Course content

The course content includes the following areas of physics:

Rotational motion and astrophysics

The topics covered are:

- kinematic relationships
- angular motion
- rotational dynamics
- gravitation
- general relativity
- stellar physics

Quanta and waves

The topics covered are:

- introduction to quantum theory
- particles from space
- simple harmonic motion
- waves
- interference
- polarisation

Electromagnetism

The topics covered are:

- fields
- circuits
- electromagnetic radiation

Units, prefixes and uncertainties

The topics covered are:

- units, prefixes and scientific notation
- uncertainties
- data analysis
- evaluation and significance of experimental uncertainties

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:

- extending and applying knowledge of physics to new situations, interpreting and analysing information to solve complex problems
- planning and designing physics experiments/investigations, using reference material and including risk assessments, to test a hypothesis or to illustrate particular effects
- carrying out complex experiments in physics safely, recording systematic detailed observations and collecting data
- selecting information from a variety of sources and presenting detailed information, appropriately, in a variety of forms
- processing and analysing physics data/information (using calculations, significant figures and units, where appropriate)
- making reasoned predictions from a range of evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- critically evaluating experimental procedures by identifying sources of uncertainty, suggesting and implementing improvements
- drawing on knowledge and understanding of physics to make accurate statements, describe complex information, provide detailed explanations and integrate knowledge
- communicating physics findings/information fully and effectively
- analysing and evaluating scientific publications and media reports

Skills, knowledge and understanding for the course assessment

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

Rotational motion and astrophysics

Kinematic relationships

Knowledge that differential calculus notation is used to represent rate of change.

Knowledge that velocity is the rate of change of displacement with time, acceleration is the rate of change of velocity with time, and acceleration is the second differential of displacement with time.

Derivation of the equations of motion $v = u + at$ and $s = ut + \frac{1}{2}at^2$, using calculus methods.

Use of calculus methods to calculate instantaneous displacement, velocity and acceleration for straight line motion with a constant or varying acceleration.

Use of appropriate relationships to carry out calculations involving displacement, velocity, acceleration, and time for straight line motion with constant or varying acceleration.

$$v = \frac{ds}{dt}$$

$$a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$$

$$\left.\begin{aligned} v &= u + at \\ s &= ut + \frac{1}{2}at^2 \\ v^2 &= u^2 + 2as \end{aligned}\right\} \text{for constant acceleration only}$$

Knowledge that the gradient of a curve (or a straight line) on a motion–time graph represents instantaneous rate of change, and can be found by differentiation.

Knowledge that the gradient of a curve (or a straight line) on a displacement–time graph is the instantaneous velocity and that the gradient of a curve (or a straight line) on a velocity–time graph is the instantaneous acceleration.

Knowledge that the area under a line on a graph can be found by integration.

Knowledge that the area under an acceleration–time graph between limits is the change in velocity and that the area under a velocity–time graph between limits is the displacement.

Determination of displacement, velocity or acceleration by the calculation of the gradient of the line on a graph or the calculation of the area under the line between limits on a graph.

Rotational motion and astrophysics (continued)

Angular motion

Use of the radian as a measure of angular displacement.

Conversion between degrees and radians.

Use of appropriate relationships to carry out calculations involving angular displacement, angular velocity, angular acceleration, and time.

$$\omega = \frac{d\theta}{dt}$$

$$\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$$

$$\left.\begin{aligned} &\omega = \omega_o + \alpha t \\ &\omega^2 = \omega_o^2 + 2\alpha\theta \\ &\theta = \omega_o t + \tfrac{1}{2}\alpha t^2 \end{aligned}\right\} \text{for constant angular acceleration only}$$

Use of appropriate relationships to carry out calculations involving angular and tangential motion.

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

Use of appropriate relationships to carry out calculations involving constant angular velocity, period and frequency.

$$\omega = \frac{2\pi}{T}$$

$$\omega = 2\pi f$$

Knowledge that a centripetal (radial or central) force acting on an object is necessary to maintain circular motion, and results in centripetal (radial or central) acceleration of the object.

Rotational motion and astrophysics (continued)

Angular motion (continued)

Use of appropriate relationships to carry out calculations involving centripetal acceleration and centripetal force.

$$a_r = \frac{v^2}{r} = r\omega^2$$

$$F = \frac{mv^2}{r} = mr\omega^2$$

Rotational dynamics

Knowledge that an unbalanced torque causes a change in the angular (rotational) motion of an object.

Definition of moment of inertia of an object as a measure of its resistance to angular acceleration about a given axis.

Knowledge that moment of inertia depends on mass and the distribution of mass about a given axis of rotation.

Use of an appropriate relationship to calculate the moment of inertia for a point mass.

$$I = mr^2$$

Use of an appropriate relationship to calculate the moment of inertia for discrete masses.

$$I = \sum mr^2$$

Use of appropriate relationships to calculate the moment of inertia for rods, discs and spheres about given axes.

rod about centre	$I = \frac{1}{12}ml^2$
rod about end	$I = \frac{1}{3}ml^2$
disc about centre	$I = \frac{1}{2}mr^2$
sphere about centre	$I = \frac{2}{5}mr^2$

Rotational motion and astrophysics (continued)

Rotational dynamics (continued)

Use of appropriate relationships to carry out calculations involving torque, perpendicular force, distance from the axis, angular acceleration, and moment of inertia.

$$\tau = Fr$$

$$\tau = I\alpha$$

Use of appropriate relationships to carry out calculations involving angular momentum, angular velocity, moment of inertia, tangential velocity, mass and its distance from the axis.

$$L = mvr = mr^2\omega$$

$$L = I\omega$$

Statement of the principle of conservation of angular momentum.

Use of the principle of conservation of angular momentum to solve problems.

Use of appropriate relationships to carry out calculations involving potential energy, rotational kinetic energy, translational kinetic energy, angular velocity, linear velocity, moment of inertia, and mass.

$$E_{k(rotational)} = \frac{1}{2}I\omega^2$$

$$E_P = E_{k(translational)} + E_{k(rotational)}$$

Gravitation

Conversion between astronomical units (AU) and metres and between light-years (ly) and metres.

Definition of gravitational field strength as the gravitational force acting on a unit mass.

Sketch of gravitational field lines and field line patterns around astronomical objects and astronomical systems involving two objects.

Use of an appropriate relationship to carry out calculations involving gravitational force, masses and their separation.

$$F = \frac{GMm}{r^2}$$

Use of appropriate relationships to carry out calculations involving period of satellites in circular orbit, masses, orbit radius, and satellite speed.

$$F = \frac{GMm}{r^2} = \frac{mv^2}{r} = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$$

Rotational motion and astrophysics (continued)

Gravitation (continued)

Definition of the gravitational potential of a point in space as the work done in moving unit mass from infinity to that point.

Knowledge that the energy required to move mass between two points in a gravitational field is independent of the path taken.

Use of appropriate relationships to carry out calculations involving gravitational potential, gravitational potential energy, masses and their separation.

$$V = -\frac{GM}{r}$$

$$E_P = Vm = -\frac{GMm}{r}$$

Definition of escape velocity as the minimum velocity required to allow a mass to escape a gravitational field to infinity, where the mass achieves zero kinetic energy and maximum (zero) potential energy.

Derivation of the relationship $v_{esc} = \sqrt{\frac{2GM}{r}}$.

Use of an appropriate relationship to carry out calculations involving escape velocity, mass and distance.

$$v_{esc} = \sqrt{\frac{2GM}{r}}$$

General relativity

Knowledge that special relativity deals with motion in inertial (non-accelerating) frames of reference and that general relativity deals with motion in non-inertial (accelerating) frames of reference.

Statement of the equivalence principle (that it is not possible to distinguish between the effects on an observer of a uniform gravitational field and of a constant acceleration) and knowledge of its consequences.

Rotational motion and astrophysics (continued)

General relativity (continued)

Consideration of spacetime as a unified representation of three dimensions of space and one dimension of time.

Knowledge that general relativity leads to the interpretation that mass curves spacetime, and that gravity arises from the curvature of spacetime.

Knowledge that light or a freely moving object follows a geodesic (the path with the shortest distance between two points) in spacetime.

Representation of world lines for objects which are stationary, moving with constant velocity and accelerating.

Knowledge that the escape velocity from the event horizon of a black hole is equal to the speed of light.

Knowledge that, from the perspective of a distant observer, time appears to be frozen at the event horizon of a black hole.

Knowledge that the Schwarzschild radius of a black hole is the distance from its centre (singularity) to its event horizon.

Use of an appropriate relationship to solve problems relating to the Schwarzschild radius of a black hole.

$$r_{Schwarzschild} = \frac{2GM}{c^2}$$

Stellar physics

Use of appropriate relationships to solve problems relating to luminosity, apparent brightness b, distance between the observer and the star, power per unit area, stellar radius, and stellar surface temperature. (Using the assumption that stars behave as black bodies.)

$$b = \frac{L}{4\pi d^2}$$

$$\frac{P}{A} = \sigma T^4$$

$$L = 4\pi r^2 \sigma T^4$$

Knowledge that stars are formed in interstellar clouds when gravitational forces overcome thermal pressure and cause a molecular cloud to contract until the core becomes hot enough to sustain nuclear fusion, which then provides a thermal pressure that balances the gravitational force.

Rotational motion and astrophysics (continued)

Stellar physics (continued)

Knowledge of the stages in the proton–proton chain (p–p chain) in stellar fusion reactions which convert hydrogen to helium. One example of a p–p chain is:

$${}^{1}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{2}_{1}\mathrm{H} + {}^{0}_{+1}\mathrm{e} + \nu_{\mathrm{e}}$$

$${}^{2}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + \gamma$$

$${}^{3}_{2}\mathrm{He} + {}^{3}_{2}\mathrm{He} \rightarrow {}^{4}_{2}\mathrm{He} + 2{}^{1}_{1}\mathrm{H}$$

Knowledge that Hertzsprung-Russell (H-R) diagrams are a representation of the classification of stars.

Classification of stars and position in Hertzsprung-Russell (H-R) diagrams, including main sequence, giant, supergiant, and white dwarf.

Use of Hertzsprung-Russell (H-R) diagrams to determine stellar properties, including prediction of colour of stars from their position in an H-R diagram.

Knowledge that the fusion of hydrogen occurs in the core of stars in the main sequence of a Hertzsprung-Russell (H-R) diagram.

Knowledge that hydrogen fusion in the core of a star supplies the energy that maintains the star’s outward thermal pressure to balance inward gravitational forces. When the hydrogen in the core becomes depleted, nuclear fusion in the core ceases. The gas surrounding the core, however, will still contain hydrogen. Gravitational forces cause both the core, and the surrounding shell of hydrogen to shrink. In a star like the Sun, the hydrogen shell becomes hot enough for hydrogen fusion in the shell of the star. This leads to an increase in pressure which pushes the surface of the star outwards, causing it to cool. At this stage, the star will be in the giant or supergiant regions of a Hertzspung-Russell (H-R) diagram.

Knowledge that, in a star like the Sun, the core shrinks and will become hot enough for the helium in the core to begin fusion.

Knowledge that the mass of a star determines its lifetime.

Knowledge that every star ultimately becomes a white dwarf, a neutron star or a black hole. The mass of the star determines its eventual fate.

Quanta and waves

Introduction to quantum theory

Knowledge of experimental observations that cannot be explained by classical physics, but can be explained using quantum theory:

- black-body radiation curves (ultraviolet catastrophe)
- the formation of emission and absorption spectra
- the photoelectric effect

Use of an appropriate relationship to solve problems involving photon energy and frequency.

$$E = hf$$

Knowledge of the Bohr model of the atom in terms of the quantisation of angular momentum, the principal quantum number n and electron energy states, and how this explains the characteristics of atomic spectra.

Use of an appropriate relationship to solve problems involving the angular momentum of an electron and its principal quantum number.

$$mvr = \frac{nh}{2\pi}$$

Description of experimental evidence for the particle-like behaviour of 'waves' and for the wave-like behaviour of 'particles'.

Use of an appropriate relationship to solve problems involving the de Broglie wavelength of a particle and its momentum.

$$\lambda = \frac{h}{p}$$

Knowledge that it is not possible to know the position and the momentum of a quantum particle simultaneously.

Knowledge that it is not possible to know the lifetime of a quantum particle and the associated energy change simultaneously.

Use of appropriate relationships to solve problems involving the uncertainties in position, momentum, energy, and time. The lifetime of a quantum particle can be taken as the uncertainty in time.

$$\Delta x \Delta p_x \geq \frac{h}{4\pi}$$

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

Quanta and waves (continued)
Introduction to quantum theory (continued)
Knowledge of implications of the Heisenberg uncertainty principle, including the concept of quantum tunnelling, in which a quantum particle can exist in a position that, according to classical physics, it has insufficient energy to occupy.
Particles from space
Knowledge of the origin and composition of cosmic rays and the interaction of cosmic rays with Earth's atmosphere. Knowledge of the composition of the solar wind as charged particles in the form of plasma. Explanation of the helical motion of charged particles in the Earth's magnetic field. Use of appropriate relationships to solve problems involving the force on a charged particle, its charge, its mass, its velocity, the radius of its path, and the magnetic induction of a magnetic field. $F = qvB$ $F = \frac{mv^2}{r}$
Simple harmonic motion (SHM)
Definition of SHM in terms of the restoring force and acceleration proportional to, and in the opposite direction to, the displacement from the rest position. Use of calculus methods to show that expressions in the form of $y = A\sin\omega t$ and $y = A\cos\omega t$ are consistent with the definition of SHM ($a = -\omega^2 y$). Derivation of the relationships $v = \pm\omega\sqrt{\left(A^2 - y^2\right)}$ and $E_k = \frac{1}{2}m\omega^2\left(A^2 - y^2\right)$.

Quanta and waves (continued)

Simple harmonic motion (SHM) (continued)

Use of appropriate relationships to solve problems involving the displacement, velocity, acceleration, force, mass, spring constant k, angular frequency, period, and energy of an object executing SHM.

$$F = -ky$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$a = \frac{d^2 y}{dt^2} = -\omega^2 y$$

$y = A\cos \omega t$ or $y = A\sin \omega t$

$$v = \pm\omega\sqrt{\left(A^2 - y^2\right)}$$

$$E_k = \frac{1}{2}m\omega^2\left(A^2 - y^2\right)$$

$$E_P = \frac{1}{2}m\omega^2 y^2$$

Knowledge of the effects of damping in SHM to include underdamping, critical damping and overdamping.

Waves

Use of an appropriate relationship to solve problems involving the energy transferred by a wave and its amplitude.

$$E = kA^2$$

Knowledge of the mathematical representation of travelling waves.

Use of appropriate relationships to solve problems involving wave motion, phase difference and phase angle.

$$y = A\sin 2\pi\left(ft - \frac{x}{\lambda}\right)$$

$$\phi = \frac{2\pi x}{\lambda}$$

Knowledge that stationary waves are formed by the interference of two waves, of the same frequency and amplitude, travelling in opposite directions. A stationary wave can be described in terms of nodes and antinodes.

Quanta and waves (continued)

Interference

Knowledge that two waves are coherent if they have a constant phase relationship.

Knowledge of the conditions for constructive and destructive interference in terms of coherence and phase.

Use of an appropriate relationship to solve problems involving optical path difference opd, geometrical path difference gpd and refractive index.

$$opd = n \times gpd$$

Knowledge that a wave experiences a phase change of π when it is travelling in a less dense medium and reflects from an interface with a more dense medium.

Knowledge that a wave does not experience a phase change when it is travelling in a more dense medium and reflects from an interface with a less dense medium.

Explanation of interference by division of amplitude, including optical path length, geometrical path length, phase difference, and optical path difference.

Knowledge of thin film interference and wedge fringes.

For light interfering by division of amplitude, use of an appropriate relationship to solve problems involving the optical path difference between waves, wavelength and order number.

$opd = m\lambda$ or $\left(m + \frac{1}{2}\right)\lambda$ where $m = 0,1,2...$

Knowledge that a coated (bloomed) lens can be made non-reflective for a specific wavelength of light.

Derivation of the relationship $d = \frac{\lambda}{4n}$ for glass lenses with a coating such as magnesium fluoride.

Use of appropriate relationships to solve problems involving interference of waves by division of amplitude.

$$\Delta x = \frac{\lambda l}{2d}$$

$$d = \frac{\lambda}{4n}$$

Explanation of interference by division of wavefront.

Quanta and waves (continued)

Interference (continued)

Knowledge of Young's slits interference.

Use of an appropriate relationship to solve problems involving interference of waves by division of wavefront.

$$\Delta x = \frac{\lambda D}{d}$$

Polarisation

Knowledge of what is meant by a plane-polarised wave.

Knowledge of the effect on light of polarisers and analysers.

Knowledge that when a ray of unpolarised light is incident on the surface of an insulator at Brewster's angle the reflected ray becomes plane-polarised.

Derivation of the relationship $n = \tan i_p$.

Use of an appropriate relationship to solve problems involving Brewster's angle and refractive index.

$$n = \tan i_p$$

Electromagnetism

Fields

Knowledge that an electric field is the region that surrounds electrically charged particles in which a force is exerted on other electrically charged particles.

Definition of electric field strength as the electrical force acting on unit positive charge.

Sketch of electric field patterns around single point charges, a system of charges and in a uniform electric field.

Definition of electrical potential at a point as the work done in moving unit positive charge from infinity to that point.

Knowledge that the energy required to move charge between two points in an electric field is independent of the path taken.

Electromagnetism (continued)

Fields (continued)

Use of appropriate relationships to solve problems involving electrical force, electrical potential and electric field strength around a point charge and a system of charges.

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_o r^2}$$

$$V = \frac{Q}{4\pi\varepsilon_o r}$$

$$E = \frac{Q}{4\pi\varepsilon_o r^2}$$

Use of appropriate relationships to solve problems involving charge, energy, potential difference, and electric field strength in situations involving a uniform electric field.

$$F = QE$$

$$V = Ed$$

$$W = QV$$

Knowledge of Millikan's experimental method for determining the charge on an electron.

Use of appropriate relationships to solve problems involving the motion of charged particles in uniform electric fields.

$$F = QE$$

$$V = Ed$$

$$W = QV$$

$$E_k = \frac{1}{2}mv^2$$

Electromagnetism (continued)

Fields (continued)

Knowledge that the electronvolt (eV) is the energy acquired when one electron accelerates through a potential difference of one volt.

Conversion between electronvolts and joules.

Knowledge that electrons are in motion around atomic nuclei and individually produce a magnetic effect.

Knowledge that, for example, iron, nickel, cobalt, and some rare earths exhibit a magnetic effect called ferromagnetism, in which magnetic dipoles can be made to align, resulting in the material becoming magnetised.

Sketch of magnetic field patterns between magnetic poles, and around solenoids, including the magnetic field pattern around Earth.

Comparison of gravitational, electrostatic, magnetic, and nuclear forces in terms of their relative strength and range.

Use of an appropriate relationship to solve problems involving magnetic induction around a current-carrying wire, the current in the wire and the distance from the wire.

$$B = \frac{\mu_o I}{2\pi r}$$

Explanation of the helical path followed by a moving charged particle in a magnetic field.

Use of appropriate relationships to solve problems involving the forces acting on a current-carrying wire in a magnetic field and a charged particle in a magnetic field.

$$F = IlB\sin\theta$$

$$F = qvB$$

$$F = \frac{mv^2}{r}$$

Electromagnetism (continued)

Circuits

Knowledge of the variation of current and potential difference with time in an RC circuit during charging and discharging.

Definition of the time constant for an RC circuit as the time to increase the charge stored by 63% of the difference between initial charge and full charge, or the time taken to discharge the capacitor to 37% of initial charge.

Use of an appropriate relationship to determine the time constant for an RC circuit.

$$\tau = RC$$

Knowledge that, in an RC circuit, an uncharged capacitor can be considered to be fully charged after a time approximately equal to 5τ .

Knowledge that, in an RC circuit, a fully charged capacitor can be considered to be fully discharged after a time approximately equal to 5τ .

Graphical determination of the time constant for an RC circuit.

Knowledge that capacitive reactance is the opposition of a capacitor to changing current.

Use of appropriate relationships to solve problems involving capacitive reactance, voltage, current, frequency, and capacitance.

$$X_C = \frac{V}{I}$$

$$X_C = \frac{1}{2\pi fC}$$

Knowledge of the growth and decay of current in a DC circuit containing an inductor.

Explanation of the self-inductance (inductance) of a coil.

Knowledge of Lenz's law and its implications.

Definition of inductance and of back EMF.

Knowledge that energy is stored in the magnetic field around a current-carrying inductor.

Knowledge of the variation of current with frequency in an AC circuit containing an inductor.

Knowledge that inductive reactance is the opposition of an inductor to changing current.

Electromagnetism (continued)

Circuits (continued)

Use of appropriate relationships to solve problems relating to inductive reactance, voltage, current, frequency, energy, and self-inductance (inductance).

$$\varepsilon = -L\frac{dI}{dt}$$

$$E = \frac{1}{2}LI^2$$

$$X_L = \frac{V}{I}$$

$$X_L = 2\pi fL$$

Electromagnetic radiation

Knowledge of the unification of electricity and magnetism.

Knowledge that electromagnetic radiation exhibits wave properties as it transfers energy through space. It has both electric and magnetic field components which oscillate in phase, perpendicular to each other and to the direction of energy propagation.

Use of an appropriate relationship to solve problems involving the speed of light, the permittivity of free space and the permeability of free space.

$$c = \frac{1}{\sqrt{\varepsilon_o \mu_o}}$$

Units, prefixes and uncertainties

Units, prefixes and scientific notation

Appropriate use of units, including electronvolt (eV), light-year (ly) and astronomical unit (AU).

Use of SI units with all physical quantities, where appropriate.

Use of prefixes where appropriate. These include femto (f), pico (p), nano (n), micro (μ), milli (m), kilo (k), mega (M), giga (G), tera (T), and peta (P).

Units, prefixes and uncertainties (continued)

Units, prefixes and scientific notation (continued)

Use of the appropriate number of significant figures in final answers. The final answer can have no more significant figures than the data with the fewest number of significant figures used in the calculation.

Appropriate use of scientific notation.

Uncertainties

Knowledge and use of uncertainties, including systematic uncertainties, scale reading uncertainties, random uncertainties, and calibration uncertainties.

Systematic uncertainty occurs when readings taken are either all too small or all too large. This can arise due to faulty measurement techniques or experimental design.

Scale reading uncertainty is an indication of how precisely an instrument scale can be read.

Random uncertainty arises when measurements are repeated and slight variations occur. Random uncertainty may be reduced by increasing the number of repeated measurements.

Calibration uncertainty arises when there is a difference between a manufacturer's claim for the accuracy of an instrument when compared with an approved standard.

Solve problems involving absolute uncertainties and fractional/percentage uncertainties.

Appropriate use of significant figures in absolute uncertainties. Absolute uncertainty should normally be rounded to one significant figure. In some instances, a second significant figure may be retained.

Data analysis

Combination of various types of uncertainties to obtain the total uncertainty in a measurement.

Knowledge that, when uncertainties in a single measurement are combined, an uncertainty can be ignored if it is less than one-third of one of the other uncertainties in the measurement.

Use of an appropriate relationship to determine the total uncertainty in a measured value.

$$\Delta W = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}$$

Units, prefixes and uncertainties (continued)
Data analysis (continued)
Combination of uncertainties in measured values to obtain the total uncertainty in a calculated value. Knowledge that, when uncertainties in measured values are combined, a fractional/percentage uncertainty in a measured value can be ignored if it is less than one-third of the fractional/percentage uncertainty in another measured value. Use of an appropriate relationship to determine the total uncertainty in a value calculated from the product or quotient of measured values. $\frac{\Delta W}{W} = \sqrt{\left(\frac{\Delta X}{X}\right)^2 + \left(\frac{\Delta Y}{Y}\right)^2 + \left(\frac{\Delta Z}{Z}\right)^2}$ Use of an appropriate relationship to determine the uncertainty in a value raised to a power. $\left(\frac{\Delta W^n}{W^n}\right) = n\left(\frac{\Delta W}{W}\right)$ Use of error bars to represent absolute uncertainties on graphs. Estimation of uncertainty in the gradient and intercept of the line of best fit on a graph. Correct use of the terms accuracy and precision in the context of an evaluation of experimental results. The accuracy of a measurement compares how close the measurement is to the ‘true’ or accepted value. The uncertainty in a measurement gives an indication of the precision of the measurement.
Evaluation and significance of experimental uncertainties
Identification of the dominant uncertainty/uncertainties in an experiment or in experimental data. Suggestion of potential improvements to an experiment, which may reduce the dominant uncertainty/uncertainties.

Skills, knowledge and understanding included in the course are appropriate to the SCQF level of the course. The SCQF level descriptors give further information on characteristics and expected performance at each SCQF level, and are available on the SCQF website.