GCSE Physics Definitions

Paper 1 Definitions

Sound waves are longitudinal waves that cannot travel through a vacuum.

Infrasound: longitudinal sound waves that are too low for humans to hear (below 20 Hz).

Ultrasound: longitudinal sound waves that are too high for humans to hear (above 20 kHz).

Seismic waves are waves that travel through the earth. There are two types: P waves & S waves.

The human ear. Sound waves are collected by the **outer ear** and pass to the **ear drum** which is made to vibrate by the alternating compression and rarefaction of the air next to it. Vibrations pass to the **oval window** by three bones called the hammer, anvil and stirrup which magnify the force of the vibrations. **Hair cells (cilia)** of different lengths in the **cochlea** detect different frequencies which send electrical impulses to the brain.
In a **transverse wave** the oscillations are perpendicular to the direction of energy transfer.
Examples: water waves, all electromagnetic waves, seismic S waves.

In a **longitudinal wave** the oscillations are parallel to the direction of energy transfer.
Examples: sound waves, ultrasound, infrasound, seismic P waves.

Refraction is the change in direction of a wave when it changes speed.

Electromagnetic waves are transverse waves that can travel at the speed of light in a vacuum.

Wavelength is the distance from any point on a wave to the next exactly equivalent point.

Frequency is the number of oscillations per second. (The units are Hz)

Period is the time for one complete oscillation. (The units are s). **T = 1/f**

Wave speed is the speed at which energy is transmitted. (The units are m/s)

Critical angle is the angle of incidence that gives an angle of refraction of 90°. Angles above this give reflection and no refraction.

The law of reflection: angle of incidence = angle of reflection

Total internal reflection: When the angle of incidence is greater than the **critical angle** only reflection occurs. This is used in fibre optics.

The **power** of a lens is a measure of how strongly refracting a lens is. **Power = 1 ÷ focal length** (in metres). A thicker lens has a greater power. Converging lenses have positive power. Diverging lenses have negative power. [The units are dioptres (D)]

Focal length is the distance from the middle of the lens to the focal point.

The **focal point** (of a converging lens) is the point where **parallel** rays of light converge after passing through the lens.

A **real image** forms where light rays focus. A real image forms on the opposite side of a lens to the object and can only be seen on a screen.

A **virtual image** is one from which light rays appear to come. It exists on the same side of the lens as the object and does not form an image on a screen.

The **geocentric model** assumes the earth is at the centre of everything.

The **heliocentric model** assumes the Sun is at the centre of the Solar System.

The **life cycle of a star like our Sun:**
Dust cloud/nebula → **protostar** →**main sequence star** → **red giant** → **white dwarf**

The **life cycle of a star much more massive than the Sun:**
Dust cloud/nebula → **protostar** → **main sequence star** → **red supergiant** → **supernova** → **neutron star** OR **black hole** (if really massive)

Planets in the solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

Centripetal force is the resultant force on an object, acting towards the centre of a circle and at right angles to its velocity, that causes the object to move in a circle.

Redshift: The wavelength of light shifts to longer wavelengths when the source is moving away from the observer. Wavelength increases and frequency decreases.

Expansion of the universe is shown by galaxies further away having a greater red shift which means they are moving away faster.

The Big Bang theory states that the Universe started as a hot dense point of energy 14 billion years ago. Evidence is cosmic microwave background radiation.

The Steady State theory states that the Universe has always existed and is expanding as matter is continuously created.

Cosmic microwave background radiation (CMBR) is microwaves detected from all directions in the sky. It provides evidence for the Big Bang theory.

Types of energy: light energy (electromagnetic energy), electrical potential energy, kinetic energy, sound energy, chemical potential energy, nuclear potential energy, elastic potential energy (strain energy), gravitational potential energy, thermal energy, internal energy.

The law of conservation of energy: Energy cannot be created or destroyed but can only be converted from one form to another.

Thermal equilibrium: an object remains at constant temperature when it radiates energy out at the same rate that it absorbs energy.

Non-renewable energy resources cannot be replaced when they have been used eg fossil fuels.

Renewable energy resources can be replaced when used eg wind power, solar power, hydroelectricity, wind turbines, geothermal energy, tidal power, wave power.

Displacement is the shortest distance between two points in a state direction.

Velocity is the speed in a stated direction.

In a **velocity-time graph**: displacement = area under the line, acceleration = gradient of the line.

A **scalar** quantity has magnitude (size) only eg mass, speed and distance.

A **vector** quantity has both magnitude and direction eg velocity, force and displacement.

Newton's First Law: If there is no resultant force acting on an object it will remain at rest OR continue to move with constant velocity.

Newton's Second Law: Force = mass x acceleration.

Weight is the force exerted by gravity on an object. Weight = mass x g. (g is the gravitational field strength and is approximately 10 N/kg on the surface of the Earth.) $W = m \times g$

Inertial mass is a measure of how difficult it is to change the velocity of an object (= F/a)

Newton's Third Law: When two bodies interact the forces they exert on each other are equal in size and opposite in direction.

A **free body diagram** shows all the forces acting on a single object.

The **moment** of a force is equal to force $\times$ distance to the pivot normal to the direction of the force.

The Principle of Moments: For an object to be in rotational equilibrium, the sum of the clockwise moments about a point must equal the sum of the anticlockwise moments about that point.

Half-life is the time taken for half the undecayed nuclei to decay. It is also equal to the time for the activity to half from an initial value.

Activity is the number of nuclear decays per second.

1 Becquerel (Bq) = 1 decay per second. It is the unit of activity of a radioactive source.

Background radiation is the natural radiation from: radon gas, rocks, medical procedures, food and drink and cosmic rays.

Contamination means that a person has particles of a radioactive isotope on their skin or inside their body. This is much more dangerous than **irradiation** by a source which will no longer pose a risk once the source is removed.

Irradiation is exposure to the radiation produced by a source without being contaminated by the source itself.

Nuclear fission: a large nucleus + neutron splits into two smaller daughter nuclei and more neutrons giving out a large amount of energy.

Control rods absorb neutrons and slow down the rate of fission. They can be raised and lowered.

Fuel rods contain uranium fuel.

The **moderator** slows down the neutrons so they are more likely to be absorbed by uranium nuclei. It increases the rate of fission.

Nuclear fusion: Small nuclei fuse to make larger ones. eg hydrogen nuclei form helium. This occurs in stars. if developed it could provide a cheap, safe source of energy.

Atomic number is the number of protons in the nucleus. ${}_{a}X$

Mass number is the total number of protons and neutrons in the nucleus. ${}^{m}X$

Isotopes have the same number of protons but different numbers of neutrons in each atom.

Fundamental particles are particles which cannot be broken down into smaller components**.**

A **positron** (β+) is an anti-matter version of an electron. It has the same mass but a positive charge.

The (incorrect) **plum pudding model** describes the atom as a positive 'dough' with electrons spread evenly out through it like plums in a pudding.

The **Bohr model** describes atoms as having a small, positive, dense nucleus at its centre with small low mass electrons orbiting around it.

A **proton** has charge = +1 and relative mass = 1. A **neutron** has charge = 0 and relative mass = 1.

An **alpha particle** (α) consists of 2 protons & 2 neutrons. It is most ionising and least penetrating.

A **beta particle** (β or β–) is a high energy electron.

A **gamma ray** (γ) is a high energy, high frequency, small wavelength electromagnetic wave.

During **alpha decay** atomic number goes down 2 and mass number goes down 4.

During **beta (minus) decay** atomic number goes up 1 but mass number is unchanged.

During **beta plus decay** atomic number goes down 1 but mass number is unchanged.

In a **PET scan** a (β^+) radioactive tracer is injected into the patient which produces a positron that annihilates with an electron to produce two gamma rays which are detected to build up a 3D image.

Momentum = mass x velocity (The units are kgm/s)

The Law of Conservation of Momentum: The total momentum before a collision is equal to the total momentum after the collision (**as long as no external force is applied**).

Stopping distance is the sum of the thinking distance and braking distance.

Thinking distance is the distance travelled from first seeing the hazard until the brakes are applied. It increases with velocity, tiredness and alcohol/drugs in the bloodstream.

Braking distance is the distance travelled by the vehicle from when the brakes are first applied until the vehicle comes to a halt. It increases with velocity, mass of the vehicle, wet/icy roads and worn tyres/brakes.

These Formulae you need to learn and be able to apply

distance travelled = average speed x time	
acceleration = change in velocity ÷ time taken	$\boldsymbol{a = \frac{(v-u)}{t}}$
force = mass x acceleration	$\boldsymbol{F = m \times a}$
weight = mass x gravitational field strength	$\boldsymbol{W = m \times g}$
momentum = mass x velocity	$\boldsymbol{p = m \times v}$
change in gravitational potential energy = mass x gravitational field strength x change in vertical height	$\boldsymbol{\Delta GPE = m \times g \times h}$
kinetic energy = ½ x mass x (speed)^2	$\boldsymbol{KE = \frac{1}{2} \times m \times v^2}$
efficiency = $\frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}}$	
wave speed = frequency x wavelength	$\boldsymbol{v = f \times \lambda}$
wave speed = distance ÷ time	$\boldsymbol{v = \frac{x}{t}}$

Paper 2 Definitions

Work done is force done x the distance moved in the direction of the force.

Power is the rate at which work is done or the rate at which energy is transferred from one form to another. (Units are watts W)

1 Watt is one joule per second. (W = J/s)

Efficiency is the fraction of energy supplied to a device that is usefully used. (May be a decimal fraction or a percentage)

Direct current (d.c.) is current that flows in the same direction all the time.

1 amp is flow of 1 coulomb of charge per second.

1 volt is one joule of energy per coulomb of charge.

In **series**: current is constant and voltage is shared between components. In **parallel**: voltage is the same across each branch and current is shared between branches.

An **ammeter** is a device for measuring current flow. Used in **series**.

The **Junction rule:** the total current entering a junction is equal to the total current leaving the junction.

Potential difference (p.d.) (voltage) is the energy transferred per unit charge.

A **voltmeter** is a device for measuring potential difference (voltage) across a component.
Used in **parallel** to one or more components.

A **thermistor** has resistance that **de**creases when temperature **in**creases. (Opposite to ordinary resistor.)

An **LDR (light dependant resistor)** has resistance that **de**creases when the light levels **in**creases.

Alternating current (a.c.) is current that changes direction many times per second.

The 3 pin plug: Live (brown) cable carries an alternating voltage of ±230 V relative to the netural (blue) cable which is approximately zero volts. The Earth (green and yellow) cable is connected to earth nearby so is at 0 V.

Electromagnetic induction: A current induced by the movement of a wire in a magnetic field. The current is increased by having: more turns in a coil, an iron core, a stronger magnetic field & by increasing the speed of movement of the wire(s).

An **alternator** consists of a spinning coil in a magnet and is used to generate an alternating current.

A **microphone** consists of a diaphragm connected to a wire coil inside a magnet. It converts air pressure variations due to sound waves into variations in electrical current.

A **loudspeaker** consists of a thin cone connected to a wire coil inside a magnet. It converts variations in electrical current into variations in air pressure (sound waves).

A **transformer** consists of two coils linked by an iron core. It is used to increase or decrease the voltage according to the number of turns in each coil.

Elastic distortion is when a material will return to its original shape and size when the force is removed. **Inelastic** distortion is when the material is permanently deformed and does not return to its original size and shape when the force is removed.

Hooke's Law: Extension is proportional to the applied force as long as the elastic limit is not exceeded. $F = k x x$
Current is rate of flow of charge.

Magnetic field lines show the direction of the force that would act on the north pole of another magnet. They point from north to south. Closer field lines indicate a stronger magnetic field. Field lines must not touch or cross.

Electric field lines show the direction of the force that would act on a positive charge. They point towards negative and away from positive. Closer field lines indicate a stronger electric field. Field lines must not touch or cross.

Fleming's Left Hand Rule: the force exerted on a current in a magnetic field acts perpendicular to both the current and the magnetic field. The direction is found using your left hand with thumb = force, first finger = field and second finger = current.

DC motors: the size of the force can be increased by having: more turns in the coil, an iron core, a larger current, a stronger magnetic field.

Absolute zero (0 K, –273°C) is the temperature at which particles stop moving and have no kinetic energy and so exert no pressure.

Specific heat capacity is the energy required to raise the temperature of 1 kg of a substance by 1°C.

Specific latent heat of fusion is the energy required to convert 1 kg of a substance from solid to liquid at its melting point.

Specific latent heat of vaporisation is the energy required to convert 1 kg of a substance from liquid to gas at its melting point.

A good thermal **insulator** will have a low thermal conductivity and a high specific heat capacity.

Upthrust is the upwards force acting on an object in a fluid (gas or liquid). It is equal to the weight of fluid displaced.

These Formulae you need to learn and be able to apply

change in gravitational potential energy = mass x gravitational field strength x change in vertical height	$\Delta GPE = m \times g \times h$
kinetic energy = ½ x mass x (speed)^2	$KE = \frac{1}{2} \times m \times v^2$
efficiency = $\frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}}$	
work done = force x distance moved in the direction of the force	$E = F \times d$
power = work done ÷ time taken	$P = \frac{E}{t}$
moment of a force = force x distance normal to the direction of the force	$M = F \times d$
energy transferred = charge moved x potential difference	$E = Q \times V$
charge = current x time	$Q = I \times t$
potential difference = current x resistance	$V = I \times R$
power = energy transferred ÷ time taken	$P = \frac{E}{t}$
electrical power = current x potential difference	$P = I \times V$
electrical power = current squared x resistance	$P = I^2 \times R$
density = mass ÷ volume	$\rho = \frac{m}{V}$
force exerted on a spring = spring constant x extension	$F = k \times x$
pressure = force normal to surface ÷area of surface	$P = \frac{F}{A}$

GCSE Physics Specifications Paper 1

On Both Papers

1.1 Recall and use the SI unit for physical quantities: metres (m), kilogram (kg), second (s), ampere (A), kelvin (K), mole (mol), hertz (Hz), newton (N), joule (J), watt (W), pascal (Pa), coulomb (C), volt (V), ohm (Ω), tesla (T)

1.2 Recall and use multiples and sub-multiples of units, including giga (G), mega (M), kilo (k), centi (c), milli (m), micro (μ) and nano (n)

1.3 Be able to convert between different units, including hours to seconds

1.4 Use significant figures and standard form where appropriate

1. Waves and Sound

4.1 Recall that waves transfer energy and information without transferring matter

4.2 Describe evidence that with water and sound waves it is the wave and not the water or air itself that travels

4.3 Define and use the terms frequency and wavelength as applied to waves

4.4 Use the terms amplitude, period, wave velocity and wavefront as applied to waves

4.5 Describe the difference between longitudinal and transverse waves by referring to sound, electromagnetic, seismic and water waves

4.6 Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$ wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = \frac{x}{t}$

4.7 Describe how to measure the velocity of sound in air and ripples on water surfaces

4.8P Calculate depth or distance from time and wave velocity

4.12P Describe the processes which convert wave disturbances between sound waves and vibrations in solids, and (a) explain why such processes only work over a limited frequency range (b) use this to explain the way the human ear works

4.13P Recall that sound with frequencies greater than 20 000 hertz, Hz, is known as ultrasound

4.14P Recall that sound with frequencies less than 20 hertz, Hz, is known as infrasound

4.15P Explain uses of ultrasound and infrasound, including (a) sonar (b) foetal scanning (c) exploration of the Earth's core

4.16P Describe how changes, if any, in velocity, frequency and wavelength, in the transmission of sound waves from one medium to another are inter-related

4.17 *Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*

2. Waves and the Electromagnetic Spectrum

4.9P Describe the effects of (a) reflection (b) refraction (c) transmission (d) absorption of waves at material interfaces

4.10 Explain how waves will be refracted at a boundary in terms of the change of direction and speed

4.11 Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength

5.1P Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle

5.2P Explain the difference between specular and diffuse reflection

5.3P Explain how colour of light is related to (a) differential absorption at surfaces (b) transmission of light through filters

5.4P Relate the power of a lens to its focal length and shape

5.5P Use ray diagrams to show the similarities and differences in the refraction of light by converging and diverging lenses

5.6P Explain the effects of different types of lens in producing real and virtual images

5.7 Recall that all electromagnetic waves are transverse, that they travel at the same speed in a vacuum

5.8 Explain, with examples, that all electromagnetic waves transfer energy from source to observer

5.9 *Core Practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter*

5.10 Recall the main groupings of the continuous electromagnetic spectrum including (in order) radio waves, microwaves, infrared, visible (including the colours of the visible spectrum), ultraviolet, x-rays and gamma rays

5.11 Describe the electromagnetic spectrum as continuous from radio waves to gamma rays and that the radiations within it can be grouped in order of decreasing wavelength and increasing frequency

5.12 Recall that our eyes can only detect a limited range of frequencies of electromagnetic radiation

5.13 Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength

5.14 Explain the effects of differences in the velocities of electromagnetic waves in different substances

5.20 Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency

5.21 Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including:

(a) microwaves: internal heating of body cells (b) infrared: skin burns (c) ultraviolet: damage to surface cells and eyes, leading to skin cancer and eye conditions (d) X-rays and gamma rays: mutation or damage to cells in the body

5.22 Describe some uses of electromagnetic radiation: (a) radio waves: including broadcasting, communications and satellite transmissions (b) microwaves: including cooking, communications and satellite transmissions (c) infrared: including cooking, thermal imaging, short range communications, optical fibres, television remote controls and security systems
(d) visible light: including vision, photography and illumination (e) ultraviolet: including security marking, fluorescent lamps, detecting forged bank notes and disinfecting water (f) X-rays: including observing the internal structure of objects, airport security scanners and medical X-rays (g) gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment

5.23 Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits

5.24 Recall that changes in atoms and nuclei can (a) generate radiations over a wide frequency range (b) be caused by absorption of a range of radiations

6.7 Recall that in each atom its electrons orbit the nucleus at different set distances from the nucleus

6.8 Explain that electrons change orbit when there is absorption or emission of electromagnetic radiation

3. Space and the Universe

2.20 Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only)

2.21 Explain that for motion in a circle there must be a resultant force known as a centripetal force that acts towards the centre of the circle

7.2P Recall that our Solar System consists of the Sun (our star), eight planets and their natural satellites (such as our Moon); dwarf planets; asteroids and comets

7.3P Recall the names and order, in terms of distance from the Sun, of the eight planets

7.4P Describe how ideas about the structure of the Solar System have changed over time

7.5P Describe the orbits of moons, planets, comets and artificial satellites

7.6P Explain for circular orbits how the force of gravity can lead to changing velocity of a planet but unchanged speed

7.7P Explain how, for a stable orbit, the radius must change if orbital speed changes (qualitative only)

7.8P Compare the Steady State and Big Bang theories

7.9P Describe evidence supporting the Big Bang theory, limited to red-shift and the cosmic microwave background (CMB) radiation

7.10P Recall that as there is more evidence supporting the Big Bang theory than the Steady State theory, it is the currently accepted model for the origin of the Universe

7.11P Describe that if a wave source is moving relative to an observer there will be a change in the observed frequency and wavelength

7.12P Describe the red-shift in light received from galaxies at different distances away from the Earth

7.13P Explain why the red-shift of galaxies provides evidence for the Universe expanding

7.14P Explain how both the Big Bang and Steady State theories of the origin of the Universe both account for red-shift of galaxies

7.15P Explain how the discovery of the CMB radiation led to the Big Bang theory becoming the currently accepted model

7.16P Describe the evolution of stars of similar mass to the Sun through the following stages: (a) nebula (b) star (main sequence) (c) red giant (d) white dwarf

7.17P Explain how the balance between thermal expansion and gravity affects the life cycle of stars

7.18P Describe the evolution of stars with a mass larger than the Sun

7.19P Describe how methods of observing the Universe have changed over time including why some telescopes are located outside the Earth's atmosphere

4. Energy

3.1 Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground: change in gravitational potential energy (joule, J) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) × change in vertical height (metre, m)
$\Delta GPE = m \times g \times \Delta h$

3.2 Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = ½ × mass (kilogram, kg) × (speed)^2 ((metre/second)^2, (m/s)^2) $KE = ½ \times m \times v^2$

3.3 Draw and interpret diagrams to represent energy transfers

3.4 Explain what is meant by conservation of energy

3.5 Analyse the changes involved in the way energy is stored when a system changes, including: (a) an object projected upwards or up a slope (b) a moving object hitting an obstacle (c) an object being accelerated by a constant force (d) a vehicle slowing down (e) bringing water to a boil in an electric kettle

3.6 Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system

3.7 Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings

3.8 Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways

3.9 Explain ways of reducing unwanted energy transfer including through lubrication and thermal insulation

3.10 Describe the effects of the thickness and thermal conductivity of the walls of a building on its rate of cooling qualitatively

3.11 Recall and use the equation: efficiency $= \frac{useful\ energy\ transferred\ by\ the\ device}{total\ energy\ supplied\ to\ the\ device}$

3.12 Explain how efficiency can be increased

5.15P Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature

5.16P Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs

5.17P Explain what happens to a body if the average power it radiates is less or more than the average power that it absorbs

5.18P Explain how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted

5.19P *Core Practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*

5. Forces and Motion

2.1 Explain that a scalar quantity has magnitude (size) but no specific direction

2.2 Explain that a vector quantity has both magnitude (size) and a specific direction

2.3 Explain the difference between vector and scalar quantities

2.4 Recall vector and scalar quantities, including: (a) displacement/distance (b) velocity/speed (c) acceleration (d) force (e) weight/mass (f) momentum (g) energy

2.5 Recall that velocity is speed in a stated direction

2.6 Recall and use the equations: a (average) speed (metre per second, m/s) = distance (metre, m) ÷ time (s) b distance travelled (metre, m) = average speed (metre per second, m/s) × time (s)

2.7 Analyse distance/time graphs including determination of speed from the gradient

2.8 Recall and use the equation: acceleration (metre per second squared, m/s^2) = change in velocity (metre per second, m/s) ÷ time taken (second, s) $a = \frac{(v-u)}{t}$

2.9 Use the equation: (final velocity)^2 ((metre/second)^2, (m/s)2) – (initial velocity)^2 ((metre/second)^2, $(m/s)^2$) = 2 × acceleration (metre per second squared, m/s^2) × distance (metre, m) $v^2 = u^2 + 2ax$

2.10 Analyse velocity/time graphs to:

(a) compare acceleration from gradients qualitatively,

(b) calculate the acceleration from the gradient (for uniform acceleration only),

(c) determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only)

2.11 Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates

2.12 Recall some typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems

2.13 Recall that the acceleration, *g*, in free fall is 10 m/s^2 and be able to estimate the magnitudes of everyday accelerations

2.14 Recall Newton's first law and use it in the following situations:

(a) where the resultant force on a body is zero, i.e. the body is moving at a constant velocity or is at rest,

(b) where the resultant force is not zero, i.e. the speed and/or direction of the body change(s)

2.15 Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) $F = m \times a$

2.16 Define weight, recall and use the equation: weight (newton, N) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg)

2.17 Describe how weight is measured $W = m \times g$

2.18 Describe the relationship between the weight of a body and the gravitational field strength

2.19 *Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*

2.22 Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration

7.1P Explain how and why both the weight of any body and the value of *g* differ between the surface of the Earth and the surface of other bodies in space, including the Moon

8. AC Electricity

3.13 Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydroelectricity, the tides and the Sun), and compare the ways in which both renewable and non-renewable sources are used

3.14 Explain patterns and trends in the use of energy resources

10. Atomic Structure and Nuclear Radiation

6.1 Describe an atom as a positively charged nucleus, consisting of protons and neutrons, surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus

6.2 Recall the typical size (order of magnitude) of atoms and small molecules

6.3 Describe the structure of nuclei of isotopes using the terms atomic (proton) number and mass (nucleon) number and using symbols in the format using symbols in the format $^{13}_{6}C$

6.4 Recall that the nucleus of each element has a characteristic positive charge, but that isotopes of an element differ in mass by having different numbers of neutrons

6.5 Recall the relative masses and relative electric charges of protons, neutrons, electrons and positrons

6.6 Recall that in an atom the number of protons equals the number of electrons and is therefore neutral

6.7 Recall that in each atom its electrons orbit the nucleus at different set distances from the nucleus

6.8 Explain that electrons change orbit when there is absorption or emission of electromagnetic radiation

6.9 Explain how atoms may form positive ions by losing outer electrons

6.10 Recall that alpha, β– (beta minus), β+ (positron), gamma rays and neutron radiation are emitted from unstable nuclei in a random process

6.11 Recall that alpha, β– (beta minus), β+ (positron) and gamma rays are ionising radiations

6.12 Explain what is meant by background radiation

6.13 Describe the origins of background radiation from Earth and space

6.14 Describe methods for measuring and detecting radioactivity limited to photographic film and a Geiger–Müller tube

6.15 Recall that an alpha particle is equivalent to a helium nucleus, a beta particle is an electron emitted from the nucleus and a gamma ray is electromagnetic radiation

6.16 Compare alpha, beta and gamma radiations in terms of their abilities to penetrate and ionise

6.17 Describe how and why the atomic model has changed over time including reference to the plum pudding model and Rutherford alpha particle scattering leading to the Bohr model

6.18 Describe the process of β– decay (a neutron becomes a proton plus an electron)

6.19 Describe the process of β+ decay (a proton becomes a neutron plus a positron)

6.20 Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, β, γ and neutron emission)

6.21 Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation

6.22 Use given data to balance nuclear equations in terms of mass and charge

6.23 Describe how the activity of a radioactive source decreases over a period of time

6.24 Recall that the unit of activity of a radioactive isotope is the Becquerel, Bq

6.25 Explain that the half-life of a radioactive isotope is the time taken for half the undecayed nuclei to decay or the activity of a source to decay by half

6.26 Explain that it cannot be predicted when a particular nucleus will decay but half-life enables the activity of a very large number of nuclei to be predicted during the decay process

6.27 Use the concept of half-life to carry out simple calculations on the decay of a radioactive isotope, including graphical representations

11. Uses and Dangers of Nuclear radiation

6.28P Describe uses of radioactivity, including: (a) household fire (smoke) alarms (b) irradiating food (c) sterilisation of equipment (d) tracing and gauging thicknesses (e) diagnosis and treatment of cancer

6.29 Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions needed

6.30P Explain how the dangers of ionising radiation depend on half-life and relate this to the precautions needed

6.31 Explain the precautions taken to ensure the safety of people exposed to radiation, including limiting the dose for patients and the risks to medical personnel

6.32 Describe the differences between contamination and irradiation effects and compare the hazards associated with these two

6.33P Compare and contrast the treatment of tumours using radiation applied internally or externally

6.34P Explain some of the uses of radioactive substances in diagnosis of medical conditions, including PET scanners and tracers

6.35P Explain why isotopes used in PET scanners have to be produced nearby

6.36P Evaluate the advantages and disadvantages of nuclear power for generating electricity, including the lack of carbon dioxide emissions, risks, public perception, waste disposal and safety issues

6.37P Recall that nuclear reactions, including fission, fusion and radioactive decay, can be a source of energy

6.38P Explain how the fission of U-235 produces two daughter nuclei and the emission of two or more neutrons, accompanied by a release of energy

6.39P Explain the principle of a controlled nuclear chain reaction

6.40P Explain how the chain reaction is controlled in a nuclear reactor, including the action of moderators and control rods

6.41P Describe how thermal (heat) energy from the chain reaction is used in the generation of electricity in a nuclear power station

6.42P Recall that the products of nuclear fission are radioactive

6.43P Describe nuclear fusion as the creation of larger nuclei resulting in a loss of mass from smaller nuclei, accompanied by a release of energy, and recognise fusion as the energy source for stars

6.44P Explain the difference between nuclear fusion and nuclear fission

6.45P Explain why nuclear fusion does not happen at low temperatures and pressures, due to electrostatic repulsion of protons

6.46P Relate the conditions for fusion to the difficulty of making a practical and economic form of power station

12. More Forces and Motion

2.23 Recall and apply Newton's third law both to equilibrium situations and to collision interactions and relate it to the conservation of momentum in collisions

2.24 Define momentum, recall and use the equation: momentum (kilogram metre per second, kg m/s) = mass (kilogram, kg) × velocity (metre per second, m/s) $p = m \times v$

2.25 Describe examples of momentum in collisions

2.26 Use Newton's second law as: force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s) $F = \frac{mv-mu}{t}$

2.27 Explain methods of measuring human reaction times and recall typical results

2.28 Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance

2.29 Explain that the stopping distance of a vehicle is affected by a range of factors including: (a) the mass of the vehicle (b) the speed of the vehicle (c) the driver's reaction time (d) the state of the vehicle's brakes (e) the state of the road (f) the amount of friction between the tyre and the road surface

2.30 Describe the factors affecting a driver's reaction time including drugs and distractions

2.31 Explain the dangers caused by large decelerations and estimate the forces involved in typical situations on a public road

2.32P Estimate how the distance required for a road vehicle to stop in an emergency varies over a range of typical speeds

2.33P Carry out calculations on work done to show the dependence of braking distance for a vehicle on initial velocity squared (work done to bring a vehicle to rest equals its initial kinetic energy)

GCSE Physics Specifications Paper 2

On Both Papers

1.1 Recall and use the SI unit for physical quantities: metres (m), kilogram (kg), second (s), ampere (A), kelvin (K), mole (mol), hertz (Hz), newton (N), joule (J), watt (W), pascal (Pa), coulomb (C), volt (V), ohm (Ω), tesla (T)

1.2 Recall and use multiples and sub-multiples of units, including giga (G), mega (M), kilo (k), centi (c), milli (m), micro (μ) and nano (n)

1.3 Be able to convert between different units, including hours to seconds

1.4 Use significant figures and standard form where appropriate

4. Energy

8.1 Describe the changes involved in the way energy is stored when systems change

8.2 Draw and interpret diagrams to represent energy transfers

8.3 Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system

8.4 Identify the different ways that the energy of a system can be changed (a) through work done by forces (b) in electrical equipment (c) in heating

8.5 Describe how to measure the work done by a force and understand that energy transferred (joule, J) is equal to work done (joule, J)

8.6 Recall and use the equation: work done (joule, J) = force (newton, N) × distance moved in the direction of the force (metre, m) $E = F \times d$

8.7 Describe and calculate the changes in energy involved when a system is changed by work done by forces

8.8 Recall and use the equation to calculate the change in gravitational PE when an object is raised above the ground: change in gravitational potential energy (joule, J) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) × change in vertical height (metre, m)
$\Delta GPE = m \times g \times \Delta h$

8.9 Recall and use the equation to calculate the amounts of energy associated with a moving object: kinetic energy (joule, J) = ½ × mass (kilogram, kg) × (speed)^2 ((metre/second)^2, (m/s)^2) $KE = ½ \times m \times v^2$

8.10 Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways

8.11 Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings

8.12 Define power as rate at which energy is transferred and use examples to explain this definition

8.13 Recall and use the equation: power (watt, W) = work done (joule, J) ÷ time taken (second, s)
$P = \frac{E}{t}$

8.14 Recall that one watt is equal to one joule per second, J/s

8.15 Recall and use the equation: efficiency $= \frac{useful\ energy\ transferred\ by\ the\ device}{total\ energy\ supplied\ to\ the\ device}$

5. Forces and Motion

9.1 Describe, with examples, how objects can interact:

(a) at a distance without contact, linking these to the gravitational, electrostatic and magnetic fields involved, (b) by contact, including normal contact force and friction, (c) producing pairs of forces which can be represented as vectors

9.2 Explain the difference between vector and scalar quantities using examples

9.3 Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only)

9.4 Draw and use free body force diagrams

9.5 Explain examples of the forces acting on an isolated solid object or a system where several forces lead to a resultant force on an object and the special case of balanced forces when the resultant force is zero

9.6P Describe situations where forces can cause rotation

9.7P Recall and use the equation: moment of a force (newton metre, N m) = force (newton, N) × distance normal to the direction of the force (metre, m)

9.8P Recall and use the principle of moments in situations where rotational forces are in equilibrium: the sum of clockwise moments = the sum of anti-clockwise moments for rotational forces in equilibrium

9.9P Explain how levers and gears transmit the rotational effects of forces

9.10 Explain ways of reducing unwanted energy transfer through lubrication

6. DC Electricity

10.2 Draw and use electric circuit diagrams representing them with the conventions of positive and negative terminals, and the symbols that represent cells, including batteries, switches, voltmeters, ammeters, resistors, variable resistors, lamps, motors, diodes, thermistors, LDRs and LEDs

10.3 Describe the differences between series and parallel circuits

10.4 Recall that a voltmeter is connected in parallel with a component to measure the potential difference (voltage), in volt, across it

10.5 Explain that potential difference (voltage) is the energy transferred per unit charge passed and hence that the volt is a joule per coulomb

10.6 Recall and use the equation: energy transferred (joule, J) = charge moved (coulomb, C) × potential difference (volt, V) $E = Q \times V$

10.7 Recall that an ammeter is connected in series with a component to measure the current, in amp, in the component

10.8 Explain that an electric current is the rate of flow of charge and the current in metals is a flow of electrons

10.9 Recall and use the equation: charge (coulomb, C) = current (ampere, A) × time (second, s) $Q = I \times t$

10.10 Describe that when a closed circuit includes a source of potential difference there will be a current in the circuit

10.11 Recall that current is conserved at a junction in a circuit

10.12 Explain how changing the resistance in a circuit changes the current and how this can be achieved using a variable resistor

10.13 Recall and use the equation: potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω) $V = I \times R$

10.14 Explain why, if two resistors are in series, the net resistance is increased, whereas with two in parallel the net resistance is decreased

10.15 Calculate the currents, potential differences and resistances in series circuits

10.16 Explain the design and construction of series circuits for testing and measuring

10.17 *Core Practical: Construct electrical circuits to:* (*a) investigate the relationship between potential difference, current and resistance for a resistor and a filament lamp* (*b) test series and parallel circuits using resistors and filament lamps*

10.18 Explain how current varies with potential difference for the following devices and how this relates to resistance (a) filament lamps (b) diodes (c) fixed resistors

10.19 Describe how the resistance of a light-dependent resistor (LDR) varies with light intensity

10.20 Describe how the resistance of a thermistor varies with change of temperature

10.21 Explain how the design and use of circuits can be used to explore the variation of resistance in the following devices (a) filament lamps (b) diodes (c) thermistors (d) LDRs

10.22 Recall that, when there is an electric current in a resistor, there is an energy transfer which heats the resistor

10.23 Explain that electrical energy is dissipated as thermal energy in the surroundings when an electrical current does work against electrical resistance

10.24 Explain the energy transfer (in 10.22 above) as the result of collisions between electrons and the ions in the lattice

10.25 Explain ways of reducing unwanted energy transfer through low resistance wires

10.26 Describe the advantages and disadvantages of the heating effect of an electric current

10.27 Use the equation: energy transferred (joule, J) = current (ampere, A) × potential difference (volt, V) × time (second, s) $E = I \times V \times t$

10.28 Describe power as the energy transferred per second and recall that it is measured in watts

10.29 Recall and use the equation: power (watt, W) = energy transferred (joule, J) ÷ time taken (second, s) $P = \frac{E}{t}$

10.30 Explain how the power transfer in any circuit device is related to the potential difference across it and the current in it

10.31 Recall and use the equations: electrical power (watt, W) = current (ampere, A) × potential difference (volt, V) $P = I \times V$ electrical power (watt, W) = current squared (ampere^2, A^2) × resistance (ohm, Ω) $P = I^2 \times R$

10.32 Describe how, in different domestic devices, energy is transferred from batteries and the a.c. mains to the energy of motors and heating devices

10.33 Explain the difference between direct and alternating voltage

10.34 Describe direct current (d.c.) as movement of charge in one direction only and recall that cells and batteries supply direct current (d.c.)

10.35 Describe that in alternating current (a.c.) the movement of charge changes direction

10.36 Recall that in the UK the domestic supply is a.c., at a frequency of 50 Hz and a voltage of about 230 V

7. Magnetism

12.1 Recall that unlike magnetic poles attract and like magnetic poles repel

12.2 Describe the uses of permanent and temporary magnetic materials including cobalt, steel, iron and nickel

12.3 Explain the difference between permanent and induced magnets

12.4 Describe the shape and direction of the magnetic field around bar magnets and for a uniform field, and relate the strength of the field to the concentration of lines

12.5 Describe the use of plotting compasses to show the shape and direction of the field of a magnet and the Earth's magnetic field

12.6 Explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic

12.7 Describe how to show that a current can create a magnetic effect around a long straight conductor, describing the shape of the magnetic field produced and relating the direction of the magnetic field to the direction of the current

12.8 Recall that the strength of the field depends on the size of the current and the distance from the long straight conductor

12.9 Explain how inside a solenoid (an example of an electromagnet) the fields from individual coils

(a) add together to form a very strong almost uniform field along the centre of the solenoid

(b) cancel to give a weaker field outside the solenoid

12.10 Recall that a current carrying conductor placed near a magnet experiences a force and that an equal and opposite force acts on the magnet

12.11 Explain that magnetic forces are due to interactions between magnetic fields

12.12 Recall and use Fleming's left-hand rule to represent the relative directions of the force, the current and the magnetic field for cases where they are mutually perpendicular

12.13 Use the equation: force on a conductor at right angles to a magnetic field carrying a current (newton, N) = magnetic flux density (tesla, T or newton per ampere metre, N/A m) × current (ampere, A) × length (metre, m) $F = B \times I \times l$

12.14P Explain how the force on a conductor in a magnetic field is used to cause rotation in electric motors

8. AC Electricity

10.36 Recall that in the UK the domestic supply is a.c., at a frequency of 50 Hz and a voltage of about 230 V

10.37 Explain the difference in function between the live and the neutral mains input wires

10.38 Explain the function of an earth wire and of fuses or circuit breakers in ensuring safety

10.39 Explain why switches and fuses should be connected in the live wire of a domestic circuit

10.40 Recall the potential differences between the live, neutral and earth mains wires

10.41 Explain the dangers of providing any connection between the live wire and earth

10.42 Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use

13.1P Explain how to produce an electric current by the relative movement of a magnet and a conductor (a) on a small scale in the laboratory (b) in the large-scale generation of electrical energy

13.2 Recall the factors that affect the size and direction of an induced potential difference, and describe how the magnetic field produced opposes the original change

13.3P Explain how electromagnetic induction is used in alternators to generate current which alternates in direction (a.c.) and in dynamos to generate direct current (d.c.)

13.4P Explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits, and the reverse effect as used in loudspeakers and headphones

13.5 Explain how an alternating current in one circuit can induce a current in another circuit in a transformer

13.6 Recall that a transformer can change the size of an alternating voltage

13.7P Use the turns ratio equation for transformers to calculate either the missing voltage or the missing number of turns:

$$\frac{potential\ difference\ across\ primary\ coil}{potential\ difference\ across\ secondary\ coil} = \frac{number\ of\ turns\ in\ primary\ coil}{number\ of\ turns\ in\ secondary\ coil}$$

13.8 Explain why, in the national grid, electrical energy is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic uses as it improves the efficiency by reducing heat loss in transmission lines

13.9 Explain where and why step-up and step-down transformers are used in the transmission of electricity in the national grid

13.10 Use the power equation (for transformers with100% efficiency): potential difference across primary coil (volt, V) × current in primary coil (ampere, A) = potential difference across secondary coil

(volt, V) × current in secondary coil (ampere, A)
$V_P \times I_P = V_S \times I_S$

13.11P Explain the advantages of power transmission in high-voltage cables, using the equations in 10.29, 10.31, 13.7P and 13.10

9. Static electricity

11.1P Explain how an insulator can be charged by friction, through the transfer of electrons

11.2P Explain how the material gaining electrons becomes negatively charged and the material losing electrons is left with an equal positive charge

11.3P Recall that like charges repel and unlike charges attract

11.4P Explain common electrostatic phenomena in terms of movement of electrons, including (a) shocks from everyday objects (b) lightning (c) attraction by induction such as a charged balloon attracted to a wall and a charged comb picking up small pieces of paper

11.5P Explain how earthing removes excess charge by movement of electrons

11.6P Explain some of the uses of electrostatic charges in everyday situations, including insecticide sprayers

11.7P Describe some of the dangers of sparking in everyday situations, including fuelling cars, and explain the use of earthing to prevent dangerous build-up of charge

11.8P Define an electric field as the region where an electric charge experiences a force

11.9P Describe the shape and direction of the electric field around a point charge and between parallel plates and relate the strength of the field to the concentration of lines

11.10P Explain how the concept of an electric field helps to explain the phenomena of static electricity

10. Atomic Structure and Nuclear Radiation

10.1 Describe the structure of the atom, limited to the position, mass and charge of protons, neutrons and electrons

12. More Forces and Motion

15.1 Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force

15.2 Describe the difference between elastic and inelastic distortion

15.3 Recall and use the equation for linear elastic distortion including calculating the spring constant: force exerted on a spring (newton, N) = spring constant (newton per metre, N/m) × extension (metre, m)
$F = k \times x$

15.4 Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = ½ × spring constant (newton per metre, N/m) × (extension (metre, m))2 $E = ½ \times k \times x$

15.5 Describe the difference between linear and non-linear relationships between force and extension

15.6 Core Practical: Investigate the extension and work done when applying forces to a spring

13. Solids, Liquids and Gases

14.1 Use a simple kinetic theory model to explain the different states of matter (solids, liquids and gases) in terms of the movement and arrangement of particles

14.2 Recall and use the equation: density (kilogram per cubic metre, kg/m^3) = mass (kilogram, kg) ÷ volume (cubic metre, m^3) $\rho = \frac{m}{V}$

14.3 Core Practical: Investigate the densities of solid and liquids

14.4 Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules

14.5 Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed

14.6 Explain how heating a system will change the energy stored within the system and raise its temperature or produce changes of state

14.7 Define the terms specific heat capacity and specific latent heat and explain the differences between them

14.8 Use the equation: change in thermal energy (joule, J) = mass (kilogram, kg) × specific heat capacity (joule per kilogram degree Celsius, J/kg °C) × change in temperature (degree Celsius, °C) $\Delta Q = m \times c \times \Delta\theta$

14.9 Use the equation: thermal energy for a change of state (joule , J) = mass (kilogram, kg) × specific latent heat (joule per kilogram, J/kg) $Q = m \times L$

14.10 Explain ways of reducing unwanted energy transfer through thermal insulation

14.11 Core Practical: Investigate the properties of water by determining the specific heat capacity of water and obtaining a temperature-time graph for melting ice

14.12 Explain the pressure of a gas in terms of the motion of its particles

14.13 Explain the effect of changing the temperature of a gas on the velocity of its particles and hence on the pressure produced by a fixed mass of gas at constant volume (qualitative only)

14.14 Describe the term absolute zero, −273 °C, in terms of the lack of movement of particles

14.15 Convert between the kelvin and Celsius scales

14.16P Explain that gases can be compressed or expanded by pressure changes

14.17P Explain that the pressure of a gas produces a net force at right angles to any surface

14.18P Explain the effect of changing the volume of a gas on the rate at which its particles collide with the walls of its container and hence on the pressure produced by a fixed mass of gas at constant temperature

14.19P Use the equation: $P_1 \times V_1 = P_2 \times V_2$ to calculate pressure or volume for gases of fixed mass at constant temperature

14.20P Explain why doing work on a gas can increase its temperature, including a bicycle pump

15.7P Explain why atmospheric pressure varies with height above the Earth's surface with reference to a simple model of the Earth's atmosphere

15.8P Describe the pressure in a fluid as being due to the fluid and atmospheric pressure

15.9P Recall that the pressure in fluids causes a force normal to any surface

15.10P Explain how pressure is related to force and area, using appropriate examples

15.11P Recall and use the equation: pressure (pascal, Pa) = force normal to surface (newton, N) ÷ area of surface (square metre, m^2) $P = \frac{F}{A}$

15.12P Describe how pressure in fluids increases with depth and density

15.13P Explain why the pressure in liquids varies with density and depth

15.14P Use the equation to calculate the magnitude of the pressure in liquids and calculate the differences in pressure at different depths in a liquid: pressure due to a column of liquid (pascal, Pa) = height of column (metre, m) × density of liquid (kilogram per cubic metre, kg/m3) × gravitational field strength (newton per kilogram, N/kg) $P = h \times \rho \times g$

15.15P Explain why an object in a fluid is subject to an upwards force (upthrust) and relate this to examples including objects that are fully immersed in a fluid (liquid or gas) or partially immersed in a liquid

15.16P Recall that the upthrust is equal to the weight of fluid displaced

15.17P Explain how the factors (upthrust, weight, density of fluid) influence whether an object will float or sink