Section 1: Forces and motion

a) Units

b) Movement and position

c) Forces, movement, shape and momentum

d) Astronomy

a) Units

Students will be assessed on their ability to:

1.1 use the following units: kilogram (kg), metre (m), metre/second (m/s), metre/second^2 (m/s^2), newton (N), second (s), newton per kilogram (N/kg), **kilogram metre/second (kg m/s)**.

b) Movement and position

Students will be assessed on their ability to:

1.2 plot and interpret distance-time graphs

1.3 know and use the relationship between average speed, distance moved and time:

$$\text{average speed} = \frac{\text{distance moved}}{\text{time taken}}$$

1.4 describe experiments to investigate the motion of everyday objects such as toy cars or tennis balls

1.5 know and use the relationship between acceleration, velocity and time:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$a = \frac{(v-u)}{t}$$

1.6 plot and interpret velocity-time graphs

1.7 determine acceleration from the gradient of a velocity-time graph

1.8 determine the distance travelled from the area between a velocity-time graph and the time axis.

c) Forces, movement, shape and momentum

Students will be assessed on their ability to:

1.9 describe the effects of forces between bodies such as changes in speed, shape or direction

1.10 identify different types of force such as gravitational or electrostatic

1.11 distinguish between vector and scalar quantities

1.12 understand that force is a vector quantity

1.13 find the resultant force of forces that act along a line

1.14 understand that friction is a force that opposes motion

1.15 know and use the relationship between unbalanced force, mass and acceleration:

force = mass × acceleration

$F = m \times a$

1.16 know and use the relationship between weight, mass and g:

weight = mass × g

$W = m \times g$

1.17 describe the forces acting on falling objects and explain why falling objects reach a terminal velocity

1.18 describe experiments to investigate the forces acting on falling objects, such as sycamore seeds or parachutes

1.19 describe the factors affecting vehicle stopping distance including speed, mass, road condition and reaction time

1.20 know and use the relationship between momentum, mass and velocity:

momentum = mass × velocity

$\boldsymbol{p = m \times v}$

1.21 use the idea of momentum to explain safety features

1.22 use the conservation of momentum to calculate the mass, velocity or momentum of objects

1.23 use the relationship between force, change in momentum and time taken:

$$\textbf{force} = \frac{\textbf{change in momentum}}{\textbf{time taken}}$$

1.24 demonstrate an understanding of Newton's third law

1.25 know and use the relationship between the moment of a force and its distance from the pivot:

moment = force × perpendicular distance from the pivot

1.26 recall that the weight of a body acts through its centre of gravity

1.27 know and use the principle of moments for a simple system of parallel forces acting in one plane

1.28 understand that the upward forces on a light beam, supported at its ends, vary with the position of a heavy object placed on the beam

1.29 describe experiments to investigate how extension varies with applied force for helical springs, metal wires and rubber bands

1.30 understand that the initial linear region of a force-extension graph is associated with Hooke's law

1.31 describe elastic behaviour as the ability of a material to recover its original shape after the forces causing deformation have been removed.

d) Astronomy

Students will be assessed on their ability to:

1.32 understand gravitational field strength, g, and recall that it is different on other planets and the moon from that on the Earth

1.33 explain that gravitational force:

- causes moons to orbit planets
- causes the planets to orbit the sun
- causes artificial satellites to orbit the Earth
- causes comets to orbit the sun

1.34 describe the differences in the orbits of comets, moons and planets

1.35 use the relationship between orbital speed, orbital radius and time period:

$$\text{orbital speed} = \frac{2 \times \pi \times \text{orbital radius}}{\text{time period}}$$

$$v = \frac{2 \times \pi \times r}{T}$$

1.36 understand that:

- the universe is a large collection of billions of galaxies
- a galaxy is a large collection of billions of stars
- our solar system is in the Milky Way galaxy.

Section 2: Electricity

a) Units

b) Mains electricity

c) Energy and potential difference in circuits

d) Electric charge

a) Units

Students will be assessed on their ability to:

2.1 use the following units: ampere (A), coulomb (C), joule (J), ohm (Ω), second (s), volt (V), watt (W).

b) Mains electricity

Students will be assessed on their ability to:

2.2 understand and identify the hazards of electricity including frayed cables, long cables, damaged plugs, water around sockets, and pushing metal objects into sockets

2.3 understand the uses of insulation, double insulation, earthing, fuses and circuit breakers in a range of domestic appliances

2.4 understand that a current in a resistor results in the electrical transfer of energy and an increase in temperature, and how this can be used in a variety of domestic contexts

2.5 know and use the relationship:

power = current × voltage

$$P = I \times V$$

and apply the relationship to the selection of appropriate fuses

2.6 use the relationship between energy transferred, current, voltage and time:

energy transferred = current × voltage × time

$$E = I \times V \times t$$

2.7 understand the difference between mains electricity being alternating current (a.c.) and direct current (d.c.) being supplied by a cell or battery.

c) Energy and potential difference in circuits

Students will be assessed on their ability to:

2.8 explain why a series or parallel circuit is more appropriate for particular applications, including domestic lighting

2.9 understand that the current in a series circuit depends on the applied voltage and the number and nature of other components

2.10 describe how current varies with voltage in wires, resistors, metal filament lamps and diodes, and how this can be investigated experimentally

2.11 describe the qualitative effect of changing resistance on the current in a circuit

2.12 describe the qualitative variation of resistance of LDRs with illumination and of thermistors with temperature

2.13 know that lamps and LEDs can be used to indicate the presence of a current in a circuit

2.14 know and use the relationship between voltage, current and resistance:

voltage = current × resistance

$V = I \times R$

2.15 understand that current is the rate of flow of charge

2.16 know and use the relationship between charge, current and time:

charge = current × time

$Q = I \times t$

2.17 know that electric current in solid metallic conductors is a flow of negatively charged electrons

2.18 understand that:

- **voltage is the energy transferred per unit charge passed**
- **the volt is a joule per coulomb.**

d) Electric charge

Students will be assessed on their ability to:

2.19 identify common materials which are electrical conductors or insulators, including metals and plastics

2.20 describe experiments to investigate how insulating materials can be charged by friction

2.21 explain that positive and negative electrostatic charges are produced on materials by the loss and gain of electrons

2.22 understand that there are forces of attraction between unlike charges and forces of repulsion between like charges

2.23 explain electrostatic phenomena in terms of the movement of electrons

2.24 explain the potential dangers of electrostatic charges, eg when fuelling aircraft and tankers

2.25 explain some uses of electrostatic charges, eg in photocopiers and inkjet printers.

Section 3: Waves

a) Units

b) Properties of waves

c) The electromagnetic spectrum

d) Light and sound

a) Units

Students will be assessed on their ability to:

3.1 use the following units: degree (°), hertz (Hz), metre (m), metre/second (m/s), second (s).

b) Properties of waves

Students will be assessed on their ability to:

3.2 understand the difference between longitudinal and transverse waves and describe experiments to show longitudinal and transverse waves in, for example, ropes, springs and water

3.3 define amplitude, frequency, wavelength and period of a wave

3.4 understand that waves transfer energy and information without transferring matter

3.5 know and use the relationship between the speed, frequency and wavelength of a wave:

wave speed = frequency × wavelength

$v = f \times \lambda$

3.6 use the relationship between frequency and time period:

$$\text{frequency} = \frac{1}{\text{time period}}$$

$$f = \frac{1}{T}$$

3.7 use the above relationships in different contexts including sound waves and electromagnetic waves

3.8 understand that waves can be diffracted when they pass an edge

3.9 understand that waves can be diffracted through gaps, and that the extent of diffraction depends on the wavelength and the physical dimension of the gap.

c) The electromagnetic spectrum

Students will be assessed on their ability to:

3.10 understand that light is part of a continuous electromagnetic spectrum which includes radio, microwave, infrared, visible, ultraviolet, x-ray and gamma ray radiations and that all these waves travel at the same speed in free space

3.11 identify the order of the electromagnetic spectrum in terms of decreasing wavelength and increasing frequency, including the colours of the visible spectrum

3.12 explain some of the uses of electromagnetic radiations, including:

- radio waves: broadcasting and communications
- microwaves: cooking and satellite transmissions
- infrared: heaters and night vision equipment
- visible light: optical fibres and photography
- ultraviolet: fluorescent lamps
- x-rays: observing the internal structure of objects and materials and medical applications
- gamma rays: sterilising food and medical equipment

3.13 understand the detrimental effects of excessive exposure of the human body to electromagnetic waves, including:

- microwaves: internal heating of body tissue
- infrared: skin burns
- ultraviolet: damage to surface cells and blindness
- gamma rays: cancer, mutation

and describe simple protective measures against the risks.

d) Light and sound

Students will be assessed on their ability to:

3.14 understand that light waves are transverse waves which can be reflected, refracted **and diffracted**

3.15 use the law of reflection (the angle of incidence equals the angle of reflection)

3.16 construct ray diagrams to illustrate the formation of a virtual image in a plane mirror

3.17 describe experiments to investigate the refraction of light, using rectangular blocks, semicircular blocks and triangular prisms

3.18 know and use the relationship between refractive index, angle of incidence and angle of refraction:

$$n = \frac{\sin i}{\sin r}$$

3.19 describe an experiment to determine the refractive index of glass, using a glass block

3.20 describe the role of total internal reflection in transmitting information along optical fibres and in prisms

3.21 explain the meaning of critical angle *c*

3.22 know and use the relationship between critical angle and refractive index:

$$\sin c = \frac{1}{n}$$

3.23 understand the difference between analogue and digital signals

3.24 describe the advantages of using digital signals rather than analogue signals

3.25 describe how digital signals can carry more information

3.26 understand that sound waves are longitudinal waves and how they can be reflected, refracted **and diffracted**

3.27 understand that the frequency range for human hearing is

20 Hz – 20,000 Hz

3.28 describe an experiment to measure the speed of sound in air

3.29 understand how an oscilloscope and microphone can be used to display a sound wave

3.30 describe an experiment using an oscilloscope to determine the frequency of a sound wave

3.31 relate the pitch of a sound to the frequency of vibration of the source

3.32 relate the loudness of a sound to the amplitude of vibration.

Section 4: Energy resources and energy transfer

a) Units

b) Energy transfer

c) Work and power

d) Energy resources and electricity generation

a) Units

Students will be assessed on their ability to:

4.1 use the following units: kilogram (kg), joule (J), metre (m), metre/second (m/s), metre/second^2 (m/s^2), newton (N), second (s), watt (W).

b) Energy transfer

Students will be assessed on their ability to:

4.2 describe energy transfers involving the following forms of energy: thermal (heat), light, electrical, sound, kinetic, chemical, nuclear and potential (elastic and gravitational)

4.3 understand that energy is conserved

4.4 know and use the relationship:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

4.5 describe a variety of everyday and scientific devices and situations, explaining the fate of the input energy in terms of the above relationship, including their representation by Sankey diagrams

4.6 describe how energy transfer may take place by conduction, convection and radiation

4.7 explain the role of convection in everyday phenomena

4.8 explain how insulation is used to reduce energy transfers from buildings and the human body.

c) Work and power

Students will be assessed on their ability to:

4.9 know and use the relationship between work, force and distance moved in the direction of the force:

work done = force × distance moved

$W = F \times d$

4.10 understand that work done is equal to energy transferred

4.11 know and use the relationship:

gravitational potential energy = mass × g × height

GPE = $m \times g \times h$

4.12 know and use the relationship:

kinetic energy = $\frac{1}{2}$ × mass × speed^2

KE = $\frac{1}{2} \times m \times v^2$

4.13 understand how conservation of energy produces a link between gravitational potential energy, kinetic energy and work

4.14 describe power as the rate of transfer of energy or the rate of doing work

4.15 use the relationship between power, work done (energy transferred) and time taken:

$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

$$P = \frac{W}{t}$$

d) Energy resources and electricity generation

Students will be assessed on their ability to:

4.16 describe the energy transfers involved in generating electricity using:

- wind
- water
- geothermal resources
- solar heating systems
- solar cells
- fossil fuels
- nuclear power

4.17 describe the advantages and disadvantages of methods of large-scale electricity production from various renewable and non-renewable resources.

Section 5: Solids, liquids and gases

a) Units

b) Density and pressure

c) Change of state

d) Ideal gas molecules

a) Units

Students will be assessed on their ability to:

5.1 use the following units: degrees Celsius (°C), kelvin (K), joule (J), kilogram (kg), kilogram/metre^3 (kg/m^3), metre (m), metre^2 (m^2), metre^3 (m^3), metre/second (m/s), metre/second^2 (m/s^2), newton (N), pascal (Pa).

b) Density and pressure

Students will be assessed on their ability to:

5.2 know and use the relationship between density, mass and volume:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{m}{V}$$

5.3 describe experiments to determine density using direct measurements of mass and volume

5.4 know and use the relationship between pressure, force and area:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

$$p = \frac{F}{A}$$

5.5 understand that the pressure at a point in a gas or liquid which is at rest acts equally in all directions

5.6 know and use the relationship for pressure difference:

pressure difference = height × density × g

$$p = h \times \rho \times g$$

c) Change of state

Students will be assessed on their ability to:

5.7 understand the changes that occur when a solid melts to form a liquid, and when a liquid evaporates or boils to form a gas

5.8 describe the arrangement and motion of particles in solids, liquids and gases

d) Ideal gas molecules

Students will be assessed on their ability to:

5.9 understand the significance of Brownian motion, as supporting evidence for particle theory

5.10 understand that molecules in a gas have a random motion and that they exert a force and hence a pressure on the walls of the container

5.11 understand why there is an absolute zero of temperature which is –273°C

5.12 describe the Kelvin scale of temperature and be able to convert between the Kelvin and Celsius scales

5.13 understand that an increase in temperature results in an increase in the average speed of gas molecules

5.14 understand that the Kelvin temperature of the gas is proportional to the average kinetic energy of its molecules

5.15 describe the qualitative relationship between pressure and Kelvin temperature for a gas in a sealed container

5.16 use the relationship between the pressure and Kelvin temperature of a fixed mass of gas at constant volume:

$$\frac{p_1}{T_1} = \frac{p_2}{T_2}$$

5.17 use the relationship between the pressure and volume of a fixed mass of gas at constant temperature:

$$p_1V_1 = p_2V_2$$

Section 6: Magnetism and electromagnetism

a) Units

b) Magnetism

c) Electromagnetism

e) Electromagnetic induction

a) Units

Students will be assessed on their ability to:

6.1 use the following units: ampere (A), volt (V), watt (W).

b) Magnetism

Students will be assessed on their ability to:

6.2 understand that magnets repel and attract other magnets and attract magnetic substances

6.3 describe the properties of magnetically hard and soft materials

6.4 understand the term 'magnetic field line'

6.5 understand that magnetism is induced in some materials when they are placed in a magnetic field

6.6 describe experiments to investigate the magnetic field pattern for a permanent bar magnet and that between two bar magnets

6.7 describe how to use two permanent magnets to produce a uniform magnetic field pattern.

c) Electromagnetism

Students will be assessed on their ability to:

6.8 understand that an electric current in a conductor produces a magnetic field round it

6.9 describe the construction of electromagnets

6.10 sketch and recognise magnetic field patterns for a straight wire, a flat circular coil and a solenoid when each is carrying a current

6.11 understand that there is a force on a charged particle when it moves in a magnetic field as long as its motion is not parallel to the field

6.12 understand that a force is exerted on a current-carrying wire in a magnetic field, and how this effect is applied in simple d.c. electric motors and loudspeakers

6.13 use the left hand rule to predict the direction of the resulting force when a wire carries a current perpendicular to a magnetic field

6.14 describe how the force on a current-carrying conductor in a magnetic field increases with the strength of the field and with the current.

d) Electromagnetic induction

Students will be assessed on their ability to:

6.15 understand that a voltage is induced in a conductor or a coil when it moves through a magnetic field or when a magnetic field changes through it and describe the factors which affect the size of the induced voltage

6.16 describe the generation of electricity by the rotation of a magnet within a coil of wire and of a coil of wire within a magnetic field and describe the factors which affect the size of the induced voltage

6.17 describe the structure of a transformer, and understand that a transformer changes the size of an alternating voltage by having different numbers of turns on the input and output sides

6.18 explain the use of step-up and step-down transformers in the large-scale generation and transmission of electrical energy

6.19 know and use the relationship between input (primary) and output (secondary) voltages and the turns ratio for a transformer:

$$\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$$

$$\frac{V_P}{V_S} = \frac{n_P}{n_S}$$

6.20 know and use the relationship:

input power = output power

$V_P I_P = V_S I_S$
for 100% efficiency

Section 7: Radioactivity and particles

a) Units

b) Radioactivity

c) Particles

a) Units

Students will be assessed on their ability to:

7.1 use the following units: becquerel (Bq), centimetre (cm), hour (h), minute (min), second (s).

b) Radioactivity

Students will be assessed on their ability to:

7.2 describe the structure of an atom in terms of protons, neutrons and electrons and use symbols such as $^{14}_{6}\mathrm{C}$ to describe particular nuclei

7.3 understand the terms atomic (proton) number, mass (nucleon) number and isotope

7.4 understand that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process

7.5 describe the nature of alpha and beta particles and gamma rays and recall that they may be distinguished in terms of penetrating power

7.6 describe the effects on the atomic and mass numbers of a nucleus of the emission of each of the three main types of radiation

7.7 understand how to complete balanced nuclear equations

7.8 understand that ionising radiations can be detected using a photographic film or a Geiger-Muller detector

7.9 explain the sources of background radiation

7.10 understand that the activity of a radioactive source decreases over a period of time and is measured in becquerels

7.11 understand the term 'half-life' and understand that it is different for different radioactive isotopes

7.12 use the concept of half-life to carry out simple calculations on activity

7.13 describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy, and in the radioactive dating of archaeological specimens and rocks

7.14 describe the dangers of ionising radiations, including:

- radiation can cause mutations in living organisms
- radiation can damage cells and tissue
- the problems arising in the disposal of radioactive waste

and describe how the associated risks can be reduced.

c) Particles

Students will be assessed on their ability to:

7.15 describe the results of Geiger and Marsden's experiments with gold foil and alpha particles

7.16 describe Rutherford's nuclear model of the atom and how it accounts for the results of Geiger and Marsden's experiment and understand the factors (charge and speed) which affect the deflection of alpha particles by a nucleus

7.17 understand that a nucleus of U-235 can be split (the process of fission) by collision with a neutron, and that this process releases energy in the form of kinetic energy of the fission products

7.18 understand that the fission of U-235 produces two daughter nuclei and a small number of neutrons

7.19 understand that a chain reaction can be set up if the neutrons produced by one fission strike other U-235 nuclei

7.20 understand the role played by the control rods and moderator when the fission process is used as an energy source to generate electricity.