# Course content

Candidates gain an understanding of physics and develop this through a variety of approaches, including practical activities, investigations and problem solving. Candidates research topics, apply scientific skills and communicate information related to their findings, which develops skills of scientific literacy.

The course content includes the following areas of physics:

**Dynamics**
In this area, the topics covered are: vectors and scalars; velocity–time graphs; acceleration; Newton's laws; energy; projectile motion.

**Space**
In this area, the topics covered are: space exploration; cosmology.

**Electricity**
In this area, the topics covered are: electrical charge carriers; potential difference (voltage); Ohm's law; practical electrical and electronic circuits; electrical power.

**Properties of matter**
In this area, the topics covered are: specific heat capacity; specific latent heat; gas laws and the kinetic model.

**Waves**
In this area, the topics covered are: wave parameters and behaviours; electromagnetic spectrum; refraction of light.

**Radiation**
In this area, the topic covered is nuclear radiation.

# Skills, knowledge and understanding

## Skills, knowledge and understanding for the course

The following provides a broad overview of the subject skills, knowledge and understanding developed in the course:

- demonstrating knowledge and understanding of physics by making accurate statements
- demonstrating knowledge and understanding of physics by describing information and providing explanations and integrating knowledge
- applying knowledge of physics to new situations, interpreting information and solving problems
- planning or designing experiments to test given hypotheses or to illustrate particular effects, including safety measures
- carrying out experimental procedures safely
- selecting information from a variety of sources

- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions based on evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- evaluating experimental procedures
- suggesting improvements to experiments/practical investigations
- communicating findings/information

## Skills, knowledge and understanding for the course assessment

The following provides details of skills, knowledge and understanding sampled in the course assessment:

| **Dynamics** |
|---|
| **Vectors and scalars** |
| Definition of vector and scalar quantities.<br>Identification of force, speed, velocity, distance, displacement, acceleration, mass, time and energy as vector or scalar quantities.<br>Calculation of the resultant of two vector quantities in one dimension or at right angles.<br>Determination of displacement and/or distance using scale diagram or calculation.<br>Determination of velocity and/or speed using scale diagram or calculation.<br>Use of appropriate relationships to solve problems involving velocity, speed, displacement, distance and time.<br>$s = vt$<br>$s = \bar{v}t$<br>$d = \bar{v}t$<br>Description of experiments to measure average and instantaneous speed. |
| **Velocity–time graphs** |
| Drawing or sketching of velocity–time or speed–time graphs from data.<br>Interpretation of a velocity–time graph to describe the motion of an object.<br>Determination of displacement from a velocity–time graph.<br>$s = \text{area under } v\text{-}t \text{ graph.}$ |
| **Acceleration** |
| Definition of acceleration in terms of initial velocity, final velocity and time.<br>Use of an appropriate relationship to solve problems involving acceleration, initial velocity (or speed), final velocity (or speed) and time.<br>$a = \frac{v-u}{t}$<br>Determination of acceleration from a velocity–time graph.<br>$a = \text{gradient of the line on a } v\text{-}t \text{ graph.}$<br>Description of an experiment to measure acceleration. |

| Dynamics |
| --- |
| **Newton's laws** |
| Application of Newton's laws and balanced forces to explain constant velocity (or speed), making reference to frictional forces.<br>Application of Newton's laws and unbalanced forces to explain and/or determine acceleration for situations where more than one force is acting.<br>Use of an appropriate relationship to solve problems involving unbalanced force, mass and acceleration for situations where one or more forces are acting in one dimension or at right angles.<br>$F = ma$<br>Use of an appropriate relationship to solve problems involving weight, mass and gravitational field strength.<br>$W = mg$<br>Explanation of motion resulting from a 'reaction' force in terms of Newton's third law.<br>Explanation of free-fall and terminal velocity in terms of Newton's laws. |
| **Energy** |
| Explanation of energy conservation and of energy conversion and transfer.<br>Use of an appropriate relationship to solve problems involving work done, unbalanced force and distance/displacement.<br>$E_w = Fd$, or $W = Fd$<br>Definition of gravitational potential energy.<br>Use of an appropriate relationship to solve problems involving gravitational potential energy, mass, gravitational field strength and height.<br>$E_p = mgh$<br>Definition of kinetic energy.<br>Use of an appropriate relationship to solve problems involving kinetic energy, mass and speed.<br>$E_k = \frac{1}{2}mv^2$<br>Use of appropriate relationships to solve problems involving conservation of energy.<br>$E_w = Fd,\ W = Fd$<br>$E_p = mgh$<br>$E_k = \frac{1}{2}mv^2$ |

| Dynamics |
| --- |
| **Projectile motion** |
| Explanation of projectile motion in terms of constant vertical acceleration and constant horizontal velocity.<br><br>Use of appropriate relationships to solve problems involving projectile motion from a horizontal launch, including the use of motion graphs.<br><br>area under $v_h$-$t$ graphs (horizontal range)<br>area under $v_v$-$t$ graphs (vertical height)<br>$v_h = \frac{s}{t}$ (constant horizontal velocity)<br>$v_v = u_v + at$ (constant vertical acceleration)<br><br>Explanation of satellite orbits in terms of projectile motion, horizontal velocity and weight. |

| Space |
| --- |
| **Space exploration** |
| Basic awareness of our current understanding of the universe.<br><br>Use of the following terms correctly and in context: planet, dwarf planet, moon, Sun, asteroid, solar system, star, exoplanet, galaxy, universe.<br><br>Awareness of the benefits of satellites: GPS, weather forecasting, communications, scientific discovery and space exploration (for example Hubble telescope, ISS).<br><br>Knowledge that geostationary satellites have a period of 24 hours and orbit at an altitude of 36 000 km.<br>Knowledge that the period of a satellite in a high altitude orbit is greater than the period of a satellite in a lower altitude orbit.<br><br>Awareness of the challenges of space travel:<br><br>♦ travelling large distances with the possible solution of attaining high velocity by using ion drive (producing a small unbalanced force over an extended period of time)<br>♦ travelling large distances using a 'catapult' from a fast moving asteroid, moon or planet<br>♦ manoeuvring a spacecraft in a zero friction environment, possibly to dock with the ISS<br>♦ maintaining sufficient energy to operate life support systems in a spacecraft, with the possible solution of using solar cells with area that varies with distance from the Sun<br><br>Awareness of the risks associated with manned space exploration:<br><br>♦ fuel load on take-off<br>♦ potential exposure to radiation<br>♦ pressure differential<br>♦ re-entry through an atmosphere<br><br>Knowledge of Newton's second and third laws and their application to space travel, rocket launch and landing.<br>Use of an appropriate relationship to solve problems involving weight, mass and gravitational field strength, in different locations in the universe.<br>$W = mg$ |
| **Cosmology** |
| Use of the term 'light-year' and conversion between light-years and metres.<br>Basic description of the 'Big Bang' theory of the origin of the universe.<br>Knowledge of the approximate estimated age of the universe.<br>Awareness of the use of the whole electromagnetic spectrum in obtaining information about astronomical objects.<br>Identification of continuous and line spectra.<br>Use of spectral data for known elements, to identify the elements present in stars. |

| Electricity |
|---|
| **Electrical charge carriers** |
| Definition of electrical current as the electric charge transferred per unit time.<br>Use of an appropriate relationship to solve problems involving charge, current and time.<br>$Q = It$<br>Knowledge of the difference between alternating and direct current.<br>Identification of a source (as a.c. or d.c.) based on oscilloscope trace or image from data logging software. |
| **Potential difference (voltage)** |
| Knowledge that a charged particle experiences a force in an electric field.<br><br>Knowledge of the path a charged particle follows: between two oppositely charged parallel plates; near a single point charge; between two oppositely charged points; between two like charged points.<br><br>Knowledge that the potential difference (voltage) of the supply is a measure of the energy given to the charge carriers in a circuit. |
| **Ohm's law** |
| Calculation of the gradient of the line of best fit on a *V-I* graph to determine resistance.<br>Use of appropriate relationships to solve problems involving potential difference (voltage), current and resistance.<br>$V = IR$<br>$V_2 = \left(\frac{R_2}{R_1 + R_2}\right)V_s$<br>$\frac{V_1}{V_2} = \frac{R_1}{R_2}$<br>Knowledge of the qualitative relationship between the temperature and resistance of a conductor.<br>Description of an experiment to verify Ohm's law. |
| **Practical electrical and electronic circuits** |
| Measurement of current, potential difference (voltage) and resistance, using appropriate meters in simple and complex circuits.<br>Knowledge of the circuit symbol, function and application of standard electrical and electronic components: cell, battery, lamp, switch, resistor, voltmeter, ammeter, LED, motor, microphone, loudspeaker, photovoltaic cell, fuse, diode, capacitor, thermistor, LDR, relay, transistor.<br>For transistors, knowledge of the symbols for an npn transistor and an n-channel enhancement mode MOSFET. Explanation of their function as a switch in transistor switching circuits. |

| Electricity |
| --- |
| Application of the rules for current and potential difference (voltage) in series and parallel circuits.<br>$I_s = I_1 = I_2 = \ldots$<br>$V_s = V_1 + V_2 + \ldots$<br>$I_p = I_1 + I_2 + \ldots$<br>$V_p = V_1 = V_2 = \ldots$<br>Knowledge of the effect on the total resistance of a circuit of adding further resistance in series or in parallel.<br>Use of appropriate relationships to solve problems involving the total resistance of resistors in series and in parallel circuits, and in circuits with a combination of series and parallel resistors.<br>$R_T = R_1 + R_2 + \ldots$<br>$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ |
| **Electrical power** |
| Definition of electrical power in terms of electrical energy and time.<br>Use of an appropriate relationship to solve problems involving energy, power and time.<br>$P = \frac{E}{t}$<br>Knowledge of the effect of potential difference (voltage) and resistance on the current in and power developed across components in a circuit.<br>Use of appropriate relationships to solve problems involving power, potential difference (voltage), current and resistance in electrical circuits.<br>$P = IV$<br>$P = I^2 R$<br>$P = \frac{V^2}{R}$<br>Selection of an appropriate fuse rating given the power rating of an electrical appliance. A 3 A fuse should be selected for most appliances rated up to 720 W, a 13 A fuse for appliances rated over 720 W. |

| Properties of matter |
|---|
| **Specific heat capacity** |
| Knowledge that different materials require different quantities of heat to raise the temperature of unit mass by one degree Celsius.<br>Use of an appropriate relationship to solve problems involving mass, heat energy, temperature change and specific heat capacity.<br>$E_h = cm\Delta T$<br>Knowledge that the temperature of a substance is a measure of the mean kinetic energy of its particles.<br>Use of the principle of conservation of energy to determine heat transfer. |
| **Specific latent heat** |
| Knowledge that different materials require different quantities of heat to change the state of unit mass.<br>Knowledge that the same material requires different quantities of heat to change the state of unit mass from solid to liquid (fusion) and to change the state of unit mass from liquid to gas (vaporisation).<br>Use of an appropriate relationship to solve problems involving mass, heat energy and specific latent heat.<br>$E_h = ml$ |
| **Gas laws and the kinetic model** |
| Definition of pressure in terms of force and area.<br>Use of an appropriate relationship to solve problems involving pressure, force and area.<br>$p = \frac{F}{A}$<br>Description of how the kinetic model accounts for the pressure of a gas.<br>Knowledge of the relationship between Kelvin and degrees Celsius and the absolute zero of temperature.<br>$0\,\mathrm{K} = -273\,^{\circ}\mathrm{C}$<br>Explanation of the pressure–volume, pressure–temperature and volume–temperature laws qualitatively in terms of a kinetic model.<br>Use of appropriate relationships to solve problems involving the volume, pressure and temperature of a fixed mass of gas.<br>$p_1V_1 = p_2V_2$<br>$\frac{p_1}{T_1} = \frac{p_2}{T_2}$<br>$\frac{V_1}{T_1} = \frac{V_2}{T_2}$<br>$\frac{pV}{T} = \text{constant}$<br>Description of experiments to verify the pressure–volume law (Boyle's law), the pressure–temperature law (Gay-Lussac's law) and the volume–temperature law (Charles' law). |

| Waves |
| --- |
| **Wave parameters and behaviours** |
| Knowledge that waves transfer energy.<br>Definition of transverse and longitudinal waves.<br>Knowledge that sound is an example of a longitudinal wave and electromagnetic radiation and water waves are examples of transverse waves.<br>Determination of the frequency, period, wavelength, amplitude and wave speed for longitudinal and transverse waves.<br>Use of appropriate relationships to solve problems involving wave speed, frequency, period, wavelength, distance, number of waves and time.<br>$v = \frac{d}{t}$<br>$f = \frac{N}{t}$<br>$v = f\lambda$<br>$T = \frac{1}{f}$<br>Knowledge that diffraction occurs when waves pass through a gap or around an object.<br>Comparison of long wave and short wave diffraction.<br>Draw diagrams using wavefronts to show diffraction when waves pass through a gap or around an object. |
| **Electromagnetic spectrum** |
| Knowledge of the relative frequency and wavelength of bands of the electromagnetic spectrum.<br>Knowledge of typical sources, detectors and applications for each band in the electromagnetic spectrum.<br>Knowledge that all radiations in the electromagnetic spectrum are transverse and travel at the speed of light. |
| **Refraction of light** |
| Knowledge that refraction occurs when waves pass from one medium to another.<br>Description of refraction in terms of change of wave speed, change in wavelength and change of direction (where the angle of incidence is greater than 0°), for waves passing into both a more dense and a less dense medium.<br>Identification of the normal, angle of incidence and angle of refraction in ray diagrams showing refraction. |

| Radiation |
| --- |
| **Nuclear radiation** |
| Knowledge of the nature of alpha (α), beta (β) and gamma (γ) radiation.<br>Knowledge of the term 'ionisation' and the effect of ionisation on neutral atoms.<br>Knowledge of the relative ionising effect and penetration of alpha, beta and gamma radiation.<br>Definition of activity in terms of the number of nuclear disintegrations and time.<br>Use of an appropriate relationship to solve problems involving activity, number of nuclear disintegrations and time.<br>$A = \frac{N}{t}$<br>Knowledge of sources of background radiation.<br>Knowledge of the dangers of ionising radiation to living cells and of the need to measure exposure to radiation.<br>Use of appropriate relationships to solve problems involving absorbed dose, equivalent dose, energy, mass and weighting factor.<br>$D = \frac{E}{m}$<br>$H = Dw_r$<br>Use of an appropriate relationship to solve problems involving equivalent dose rate, equivalent dose and time.<br>$\dot{H} = \frac{H}{t}$<br>Comparison of equivalent dose due to a variety of natural and artificial sources.<br>Knowledge of equivalent dose rate and exposure safety limits for the public and for workers in the radiation industries in terms of annual effective equivalent dose.<br><br>♦ Average annual background radiation in UK: 2·2 mSv.<br>♦ Annual effective dose limit for member of the public: 1 mSv.<br>♦ Annual effective dose limit for radiation worker: 20 mSv.<br><br>Awareness of applications of nuclear radiation: electricity generation, cancer treatment and other industrial and medical uses.<br>Definition of half-life.<br>Use of graphical or numerical data to determine the half-life of a radioactive material.<br>Description of an experiment to measure the half-life of a radioactive material.<br>Qualitative description of fission, chain reactions, and their role in the generation of energy.<br>Qualitative description of fusion, plasma containment, and their role in the generation of energy. |
| **Units, prefixes and scientific notation** |
| Use of appropriate SI units and the prefixes nano (n), micro (μ), milli (m), kilo (k), mega (M), giga (G).<br>Use of the appropriate number of significant figures in final answers. This means that the final answer can have no more significant figures than the value with the least number of significant figures used in the calculation.<br>Appropriate use of scientific notation. |