green empowerment
Village Solutions for Global Change

Electricity Basics

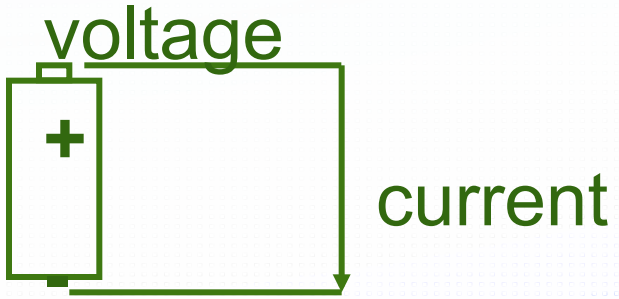
Electricity basics

The flow of electrical current through a wire is a flow of electrons.
It is analogous to the *flow of water through a pipe*

Voltage is similar to *water pressure.* It is **noted V** and **measured in Volts**

Current is similar to *flow rate.* It is **noted I** and **measured in Amperes**

For a same wire (/pipe),
the higher the voltage (/pressure),
the higher the current (/flow rate)



Resistance

- Resistance is the opposition to the passage of an electric current
  - Symbol: **'R'** (resistance)
  - Unit: **'Ω'** (Ohms)

- The smaller the pipe, the greater the resistance to water flow
- The thinner the wire, the greater the resistance to electric current

- A traditional incandescent light bulb is a high resistance wire

Key Formula 1: Ohm's Law

- Current, Voltage and Resistance are related.
  If you know any two you can calculate the third

$$V = I \times R$$

$$2\ A \times 0.1\ \Omega = 0.2\ V$$

$$20\ A \times 0.1\ \Omega = 2.0\ V$$

$$R = V / I$$

$$12V / 1.0\ A = 12.0\ \Omega$$

$$I = V / R$$

$$12V / 2.0\ \Omega = 6.0\ A$$

$$110V / 2.0\ \Omega = 55\ A$$

What happens if you plug into 110V a bulb designed for 12V?

Source: Jica

Power & Energy

- Power is measured in W (Watt) and it is the rate at which energy is generated or consumed at a given time
- Energy is measured over time in Wh (Watt-hour). That's what the electricity company usually bills for.
- When a 1 W appliance is used for one hour, the energy used is 1 Wh
- Energy can be stored in a battery, like water stored in a bucket or pond

Source: Jica

Power & Energy Examples

- If power rating of an incandescent light bulb is 60 Watts (W)

  and the bulb is used for 5 hours a day

  Its total energy used per day is
  60 W * 5 hours = 300 Watt-hours (Wh)

- If power consumption for a color TV is 100 Watts (W) and it is used for 2 hours a day

  Its total energy use per day is
  100 W x 2 hours = 200Wh

Key Formula 2: Electrical Power

The power used by an electrical device is calculated as:

Power = Voltage x Current

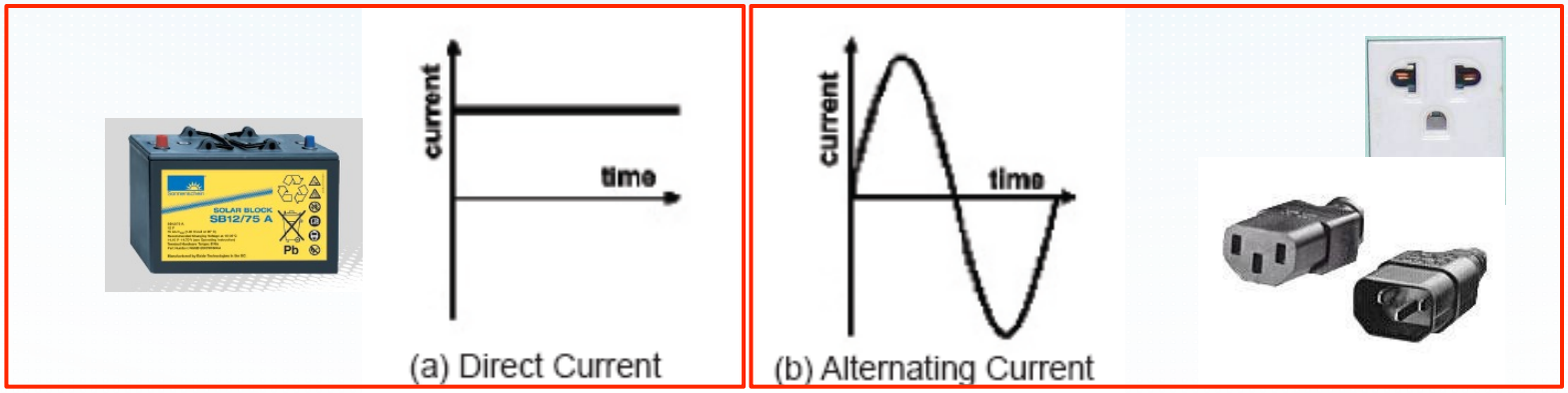
P = V x I

Examples: 60 Watts = 12 Volts x 5 Amp

60 Watts = 120 Volts x .5 Amp

DC vs. AC

Electricity from a battery or solar panel is called Direct Current (DC)
There is a Positive contact/wire (+) and a Negative (-)



The grid electricity is Alternative Current (AC)
Each wire changes from + to – 50 times or 60 times per second

Devices made for one type of current CANNOT be used with the other
When measuring V or I, need to use different multimeter settings

AC Advantages

- The main advantage of AC over DC is that transformers can be use to change the AC voltage from a lower value to the higher value or the other way around
  - That is 230 Volts AC can be easily raised to 1000 Volts AC, or 230 Volts AC can be lowered to 110 Volts or 12V AC
- Another advantage is that it can run AC motors that are simpler in construction than the equivalent DC motors

Simple electrical circuit

On/off switch

\+

12V DC

Light bulb (load)

e.g.
11W
50W

\-

I = ? Amp

110V AC

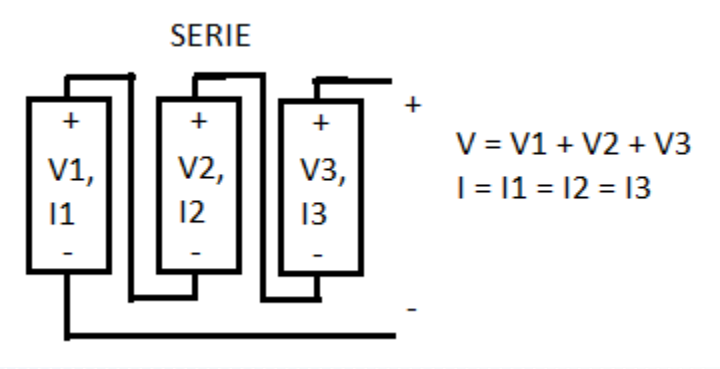
e.g.
11W
30W
50W

I = ? Amp

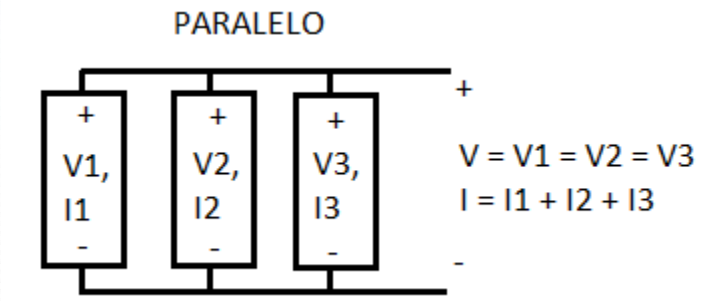
Remember: P = V x I I = P /V

Series vs. parallel

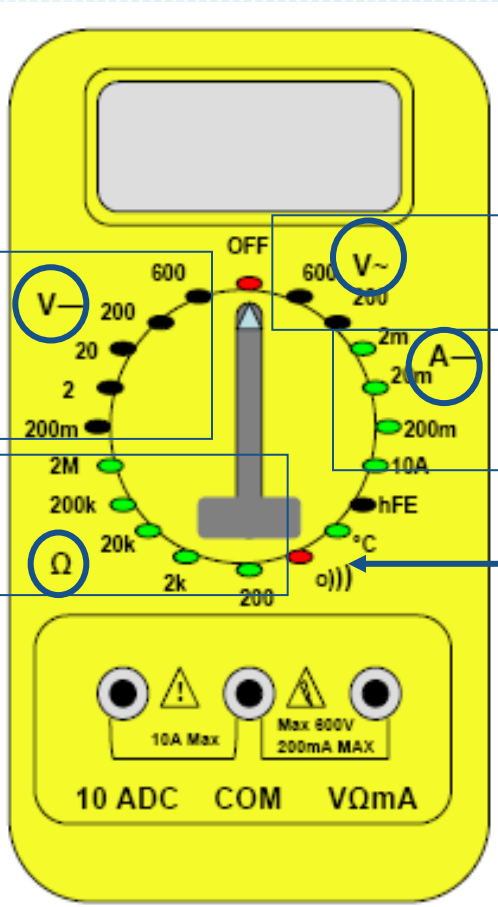
- When devices are connected i**n series**,
  - The same current passes through all components: I = I1 = I2 etc.
  - In DC the (+) contact of one device is connected to the (-) of the next one.
  - The voltage across the full circuit is the sum of the voltages across all components. V = V1 + V2 + V3, etc.



- When components are connected in **parallel**, the current is split between all
  - In DC, the contacts of same polarity (+) o (-) are connected together
  - The voltage is the same across all components: V = V1 = V2 = V3,
  - The total current is the sum of currents in each branch: I = I1 + I2 + I3.



Using a Voltmeter: select what will be measured



0.2 - 600 Volts DC

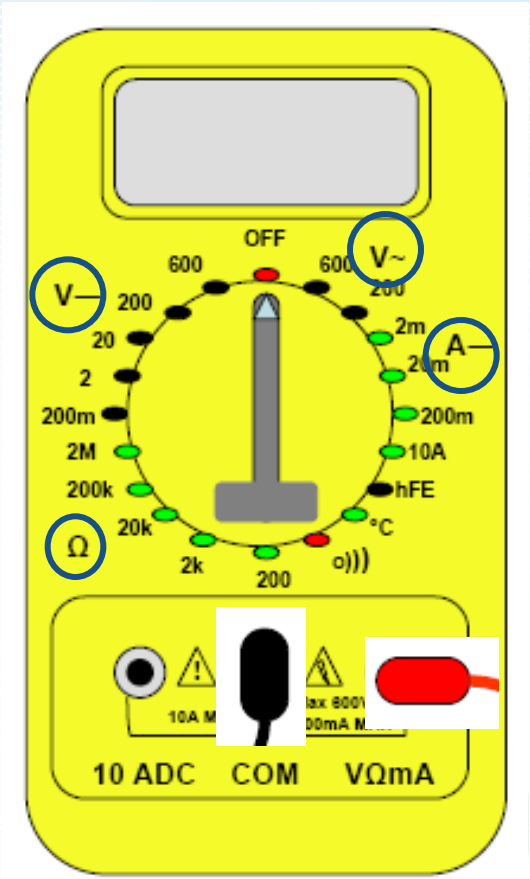
200 - 600 Volts AC

DC Amps

resistance

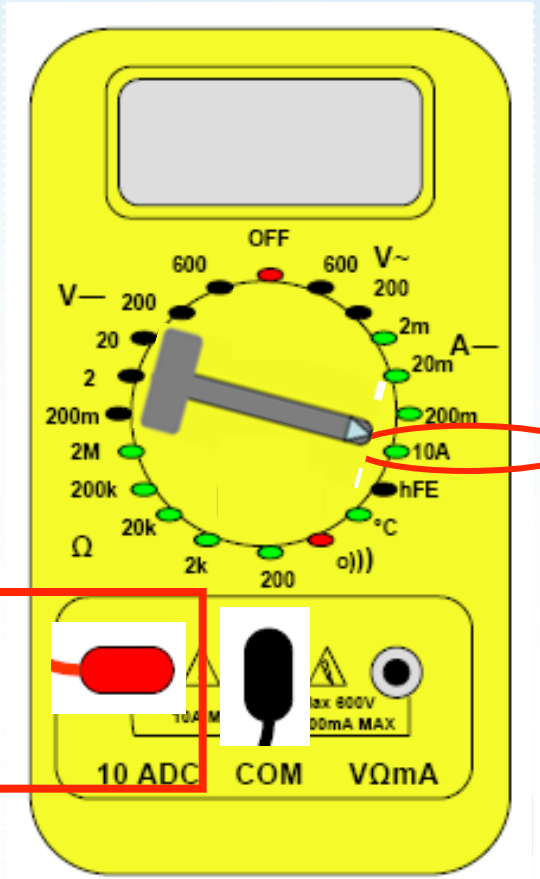
continuity check

Using a Voltmeter: connect probes (“test leads”)



for most measurements

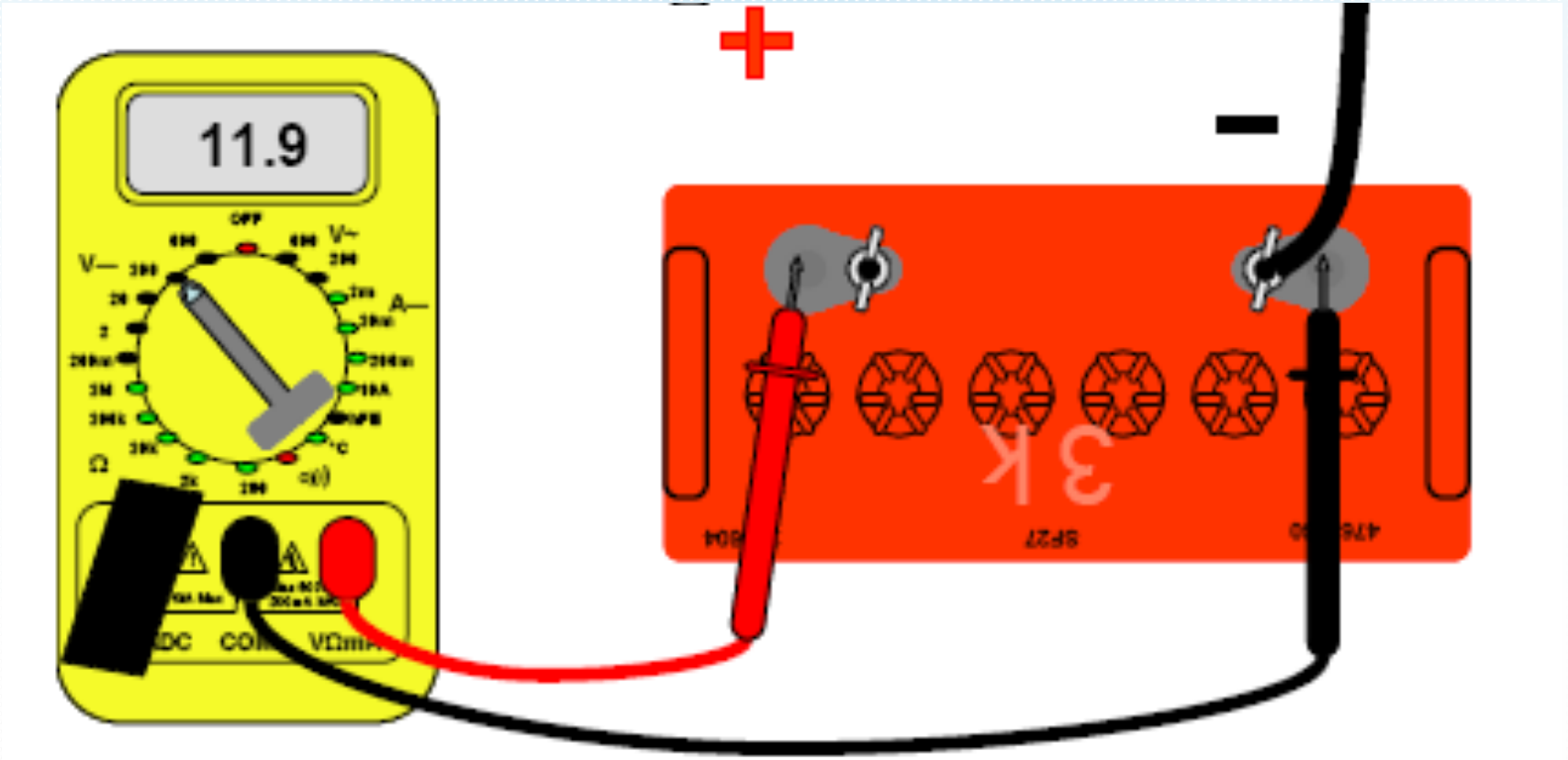
Using a Voltmeter: connect probes (“test leads”)



for high DC current only

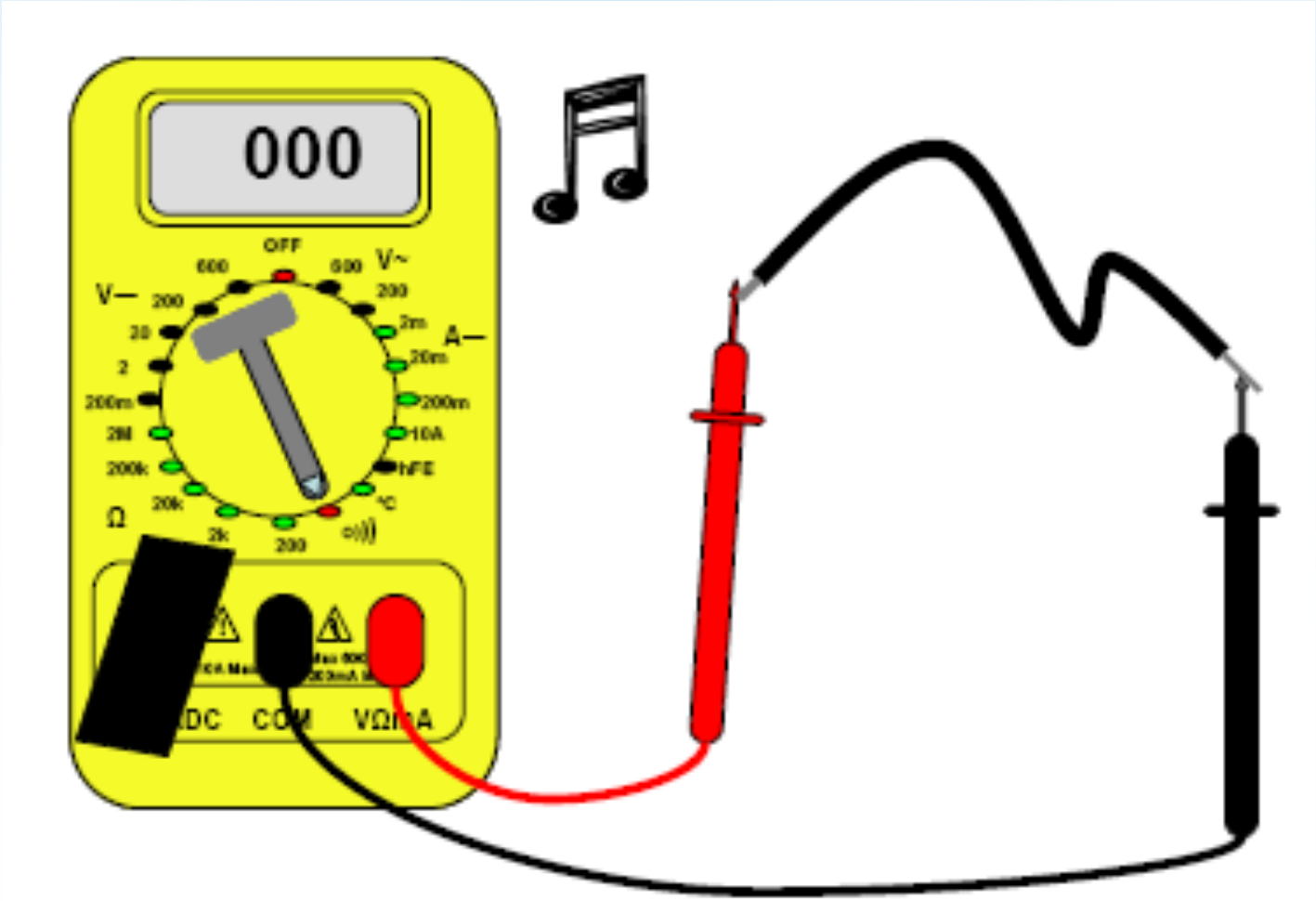
Do not leave probe connected like this!!!

Measuring Battery Voltage



Warning!
DO NOT try to measure a (short circuit) battery current like this, you would destroy the voltmeter!

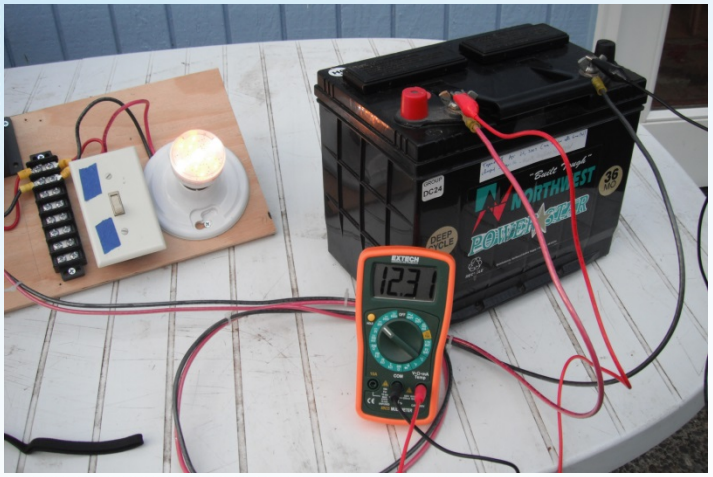
Checking continuity

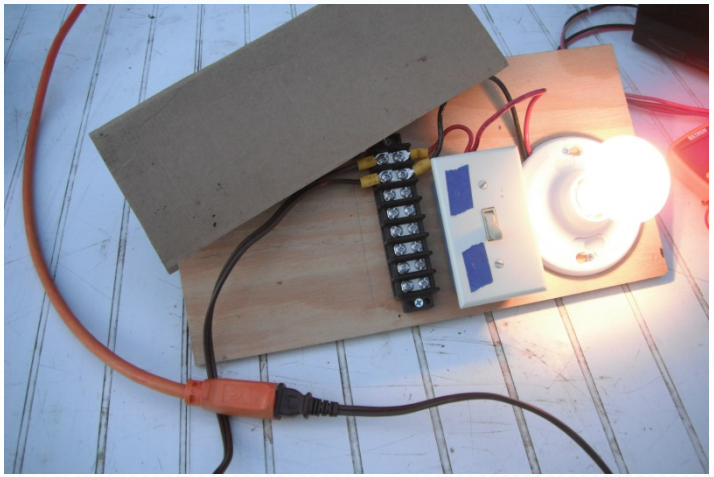


Basic Electricity – Demo

Using a basic circuit of light bulb socket + switch

- Install a 12V bulb, Connect to a 12V battery, measure voltage & current, compute power
- Install a 220V bulb, connect to AC outlet, measure voltage & current, compute power





Summary – Key Points

- Current symbol: **'I'**, unit: **'A'** (Ampere or Amp)
  - I = V / R
- Voltage symbol: **'V'**, Unit: **'V'** (Volt)
  - V = I x R
- Resistance symbol: **'R'** and Unit: **'Ω'** (Ohm)
  - R = V / I
- Power symbol: **'P'** and Unit: **'W'** (Watt)
  - P = I x V
- Meters
  - Multimeter and clamp meter
- AC: variable polarity and DC: fixed polarity