

ELECTRICITY UNIT

Electricity is the movement of electrons (or other charged particles) through a conductor. (A conductor is something that electrons can move through – haha.)

** Electrons are negatively charged. Review Bohr model of atom.*

There are two types of electricity: current electricity (above) and static electricity.

Static Electricity

Static electricity is the transfer of electrons from one object to another object. The two objects become charged positive and negative.

① **Opposite charges attract** + ⇒ ⇐ -

② **Similar charges repel** + ⇐ ⇒ +

③ Static electricity doesn't have enough power to do any work.

④ It is used for:

- photocopiers
- air filters
- spray painting cars
- capacitors

⑤ It can be discharged by touching metal or water or by humidity.

(Try out the van der graaf static generator)

◆ The fundamental unit of electricity is charge. ◆

Electrons are too small to count, so we normally use a bigger unit: Coloumbs

Charge: symbol Q, units Coloumbs (C)

$$1 \text{ C} = 6.24 \times 10^{18} \text{ e}^-$$

$$1 \text{ e}^- = 1.602 \times 10^{-19} \text{ C.}$$

It is actually very hard to measure charge directly with any accuracy. We normally measure current, voltage, etc. and calculate what the charge must be from that.

How many electrons are used to make a piece of toast? (estimate power of toaster, time to toast, 120 V)

Current Electricity

Current:

Current is the how many electrons go through a wire each second.

Symbol **I** ,units: amperes or amps (A) or milliamps (mA). 1A = 1000 mA

Formula: current = charge / time $I = Q / t$

High current makes friction --> heat --> melting or fire.

(demonstrate with nail melting transformer)

Current is like how big your hose pipe is, how much water comes out of it.

Voltage:

symbol **V** , units: volts (V)

Voltage is the energy that each electron has.

Voltage = Energy / Charge $V = E/Q$ Units: Volts (V)

High voltage makes sparks. It takes about 40,000V for a spark to jump through 1 cm of air. The coil/condenser in car engine makes high voltage for spark plugs.

Voltage is like water pressure in a hose pipe.

(demonstrate sparks with tesla coil)

IMPORTANT NOTE:

Voltage is also often called “electric potential” or “potential difference”.

A lightning bolt can transfer 15-20 C of charge at 300-600 million volts with a current of 30,000 A. We don't have any conductors that can handle that much current and probably no insulators to handle that much voltage.

How is electricity produced?

All electricity is produced by one of these methods:

Name of process	Description	Device
electromagnetic induction	wire going through a magnetic field	generator
voltaic cells	chemical reaction causes electrons to move	battery
photoelectric effect	light hits semiconductor makes electrons move	solar cell
thermoelectric effect	two different metals wires joined at one end at two different temperatures produce small voltage	thermocouple

The 4 processes above produce current electricity.

The processes below only produce voltages (static charges)

Name of process	Description	Device
piezoelectric effect	quartz crystals develop opposite voltages on ends when compressed	BBQ spark lighter
pyroelectricity	Heating quartz produces charges on ends of crystal	?
friction	Rubbing transfers electrons from one substance to another	van der Graaf generator brushing hair

Fuel cells make electricity directly from combining H and O, producing H₂O as a byproduct. I think that the mechanism is similar to batteries – some sort of chemical reaction.

What is electricity? Here are the main quantities and units

Quantity	What it is in words (& formulas)	Symbol	Units
Electricity	non-moving charges: static moving charges: current often meaning electrical energy	---	use other quantities
Charge	large # of electrons, protons, ions	Q	Coulomb (C)
Current	flow of charges per unit time $I = Q/t$	I	Amps, Amperes, (A)
Voltage	<i>the energy that each charge has</i> $V = E/Q$	V	Volts (V)
Resistance	the opposition to current flowing $V = IR$	R	Ohms (Ω)
Energy	$E = QV$ $E = P t$	E	Joules (J)
Power	energy used per second $P = IV$ $P = E/t$	P	Watts (W)
Capacitance	how much charge can be stored $C = Q/V$	C	Farads (F)