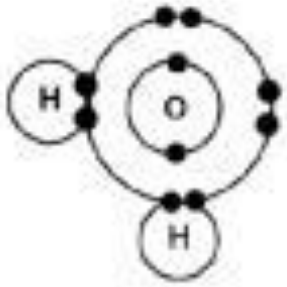
Electrostatics

To start off…

- The atom is made up of protons, neutrons, and electrons.
  - Electrons have a negative (-) charge.
  - Nucleus stays still – only electrons move
    - Protons have a positive (+) charge.
    - Neutrons don’t have any charge.

Electrons on the move

- Electrons can be ripped off of one object and put on another object. This causes the object to become charged. (ex: tires on road, slippers on carpet)
- Charge is given the symbol “q” and measured in coulombs (c).
- Ion – atom that gains or loses an electron
- Electrons can usually be ripped off easier in dry weather.



Water: 2 hydrogen atoms sharing electrons with 1 oxygen atom

Insulators and Conductors

- Insulators – electrons are bound tightly to the nucleus and cannot move.
  - Glass
  - Ceramic
  - Wood
  - Rubber
- Conductors - Electrons move freely
  - Metals
- Semiconductors – conductivity is temperature dependent.
  - Silicon
  - Carbon
  - Germanium

Charges

- The Earth is always considered to have an equal number of protons and electrons; therefore, it has **no (zero)** charge. However, a charged object can always give its charge to the Earth.

Charge

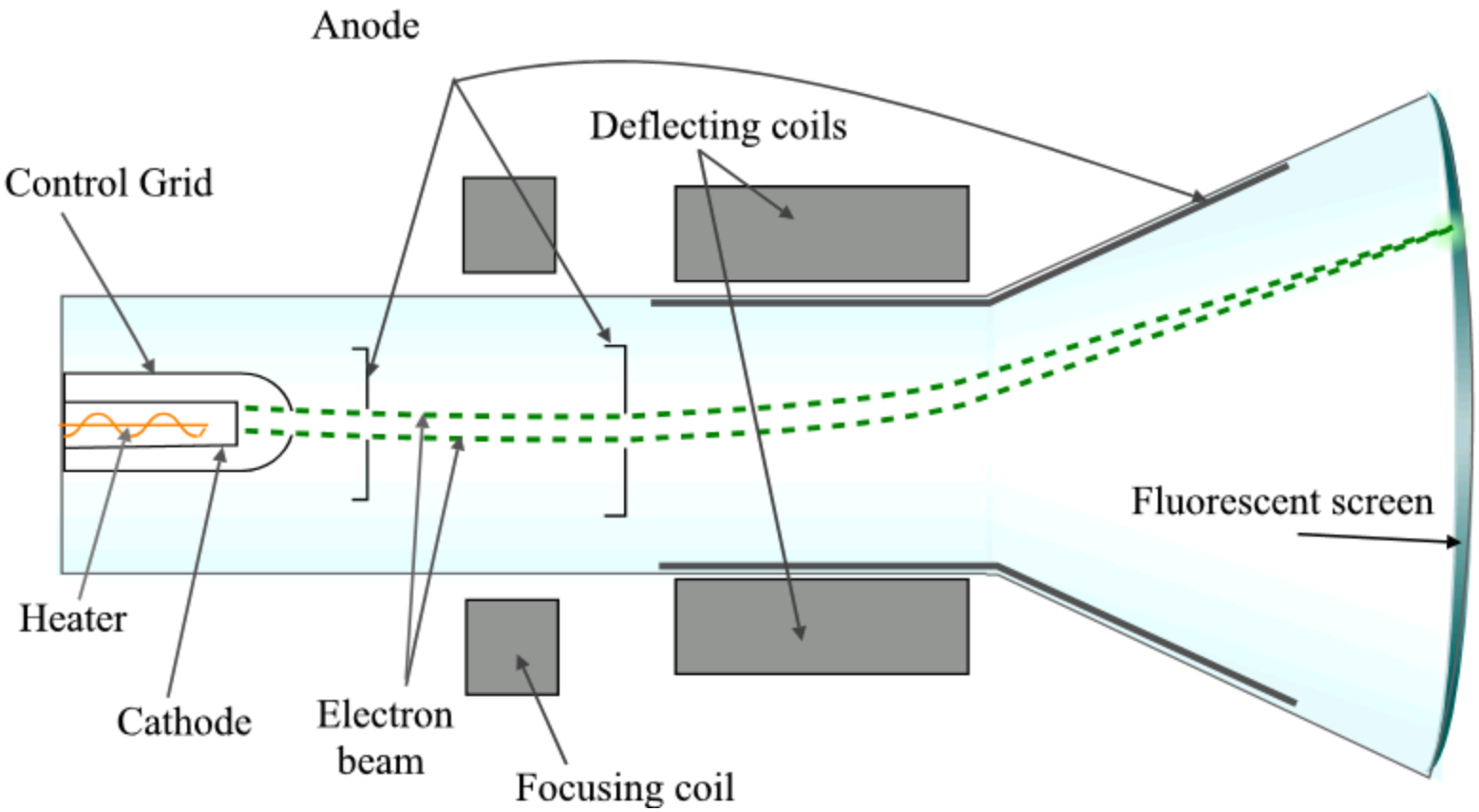
$e = -1.602 \times 10^{-19} C$

$p = 1.602 \times 10^{-19} C$

$m_e = 9.11 \times 10^{-31} kg$

- Attraction:
  - A positive(+) and a negative (-) charge will attract
  - A negative (-) and a negative (-) charge will repel.
  - A positive (+) and a positive (+) charge will repel.

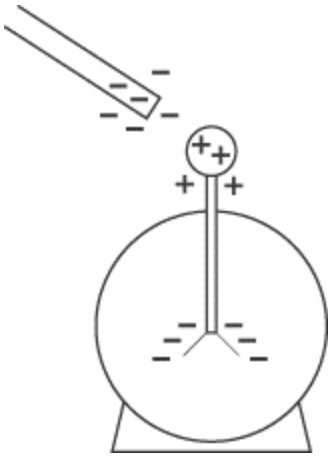
Cathode Ray Tube



http://en.wikipedia.org/wiki/Cathode_ray_tube

Electroscope

- One of the first devices used to measure charge.
- Charging by Induction – charge one object by bringing a charged object close to it. Grounding it, then removing 1st the ground then the charged objects.
- Charging by Conduction – transfer of electrons by contact.
- http://physics.bu.edu/~duffy/semester2/c01_conductors.html



- **Gravitational force**
- $F=Gmm/r^2$
- $G= 6.67x10^{-11}\ Nm^2/kg^2$
- Weak
- Only attracts
- Inverse square law

Electrostatic Force

$F= kqq/r^2$

$K=9 \times 10^9\ Nm^2/C^2$

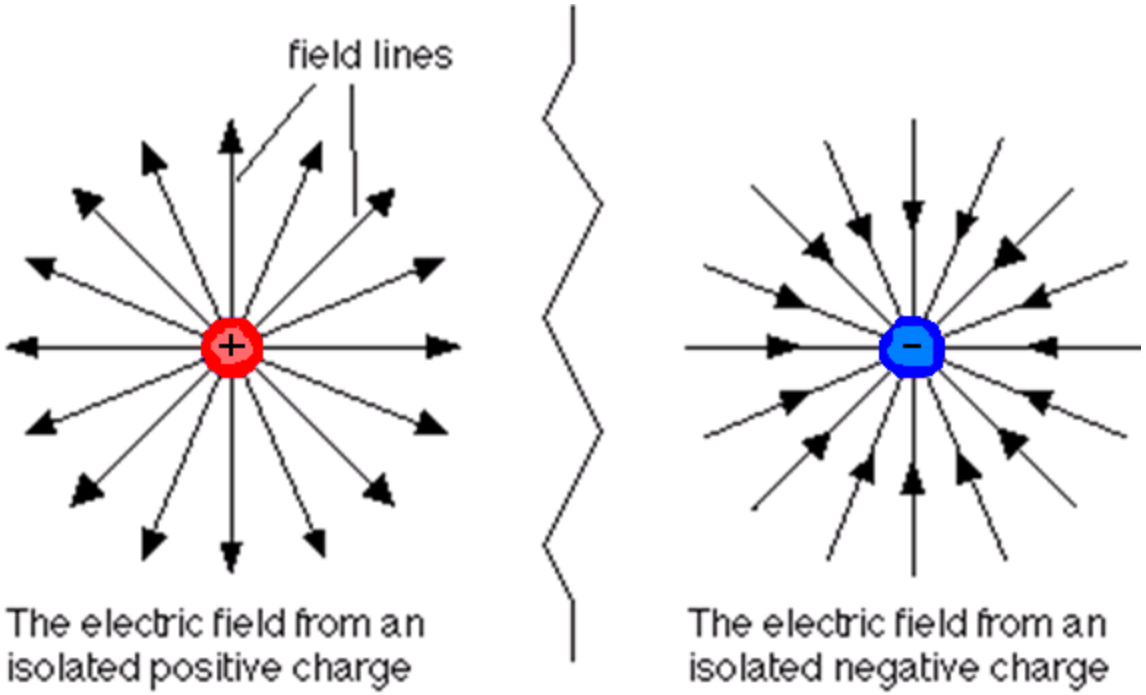
strong

Can attract or repel

Inverse square law

The Electric Field

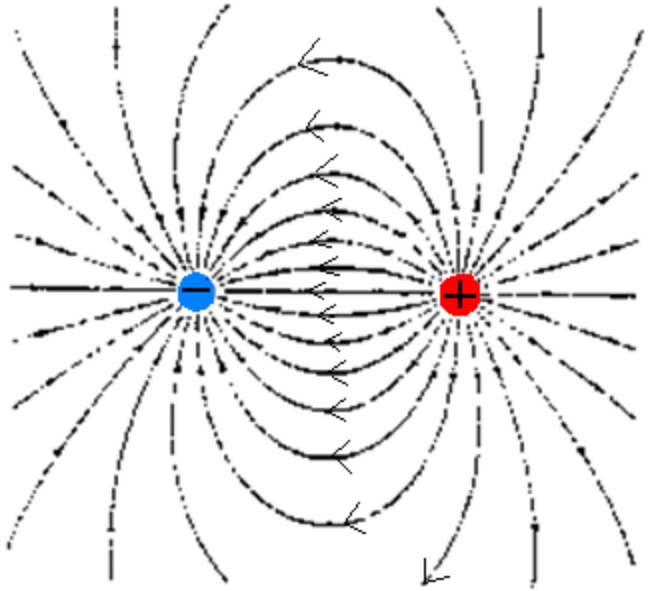
It radiates outward from positive charges into negative charges, permeating all of space.



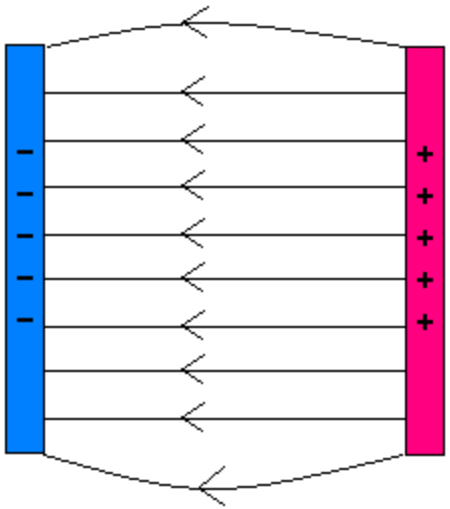
http://physics.bu.edu/~duffy/PY106/Electricfield.html

The electric field travels from a positive charge to a negative charge. Notice that the Electric Field is constant between charged plates.

diapole



parallel plate



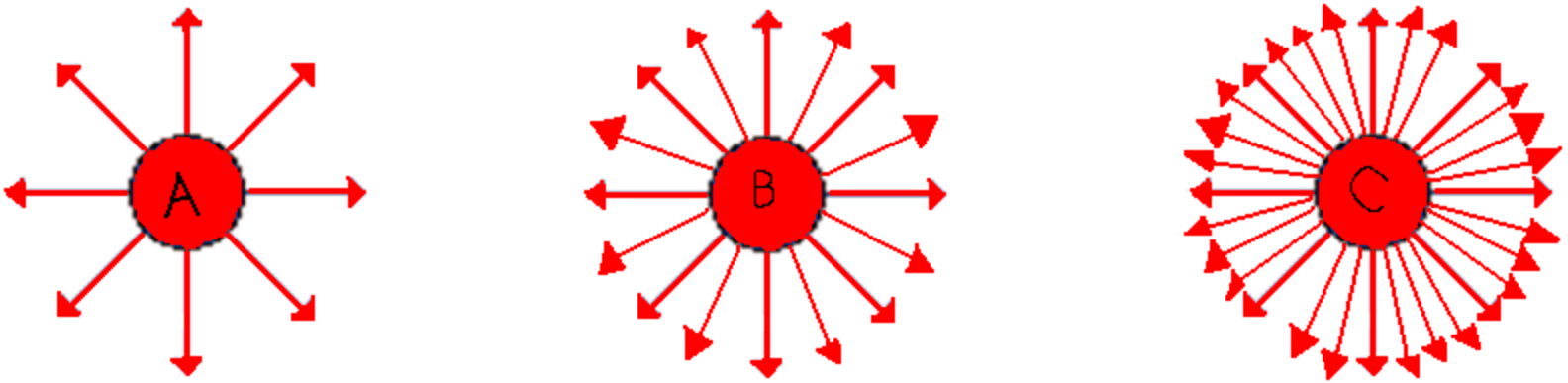
http://www.physics.smu.edu/~scalise/emmanual/field/lab.html

Field Lines always enter and exit a charge at 90º

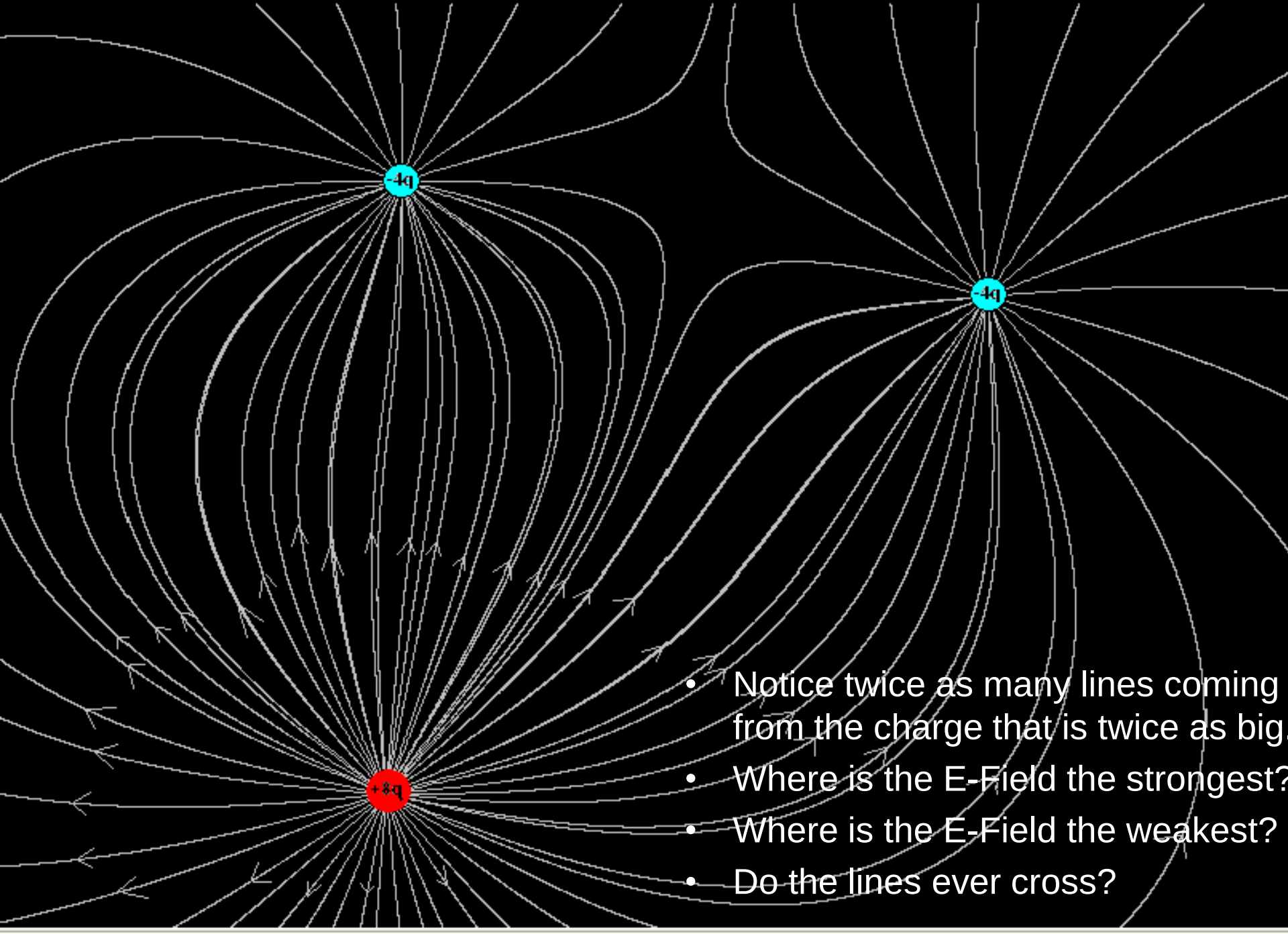
Field lines never cross.

Drawings of the electric field use more lines to denote a stronger field

Density of Lines in Patterns



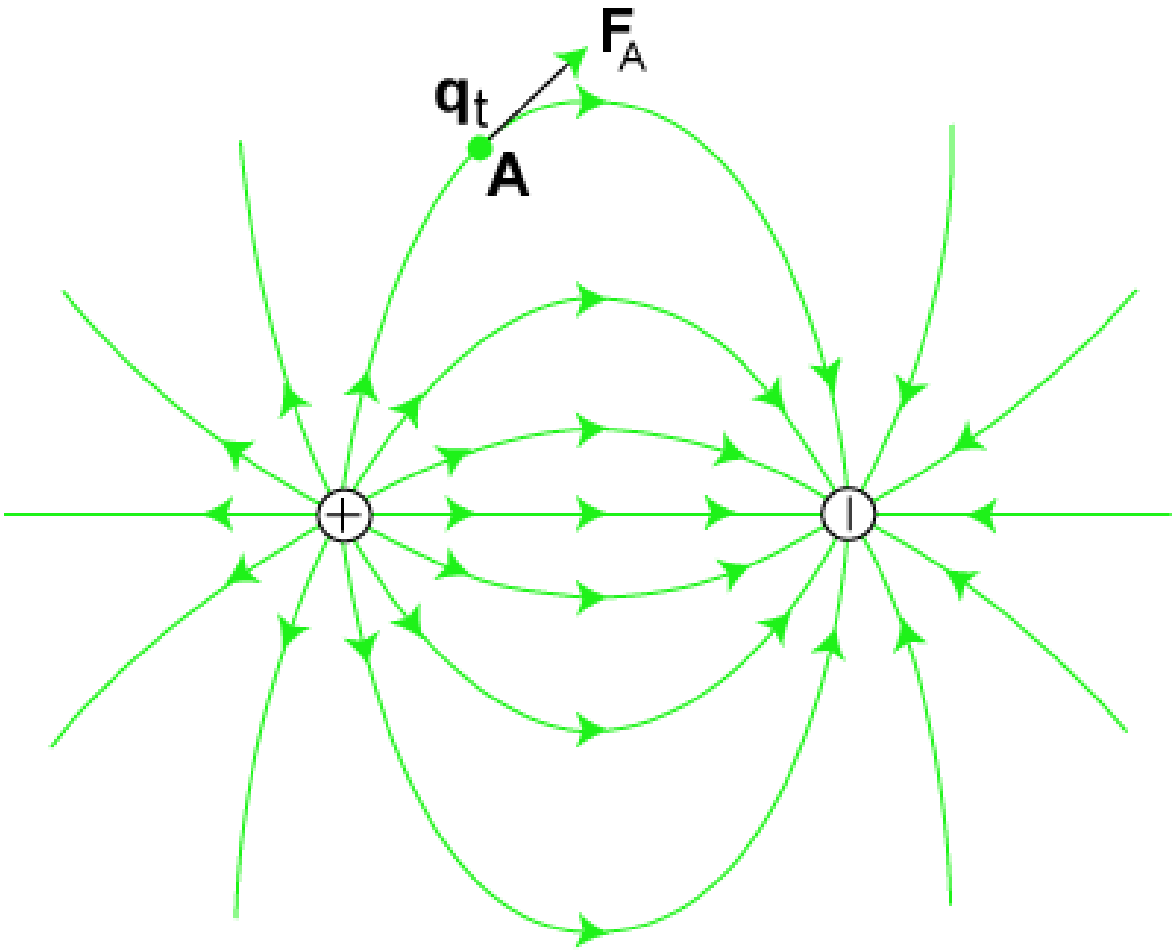
The density of electric field lines around these three objects reveals that the quantity of charge on C is greater than that on B which is greater than that on A.



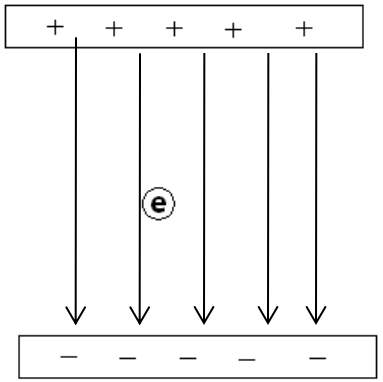
- Notice twice as many lines coming from the charge that is twice as big.
- Where is the E-Field the strongest?
- Where is the E-Field the weakest?
- Do the lines ever cross?

$E=F/q_t \quad a=q_tE/m$

If you place a test charge in an electric field how does it behave?



An electron is placed between two charged plates, where it feels a force of 8.0×10^{-10} N. What is the strength of the Electric Field and what acceleration will the electron have?



$E = F/q$

$E = 8.0 \times 10^{-10}\ N / -1.6 \times 10^{-19} C$

$E = -5 \times 10^{9}\ N/C$

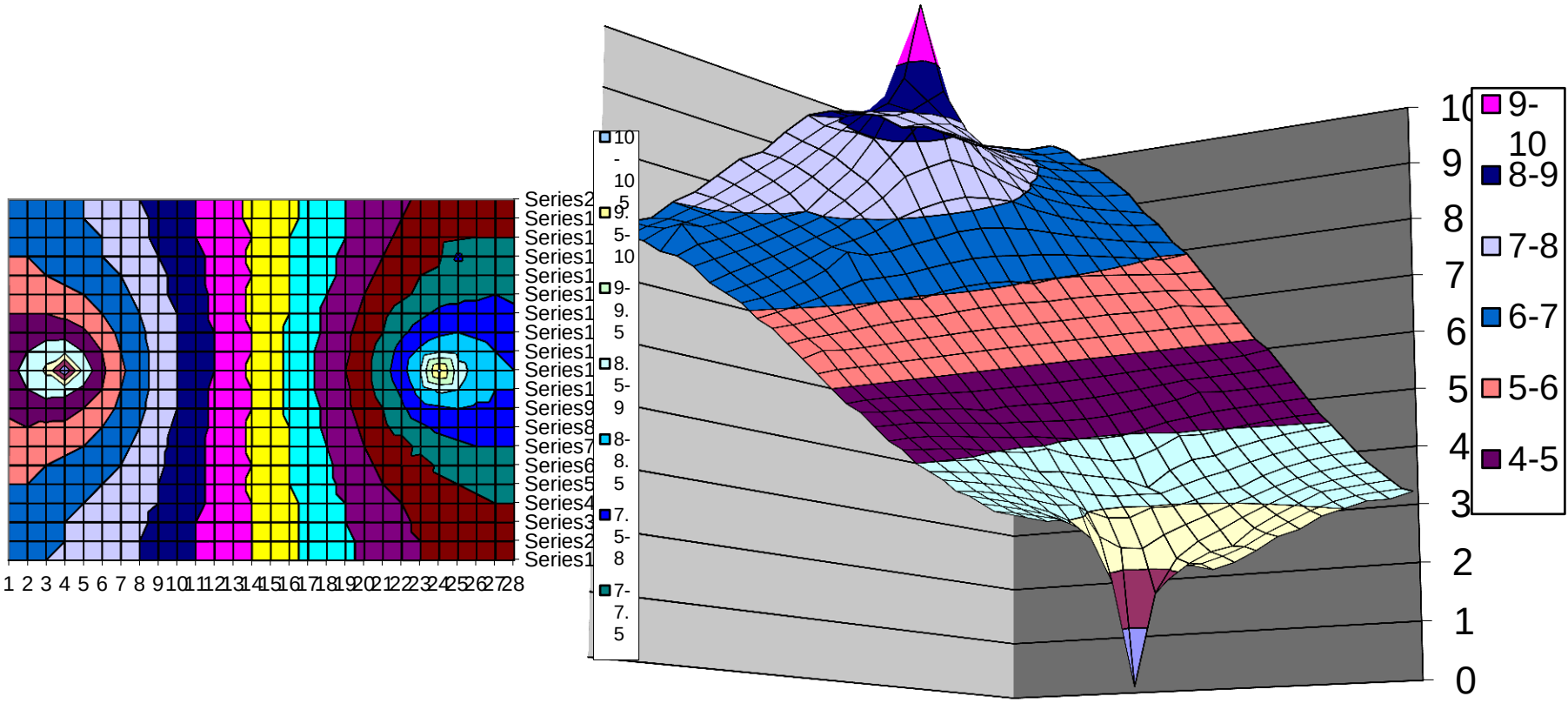
$a = qE/m$

$a = (-1.6 \times 10^{-19} C)(-5 \times 10^{9}\ N/C) / (9.11 \times 10^{-31}\ kg)$

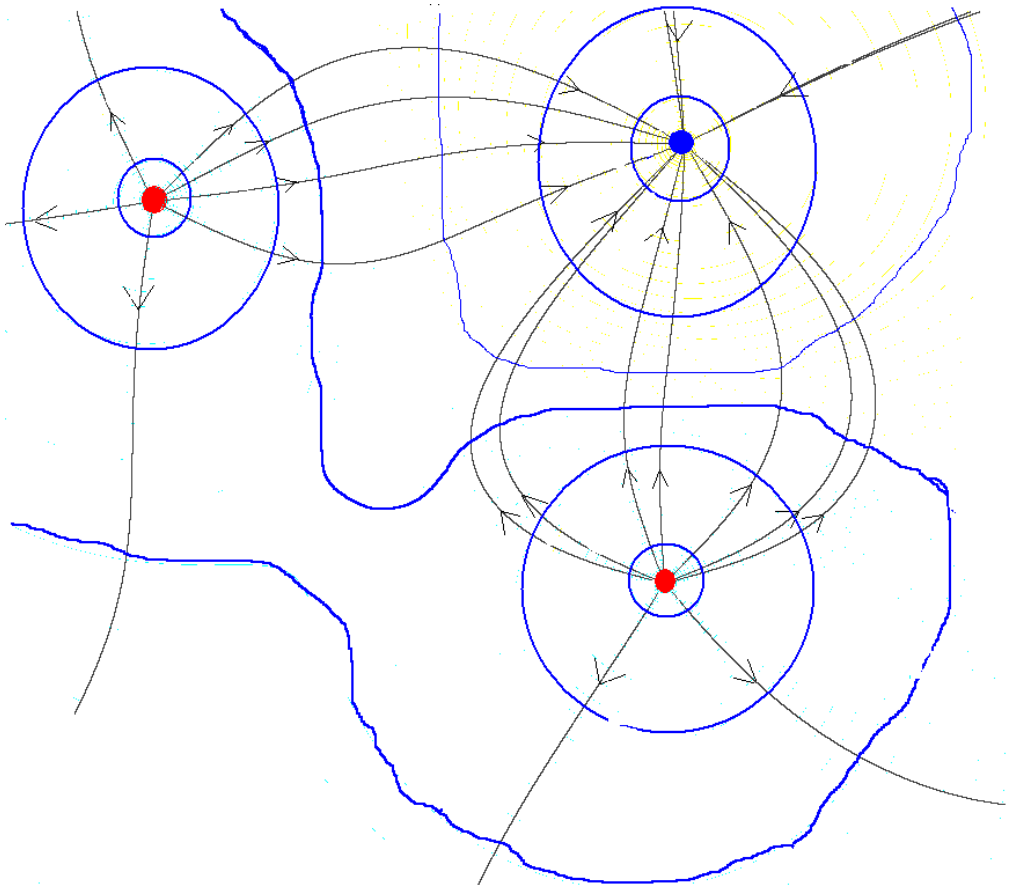
$a = 8.78 \times 10^{20}\ m/s^2$

Voltage

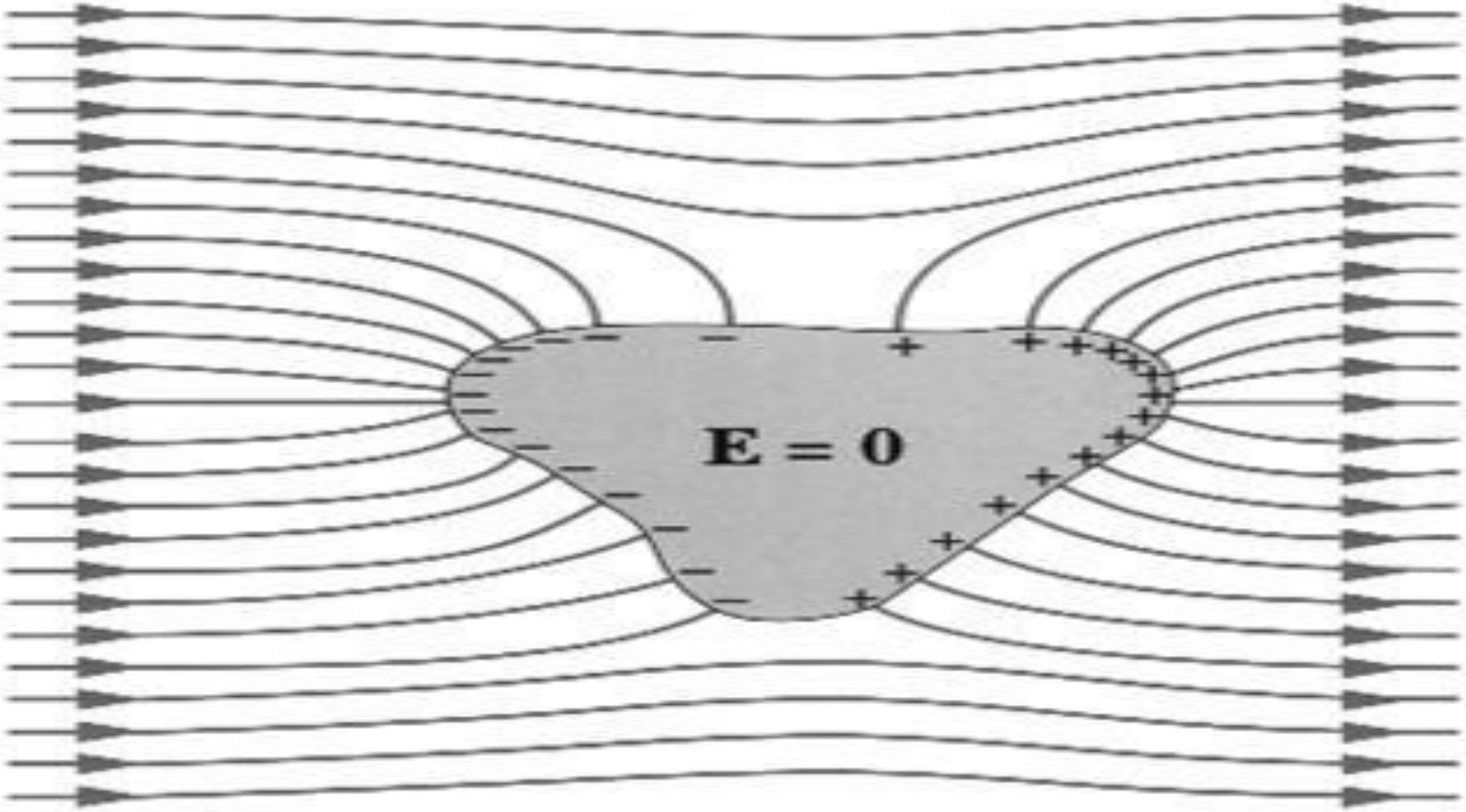
Is the potential that a positive charge would have to accelerate in an electric field.



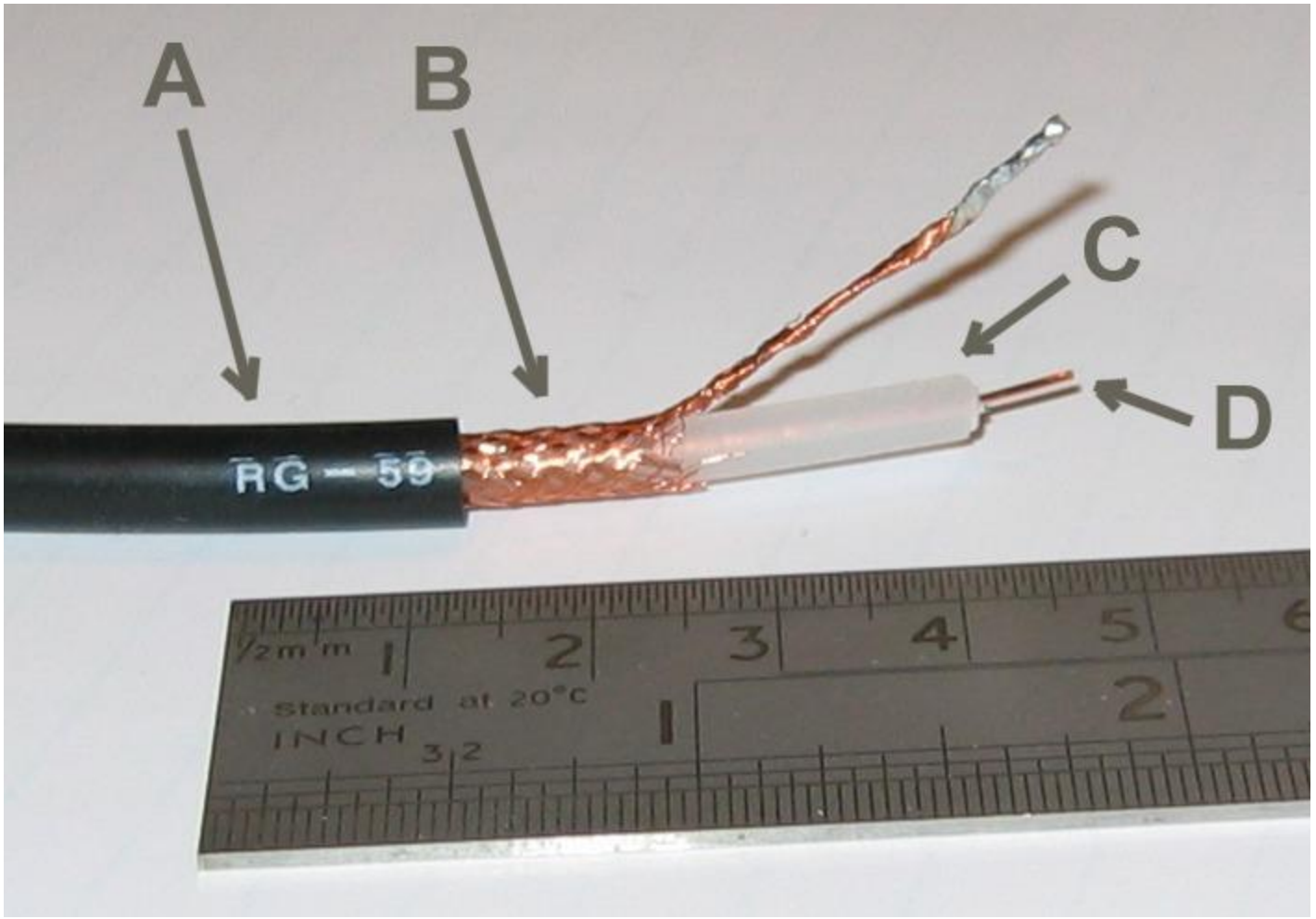
Equipotential lines, drawn here in blue, show areas where the voltage is the same. Notice that the are always perpendicular to the electric field lines.



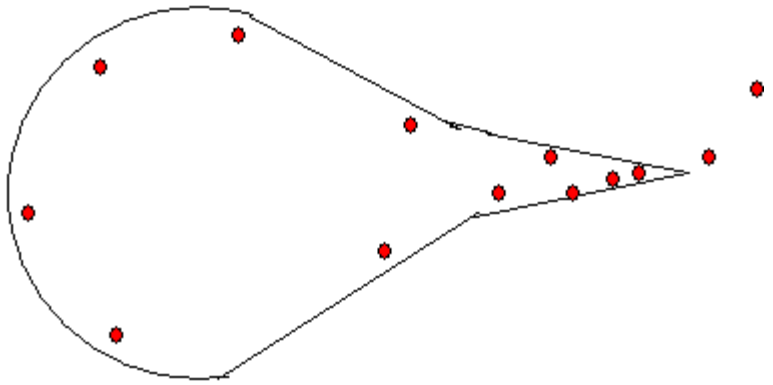
There is no electric field inside a conductor



Coax Cable

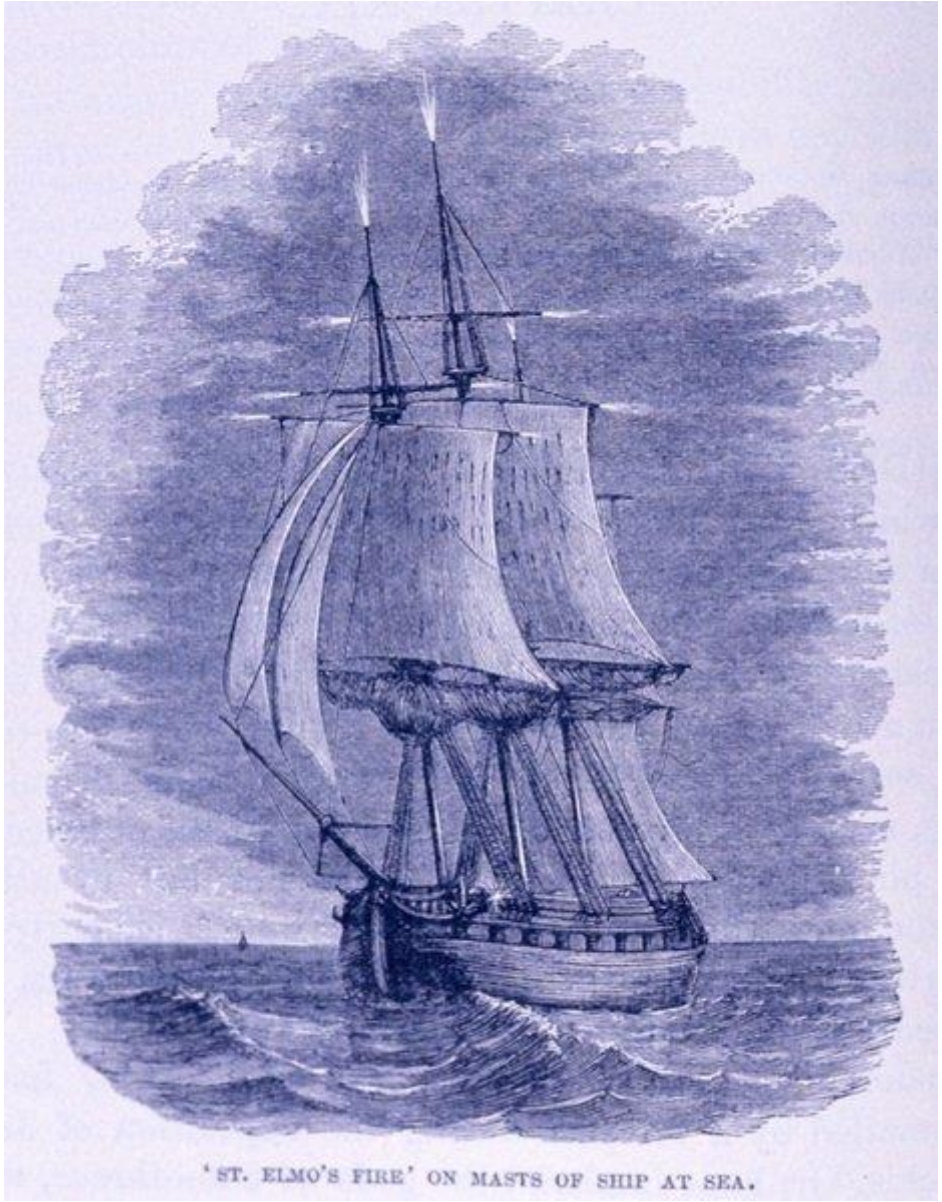


Charges leak off a sharp point



Other Oddities

- St. Elmo's Fire



'ST. ELMO'S FIRE' ON MASTS OF SHIP AT SEA.

http://www.usatoday.com/weather/tg/wflash/wflash2.htm
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Benjamin Franklin

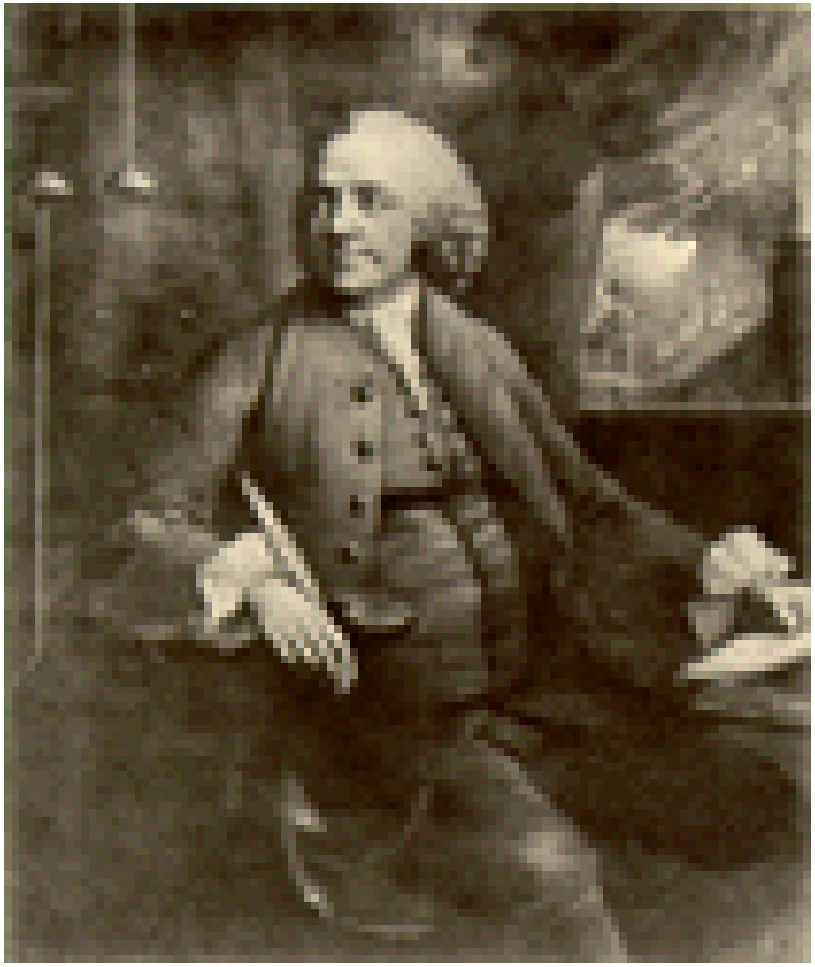
Invented the lightning rod as he was working to prove that lightning was electricity that came from the clouds

Utilized the property of charges that they leak off of a pointed surface.

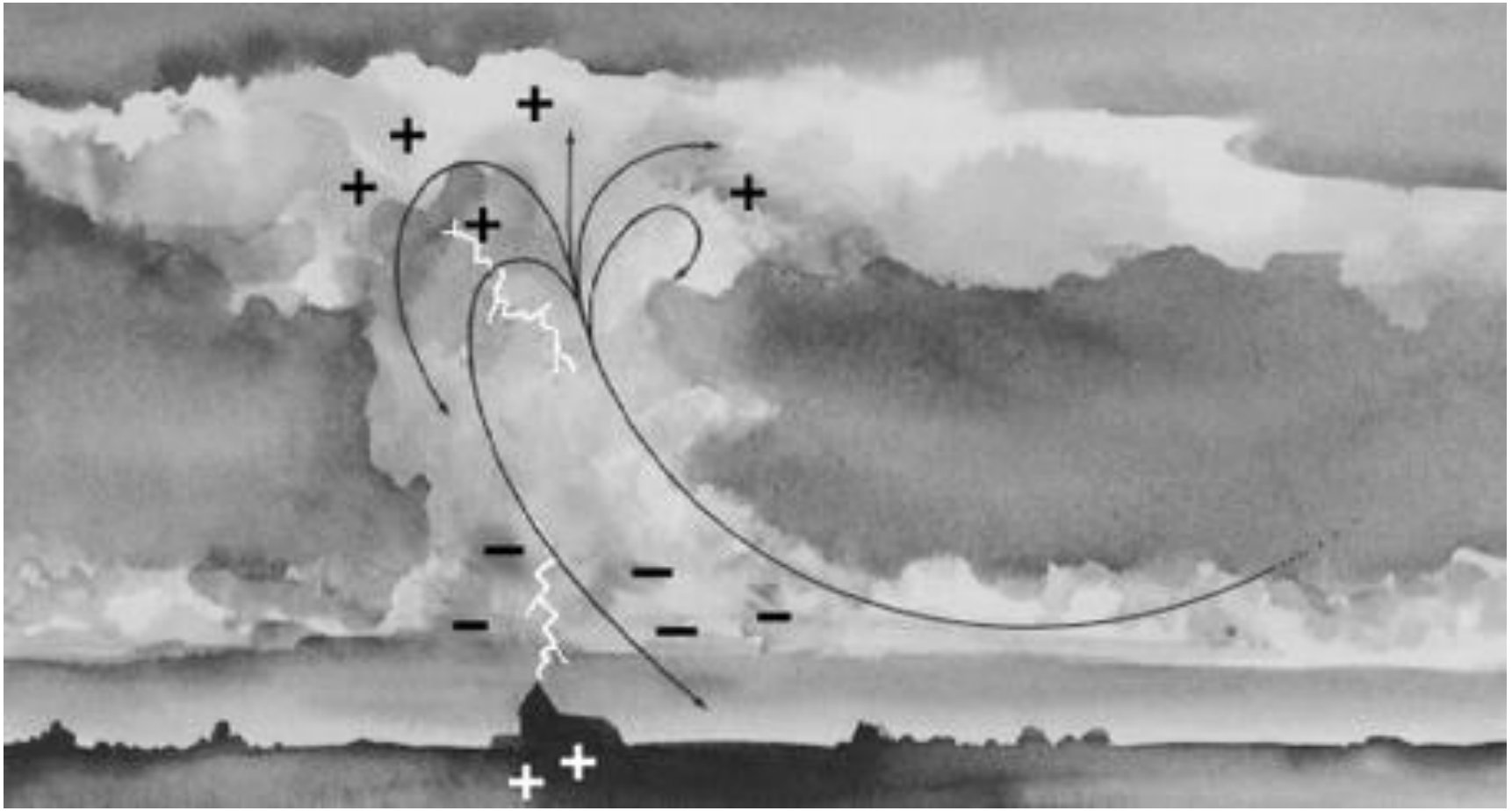
He did his kite experiment – not an actual lightning storm – got a spark to jump from the key to his finger

Invented lightening bells

Coined the term positive and negative.

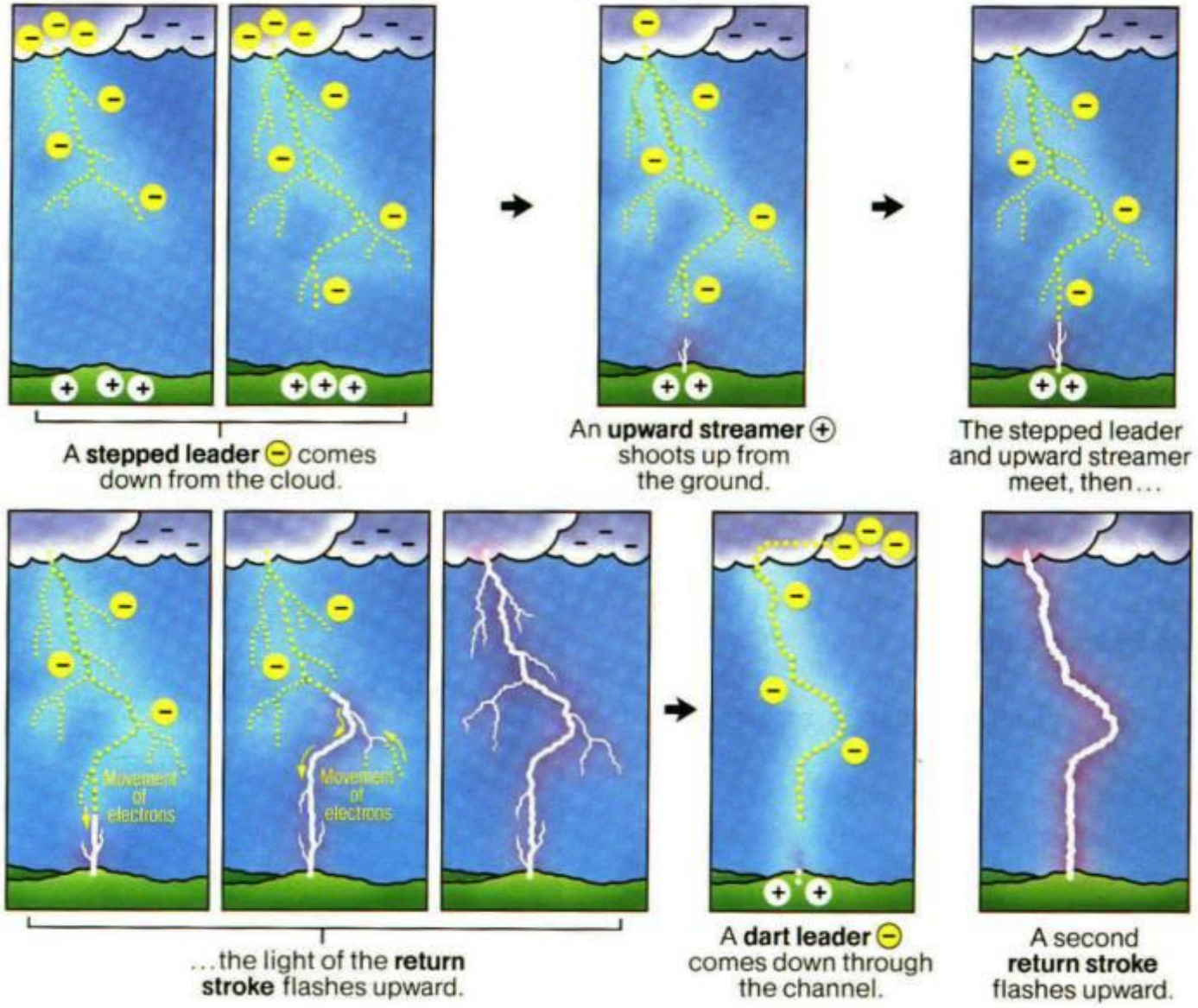


Lightning

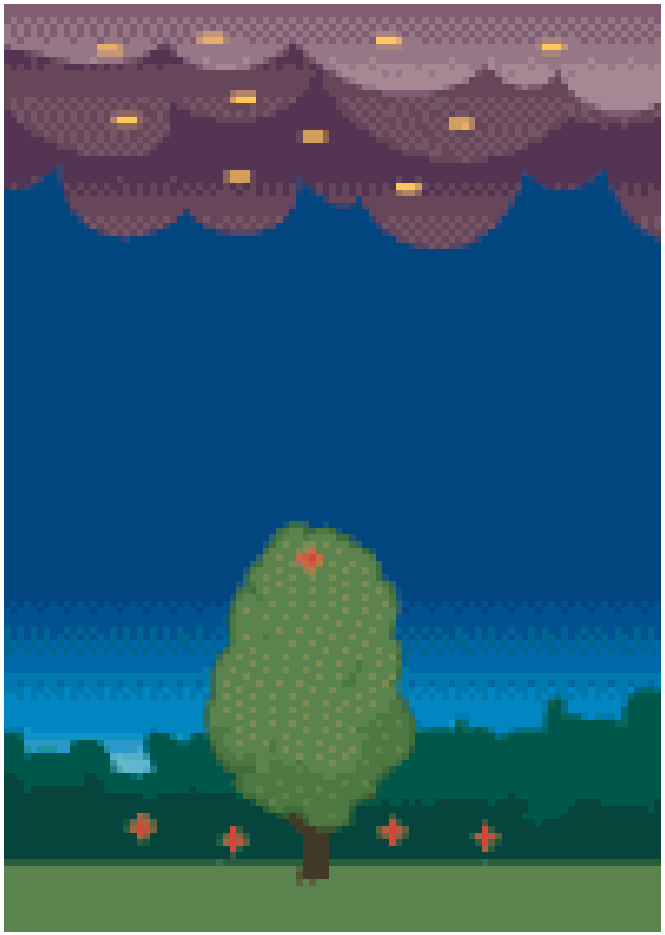


http://www.exploratorium.edu/ronh/weather/weather.html

What Happens When Lightning Strikes the Ground



How lightning works

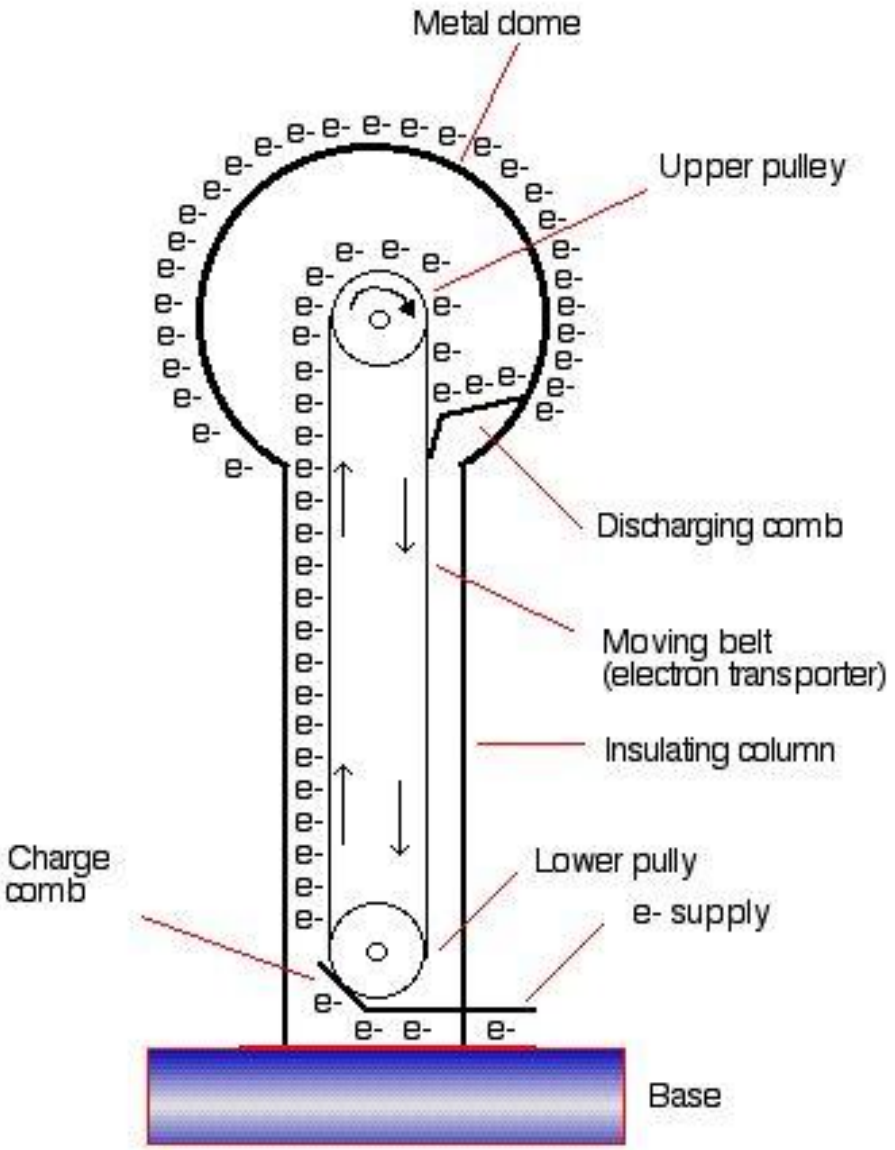


– To be continued

Van de Graff generator

With a Van de Graff generator the effect of rubbing flannel against a glass rod is expedited. An electric motor spins the lower pulley, and a rubber belt runs from the lower pulley to the upper pulley. The brush at the bottom of the pulley supplies electrons to the upper dome via the the belt and the discharging comb (see figure above). The discharging comb takes electrons from the belt and places them on the dome creating an excess of electrons on the upper dome.

This excess of electrons creates a charge or a voltage on the dome that gives a spectacular light display. The fantastic sparks are created when the abundance of electrons on the dome gets large enough that it ionizes the surrounding air and the air turns from an insulator to a conductor. With the air like this the electrons leap off the domb creating a brilliant spark.



- http://physics.bu.edu/~duffy/semester2/menu_semester2.html
- http://www.lhup.edu/~dsimanek/scenario/e-stat.htm

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