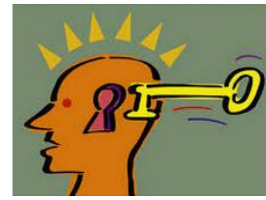
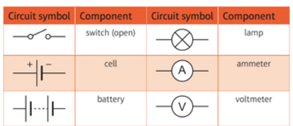
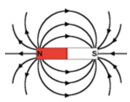


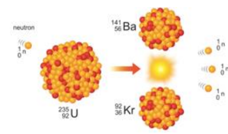
Science
Crucial Knowledge

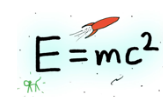


Circuit symbol	Component	Circuit symbol	Component
	switch (open)		lamp
	cell		ammeter
	battery		voltmeter



Physics





<u>Paper 1</u>

Topic P1	Energy
Topic P2	Electricity
Topic P3	Particle Model of Matter
Topic P4	Atomic Structure

<u>Paper 2</u>

Topic P5	Forces
Topic P6	Waves
Topic P7	Magnetism & Electromagnetism

Physics is the study of forces and energy

Physics P1 Energy P1

Equations

- Kinetic energy = ½ x mass x velocity² — $KE = \frac{1}{2}mv^2$
- Gravitational potential energy = mass x gravitational field strength x height — $GPE = mgh$
- Work done = force x distance — $W = Fs$
- Power = work done ÷ time — $P = E \div t$
- Efficiency = useful output energy ÷ total input energy

Conservation of energy

- Energy cannot be created or destroyed, only transferred from one form to another
- Energy is usually wasted as heat
- Example: A car uses petrol to move. The chemical energy in the petrol is transferred to kinetic energy, heat energy and sound energy. The total amount of energy overall is the same

Chemical energy → kinetic energy + heat energy + sound energy
10,000 J → 6000 J + 3000 J + 1000 J

Specific heat capacity

- The energy required to raise the temperature of one kilogram of a substance by one degree Celsius

Renewable energy sources will not run out **Non-renewable energy sources will run out**

Renewable resource	Advantages ☺	Disadvantages ☹
Solar	No CO_2 pollution Free	Not work at night/cloudy
Wind	No CO_2 pollution	Unreliable Eyesore
Tidal	No CO_2 pollution	Destroys habitats
Hydroelectric	No CO_2 pollution	Expensive Destroys habitats
Geothermal	No CO_2 pollution	Few areas suitable
Biofuel	Carbon neutral	Land needed to grow

Non -renewable resource	Advantages ☺	Disadvantages ☹
Fossil fuels: Coal Oil Gas	Readily available	CO_2 pollution Acid rain Greenhouse effect Climate change
Nuclear	No CO_2 pollution	Expensive Radioactive waste

Equations

- Potential difference = current x resistance $V = IR$
- Charge = current x time $Q = It$
- Power = current x voltage $P = IV$
- Power = current^2 x resistance $P = I^2R$
- Energy transferred = power x time $E = Pt$
- Energy transferred = charge x potential difference $E = QV$

Electric current

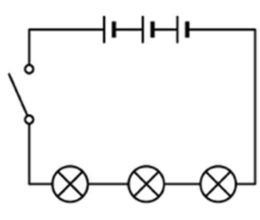
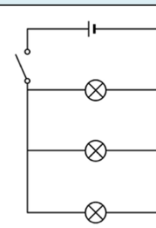
- Is the flow of electrical charge
- Measured in amps (A)

Potential difference (also called voltage)

- The “push” on the electrons provided by a cell or battery
- Measured in volts (V)

Resistance

- How difficult it is for the current to flow
- Measure in ohms (Ω)

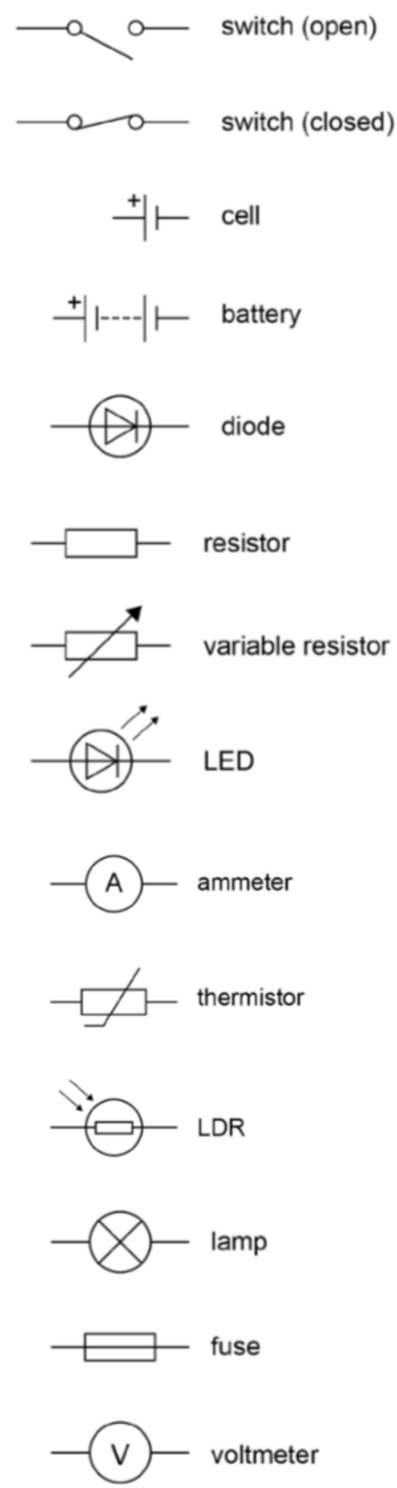
Series circuit	Parallel circuit
	
Current is the same at all points	Current splits at a junction
Potential difference is shared by components	Potential difference is the same across all components
Total resistance is the resistance of all the components added together	Total resistance is less than the resistance of the lowest resistor

Mains electricity and wiring in plugs

- Is an ac supply – frequency of 50 Hz and 230 V
- Live wire – brown
- Neutral wire – blue
- Earth wire – green and yellow stripes

The National Grid

- A system of cables and transformers linking power stations to homes
- Step-up transformers increase the potential difference
- Step-down transformers reduce the potential difference
- This prevents energy being lost in the cables



Physics P3 Particle Model of Matter

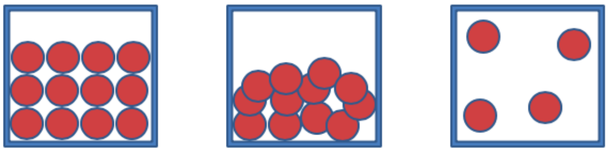
P3

Equations

- Density = mass ÷ volume $\rho = m \div V$

Particle model of matter

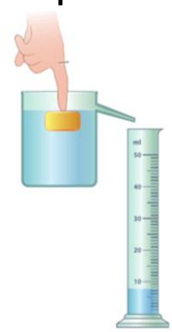
- Solid Liquid Gas



Changes of state

- Solid → liquid: melting
- Liquid → gas: evaporation
- Gas → liquid: condensation
- Liquid → solid: freezing
- Solid → gas: sublimation

Using a displacement can



Working out the density of an object

- Measure mass using a balance
- Measure volume using a ruler if the object is a regular shaped solid (length x width x depth)
- If object is irregular shaped use a displacement can to measure volume
- To use a displacement can, fill it with water then put the object in the water
- Catch the displaced water in a measuring cylinder. This is the volume of the object
- Calculate density using the equation: Density = mass ÷ volume

Particle motion in gases

- The temperature of a gas is related to the average kinetic energy of the molecules
- If the molecules have more kinetic energy they move faster, this means the temperature is higher
- At a fixed volume, higher temperature means the pressure will also be higher

Specific heat capacity

- The amount of energy required to raise the temperature of one kilogram of a substance by one degree Celsius

Specific latent heat

- The amount of energy required to change the state of one kilogram of a substance with no change in temperature

State symbols → (s) (l) (g) (aq)

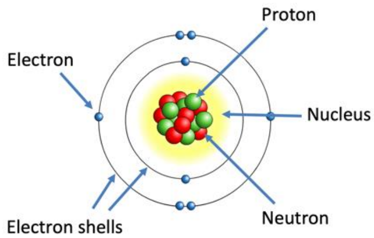
State symbol	Meaning	Example
(s)	Solid	Iron oxide$_{(s)}$
(l)	Liquid	Water$_{(l)}$
(g)	Gas	Carbon dioxide$_{(g)}$
(aq)	Aqueous, dissolved in water	Sodium chloride solution$_{(aq)}$

Physics P4 Atomic Structure & Radioactivity

P4

Structure of the atom

- Atomic number – the number of protons in an atom
- Atomic mass – number of protons + neutrons added together
- Isotopes are atoms of the same element with a different number of neutrons



Subatomic particle	Mass	Charge	Position in the atom
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	Very small	-1	Electron shells

Atomic models

- Plum pudding model – negative electrons embedded throughout the atom, rest of atom is positive
- Nuclear model – most of the mass of an atom in the nucleus, most of the atom is empty space

Radioactive decay

- Some elements have an unstable nucleus. This gives out radiation to become more stable
- This is a totally random process
- Activity (the amount of radiation given out) is measured in becquerels (Bq)

Nuclear radiation given out by an unstable nucleus

- Alpha particle – two neutrons and two protons
- Beta particle – high speed electron
- Gamma ray – electromagnetic radiation
- A neutron

Radiation	Mass	Charge	Range in air	Penetration power	Ionising ability
Alpha	4	+2	A few cm	Low	High
Beta	Very small	-1	A few m	Medium	Medium
Gamma	0	0	Very large	High	Low

Half-life

- The time it takes for half the number of radioactive nuclei to decay is called the half-life
- The half-life of a given isotope is always the same, no matter how much of the isotope you start with

Radioactive contamination and irradiation

- Contamination is the unwanted presence of materials containing radioactive atoms
- Irradiation is exposing an object to nuclear radiation

Precautions when using radioactive materials

- Tweezers
- Point away from the body
- Hold at arm's length
- Keep samples in lead lined boxes

Physics P5 Forces P5

Equations

- Speed = distance ÷ time — $v = s \div t$
- Acceleration = change in velocity ÷ time — $a = (v - u) \div t$
- Weight = mass x gravitational field strength — $W = mg$
- Force = mass x acceleration — $F = ma$
- Work done = force x distance — $W = Fs$
- Force = spring constant x extension — $F = ke$
- Momentum = mass x velocity — $p = mv$ (Higher only)

Scalars and vectors

- Scalars have magnitude (number) only. Eg – speed, distance, time, energy, mass
- Vectors have magnitude and direction. Eg – velocity, displacement, acceleration, force, momentum

Contact and non-contact forces

- Contact forces – objects must be touching. Eg – friction, air resistance, normal contact force
- Non-contact forces – objects are not touching but still feel a force. Eg – gravity, electrostatic, magnetic

Acceleration

- Acceleration is the change in velocity
- An object that slows down is decelerating (negative acceleration)

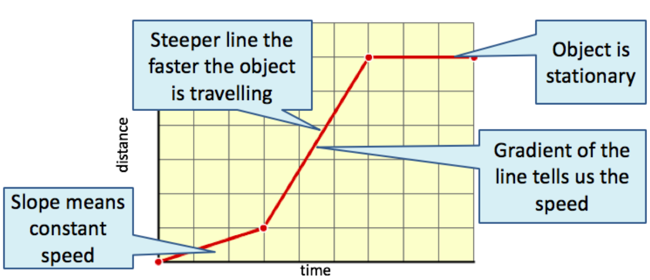
Newton's Laws

- First Law - An object at rest will remain at rest unless a force acts on it
- First Law - A moving object will continue to move in a straight line at a constant velocity unless a force acts on it
- Second Law - The acceleration of an object is proportional to the resultant force acting on the object
- Third Law - When two objects interact they exert equal and opposite forces on each other

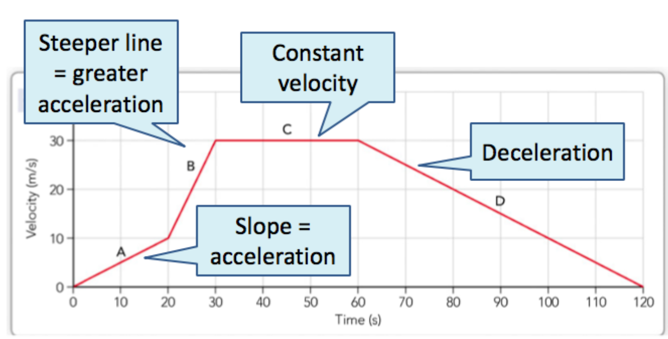
Stopping distances and braking distance

- Stopping distance = thinking distance + braking distance
- Factors that affect braking distance – icy or wet roads, worn tyres and brakes

Distance-time graph



Velocity-time graph



Distance travelled can be worked out by finding the area under the graph

Physics P6 Waves P6

Equations

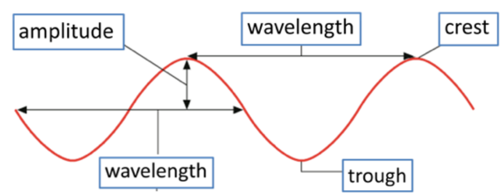
- Wave speed = frequency x wavelength $v = f \times \lambda$

Transverse waves

- Motion of particles is at right angles to direction of the wave
- Water waves
- Electromagnetic (EM) waves

Longitudinal waves

- Motion of particles is in the same direction as the movement of the wave
- Sound waves



Frequency and period

- Frequency is the number of waves passing a point in 1 second
- Frequency is measured in hertz (Hz)
- Period is the time taken for one wave to pass a point
- Period is measured in seconds (s)

EM wave	Uses ☺	Dangers ☹
Radio waves	Communication Broadcasting – TV, radio	No danger
Microwaves	Cooking food, communication Mobile phones	Slight heating effect, depends on the frequency
Infra-red	Cooking food, night vision goggles Remote controls	Burns to skin
Visible light	Photography, fibre optics	Damage to eyes if bright enough
Ultraviolet	Security marking, sterilising water Sun tanning	Mutation in cells/DNA Cancer
X-rays	Hospitals, Luggage - airports	Mutation in cells/DNA Cancer
Gamma rays	Sterilising medical tools Detect/treat cancer, sterilising food	Mutation in cells/DNA Cancer

Long wavelength → Short wavelength

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

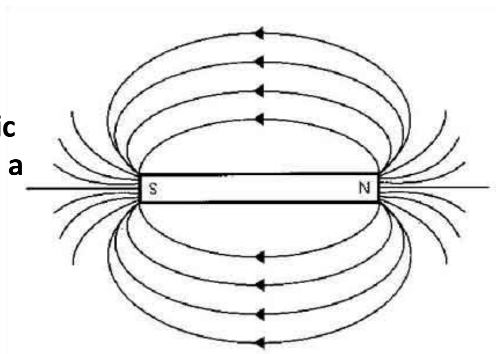
Low frequency → High frequency

Physics P7 Magnetism & Electromagnetism

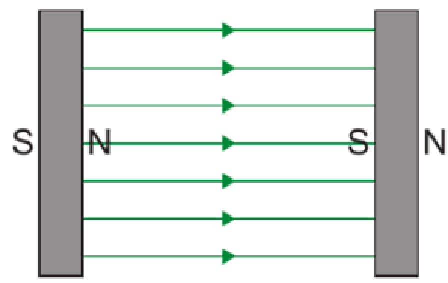
P7

Magnets

- Like poles (two that are the same) repel, opposite poles attract
- Magnetic force is strongest at the poles of a magnet
- A permanent magnet produces its own magnetic field
- An induced magnet is a material that becomes a magnet when placed in a magnetic field
- Magnetic materials – iron, steel, cobalt, nickel
- Magnetic field lines point from the north seeking pole to the south seeking pole
- Two flat magnets produce a uniform magnetic field



The magnetic field around a bar magnet



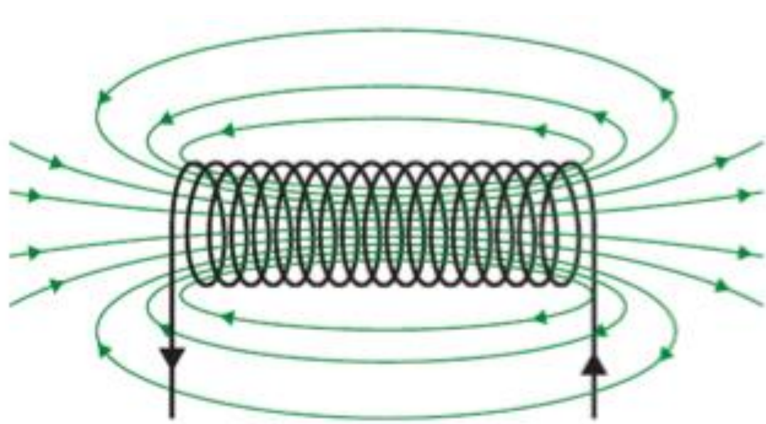
The magnetic field between two flat magnets

Electromagnetism

- When a current flows through a wire a magnetic field is produced around the wire
- A solenoid is a coil of wire
- The magnetic field around a solenoid is similar in shape to that of a bar magnet
- Adding an iron core increases the strength of the magnetic field in a solenoid
- An electromagnet is a solenoid with an iron core
- An electromagnet can be switched on and off

Ways to increase the strength of an electromagnet

- Add more coils of wire
- Increase the current in the wire
- Add an iron core



The magnetic field around a solenoid