# L 24 Electricity & Magnetism [2]

- static electricity
  - the charging process
  - -the van de Graff generator
  - -electrostatic shielding
- liquid and gaseous conductors
- lightning
- frogs legs and batteries
- · voltage, current, and resistance

### review – electric charge

- Matter has two basic properties
  - mass → gravitational force
  - charge → electric and magnetic forces
     – positive charge
     – negative charge
- electric forces



- electric forces
  - like charges repel +/+ or / unlike charges attract + / -
- charge is measured in Coulombs [C]
- all charge is a multiple of the basic unit of charge  $\rightarrow$  e = 1.60217646 x 10<sup>-19</sup> C
- charges cannot be divided into smaller units

# Where is the charge?

- the charge is bound in atoms
  positive → protons
  - negative  $\rightarrow$  electrons
- matter is electrically neutral → it has the same amount of positive and negative charge
- only the electrons can be transferred from one object to another by rubbing (friction)
  - to make an object (-) put electrons on it
  - to make an object (+) remove electrons from it

# Charging by friction

- If you rub plastic with fur, electrons are rubbed onto the plastic making it negative
- if you rub glass or plastic with silk, electrons are rubbed off the glass making it positive
- charge can be transferred to other objects
   charge can be transferred to or from conductors or non-conductors
  - charge (electrons) can only move through conductors.
- only the electrons can be transferred and move through conductors











### **Electrostatic shielding**

- The effect of the high voltage on the van de Graff generator stops on the outside of the metal cage → The rabbit is unharmed!
- Being inside your car during a lightning storm offers you some protection
- radio signals cannot penetrate through a metal enclosure
- the metal bars (rebar) that reinforce the concrete walls affects radio transmissions

## Liquid and gaseous conductors

- Except for mercury, which is a conducting liquid at room temperatures, the metallic conductors are solids
- Non-conducting liquids can be made conducting by adding ionic substances such as salt or acids
- Gases are non-conducting unless they are ionized (electrons removed from the atoms), then they become good conductors

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### A salt water solution is a conductor

- When salt NaCl (sodium chloride) is added to water H<sub>2</sub>O, the NaCl molecule dissociates into a positive ion Na<sup>+</sup>, and a negative ion Cl<sup>-</sup>.
- Thus the solutions contains both positive and negative ions, both of which can conduct electricity.
- Electric current can pass through dirty bath water and through you also!
- we are conductors water + Na<sup>+</sup> + Cl<sup>-</sup>

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# Gas discharges When a high voltage is applied to a gas-filled tube, the gas becomes ionized → one or more electrons are removed from each atom. The ionized gas is a conductor → current can flow. The excited gas atoms emit light of a characteristic color



# applications of electrostatics

- electrostatic attraction to put ink droplets on paper
  - Xerox machines
  - Inkjet printers
  - Paint sprayers
- Sorting particles by charge and weight
- electrostatic precipitators use the attraction of charged dust to remove dust particles from smoke.

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### Batteries and frog's legs

- <u>Galvani</u> found that a frog leg hung on a copper hook twitched when touched by an iron scalpel.
- <u>Volta</u> realized that the frog's leg was just acting as a conductor, and the two metals produced the current --- the first battery
- Volta replaced the frog's leg with brine soaked paper placed between strips of Cu and Zn





# Potential difference or Voltage (V)

- Voltage is what causes charges to move in a conductor → it produces an electrical force on the electrons which causes them to move
- Voltage plays a role similar to pressure in a pipe → to get water to flow there must be a pressure difference between the ends, this pressure difference is produced by a pump
- A battery is like a pump for charge → it provides the energy for pushing the charges around a circuit



# Inside a Duracell 1.5 Volt battery



