proton on the electron. Repeat for the gravitational acceleration.