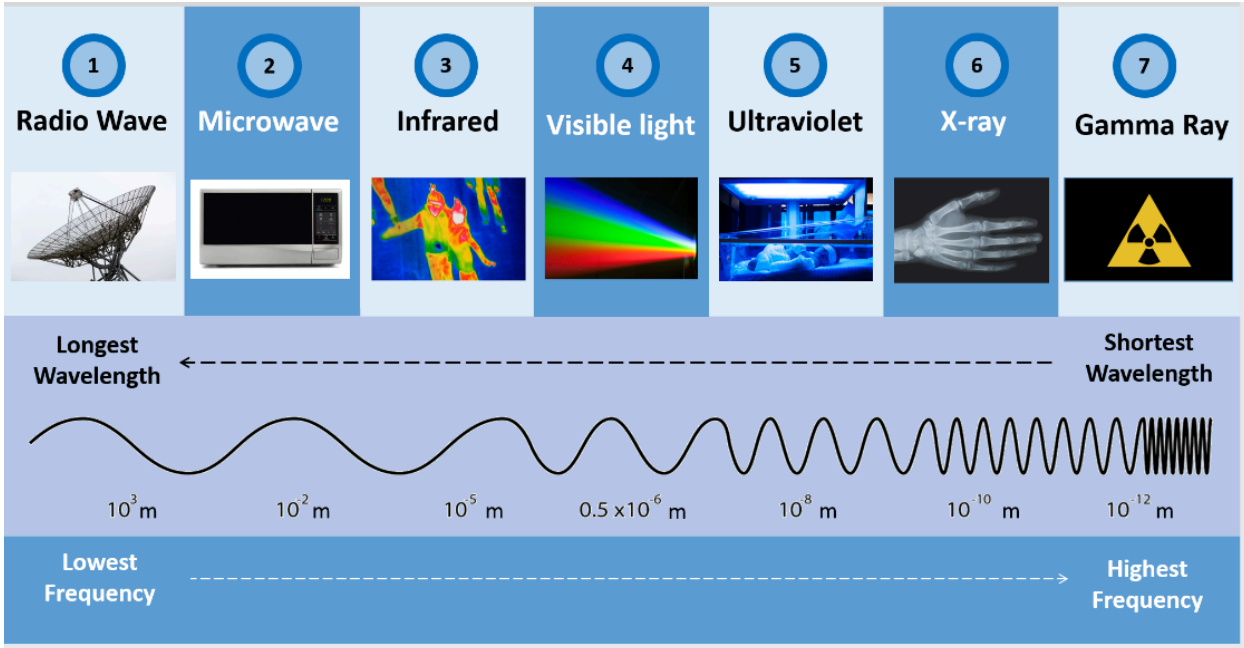
Physics Notes:

EM spectrum: range of EM waves in order of increasing frequency

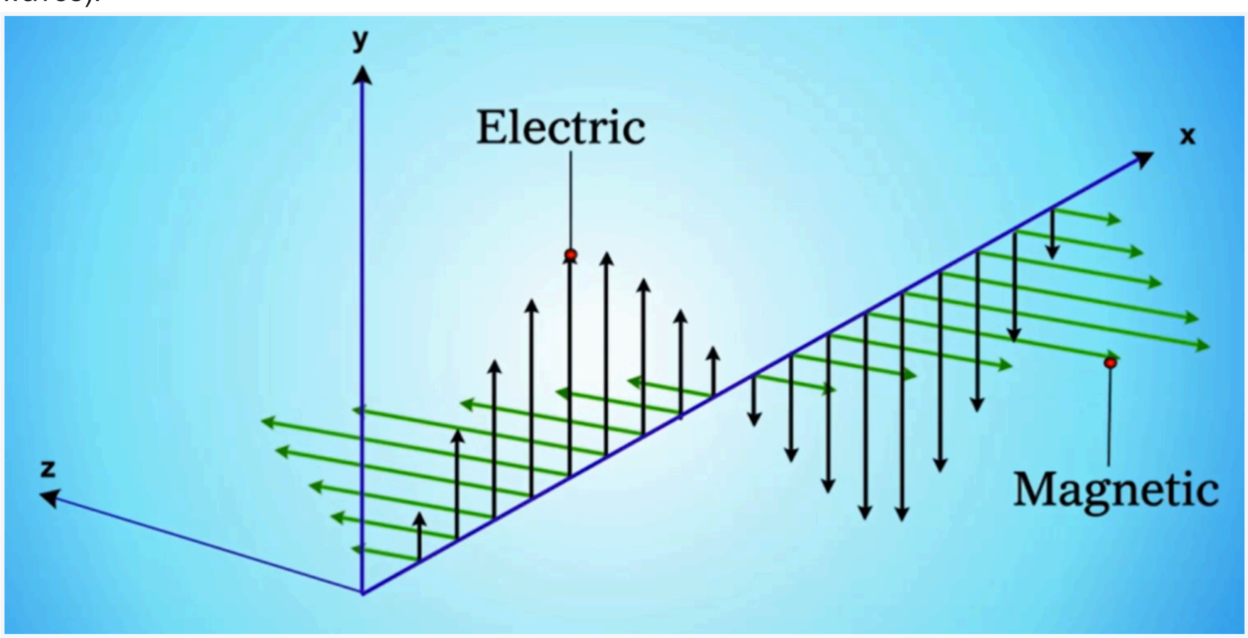


Characteristics:

EM waves are transverse waves, can travel via vacuum at same speed 3.0×10^8 m/s

The longer the wavelength, the lower the frequency, the lower the energy, vice versa.

The direction of oscillation is PERPENDICULAR to the direction of wave travel (transverse waves).

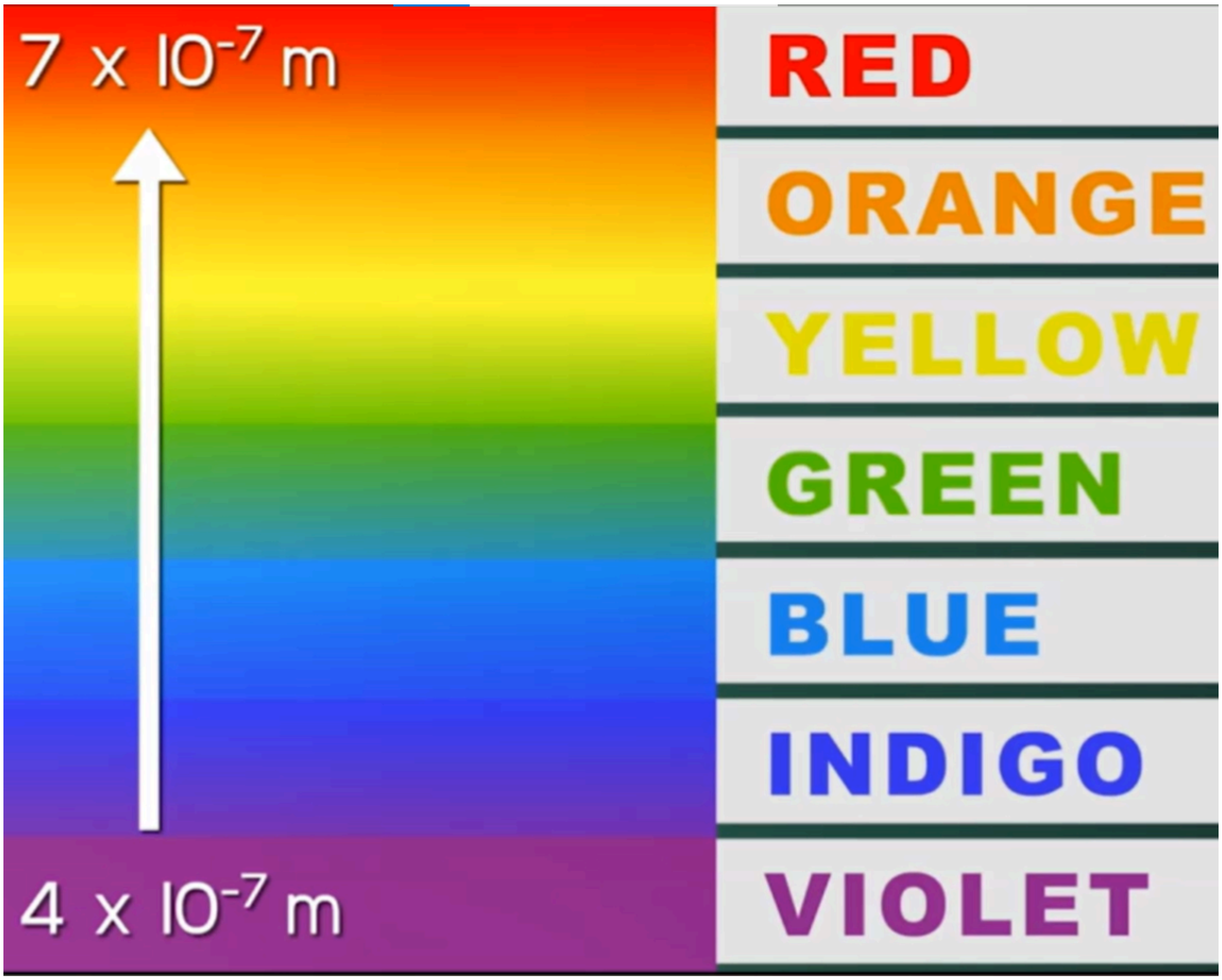


Utility:
RADIO **telescopes** study the radio frequency portion of the electromagnetic spectrum emitted by astronomical objects, such as stars.
Radio waves produced by oscillating electric currents in a transmitting **antenna** is picked by radio and TV aerials at the receiving end.

MICROWAVES of a particular frequency are readily absorbed by water molecules. Almost all food contains water, so food can be heated quickly in a microwave **oven**.
A **radar** sends out microwaves, which get reflected by other objects. When these reflected signals are detected, the radar operator will get a 'picture' of the surroundings.
When using a **satellite** phone network to make an overseas call, microwave signals are sent out to space by a large aerial dish to satellites orbiting the earth. These satellites then relay the signals to the receiving dish overseas.

Advanced security systems use passive INFRARED (PIR) **motion detectors**. These sensors "see" the infrared energy emitted by an intruder's body heat. When an intruder walks into the field of view of the detector, the sensor detects a sharp increase in infrared energy.
The transmitter in the **remote control** handset sends out pulses of infrared light when the user presses a button. Each button has a unique pattern of infrared pulses. A receiver in the device recognizes this pattern, causing the device to respond accordingly.
Infrared **cameras** detect infrared energy (heat) and converts it into an electronic signal. The signals are processed to produce a **thermal image** on a video monitor.

Light wavelength:



In telecommunication, **digital signals** are sent through optical fibres using short pulses of LIGHT.
In medicine, lasers are used to **seal blood vessels**. In industry, lasers are used to **weld metals together**.

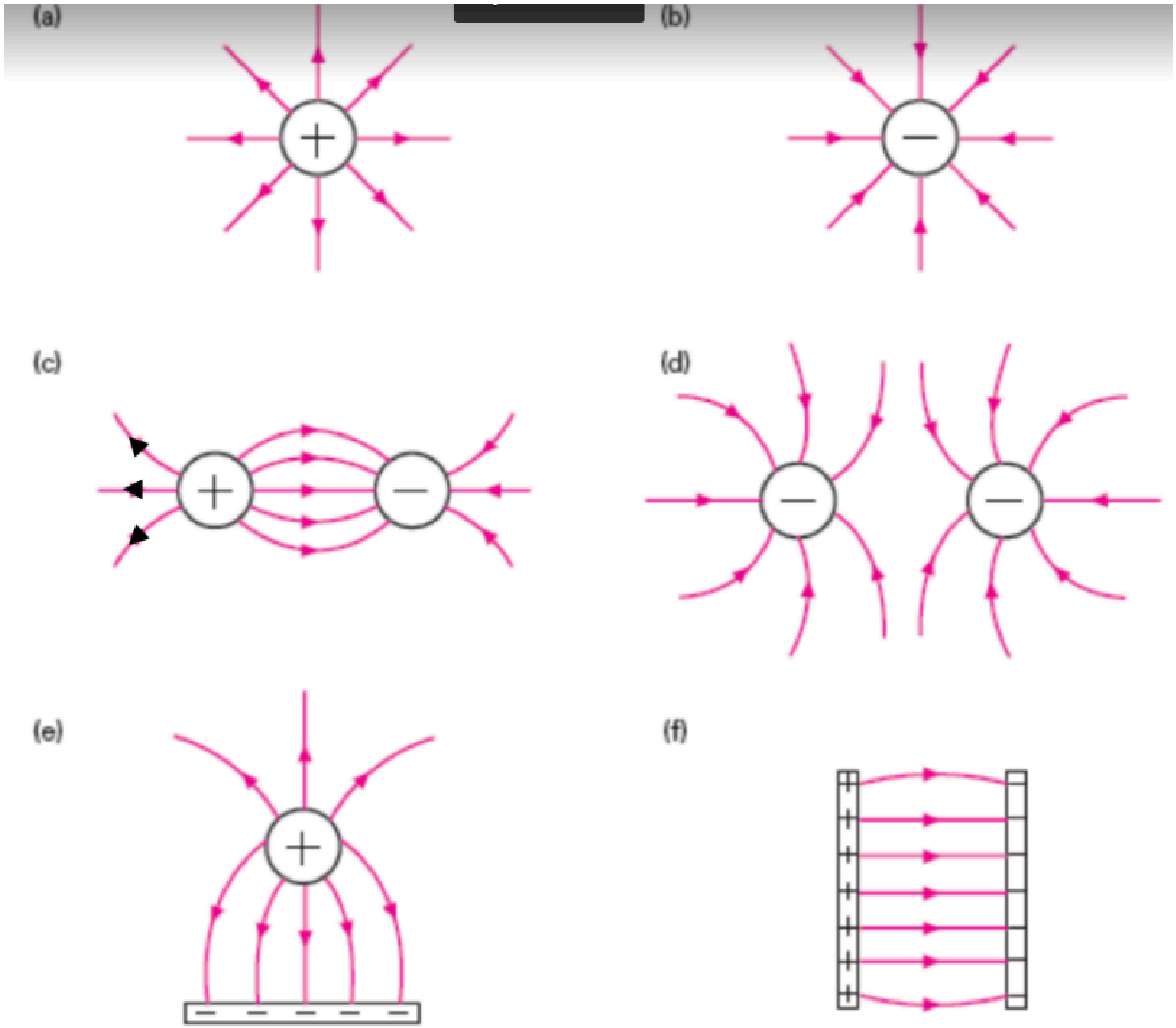
Prolonged exposure to UV rays increases your risk of developing skin cancer. This is because UV rays carries enough energy to remove electrons from atoms or molecules, thereby ionizing them. Living cells and tissue can be damaged by UV radiation.
UV counterfeit currency detectors are used to detect special inks in the bills that only appear under the proper wavelength of UV light.
Sunbeds work by exposing the skin to UV radiation, similar to that found in sunshine. This releases a chemical which causes the skin to tan.
UV sterilizer uses UV light that kills microorganisms that go through it by altering and damaging their DNA.

Living cells and tissue can be damaged by X-rays. This is because X-rays carry enough energy to remove electrons from atoms or molecules, thereby ionizing them. Overexposure to X-rays

increases the risk of developmental problems and cancer. The risk of radiation is greater to a fetus, so pregnant patients are advised to avoid exposure to X-rays.
When a beam of X-rays strike a crystal, the crystalline atoms "spread" the X-rays into many specific directions. The pattern of the "spread" can be studied to understand the crystal structure.
After the X-rays pass through the baggage, they are picked up by a detector. The "picture" formed on the monitor is used by airport staff to determine if there are dangerous items in the baggage.
On a photographic film, dark areas show where the X-rays have passed through soft body tissues. White areas show where denser material, such as bones, have absorbed the X-rays. An image of varying densities will show up on film according to the amount of X-rays that reach each area.

Because GAMMA rays kill bacteria and cells, they have been used to treat certain types of cancer. In a controlled procedure, multiple concentrated beams of gamma rays are focused onto a tumor to kill the cancer cells.
Medical instruments are sealed in an air-tight bag and then placed in a very large field of radiation that can penetrate the bag to kill bacteria.
Manufacturers use gamma rays to check for cracks or flaws in their products. Similar to X-rays (but more powerful), gamma rays take pictures of the inside of products to show flaws that are not visible from the outside.

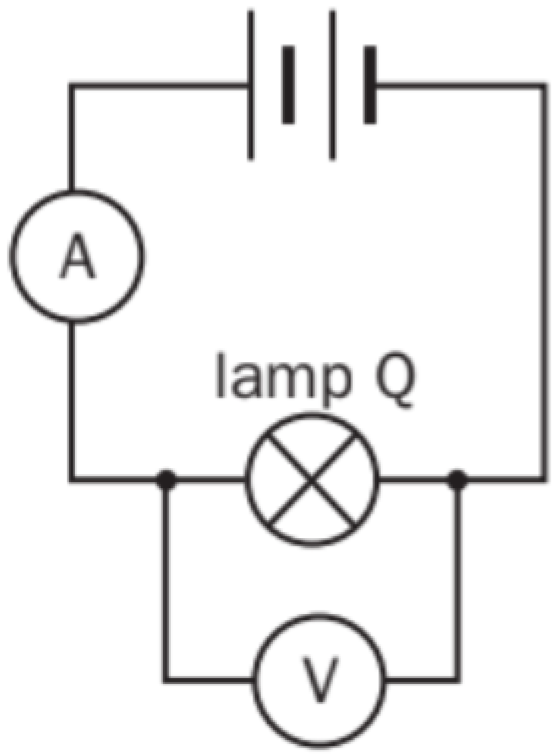
Static Electricity
Like charges repel, unlike charges attract
SI unit for amt. of charge: Coulomb, C
Ebonite rod rubbed with duster, duster becomes negatively charged by friction as electrons flow from rod to duster.
Uncharged: equal amount of positive and negative charge
Charge metal ball by induction: polyethylene strip rubbed with woollen cloth, brought close to ball, earth ball momentarily to induce charges before earthing, remove polyethylene strip
Negative charged electrons are transferred from acetate rod to cloth, cloth has more negative charge than positive charge. Paper is attracted to rod as electrons in paper are attracted to rod, leaving positive charge further from rod, and forces of attraction between unlike charges is greater than forces of repulsion of like charges.
Excess charges in the metal sphere will be neutralised when earthed.
Insulator: plastic / perspex / polythene / rubber / ebonite / glass
Paint droplets are positively charged and spread out as like charges repel.
A stationary negative charge in an electric field experiences an electric force horizontally to the right as the direction of the electric field is horizontally to the left.



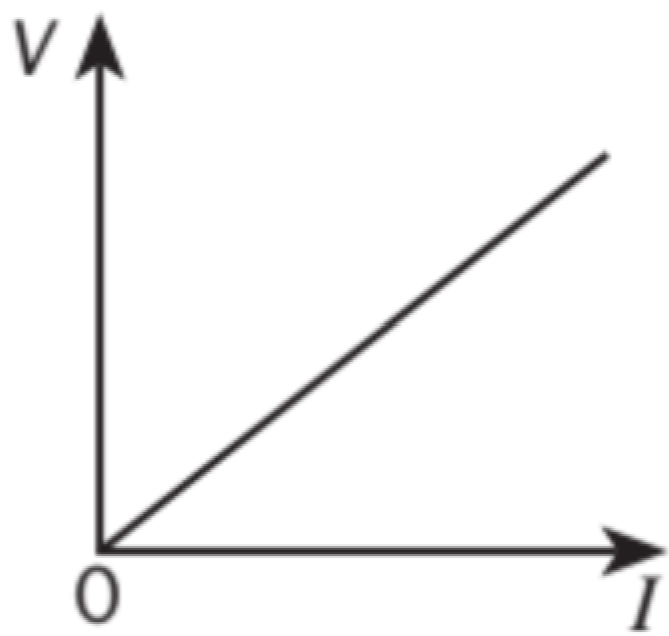
Electrons move from fuel to pipe
Spark sudden discharge to ignite the fuel
Electrons flow along the cable from earth to aircraft to neutralise positive charges

Current of Electricity

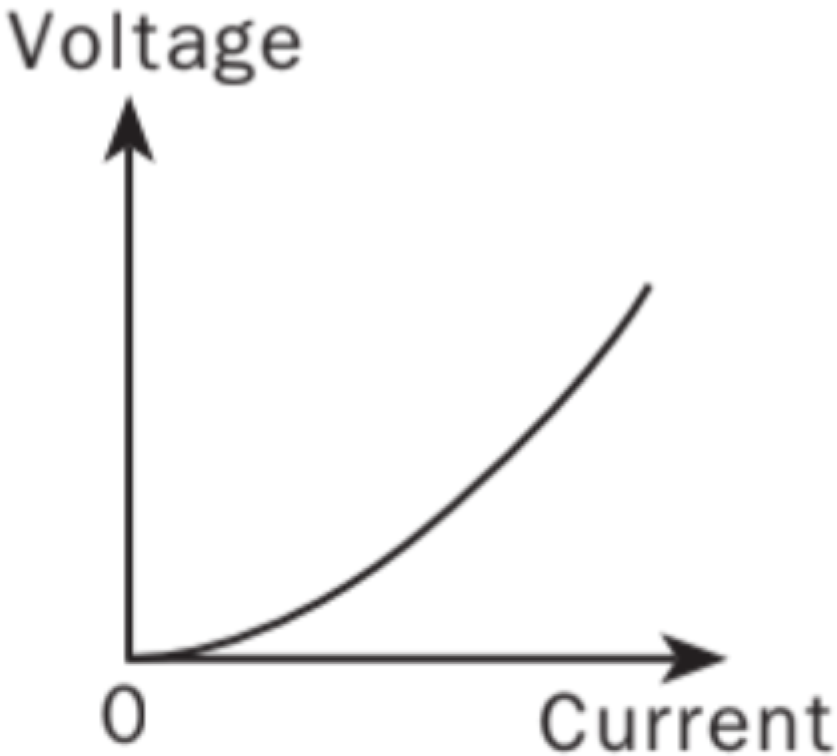
Cell has emf of 2v, means cell supplies 2 joules of energy per coulomb of charge it delivers.
To find R of lamp Q:



Characteristic V–I graph of a conductor that obeys Ohm's law:



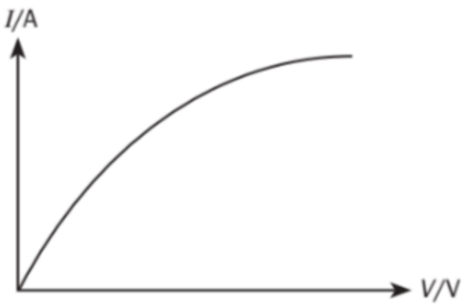
Resistance increasing as current increases:



Q = It
I = V / R
V can be p.d., emf
V = W / Q
R = ρl/A
A = $\pi(d/2)^2$
Conventional current flows from positive to negative terminal of battery.
emf vs p.d.: emf is W / Q around a complete circuit, p.d. Is W / Q via the component
An ohmic conductor is a conductor in which the current passing through it is directly proportional to the potential difference across it, provided that physical conditions (such as temperature) remain constant.

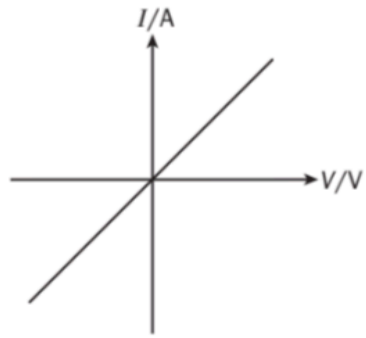
Identify the conductor each graph corresponds to.

(i) Conductor: Filament lamp



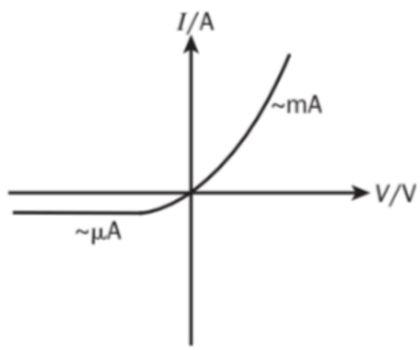
▲ **Figure 17.2**

(ii) Conductor: Pure metal at a constant temperature



▲ **Figure 17.3**

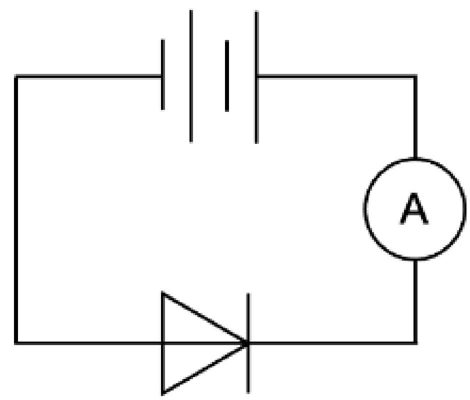
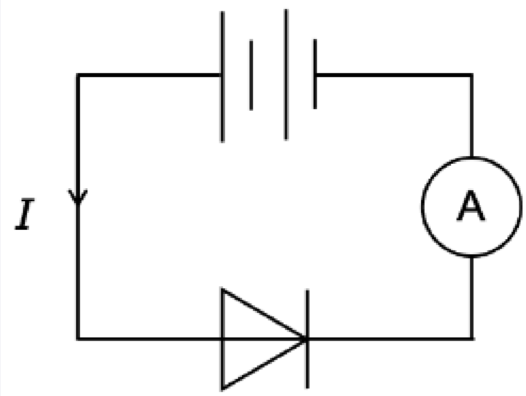
(iii) Conductor: Semiconductor diode



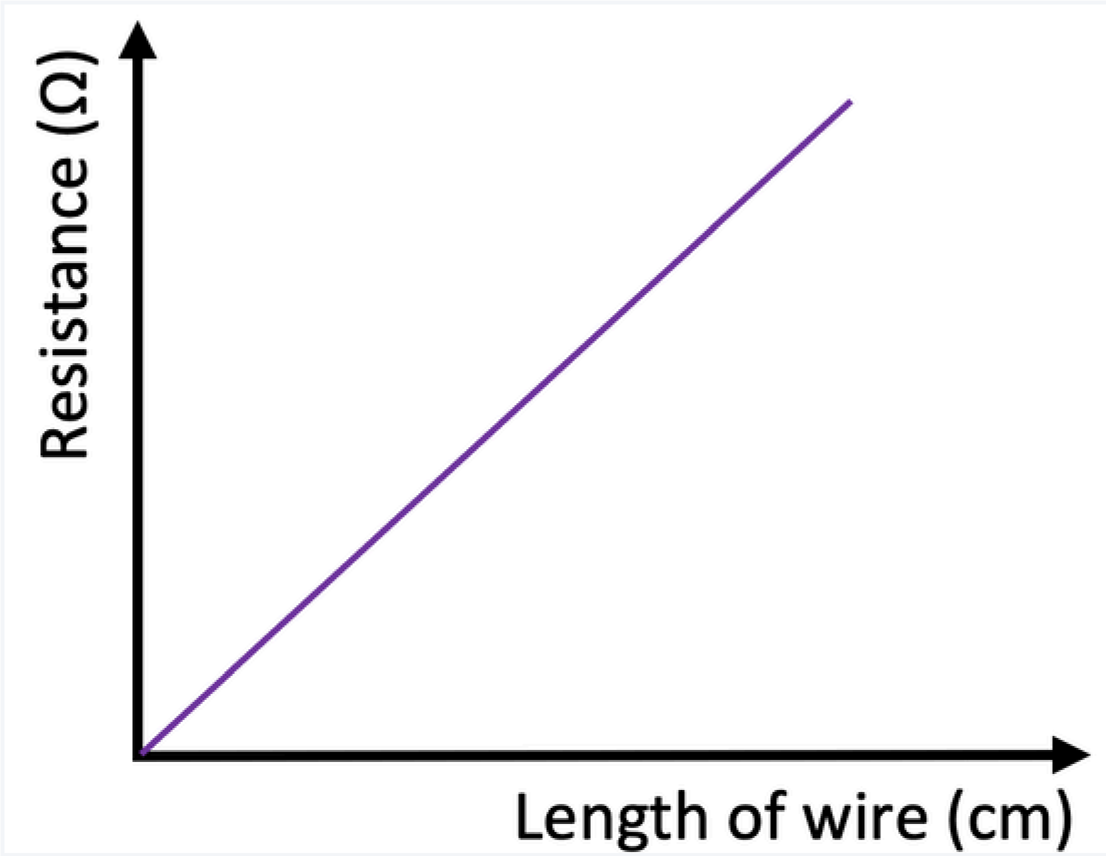
Ohmic conductor: current passing via metallic conductor is directly proportional to the p.d. across it, provided that physical conditions (such as temperature) remain constant so that resistance remains constant.
When the temperature of a metallic conductor increases, the metal ions in the conductor vibrate more vigorously. The moving electrons (charge carriers) collide with the metal ions more frequently, slowing down their drift and lowering the current, increasing electrical resistance. As the current flowing through the filament increases, the heating effect of the current causes the temperature of the filament to increase, and therefore the resistance of the filament increases.
The longer-lasting bulb type has a filament of larger mass and larger cross-sectional area, thus it has the larger heat capacity. As a result, it takes a longer time to fuse.

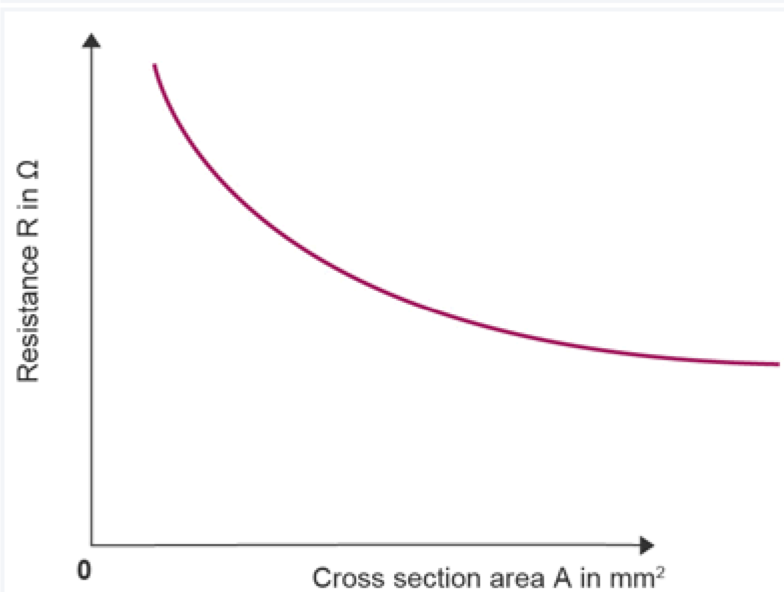
LED is a semiconductor diode that produces light.
A semiconductor diode is a device that allows current to flow in one direction only. As LED does not allow current to flow in the other direction, it must be connected in the correct direction for it to light up. The longer leg of the LED connects to the positive terminal and the shorter leg connects to the negative terminal of the battery.

Filament lamps (non-ohmic) have low energy efficiency. The higher their potential difference, the higher their resistance, the brighter they are.

Reverse direction (also known as reverse bias)	**Forward direction (also known as forward bias)**
Negative values of *V*	Positive values of *V*
	 *Notice the change in polarity of the power source connected to the diode.*
For an ideal diode, there is no current flowing through the diode and ammeter. For an actual diode, there is little current flowing through the diode and ammeter. The current is in the microampere (μA) range.	There is current flowing through the diode and ammeter. The current is in the milliampere (mA) range. The current does not increase proportionally as the potential difference increases.
The resistance is very high.	The resistance decreases as the potential difference increases

Thermistor: Resistance varies with temperature
Negative temperature coefficient thermistor has resistance decrease as temperature increases.





$$R = \frac{\rho L}{A}$$

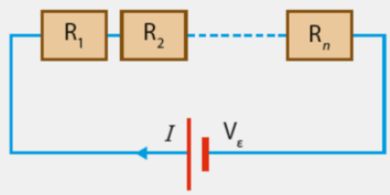
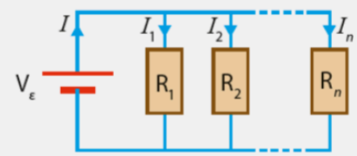
1/Rt = 1/R1 + 1/R2 + 1/R3 +...

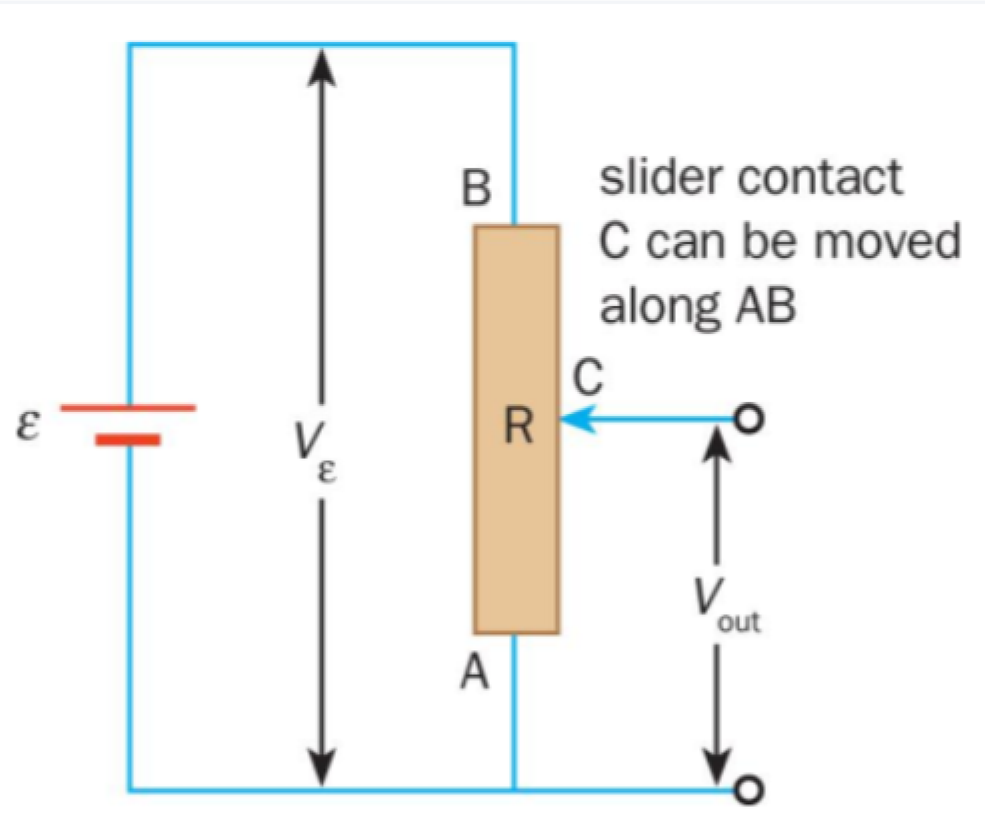
Rs = R1 + R2 + R3 +…

D.C. Circuits

In series, current is the same throughout circuit components, p.d. across the whole circuit equals the sum of p.d. across all components.

In parallel, current splits to each parallel branch and recombines at the point where wires recombine, p.d. of the whole circuit equals p.d. across each branch.

	Series Circuit	Parallel Circuit
Circuit Diagram		
Effective Resistance R_e	$R_e = R_1 + R_2 + \dots + R_n$	$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$
Current in the Circuit	$I = \frac{V_e}{R_e}$	$I = \frac{V_e}{R_e} = I_1 + I_2 + \dots + I_n$
P.d. Across Any One Resistor R_i	$V_i = IR_i$	V_ε



$$V_{out} = \left(\frac{R_{AC}}{R_{AC} + R_{BC}}\right) \times V_{\varepsilon}$$

where $R_{AC} + R_{BC}$ is the total resistance of the resistor R.

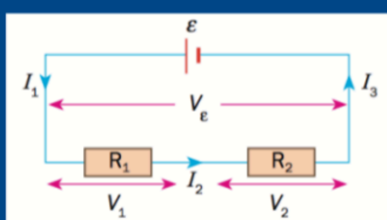
or

$$V_{out} = \left(\frac{AC}{AC + BC}\right) \times V_{\varepsilon}$$

where AC + BC is the total length of the resistor R.

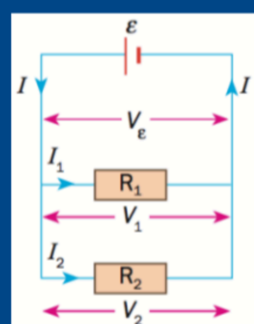
D.C. Circuits

Series circuits



- Current
  $I_1 = I_2 = I_3$
- Potential difference
  $V_{\varepsilon} = V_1 + V_2$
- Effective resistance
  $R = R_1 + R_2$

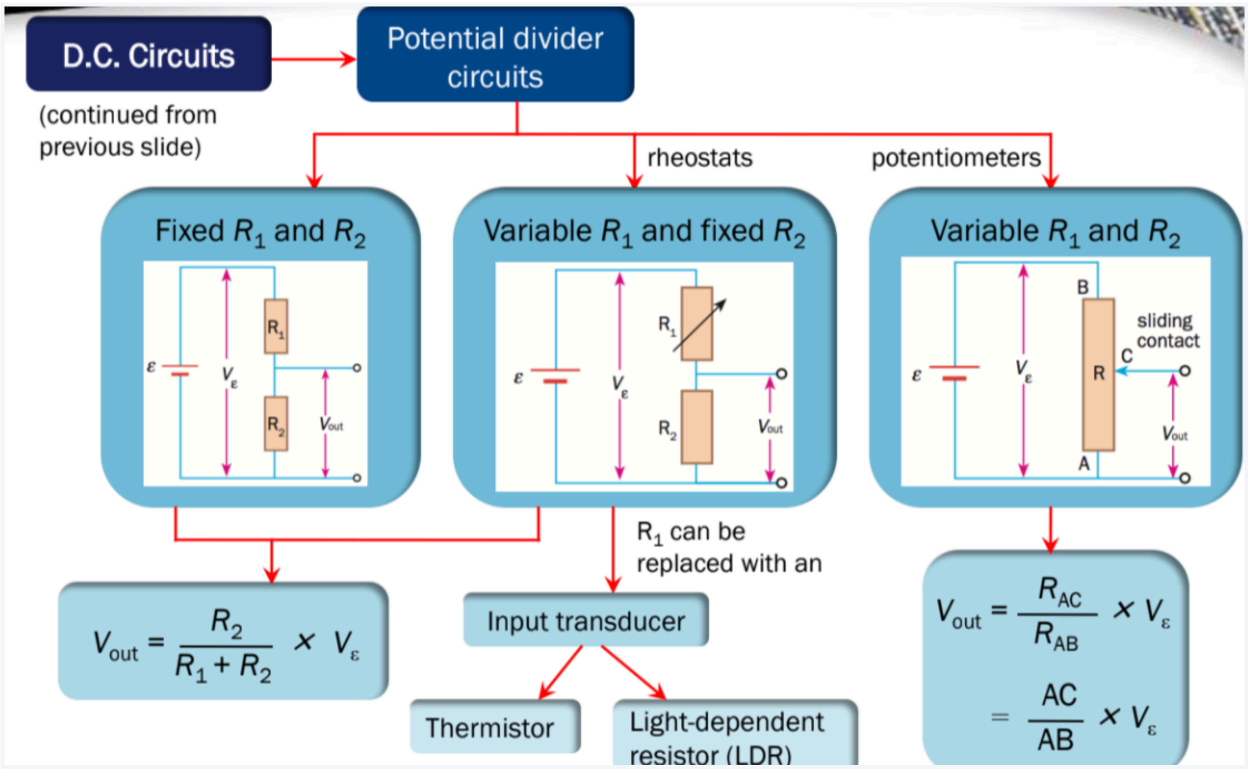
Parallel circuits



- Current
  $I = I_1 + I_2$
- Potential difference
  $V_{\varepsilon} = V_1 = V_2$
- Effective resistance
  $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

Potential divider circuits

(continued on next slide)



Practical Electricity

P = W / t

P = VI

$P = V^2 / R$

$P = I^2R$

Conducting wires covered by insulating material.

Overheated cables lead to fires, caused by overloaded power sockets with unusually large current flowing via wires, and inappropriate wires used like insufficient thickness for high power requirements.

Water provides a conducting path for current.

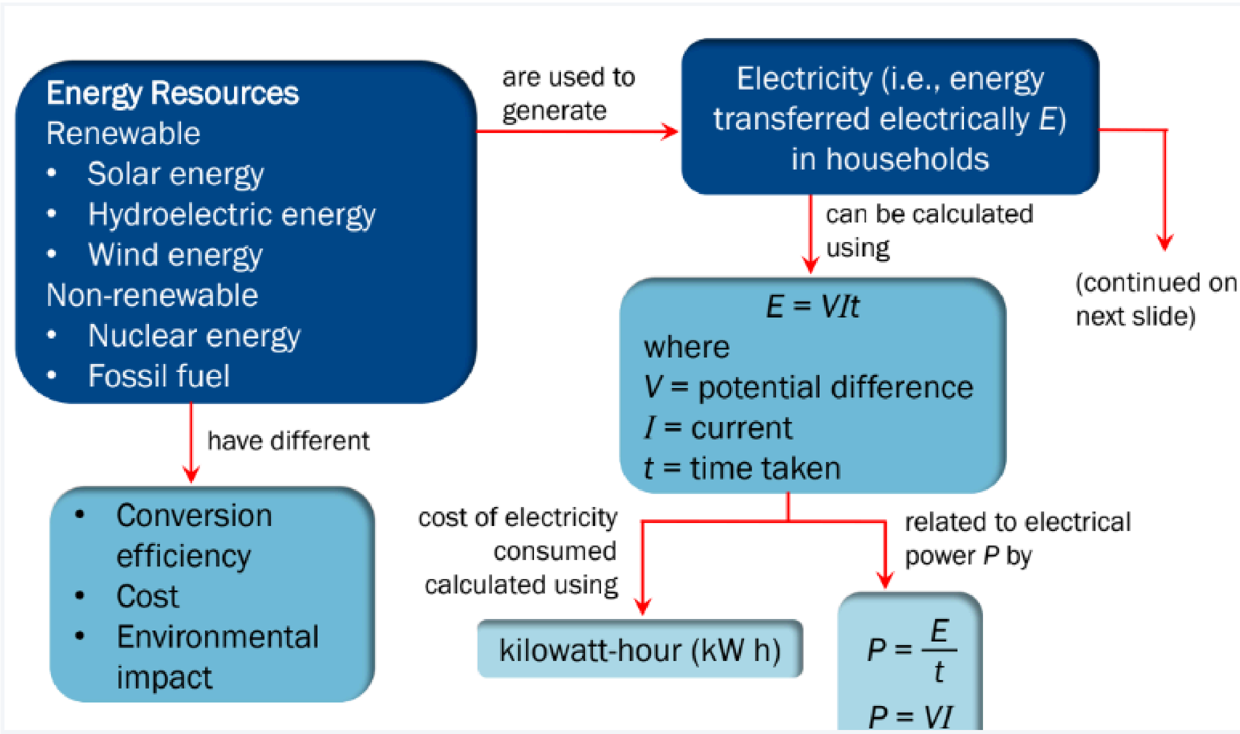
Circuit breakers connected to live wires switch off electrical supply in circuit when large currents flow via them, and can be reset after it trips.

A fuse connected to live wires must be replaced after it blows. It consists a short thin piece of wire that heats up and melts.

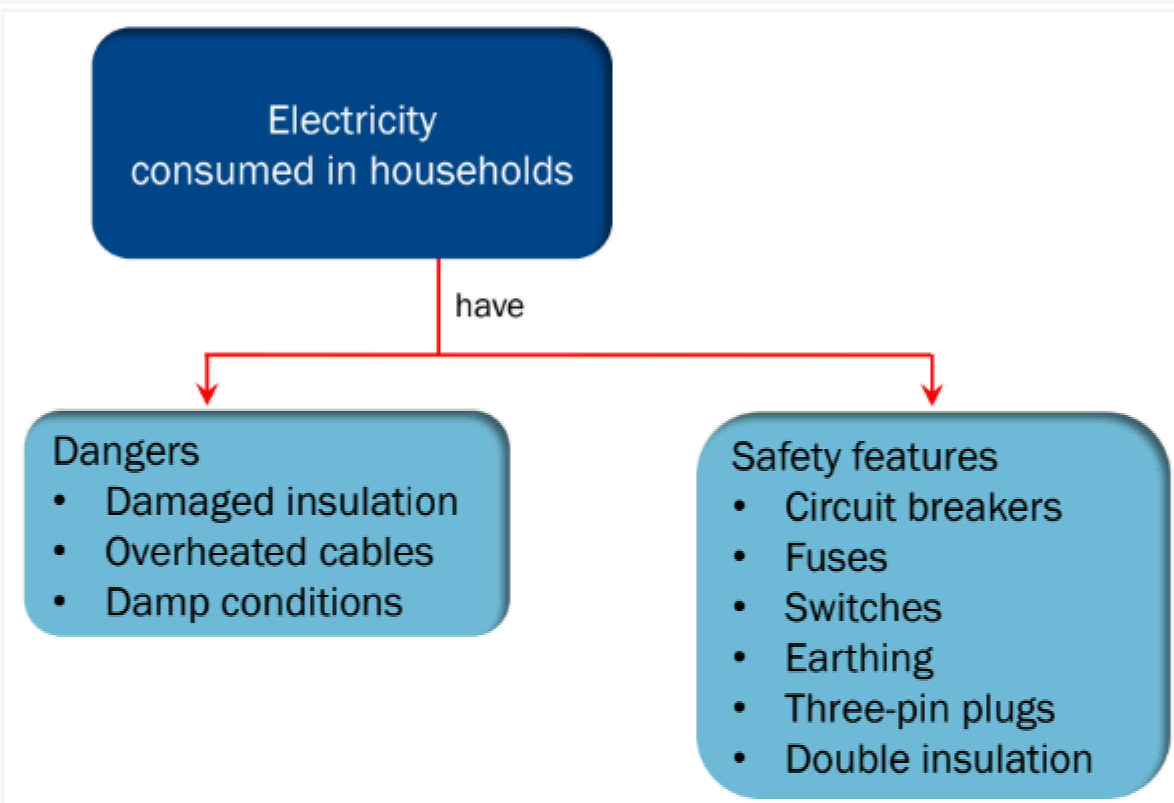
Switches are connected to live wires.

Live, neutral, earth wires are coloured brown, blue, and yellow&green respectively.

Double insulation: electric cable, internal components, outer casing



Energy Resources
Renewable
• Solar energy
• Hydroelectric energy
• Wind energy
Non-renewable
• Nuclear energy
• Fossil fuel
are used to generate
Electricity (i.e., energy transferred electrically E) in households
can be calculated using
(continued on next slide)
$E = VIt$
where
V = potential difference
I = current
t = time taken
have different
• Conversion efficiency
• Cost
• Environmental impact
cost of electricity consumed calculated using
kilowatt-hour (kW h)
related to electrical power P by
$P = \frac{E}{t}$
$P = VI$



Electricity consumed in households
have
Dangers
• Damaged insulation
• Overheated cables
• Damp conditions
Safety features
• Circuit breakers
• Fuses
• Switches
• Earthing
• Three-pin plugs
• Double insulation

PQUM

Quantity	SI unit symbol	Base or derived?	Quantity	SI unit symbol	Base or derived?
volume	m^3	derived	luminous intensity	cd	base
weight	N	derived	density	kg/m^3	derived

Base quantity	SI unit	Unit symbol	Base quantity	SI unit	Unit symbol
mass	kilogram	kg	length	metre	m
amount of substance	mole	mol	current	ampere	A
temperature	kelvin	K	time	second	s

Quantity	Scalar or vector?	Quantity	Scalar or vector?
acceleration	v	pressure	s
current	s	speed	s
density	s	temperature	s
distance	s	time	s
energy	s	velocity	v
force	v	volume	s
mass	s	weight	v

Prefix	Multiplication factor	Symbol
Tera	$\times 10^{12}$	T
Giga	$\times 10^{9}$	G
Mega	$\times 10^{6}$	M
Kilo	$\times 10^{3}$	k
Deci	$\times 10^{-1}$	d
Centi	$\times 10^{-2}$	c
Mili	$\times 10^{-3}$	m
Micro	$\times 10^{-6}$	μ
Nano	$\times 10^{-9}$	n

Metre rule:
Placed on edge to minimise parallax error
Not measured from 0cm to avoid end error caused by wear and tear of 0cm mark
Precision of 0.1cm or 1mm

Vernier Calipers:
Precision of 0.01cm or 0.1mm

Micrometre screw gauge:
2.5cm range
Precision of 0.001cm or 0.01mm

Digital callipers:
To eliminate zero error, press zero button when jaws are closed
Precision of 0.001cm or 0.01mm

Digital Micrometre screw gauge:
Precision of 0.0001cm or 0.001mm

$F = 1 / T$

… of pendulum	Effect on period

Weight	no
No. of Oscillations	no
Length	The longer, the longer
Gravity	The lower, the longer

Ticker tape timer: 50 dots / s

Electronic balance	0.1 g	0.1 g
Spring balance (0 – 10 N)	0.1 N	0.05 N
Measuring cylinder	1 cm^3	0.5 cm^3
Stopwatch (digital) *	0.01 s*	0.1 s*
Thermometer (–10 °C to 110 °C)	1°C	0.5 °C
Ammeter (0 – 1 A)	0.02 A	0.01 A
Voltmeter (0 - 3 V)	0.1 V	0.05 V

Kinematics
v = grad. of s-t graph
a = grad. of v-t graph

s = area under v-t graph
In absence of air resistance, all objects fall under gravity with constant acceleration g, undergoing freefall.
g = $10 m/s^2$

$v^2 = u^2 + 2as$
$s = ut + 0.5at^2$
$v = u + at$
$s = 0.5(u + v)t$
$s = vt - 0.5at^2$

Dynamics
N1L: inertia
N2L: f=ma
N3L: for every action there is an equal and opposite reaction
Weight = mg
terminal velocity is max velocity when air resistance equals downward gravitational force, acceleration = 0 and velocity is constant.

Energy
Principle of conservation of energy: energy can’t be created or destroyed, only converted
$KE = 0.5mv^2$
GPE = mgh
Work = force x displacement
Efficiency = useful energy / total energy
Fall at constant speed: no KE change, GPE converts to internal store of energy
Objects in thermal equillibrium: no energy transfer by heating
Energy is transferred mechanically, electrically, increasing another form of energy
Isolated system: no energy transfer in/out
Total energy conserved: same
Total initial energy = total final energy
Apex of vertical flight: 0m/s, KE = 0
Decrease in KE = increase in GPE vice versa

Turning effects of forces
(Distance from pivot)(force) = moment
Equilibrium: sum of CW moment = sum of ACW moment
Lower CG = higher stability
Wider base area = higher stability

Pressure
Pressure = force / area

Lower pressure, lower sinkability
Fluid pressure = (density)(acceleration of gravity)(height)
mmHg, pascal

Kinetic Molecular Model

Thermal processes

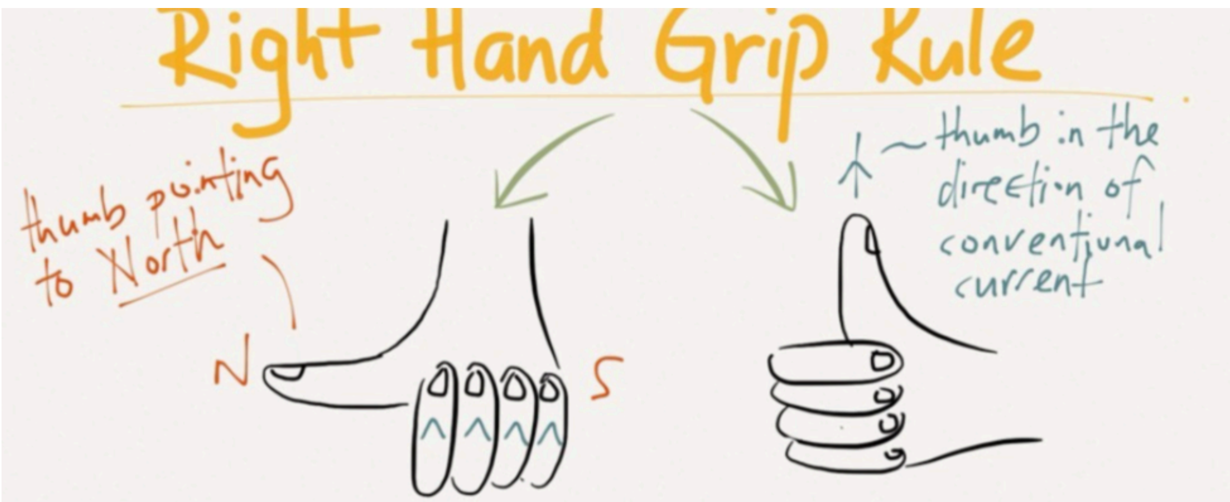
Thermal properties of matter

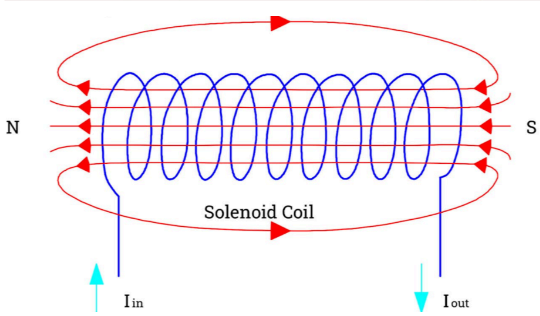
Waves

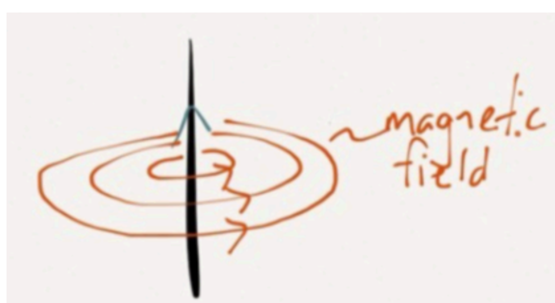
Light

Magnetism
The closer the field lines, the stronger the magnetic field

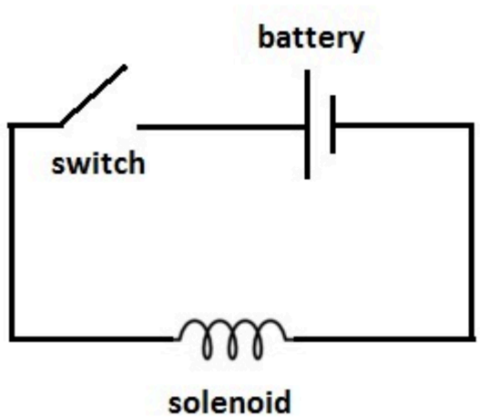
Electromagnetism

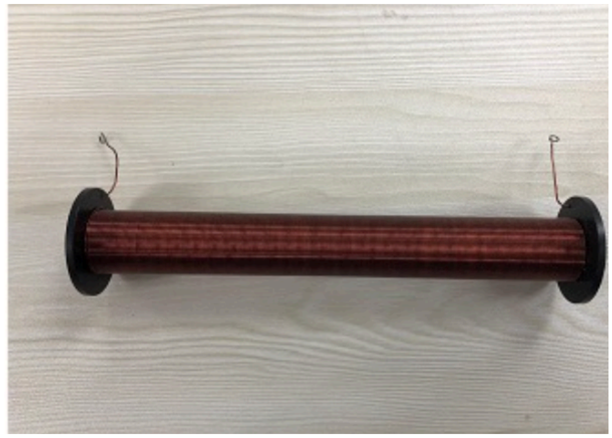




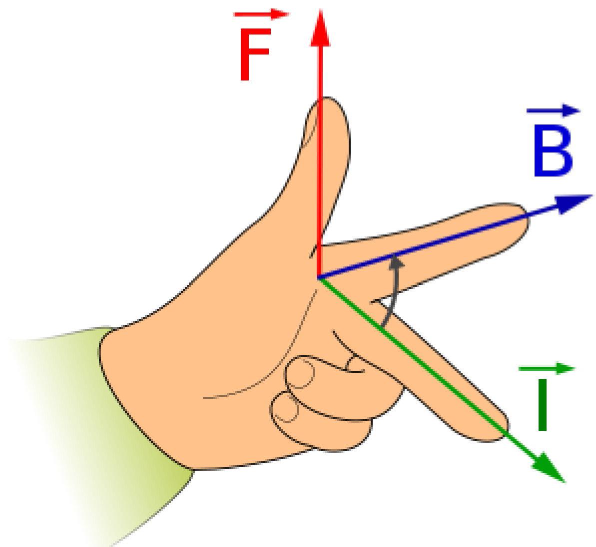


The larger the current, the stronger the magnetic field established around the straight wire.
The larger the current/ no. of coils around solenoid core, the stronger the magnetic field around a solenoid.
Solenoid: many coils of usually copper wire connected to electrical source and switch.





When the switch is closed, current flows through the solenoid, thereby creating a magnetic field around the core. The attraction of the iron (which is a magnetic material) armature to the core becomes sufficient to cause the soft-iron armature to move towards the core. This resulted in the springy metal breaking contact with the armature, thereby breaking open the circuit.



Electromagnetic induction

Radioactivity

Each alpha decay emit 1 alpha particle consisting 2 protons & 2 neutrons.
Beta decay converts neutron to proton.
All 3 types of radioactive emission ionizes gas.
Beta particles have weaker ionizing effect than alpha particles.
Alpha particles have weaker penetrating power than beta particles.

$R = I \times \frac{1}{2}^{\text{no. of half-lives}}$

No. of half-lives = time / half-life
Bq = activity of one decay /s

Short half life, emit gamma radiation, can be used for medical scanning.
Reactor in nuclear power station produces energy to boil water and produce steam.
Number of protons = number of excess protons + number of electrons
Unlike charges attract.
Lead stops beta and alpha radiation, does not fully stop gamma radiation.
Background radiation: counts that detector picks up from surroundings in absence of specific radioactive source.
Sources of surrounding radioactivity: cosmic sources(sun, space), air sources(radon)
Radioactive decay is random process, need take repeat readings of count rate.
Wear lead clothing to safely move radioactive isotopes.
Alpha particles have strong ionizing power
Ionisation cause cells mutations and cancers.
Radioactive decay is spontaneous, unaffected by external factors.
number of undecayed nuclei decreases, activity decreases as it is directly proportional to the number of undecayed nuclei [1].

Mass, weight, density