Numbers and Units,
Current and Voltage

Numbers

- In electronics, we sometimes have to deal with very large or very small numbers:

speed of light	300,000,000 m/s
microwave frequency	2,450,000,000 Hz
charge on an electron	0.00000000000000000016 C

Numbers

- We use **scientific notation**:

$$a \times 10^b$$

property	decimal notation	scientific notation
speed of light	300,000,000 m/s	3×10^8 m/s
microwave frequency	2,450,000,000 Hz	2.45×10^9 Hz
charge on an electron	0.00000000000000000016 C	1.6×10^{-19} C

There are number of worksheets available in blackboard Learn

Units

- All measurable quantities have a **unit**:

400 meters   400 m

6 inches   6''

1 kilogram   1 kg

30 minutes   30 minutes

60 miles/hour   60 mph

- There are many different **number systems**...

SI Units

- Le Système International d'Unités
  - (International System of Units)
  - 'SI'

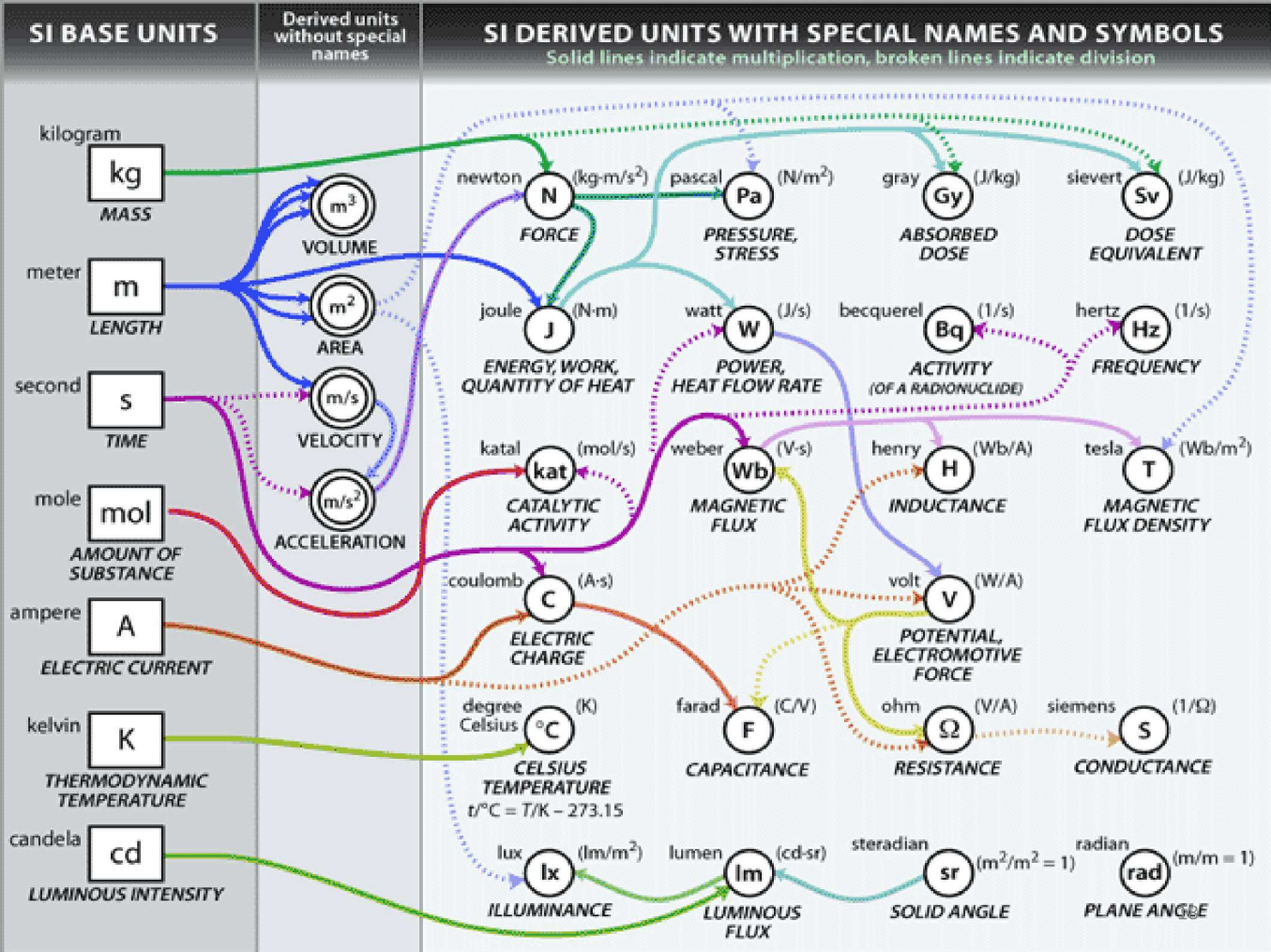- Adopted in the 1960's

  meter, m
  kilogram, kg
  second, s

Units

- Most units are devised from 7 **fundamental units**:

name	unit symbol	quantity
meter	m	length
kilogram	kg	mass
second	s	time
ampere	A	electric current
kelvin	K	temperature
candela	cd	luminous intensity
mole	mol	amount of substance

SI Prefixes

2TB hard drive

- The SI convention defines multiplying **prefixes** to indicate multiple or fractional values of units:

name	symbol	factor
kilo	k	10^3
mega	M	10^6
giga	G	10^9
tera	T	10^{12}
peta	P	10^{15}

increasing

name	symbol	factor
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

decreasing

Atoms

- The **atom** is a basic unit of matter:
  - a dense, central nucleus surrounded by a cloud of negatively charged electrons
- The **nucleus** contains a mix of positively charged protons and electrically neutral neutrons:
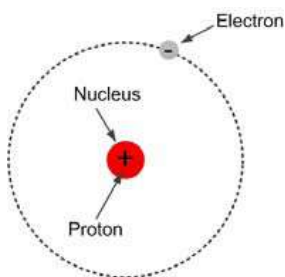 - except for a hydrogen atom which only has one proton

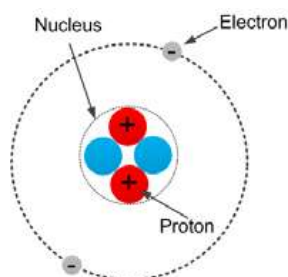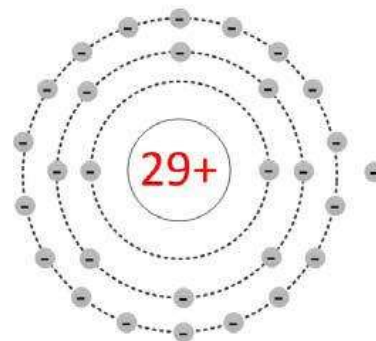| component	charge
proton	positive
electron	negative
neutron	neutral
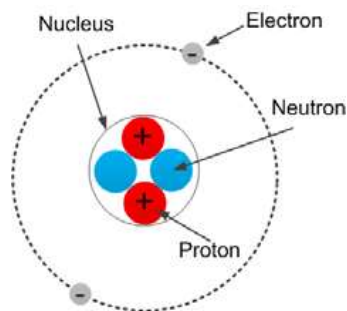
Atomic Structure

- The atomic structure of any **stable atom** has an equal number of electrons and protons
- Each orbiting electron carries a negative charge equal in magnitude to the positive charge of the proton

Hydrogen
1 electron + 1 proton
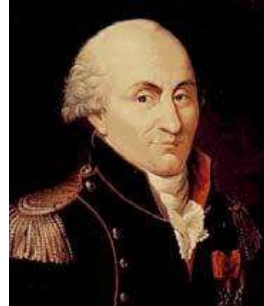
Helium
2 electrons + 2 protons
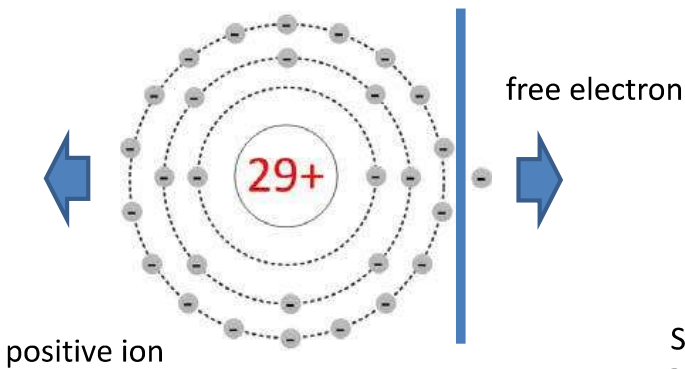
Copper
29 electrons + 29 protons

Electric Charge

- Electric **charge** is measured in Coulombs, C
- The charge on one electron is 1.6×10^{-19} C
  - usually referred to as *e*

free electron

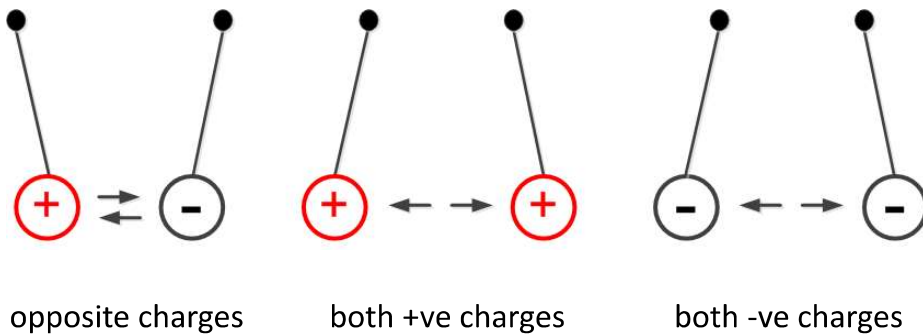positive ion

Charles Augustin Coulomb,
French (1736-1806)
Scientist and inventor who formulated
Coulomb's Law, which defines the force
between two electrical charges

Electric Force

- Charges of opposite polarity **attract**
- Charges of the same polarity **repel**

opposite charges   both +ve charges   both -ve charges

Fill in the Blanks

- Two atoms walk into a bar:

    The first atom "I think I've lost an electron!"

    The second atom says "Are you sure?"

    The first atom replies "I'm _____!"

    A. neutral B. negative C. positive

- A neutron walks into a bar and asks how much for a drink:

    The bartender replies, "For you, _____ charge."

    A. no B. negative C. positive

Voltage

- In a battery, charge is separated into regions of positive and negative charge
- Through chemical action, a concentration of positive charge (**ions**) is established at the positive terminal, with an equal concentration of negative charge (**electrons**) at the negative terminal:
    - a **voltage** is created between the two terminals

Count Alessandro Volta,
Italian (1745-1827)
Physicist who developed the
world's first capacitor and
chemical battery

Voltage – symbols and unit

Symbol	V
Unit	volts
Unit symbol	V

E.g:
- Voltage of a AA battery of 1.5 volts,
  or V=1.5V
- Voltage across a bulb 240 volts
  or V=240V

Voltage Source

- A **dc voltage source** is a fixed voltage that can be used to power an electronic device or an electrical system

- dc voltage sources are divided into three basic types:
  - batteries (chemical action or solar energy)
  - generators (electromechanical)
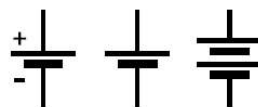 - power supplies (rectification from ac sources)

batteries

power supply

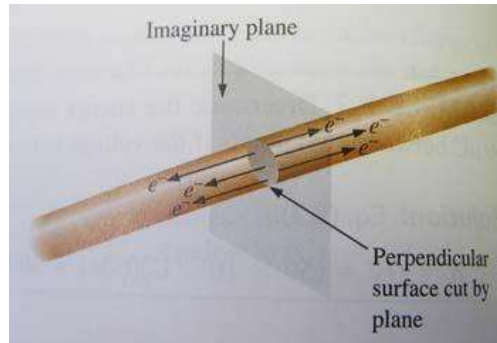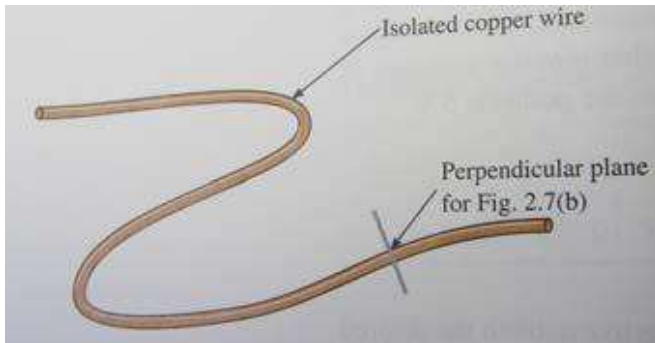circuit symbols for a dc voltage source

unit: volt, V

Current

- There is motion of free electrons (in random directions) in an isolated piece of copper wire, but the net flow of charge fails to have a particular direction due to the lack of any drive:
  - hence, **no current is generated**

Current

- When a copper wire is placed across battery terminals, the voltage forces the electrons to move towards the positive terminal of the battery:
  - hence **a current is formed**
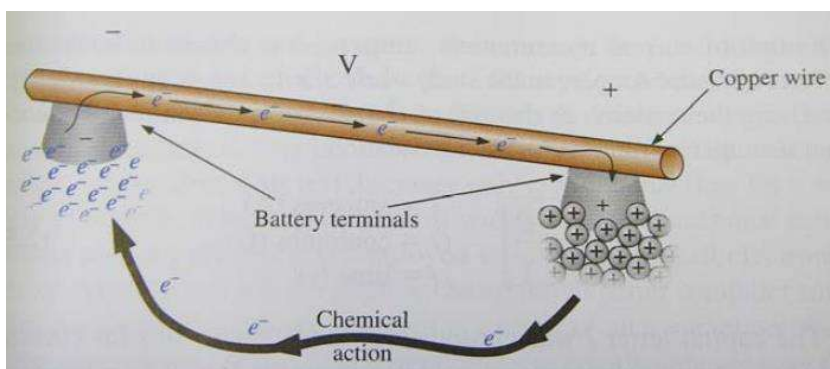
Current

- 'Conventional current', the direction of current flow, is defined to be **from positive to negative**

- However, electrons are negatively charged, so the electrons themselves are flowing in the opposite direction, **from negative to positive**

- Electrical theory was devised before the charge on an electron was found to be negative!

Current

- The current describes the **rate of charge transport**
- If a charge of Q has passed a point in a time, t, then the current is defined as:

$$I = \frac{Q}{t}$$

name	symbol	unit symbol	quantity
current	I	A	amperes
charge	Q	C	coulombs
time	t	s	seconds

Symbol for a dc current source

André-Marie Ampère, French (1775-1836) Mathematician and physicist who was one of the founders of electromagnetism

Example

- The charge flowing through the imaginary plane of a copper wire is 0.16 C every 64 ms. Determine the current in amperes.
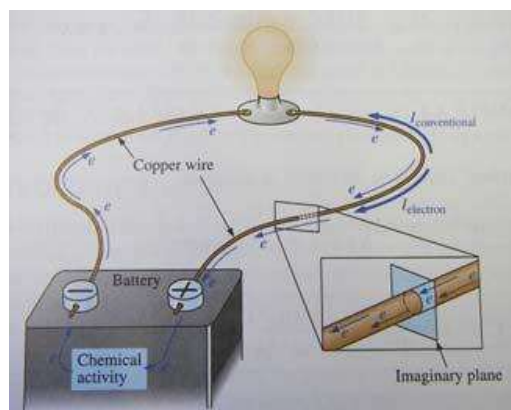
Solution:

$I = Q/t$
$Q = 0.16$ C and $t = 64$ ms $= 6.4 \times 10^{-2}$ s or 0.064 s

Substituting in the equation → $I = 0.16/0.064 = 2.5$ A

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Voltage vs. Current

- The applied voltage has established a flow of electrons in a particular direction:
  - the applied voltage is the starting mechanism
  - the current is a reaction to the applied voltage

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Voltage and Current

- How are voltage and current related?
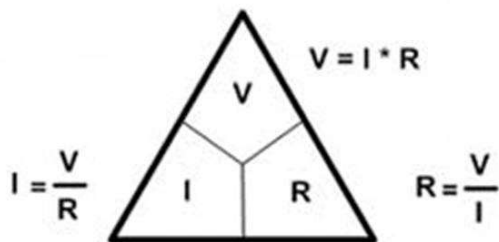
  Voltage = Resistance x Current

  V=RI or **V=IR**

- Resistance resists the current flow

Resistance	
Symbol	R
Units	Ohms
Unit sysmbol	Ω

E.g.: Resistance of a bulb is 500Ω

Voltage, Current and Resistance Triangle

- The triangle is an easy way to rearrange the equation
- Detailed lectures in week 3

Exercise

(1) The following table lists the seven fundament units. Fill in the blanks.

name	unit symbol	quantity
meter	m	length
kilogram		mass
second	s	
	A	electric current
kelvin		temperature
candela	cd	
	mol	amount of substance

(1) Write 147 nF using scientific notation?

(2) How many micro grams makes 1 kg?

(3) What is the unit of energy? Newton (N) / joule(J)/ Ampere (A)

(4) Put the following SI prefixes in ascending order?
milli, nano, kilo, maga