

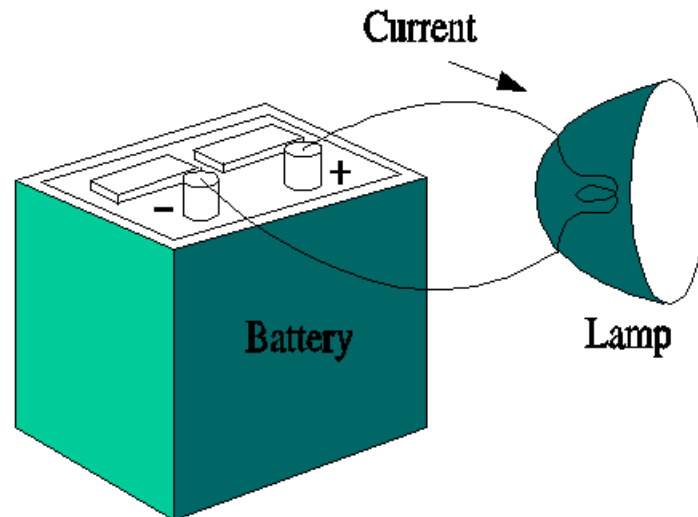


- An electric circuit is an interconnection of electrical elements.

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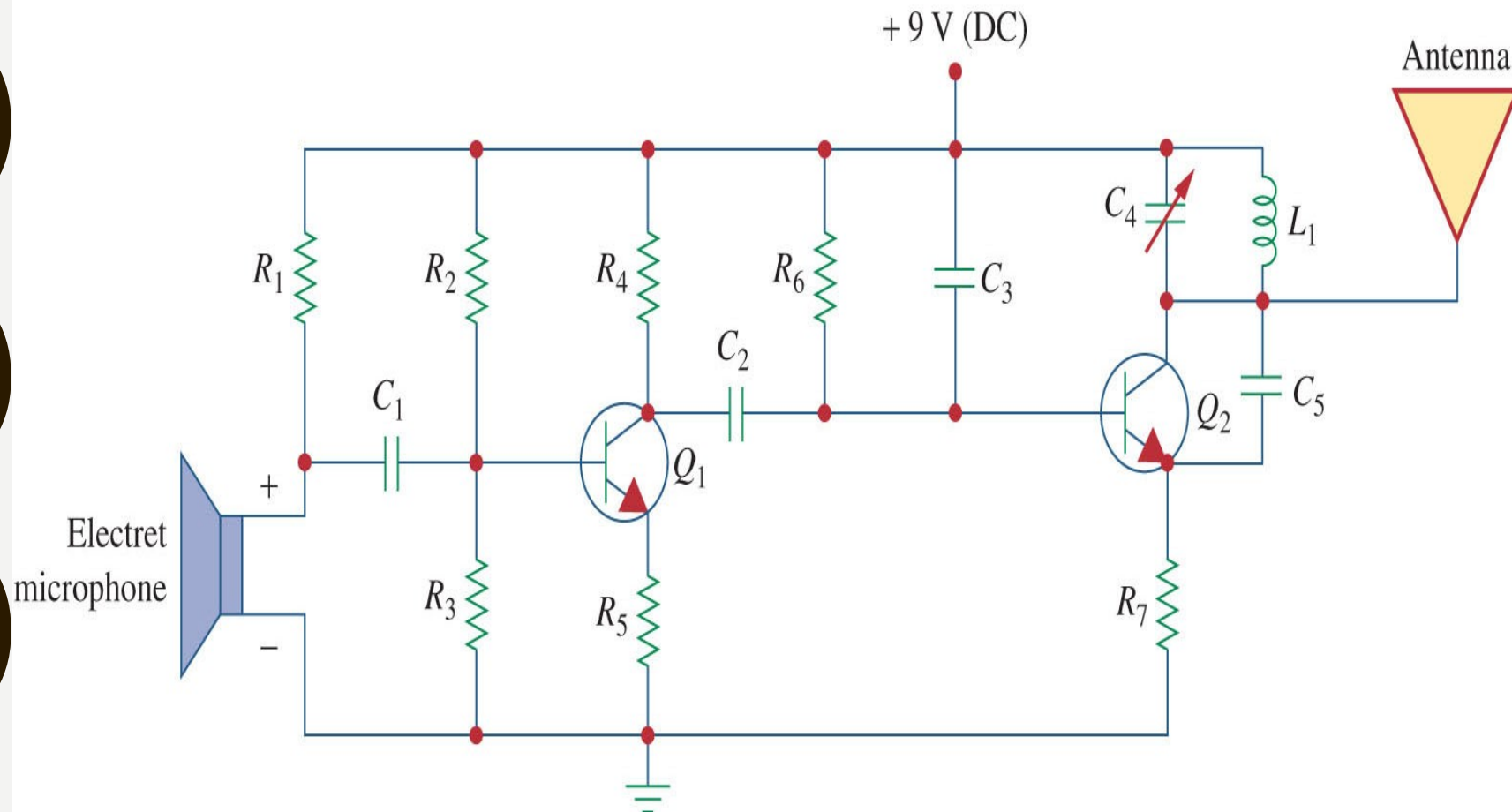
FUNDAMENTALS OF ELECTRIC
CIRCUITS

Fig. 1.1 A simple electric circuit





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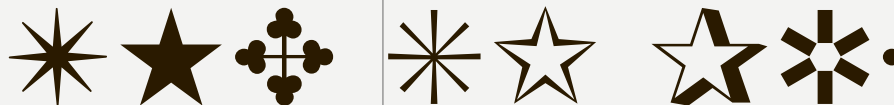




- **When taking measurements, we must use units to quantify values**
- **We use the International Systems of Units (SI for short)**

BASIC SI UNITS

Quantity	Basic Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic Temperature	kelvin	K
Luminous intensity	candela	cd



- **Prefixes on SI units allow for easy relationships between large and small values**

TABLE 1.2

The SI prefixes.

Multiplier	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

TABLE 1.2**The SI prefixes.**

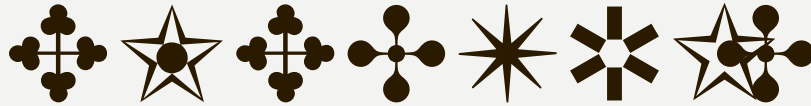
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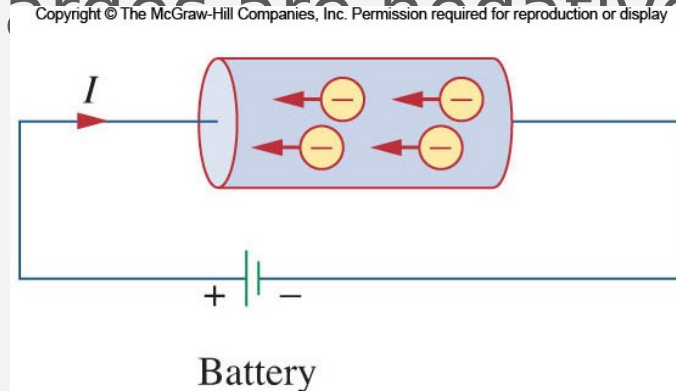
- **Charge** is a basic SI unit, measured in **Coulombs (C)**
- Charge of single electron is 1.602×10^{-19} C
- One Coulomb is quite large, 6.24×10^{18} electrons.



- In the lab, one typically sees (pC, nC, or μC)
- Charge is always multiple of electron charge
- Charge cannot be created or destroyed, only transferred.



- The movement of charge is called a current
- Historically the moving charges were thought to be positive
- Thus we always note the direction of the equivalent positive charges, even if the moving charges are negative.





- Current, i , is measured as charge moved per unit time through an element.

$$i \equiv \frac{dq}{dt}$$

- Unit is Ampere (A), is one Coulomb/second

Voltage: a force that pushes the current through the circuit (in this picture it would be equivalent to gravity)

Resistance: friction that impedes flow of current through the circuit (rocks in the river)

Current: the actual “substance” that is flowing through the wires of the circuit (electrons!)

***How you
should be
thinking about
electric
circuits:***

Voltage: a force that
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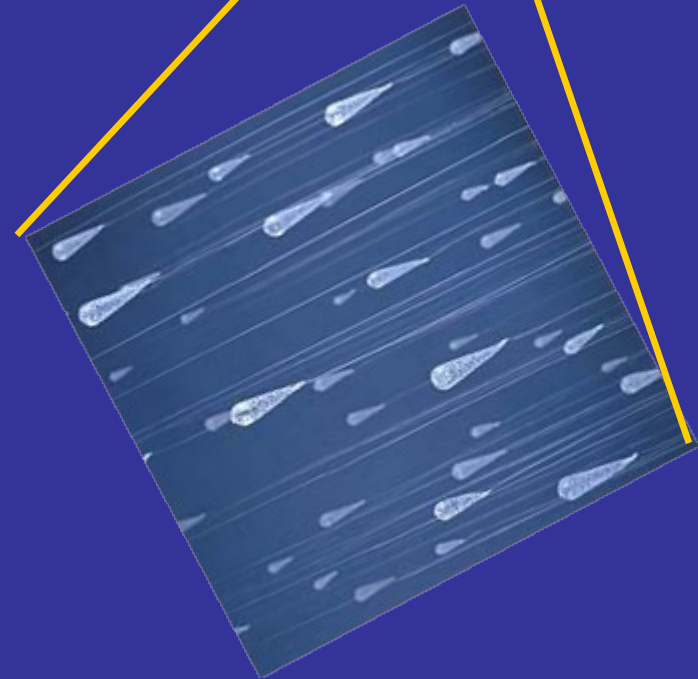
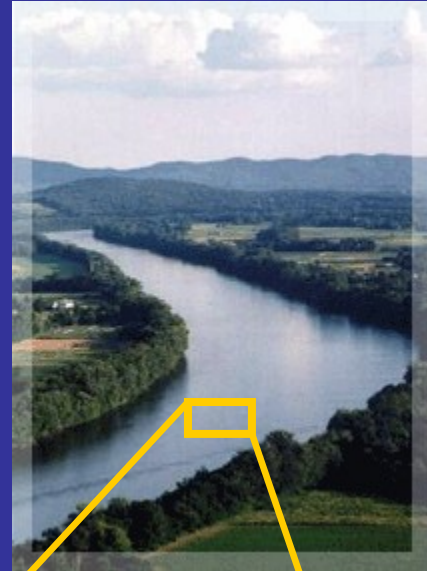
***How you
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**Resistance: friction that
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***How you
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**Current: the actual
“substance” that is
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wires of the circuit
(electrons!)**



Example 1.1

If a current of 5 A flows for 2 minutes, find the quantity of electricity transferred.

Solution

Quantity of electricity $Q = It$ coulombs

$$I = 5 \text{ A}, t = 2 \times 60 = 120 \text{ s}$$

$$\text{Hence, } Q = 5 \times 120 = 600 \text{ C}$$

Force

The *unit of force* is the newton (N) where one newton is one kilogram meter per second squared. The newton is defined as the force which, when applied to

Example 1.2

A mass of 5000 g is accelerated at 2 m/s^2 by a force. Determine the force needed.

Solution

Force = mass $\times$ acceleration

$$= 5 \text{ kg} \times 2 \text{ m/s}^2 = 10 \frac{\text{kg m}}{\text{s}^2} = \mathbf{10 \text{ N}}$$

Example 1.3

Find the force acting vertically downwards on a mass of 200 g attached to a wire.

Solution

Mass = 200 g = 0.2 kg and acceleration due to gravity, $g = 9.81 \text{ m/s}^2$

Force acting downwards = weight = mass $\times$ acceleration

$$= 0.2 \text{ kg} \times 9.81 \text{ m/s}^2$$

$$= \mathbf{1.962 \text{ N}}$$

Work

The *unit of work or energy* is the *joule* (J) where one joule is one Newton meter.

The joule is defined as the work done or energy transferred when a force of one newton is exerted through a distance of one meter in the direction of the force.

Thus,

work done on a body, in joules $W = Fs$

where F is the force in Newtons and s is the distance in meters moved by the body in the direction of the force. Energy is the capacity for doing work.

Example 1.4

A portable machine requires a force of 200 N to move it. How much work is done if the machine is moved 20 m and what average power is utilized if the movement takes 25 s?

Solution

$$\begin{aligned}\text{Work done} &= \text{force} \times \text{distance} \\ &= 200 \text{ N} \times 20 \text{ m} \\ &= 4000 \text{ Nm or 4 kJ}\end{aligned}$$

$$\begin{aligned}\text{Power} &= \frac{\text{work done}}{\text{time taken}} \\ &= \frac{4000 \text{ J}}{25 \text{ s}} = 160 \text{ J/s} = 160 \text{ W}\end{aligned}$$

Power

The *unit of power* is the watt (W) where one watt is one joule per second. Power is defined as the rate of doing work or transferring energy. Thus,

power in watts, $P = \frac{W}{t}$

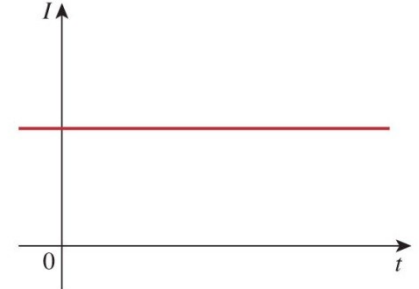
where W is the work done or energy transferred in joules and t is the time in seconds. Thus,

energy, in joules, $W = Pt$

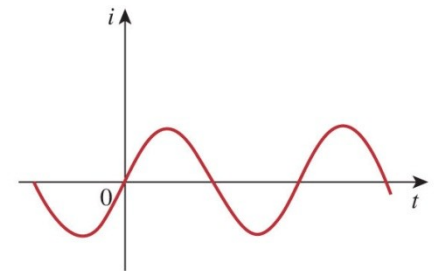


- A current that remains constant with time is called Direct Current (DC)
- Such current is represented by the capital I , time varying current uses the lowercase, i .
- A common source of DC is a battery.
- A current that varies sinusoidally with time is called Alternating Current (AC)
- Mains power is an example of AC

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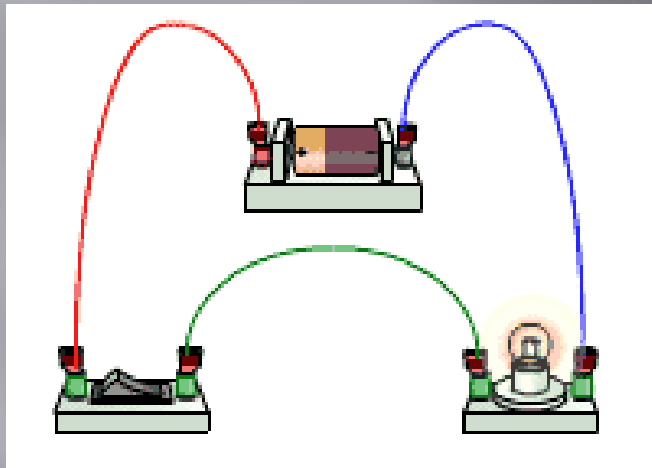
(a)



(b)

circuit diagram

Scientists usually draw electric circuits using symbols;



cell



lamp

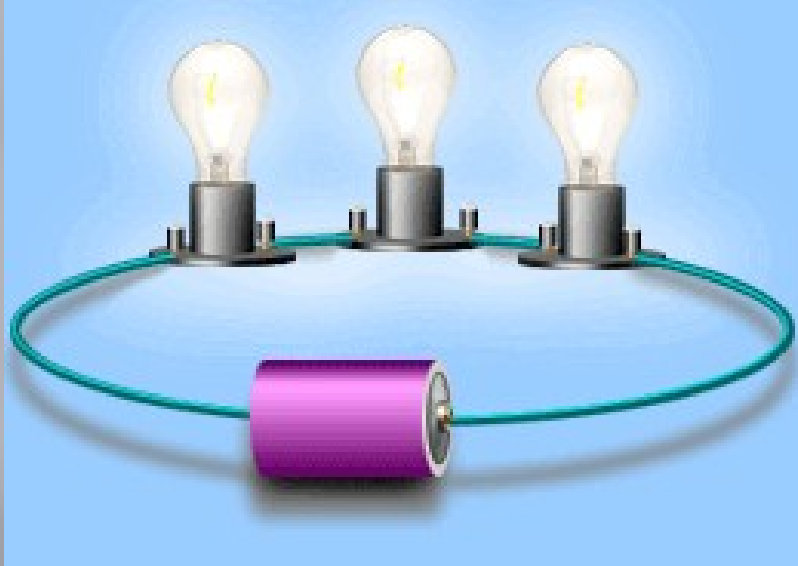


switch

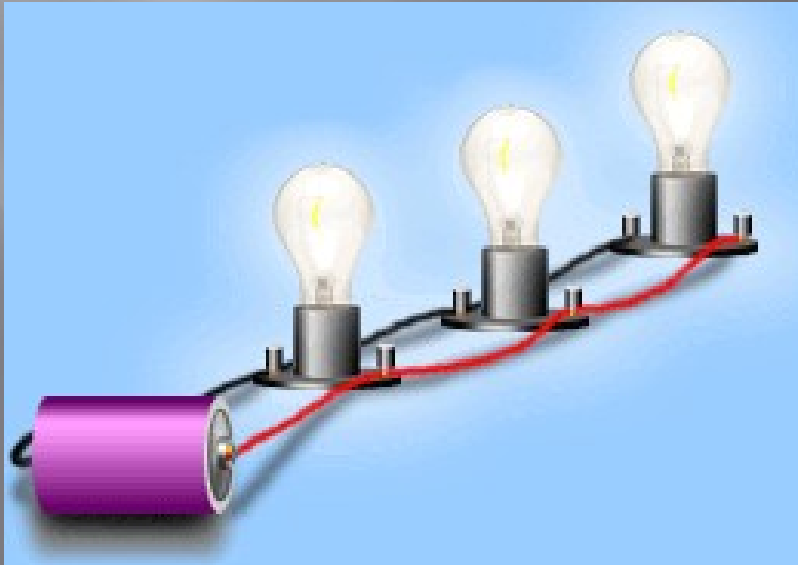


wires

Simple Circuits



- Series circuit
 - All in a row
 - **1 path** for electricity
 - 1 light goes out and the circuit is broken

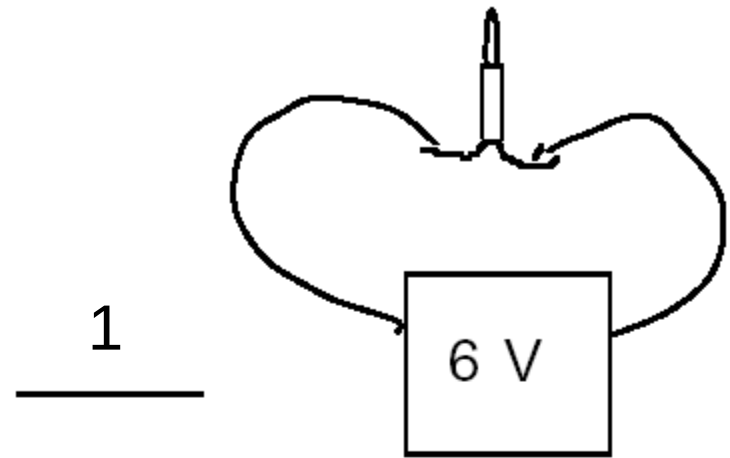


- Parallel circuit
 - **Many paths** for electricity
 - 1 light goes out and the others stay on

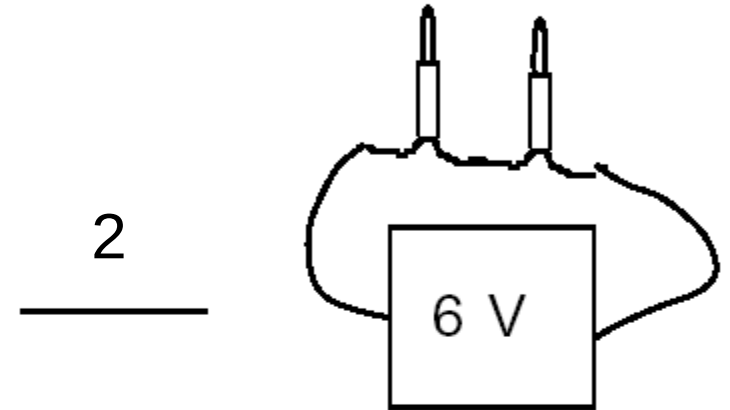
SERIES CIRCUITS



Connect one bulb to the battery.



Connect 2 bulbs and the battery to form a series circuit.



Connect 3 bulbs and the battery to form a series circuit.

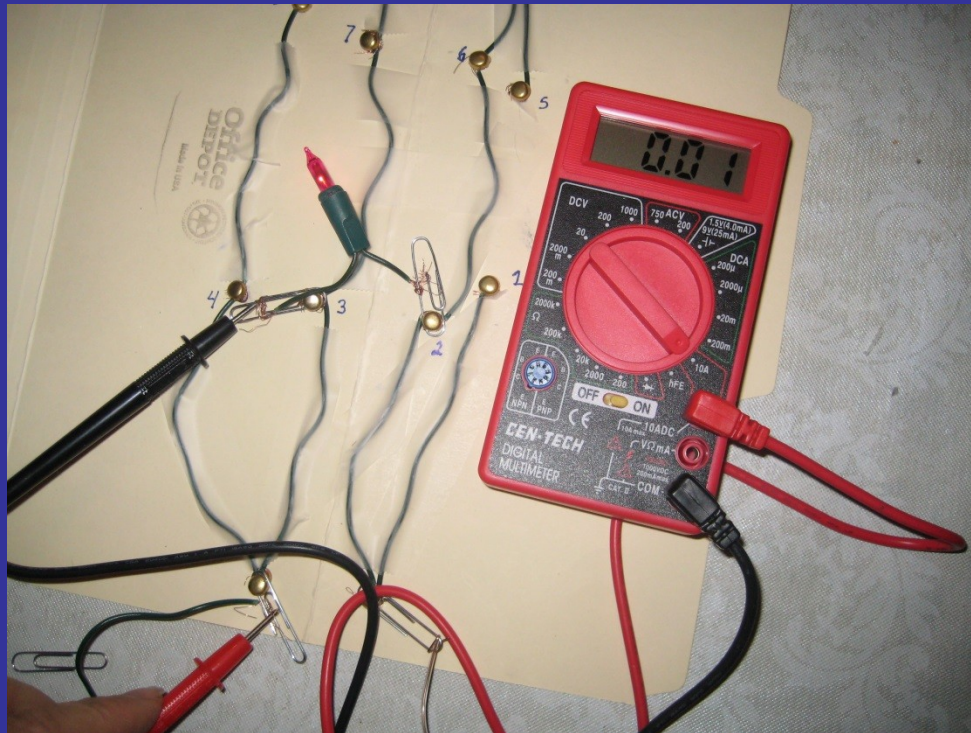


PARALLEL CIRCUIT

- Place two bulbs in parallel. What do you notice about the brightness of the bulbs?
- Add a third light bulb in the circuit. What do you notice about the brightness of the bulbs?
- Remove the middle bulb from the circuit. What happened?

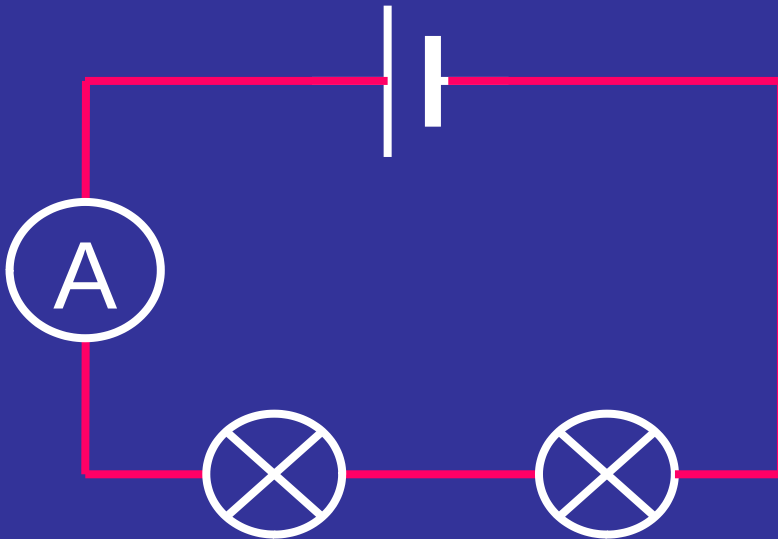
measuring current

Electric current is measured in **amps** (A) using an ammeter connected in series in the circuit.

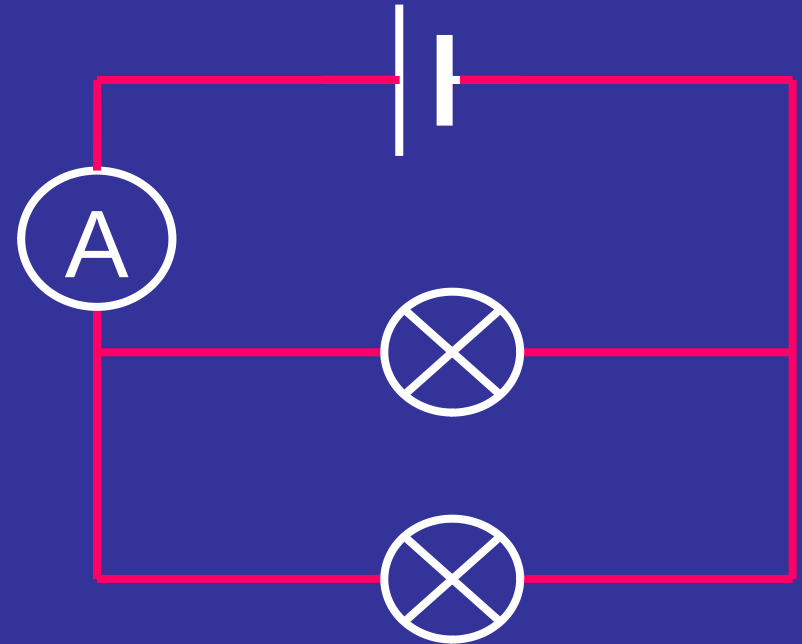


measuring current

This is how we draw an ammeter in a circuit.



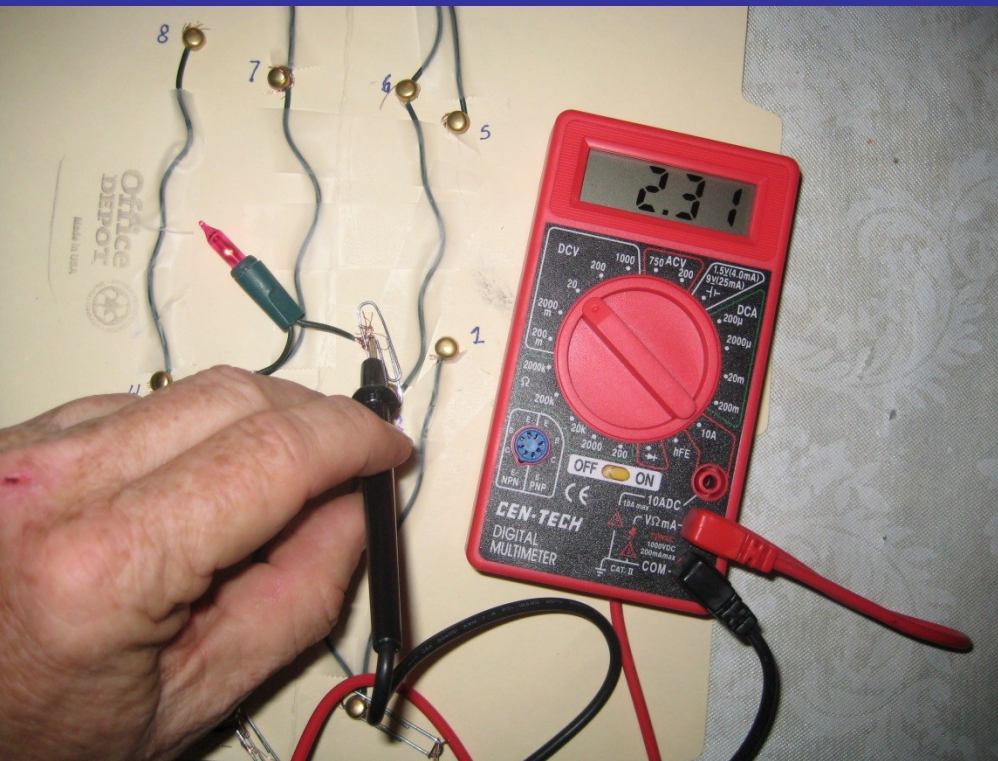
SERIES CIRCUIT



PARALLEL CIRCUIT

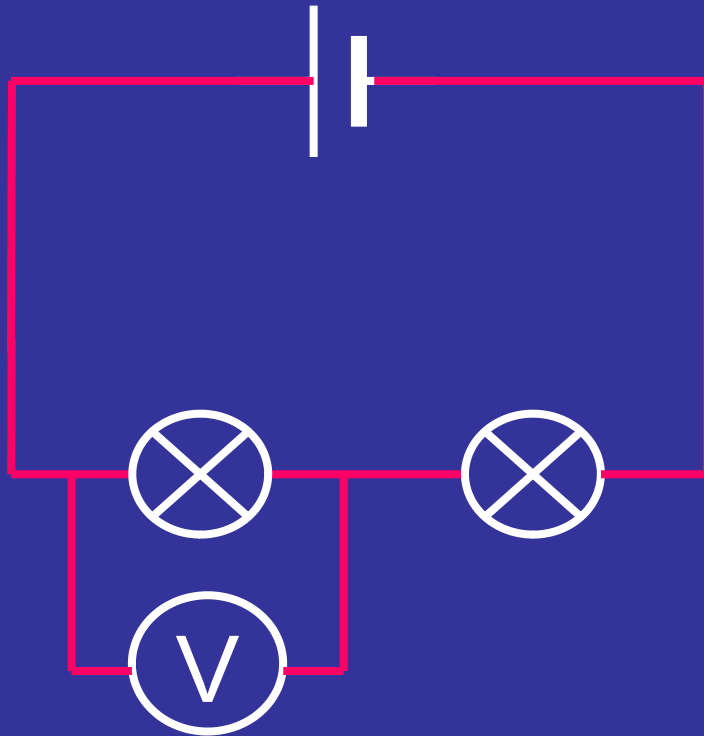
measuring voltage

The 'electrical push' which the cell gives to the current is called the voltage. It is measured in **volts** (V) on a **voltmeter**

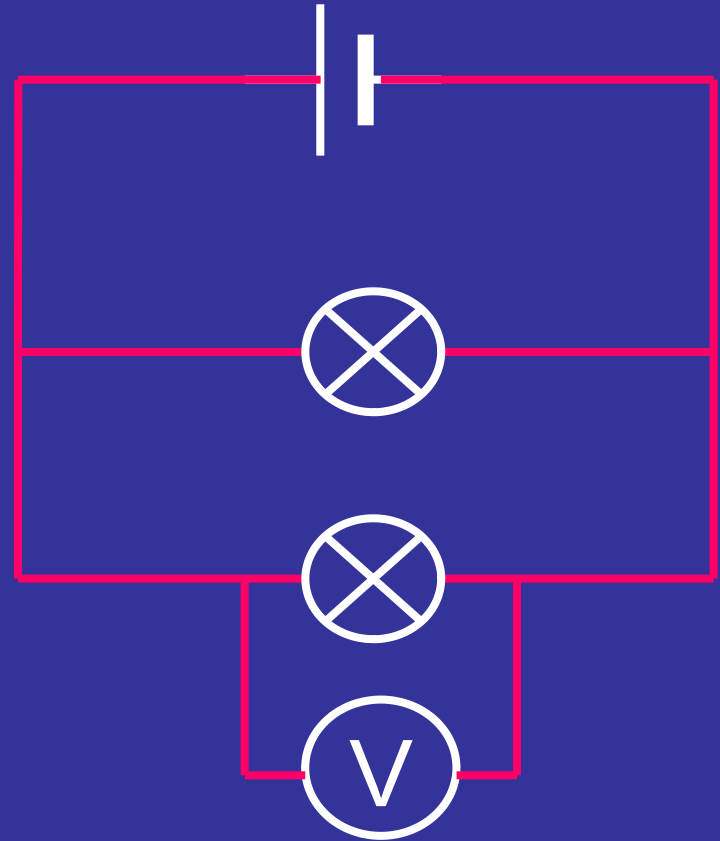


measuring voltage

This is how we draw a voltmeter in a circuit.



SERIES CIRCUIT



PARALLEL CIRCUIT

