ELECTRIC CIRCUIT FUNDAMENTALS

CIRCUIT EXAMPLES

MILL + PUMP : Transfer of energy by movement of mass

PICKUP + DROP BALL

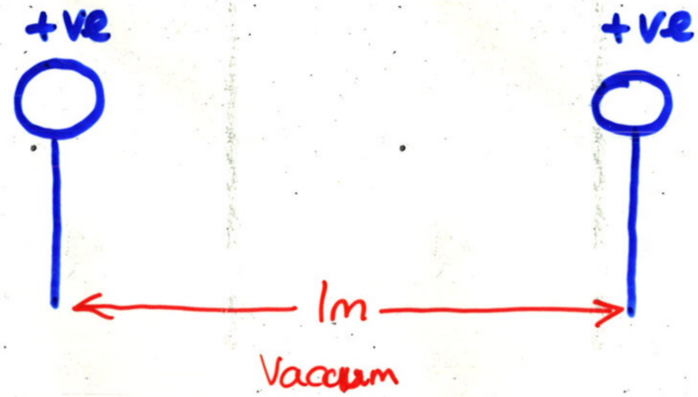
ELECTRIC CIRCUITS

Transfer of energy by movement of charge

⇒ charge is a fundamental quantity

- electrical property of matter
- two values - positive or negative
- like charges repel, unlike charges attract
- How should we quantify charge?
- In a measurable way?
- Measure the force

SI Unit of charge: Coulomb



Measure repulsive force

1C charge $\longleftrightarrow$ $10^{-7}c^2$ Newtons

How big is that force?

Charge on an electron ~ -1.6×10^{-19} C

$\Rightarrow$ -1 Coulomb ~ 6×10^{18} electrons

MOVEMENT OF CHARGE

Conductors – allow movement of charge.
- metals, carbon, acids

Insulators – inhibit movement of charge
- dry air, glass, ceramic, plastic

CURRENT

- how we measure movement of charge.

- current : amount of charge passing through a surface area per unit time
- In this course : surface area = cross section of wire (most of the time)

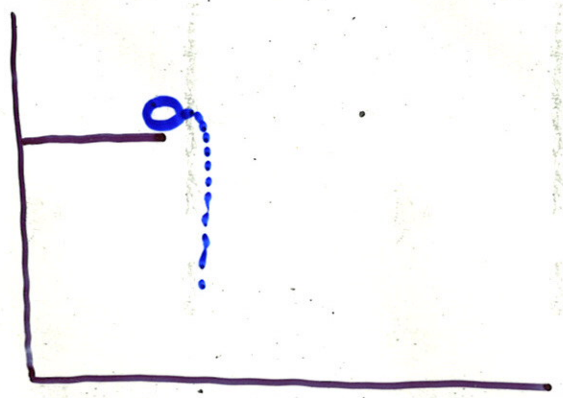
$$i(t) = \frac{dq(t)}{dt}$$

where $q(t)$ = charge

- Is that definition complete?
- No! Need a direction (recall speed vs velocity)
- CONVENTION
  - Note that formula implies flow of positive charge
  - important in some applications, but in most circuits in this course ~~current~~ charge carried by electrons

VOLTAGE

GRAVITATIONAL EXAMPLE



energy just before impact = $\frac{1}{2} m v^2$

= potential energy lost

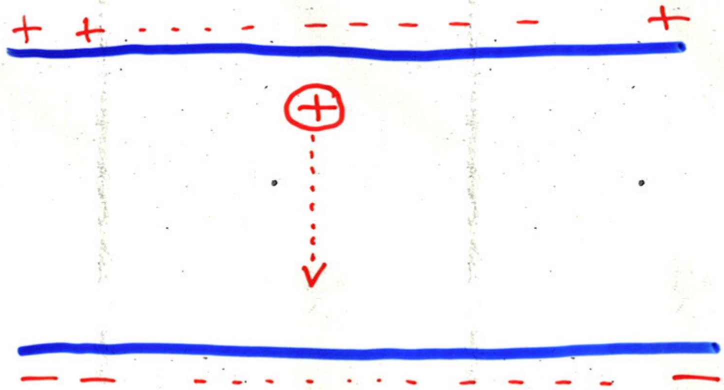
= (grav. force on ball) × (diff in elevation)

$\Rightarrow$ diff in elevation = $\dfrac{\text{energy converted}}{\text{weight}}$

Also to lift back up

energy required = diff in elevation × weight

What happens in an electric field?



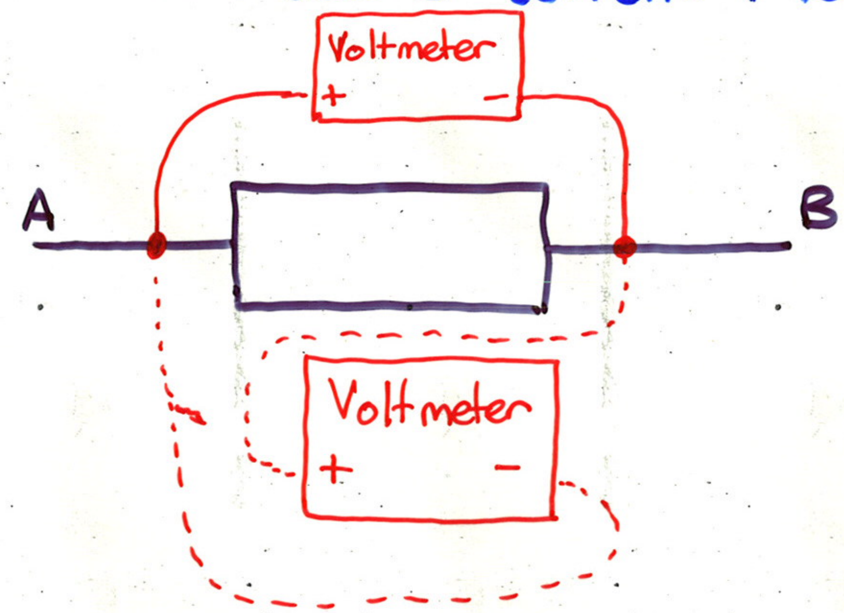
diff. in potential = $\frac{\text{energy converted}}{\text{charge}}$

or to push charge up

energy required = (potential diff) × charge

This potential difference called voltage

How to measure current + voltage



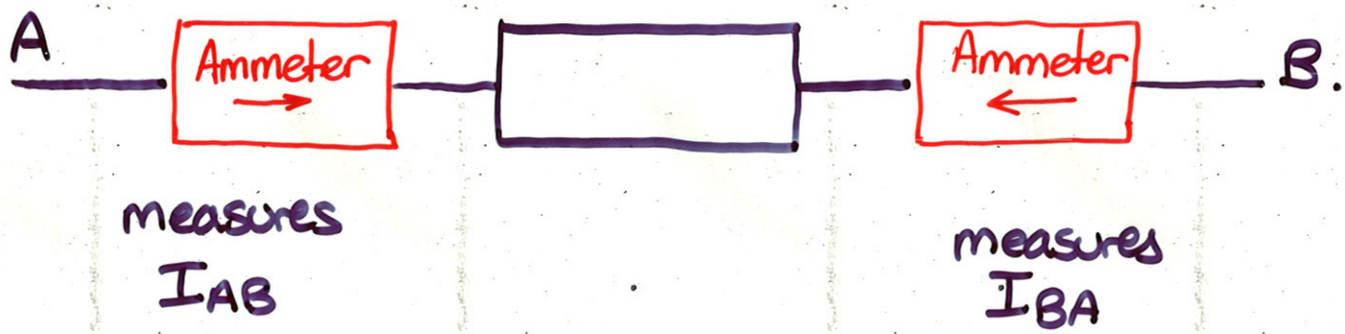
measures V_{AB}

measures V_{BA}

V_{AB} = energy converted per unit charge moving A to B

V_{BA} = " " " " " " B to A

$$V_{BA} = -V_{AB}$$



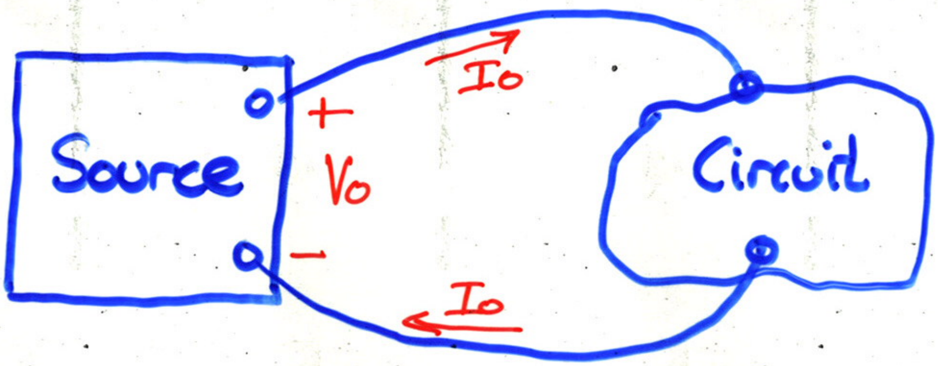
I_{AB} rate of flow of positive charge from A to B

I_{BA} " " " " " " " B to A

$$I_{BA} = -I_{AB}$$

POWER

Power - rate of change of work (energy) per unit time



V_o, I_o constant

What is the power in the circuit?

Consider a time interval T

How much charge moves?

$$I_o T$$

What is the drop in potential?

$$V_o$$

Remember: potential diff = $\dfrac{\text{energy converted}}{\text{charge}}$

$$\Rightarrow \quad \text{Energy} = V_o \times I_o T$$

$$\text{Power} = \frac{\text{Energy}}{T} = V_o I_o$$

CONSERVATION OF POWER.

Ⓐ Sum of all power dissipated = 0

Ⓑ Sum of dissipated power

= Sum of generated power

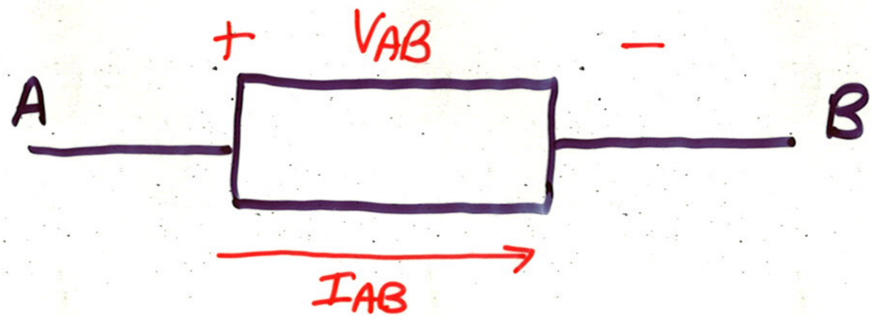
- But what if we don't know what is generating power and what is dissipating/absorbing power
- e.g., rechargable battery; car battery.

PASSIVE SIGN CONVENTION

We need a convention to help us be consistent

Power dissipated/absorbed is positive

- How can we get this right in a consistent way

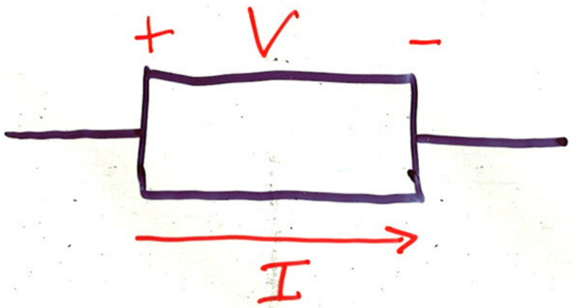


- My recommendation
  - always put "+" and tail together
    "−" and head together

- Then

$$P = VI = V_{AB} I_{AB}$$

obeys passive sign convention



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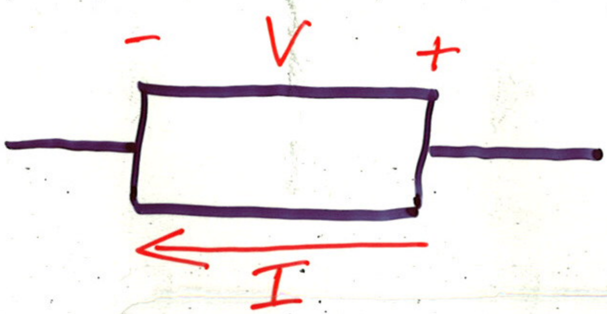
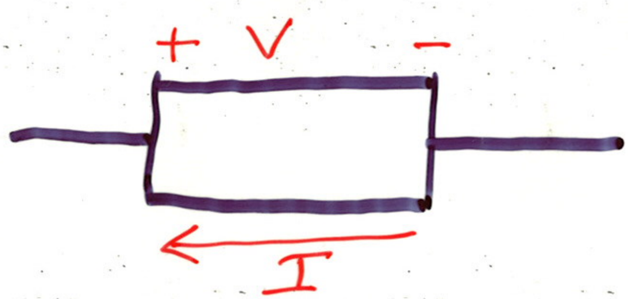
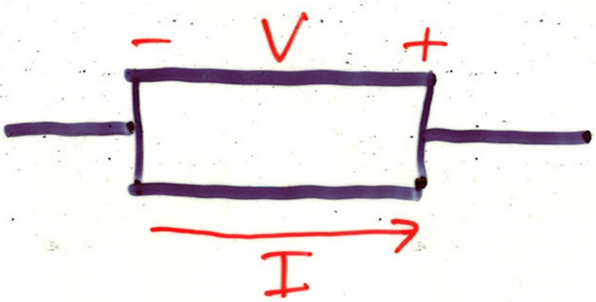
VI = power dissipated



VI = power dissipated



VI = power generated
(use with care)



VI = power generated
(use with care)