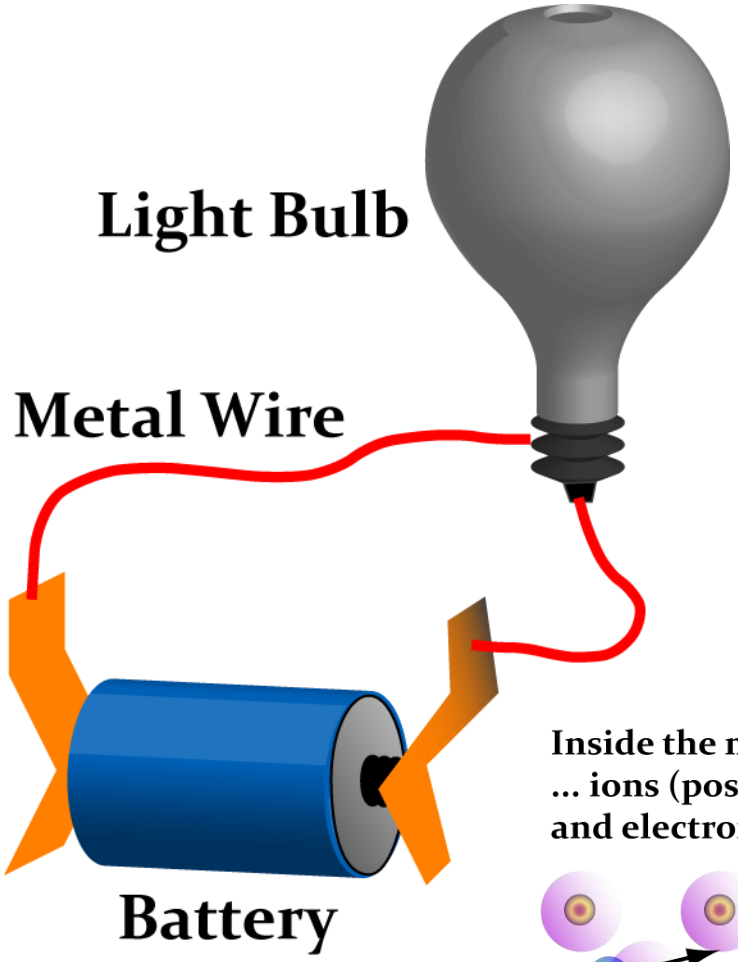
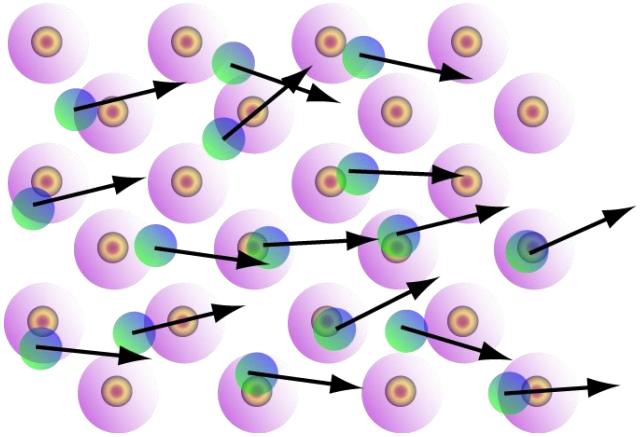
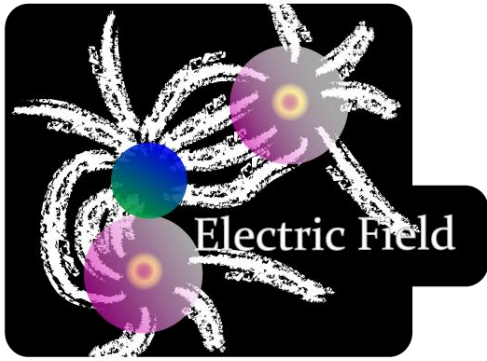
Is an energy crisis possible?
Are the following responses to this question True or False? (More than one response may be True.)
False: No, because energy is always conserved.
False: No, because energy is constant.
False: No, because the free market will always provide sufficient energy resources.
False: No, because humans are infinitely resourceful.
False: Energy is a gift of the gods.
False: Yes, because energy is destroyed by human technology.
False: Yes, unless fossil fuels are renewable.
True: Yes, if the human race does not discover new energy resources.
True: Yes, if necessary fuels are in shortage.
You are correct.
Your receipt no. is 162-9892 Previous Tries

Electricity and Magnetism



Inside the metal …
… ions (positive charge)
and electrons (negaitve charge)





Static Electricity

Historical Development


The Mystery of the Physical World

Static Electricity

Discovered by the Greek philosopher Thales of Miletus – the first philosopher of Western Civilization (624 – 546 BC).

► When amber is rubbed with fur, it acquires the ability to attract other materials such as feathers or bits of straw. The force, first observed by Thales, is very weak.

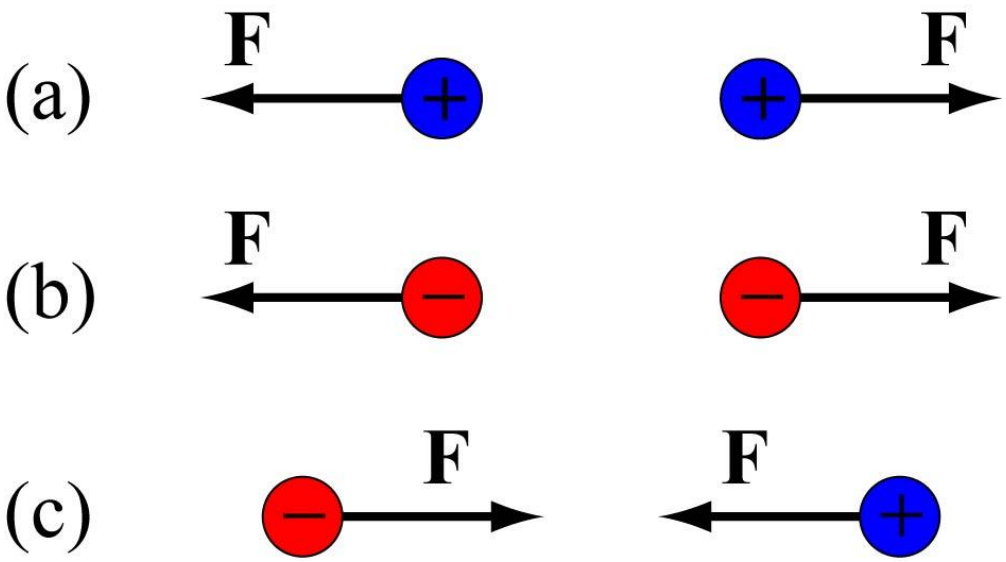
► William Gilbert (1544 – 1603) showed that many other materials exhibit this small force. He coined the word "electric" (after the Greek word for amber – *ilektron*, or ηλεκτρον) for this phenomenon. So etymologically, electricity means "***ambericity***."

(possessing the phenomenon of amber)

The electric force

Like charges repel and unlike charges attract.

When objects made of different materials are rubbed together, they become charged with equal but opposite charges. Charged objects either repel one another (for like charges, a or b) or attract one another (for unlike charges, c).



Charles Augustin de Coulomb

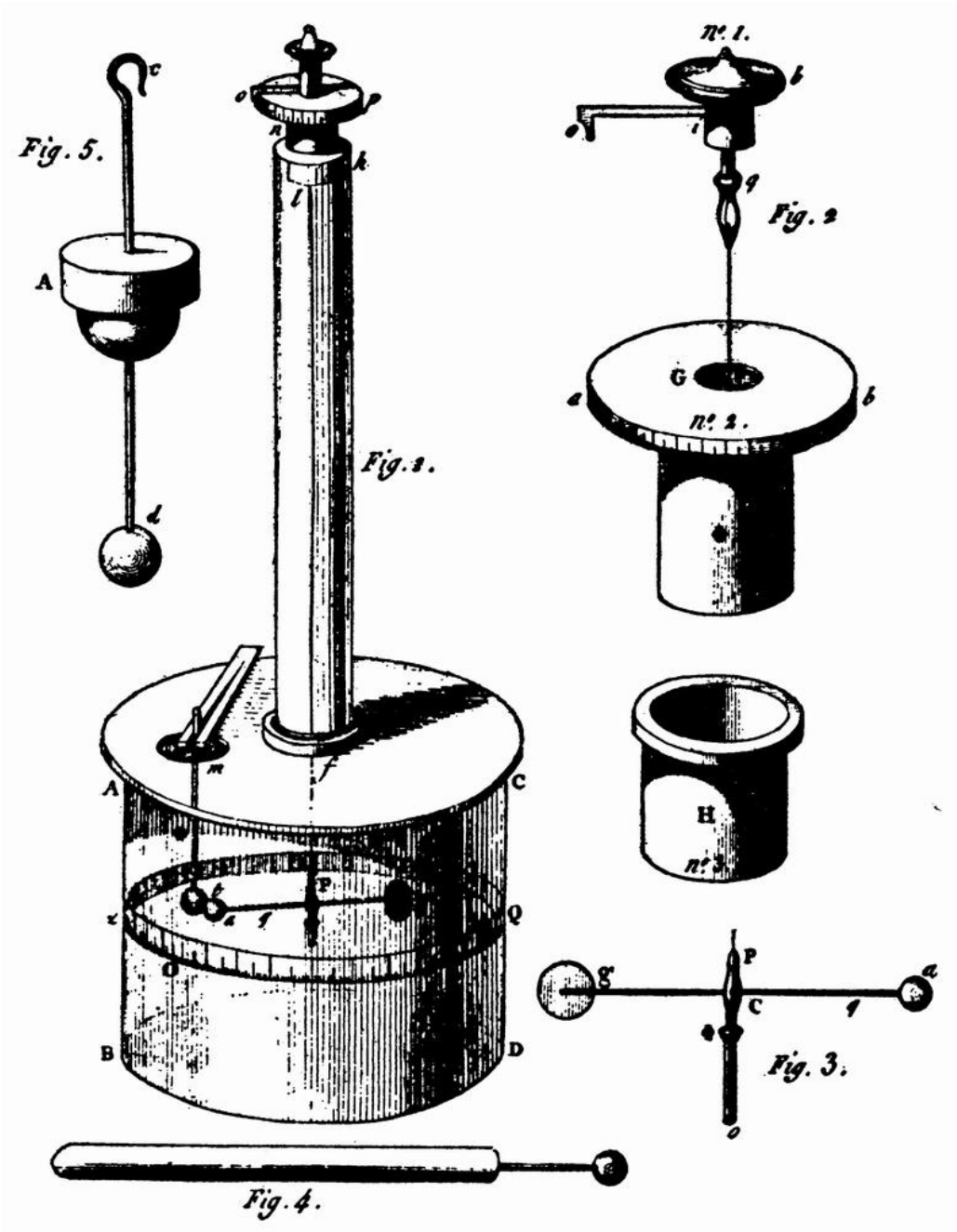
The force between two small charged objects is…

$$F = \frac{K Q_1 Q_2}{r^2} \quad \text{where} \quad K = 8.99 \times 10^9 \ \text{Nm}^2/\text{C}^2$$

. . . an inverse square law, like gravity.

International unit of charge:
1 coulomb (C) = 1 ampere-second

Coulomb's torsion balance



Sept 2012

But what is electric charge?

Early theories: There is an "electric fluid" that flows in materials.

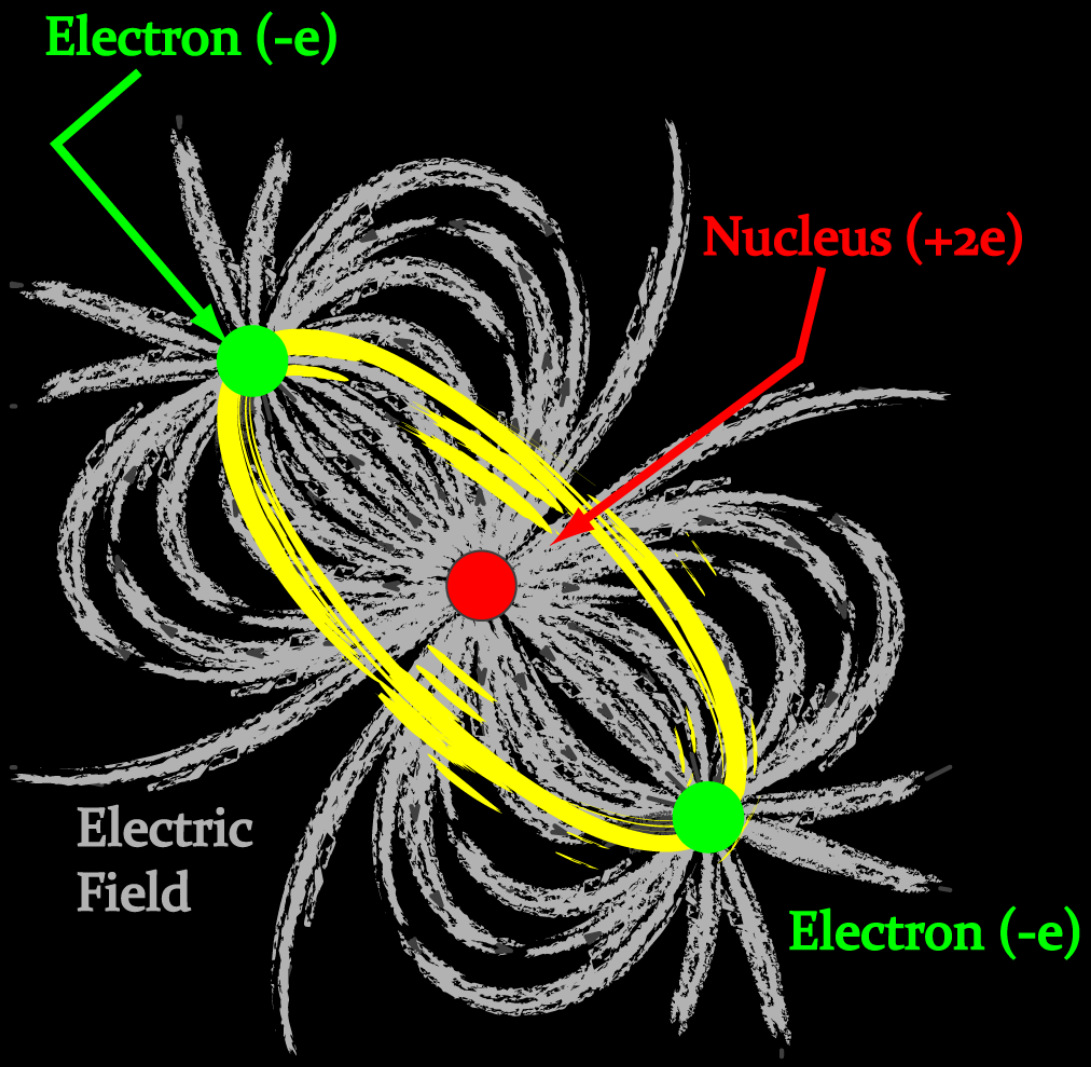
Modern science: Electric charge is a property of the elementary particles of matter – i.e., of subatomic particles.

proton charge = *e* (positive)
electron charge = - *e* (negative)
neutron charge = 0

Elementary charge
***e* = 1.6 x 10^{-19} C**

Neutral matter has an equal number of protons and electrons. An object is electrically charged if the numbers of protons and electrons are not equal.

An atom is a bound state of subatomic particles – electrons and the nucleus.



The discovery of the electron (J J Thomson 1897)

Thomson: The cathode ray is a beam of identical particles –- electrons.

Static Electricity

The Field Theory

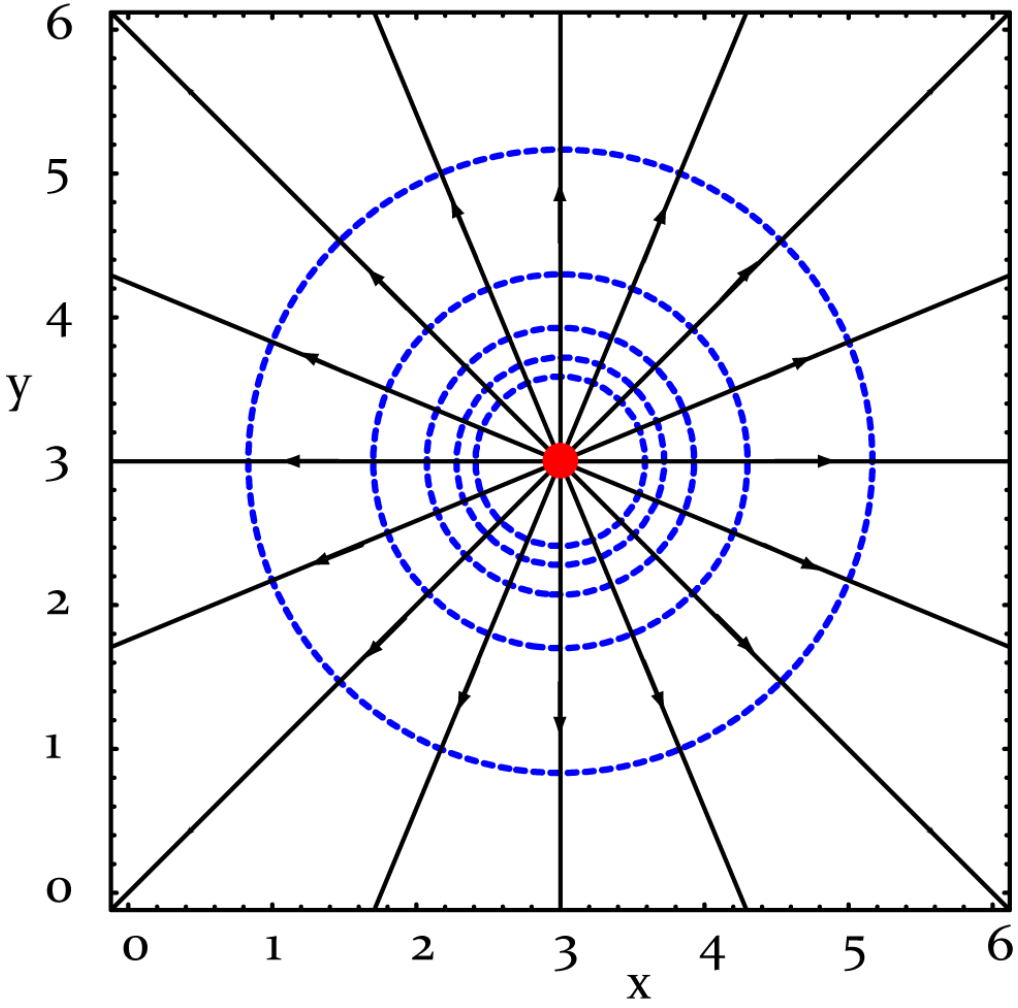
Field Theory

Electric effects are produced by a field that extends in space --- not by action at a distance.

The Electric Field

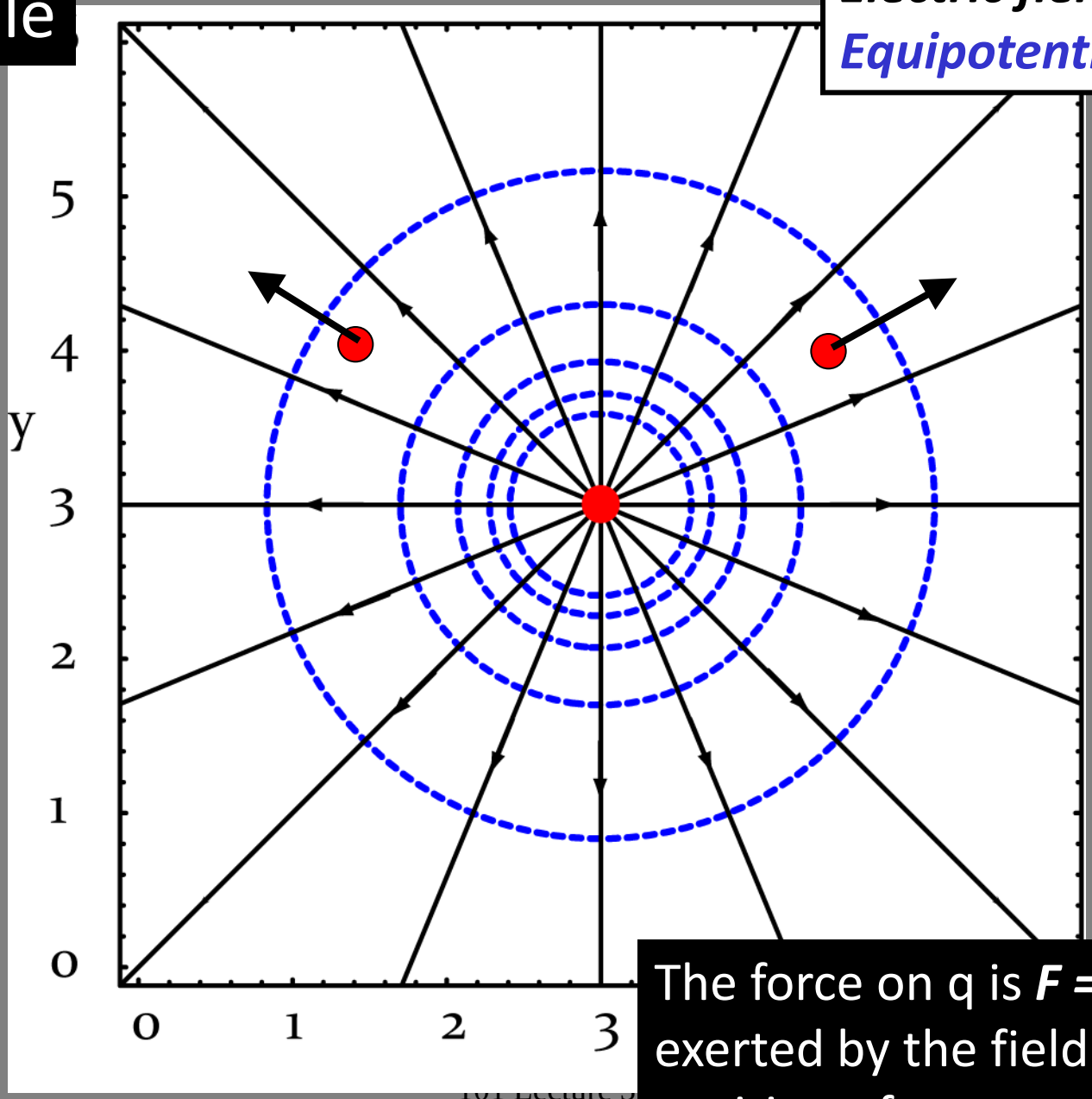
Definition: The electric field is a physical entity which is created by electrically charged particles[☆], and which exerts forces on electrically charged particles.

Electric field lines
Equipotential curves



☆ **or by electromagnetic induction**

Example



The force on q is ***F = q E(x),*** exerted by the field at ***x,*** the position of q.

Electric field — quantitative

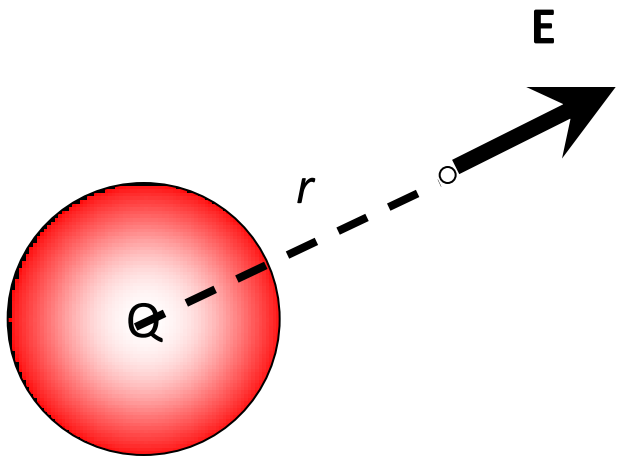
E(x)

The definition = force per unit charge

$$\mathbf{E(x)} = \frac{\mathbf{F}}{q}$$

where *q* is a small hypothetical test charge located at position **x.**

► **An example : a charged sphere**



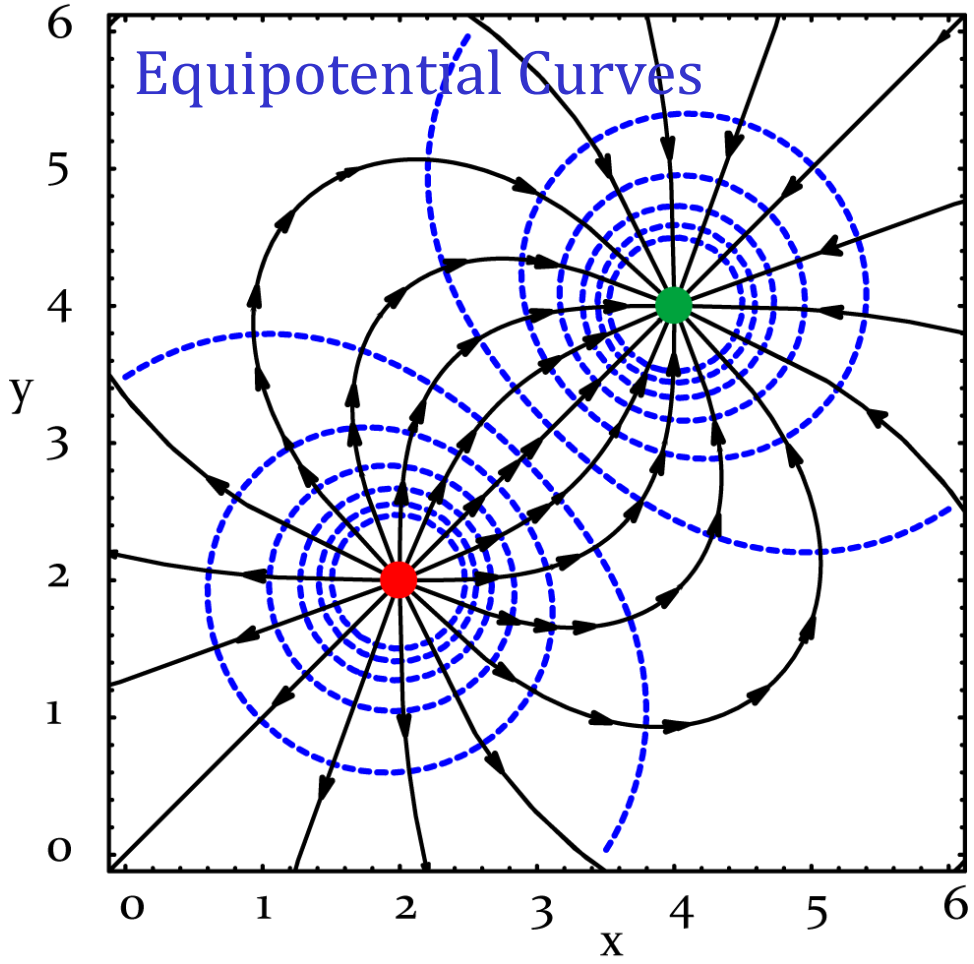
$$\mathbf{E(x)} = \frac{KQ}{r^2}\hat{\mathbf{r}}$$

***K* = 8.99 x 10^9 Nm^2/C^2**

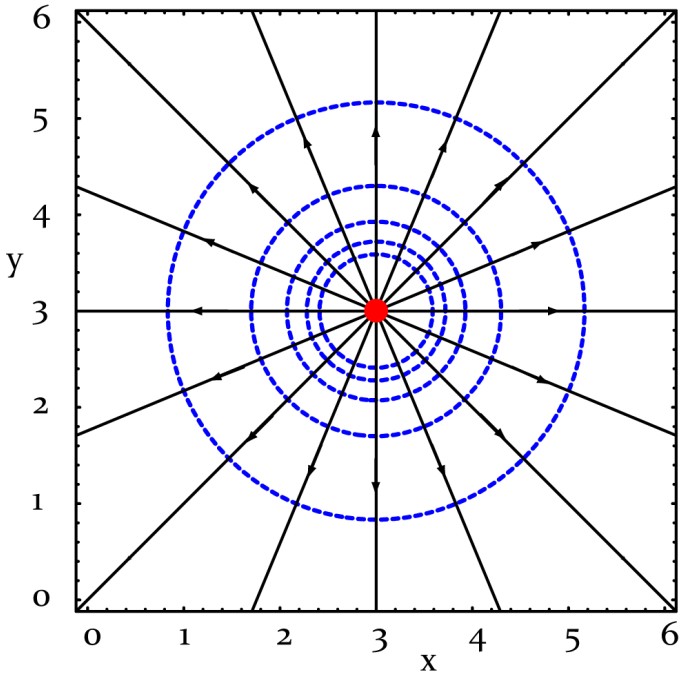
The Electric Potential

Electric field = ***force per unit charge*** acting on a test charge, **E(x)** = **F** /q .

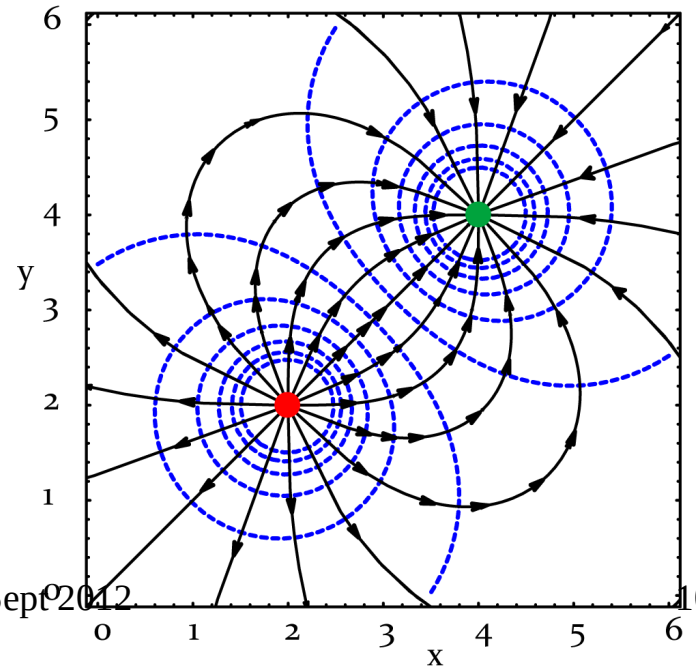
Electric potential = ***potential energy per unit charge*** of a test charge in the field, V(**x**) = U /q .

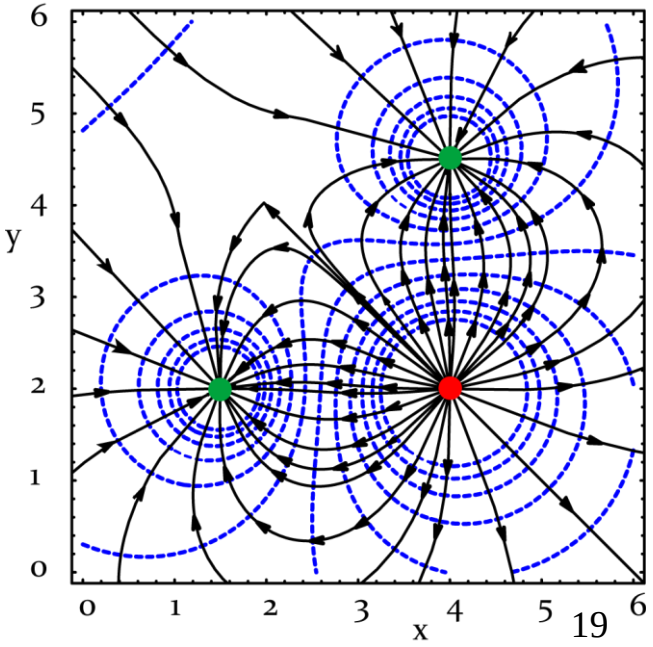


The unit of electric potential is the volt (V) named in honor of the great **Alessandro Volta**.



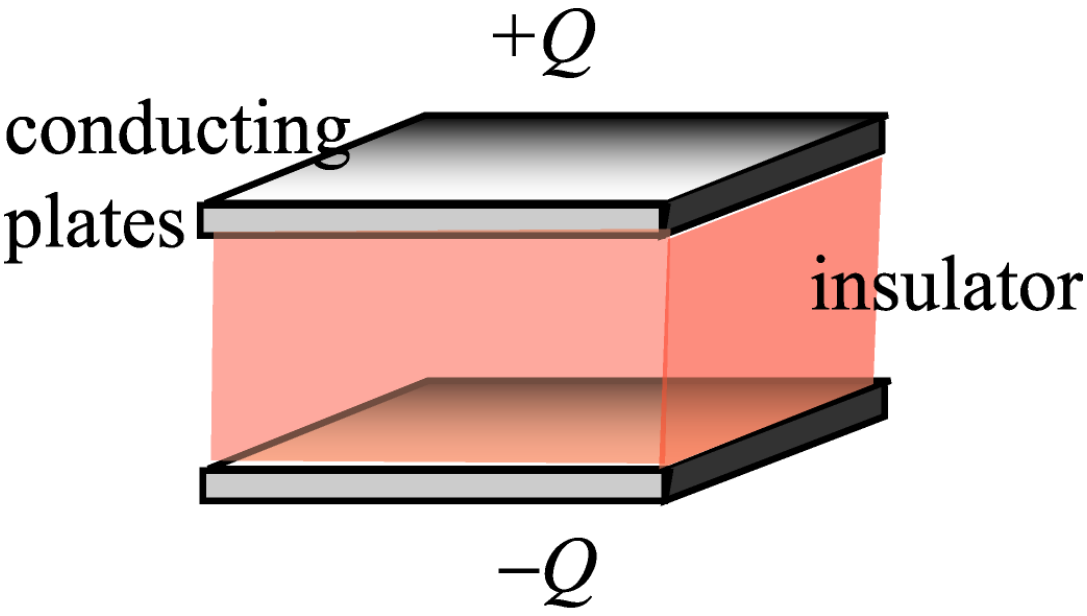
Electric Field Lines and Equipotential Curves





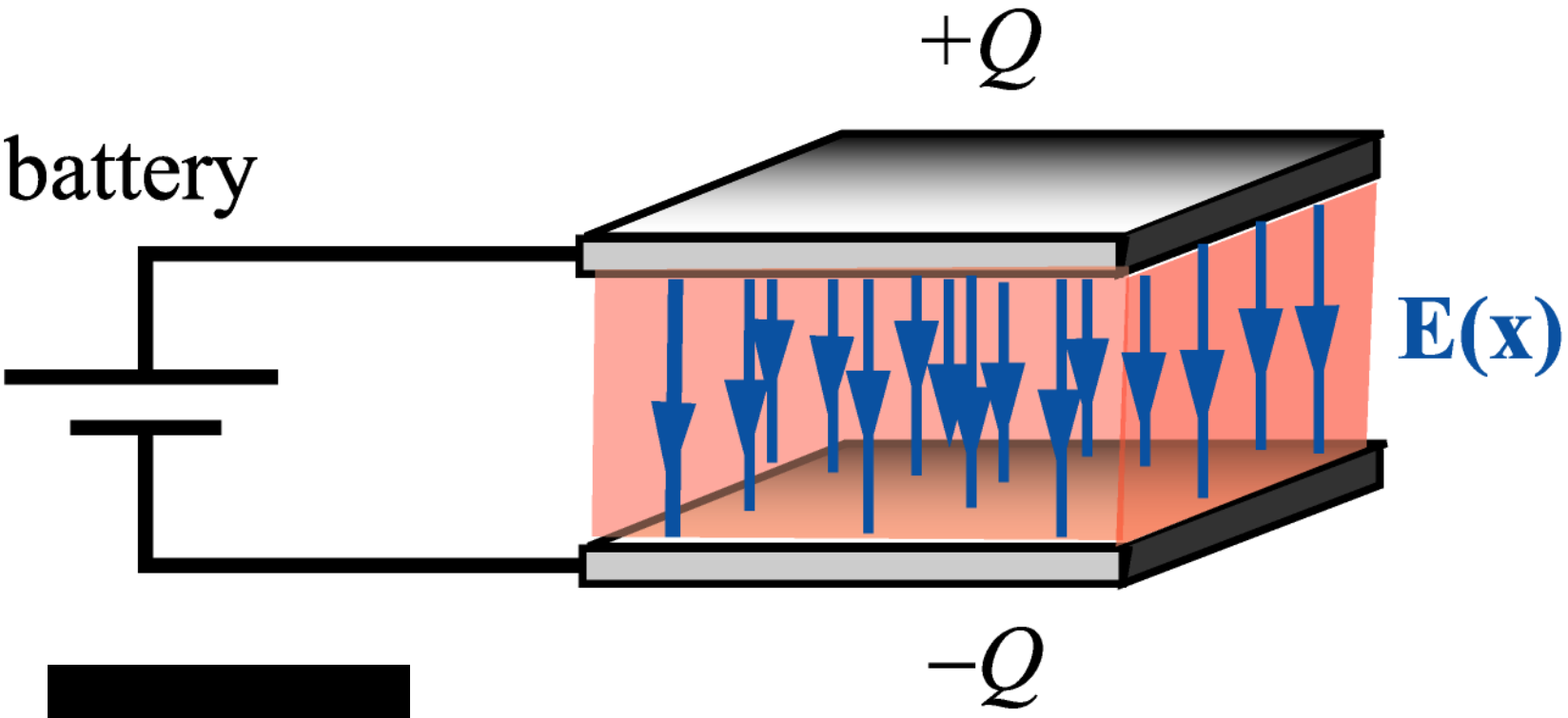
Capacitors

A capacitor is a system of two conducting (metal) plates separated by an insulating layer. ***We use it to store separated charge***, +Q on one plate and -Q on the other.



When the plates are connected by a wire, electric current flows in the wire to neutralize the charge difference.

Diagram of a capacitor



Q = CV

U = ½ QV

V = the voltage of the battery
C = the capacitance (in farads)

END