### **Electricity**

--- Current and voltage

# Summary of conductors and insulators

- Conductors need free (mobile) charges
   In metals there are free electrons
- Insulators have all charges firmly bound (glass, most plastics)
- air?
- Human body?



The flux through the Gaussian surface is zero. There's no net charge inside, hence no charge on this interior surface.

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#### Faraday's Cage

(b) The conducting box has been polarized and has induced surface charges.



# The electric field is perpendicular to all conducting surfaces.

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### Electric current



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# Q0

The electric current in this case,

- 1) increases
- 2) decreases
- 3) remains unchanged as a function of time.



# Voltage

Before plates are connected, certain electric energy is stored. These energy stored is characterized electric potential difference or Voltage.

## conduction electrons in a wire



The electron has frequent collisions with ions, but it undergoes no net displacement.

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No connected to charged plates



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When connected to plates

## Maintain a constant electric current



#### A Battery keeps current flowing !!



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$$\Delta V = rac{W_{chem}}{q}$$

Voltage of a battery

### **Electric potential**



Gravitational Potential Energy mgh Gravitational Potential gh Electrical potential Energy qV Electrical potential V

#### **Some Typical Voltages**

| Voltage Source            | (approx.)          |
|---------------------------|--------------------|
| Thundercloud to ground    | 10 <sup>8</sup> V  |
| High-voltage power line   | 10 <sup>6</sup> V  |
| Power supply for TV tube  | 104 V              |
| Automobile ignition       | 104 V              |
| Household outlet          | 120 V              |
| Automobile battery        | 12 V               |
| Flashlight battery        | 1.5 V              |
| Resting potential across  |                    |
| nerve membrane            | 10 <sup>-1</sup> V |
| Potential changes on skin |                    |
| (EKG and EEG)             | 10 <sup>-4</sup> V |

# Sources of electric potential

- Batteries
- Van de Graaff generator
- Power stations
- Alternators
- Wind generators
- Solar panels
- Piezoelectric materials



### Electric current v d Electrons The bigger the voltage, Wire The bigger the current. The electron current *i* is the number of electrons passing through this cross section

of the wire per second.

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# Current: the flow of charges.

- I = Q/t
- SI Unit ampere
  A
- What kind of charges?
   electrons, ions, holes



A and B copper wires of same lengths connected to two identical batteries. A with bigger cross-section than the other. A should carry a

- 1) Bigger current;
- 2) Smaller current;
- 3) Same current;
- 4) None of above .



# Q2

A and B copper wires of same cross sections. A is longer than B. A should carry a

- 1) Bigger current;
- 2) Smaller current;
- 3) Same current;
- 4) None of above.



## Ohm's Law

#### $I = \sigma A V/d = V / R$

where A is a cross section area of a wire, d is length.

V is the voltage across the wire. We call the quantity characterizing the material conductivity  $\sigma$ .

Inverse of  $\sigma$  is called resistivity  $\rho$ ,  $\rho = 1/\sigma$ 

 $R = \rho d/A$