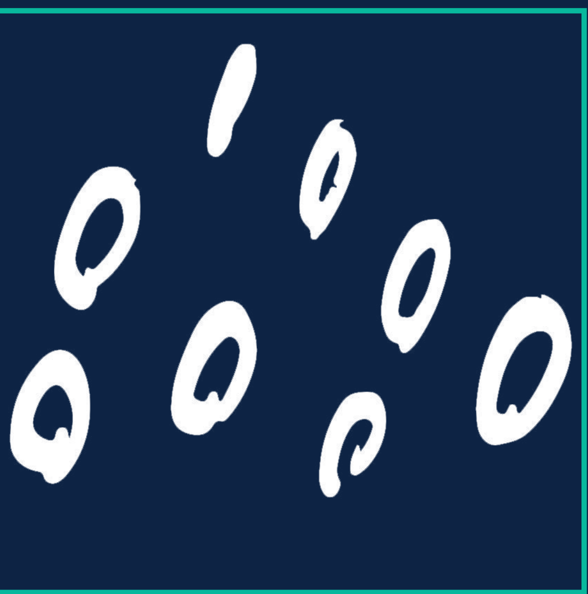
OXFORD AQA
INTERNATIONAL QUALIFICATIONS

International AS and A-level

Physics

(9630) Specification



For teaching from September 2019 onwards

For International AS exams
May/June 2020 onwards

For International A-level exams
May/June 2020 onwards

For teaching and examination outside the United Kingdom

Contents

Are you using the latest version of this specification?

- You will always find the most up-to-date version of this specification on our website at **oxfordaqa.com/9630**
- We will write to you if there are significant changes to the specification.

1 Introduction

1.1 Why choose OxfordAQA International AS and A-levels?

Our International qualifications enable schools that follow a British curriculum to benefit from the best education expertise in the United Kingdom (UK).

Our International AS and A-levels offer the same rigour and high quality as AS and A-levels in the UK and are relevant and appealing to students worldwide. They reflect a deep understanding of the needs of teachers and schools around the globe and are brought to you by Oxford University Press and AQA, the UK's leading awarding body.

Providing valid and reliable assessments, these qualifications are based on over 100 years of experience, academic research and international best practice. They have been independently validated as being to the same standard as the qualifications accredited by the UK examinations regulator, Ofqual. They reflect the latest changes to the British system, enabling students to progress to higher education with up-to-date qualifications.

You can find out about OxfordAQA at **oxfordaqa.com**

1.2 Why choose our International AS and A-level Physics?

In developing our specifications, we consulted widely with teachers, learned societies and professionals from universities and industry. Our content is designed to stimulate student's interest in, and enthusiasm for, physics and provides an excellent grounding for further study.

Our assessments reward students' knowledge, understanding and application of a wide range of physics topics. These include all of those topics that universities expect students to understand in order to progress to higher education. This specification also includes a number of areas, such as energy resources, which are particularly relevant to students studying in an international context.

Our exams include a range of question styles, allowing students to demonstrate a range of skills. Our extensive experience allows us to write exams which are challenging but do not put unhelpful barriers to students. For example, we have a reduced word count in questions, eliminating any information that is not required for students to answer the question. This will particularly help students who speak English as a second language. Multiple choice questions are given at the end of papers allowing students to manage their time better.

Practical work is at the heart of science. Our specification includes ten required practicals that have been designed to give students a broad range of practical experiences. These will be assessed via the written papers, giving more flexibility to schools allowing them to choose how to deliver practical work through their teaching. The required practicals have also been chosen to minimise the use of resources or equipment that could potentially present difficulties in resourcing. This method of assessing practical work ensures all students are given the opportunity to gain key skills without the pressures of coursework or practical exams.

Our clear modular structure allows teachers to plan delivery of the content, and for students to be able to prepare for each exam appropriately. The knowledge and understanding from each module builds on the previous ones, and the skills required for each exam build to allow students to gain confidence in their practical, mathematical and communications skills as they learn.

Helpful resources support this specification. These include schemes of work and a Practical handbook which harmonises the rules for International A-level Biology, Chemistry and Physics. This allows your students to be confident in the knowledge that they are using the same rule in each of their OxfordAQA. The Practical handbook also includes example methods for each of the required practicals, allowing you to plan your practical work with confidence.

You can find out more about our International AS and A-level Physics qualifications at **oxfordaqa.com/science**

1.3 Recognition

OxfordAQA meet the needs of international students. They are an international alternative and comparable in standard to the Ofqual regulated qualifications offered in the UK. Our qualifications have been independently benchmarked by UK ENIC, the UK national agency for providing expert opinion on qualifications worldwide. They have confirmed they can be considered 'comparable to the overall GCE A-level and GCSE standard offered in the UK'.

To read their report and see the latest list of universities who have stated they accept these international qualifications, visit **oxfordaqa.com/recognition**

1.4 The Oxford International Programme learner attributes

In order to equip students with the skills they need for success both now and in the future, we have worked with Oxford University Press to create the Oxford International Programme. This combines the Oxford International Curriculum with OxfordAQA qualifications, creating an integrated offer for international schools, from Early Years to A-level.

At its core we have introduced the Oxford International Programme learner attributes – the skills and competencies that enable our students to thrive academically, socially and personally.

The learner attributes, alongside our focus on demonstrating higher order critical thinking skills, ensure that students are equipped to get the grades that will take them places, and build the skills they need to be successful when they get there.

Empowered & independent

Our students are independent, critical thinkers who are adaptable and look to develop strategies to be lifelong learners. They are confident leading on projects but also work well in a collaborative environment.

Inventive & curious

Our students are inventive, resourceful, and creative. They question the world around them with a sense of wonder, and aspire to shape a better future for themselves and their community.

Future-ready

Our students are more prepared to succeed in the world that lies ahead and have the knowledge, skills, and drive to achieve any objective they may set themselves. They are comfortable being challenged, acquiring new skills quickly, and seeking new adventures.

Ambitious & self-motivated

Our students are ambitious and want to strive for success in every aspect of their lives. They take the initiative, approaching every task with an eagerness to learn and take ownership of their own learning with the utmost integrity.

1.5 Support and resources to help you teach

We know that support and resources are vital for your teaching and that you have limited time to find or develop good quality materials. That's why we've worked with experienced teachers to provide you with resources that will help you confidently plan, teach and prepare for exams.

Teaching resources

You will have access to:

- sample schemes of work to help you plan your course with confidence
- teacher guidance notes to give you the essential information you need to deliver the specification
- training courses to help you deliver our qualifications
- student textbooks that have been checked and approved by us
- engaging worksheets and activities developed by teachers, for teachers.

Preparing for exams

You will have access to the support you need to prepare for our exams, including:

- specimen papers and mark schemes
- exemplar student answers with examiner commentaries
- a searchable bank of past AQA exam questions mapped to these new International qualifications.

Analyse your students' results with Enhanced Results Analysis (ERA)

After the first examination series, you can use this tool to see which questions were the most challenging, how the results compare to previous years and where your students need to improve. ERA, our free online results analysis tool, will help you see where to focus your teaching.

Information about results, including maintaining standards over time, grade boundaries and our post-results services, will be available on our website in preparation for the first examination series.

Help and support

Visit our website for information, guidance, support and resources at **oxfordaqa.com/9630**

You can contact the subject team directly at **info@oxfordaqa.com** or call us on +44 (0)161 696 5995 (option 1 and then 1 again)

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm.

2 Specification at a glance

The titles of the qualifications are:

- OxfordAQA International Advanced Subsidiary Physics
- OxfordAQA International Advanced Level Physics.

These qualifications are modular. The full International A-level is intended to be taken over two years. The specification content for the International AS is half that of an International A-level. The International AS can be taken as a stand-alone qualification or can be used to count towards the International A-level. Students can take the International AS in the first year and then take the International A2 in the second year to complete the International A-level or they can take all the units together in the same examination series at the end of the course.

The International AS content will be 50% of the International A-level content but International AS assessments will contribute 40% of the total marks for the full International A-level qualification with the remaining 60% coming from the International A2 assessments.

Candidates may resit a unit any number of times within the shelf-life of the specification. The best result for each unit will count towards the final qualification. Exams will be available in January and May/June.

The guided learning hours (GLH) for an OxfordAQA International Advanced Subsidiary is 180.

The guided learning hours (GLH) for an OxfordAQA International Advanced Level is 360.

These figures are for guidance only and may vary according to local practice and the learner's prior experience of the subject.

2.1 Subject content

3.1 Measurements and their errors

3.2 Mechanics and materials

3.3 Particles, radiation and radioactivity

3.4 Electricity

3.5 Oscillations and waves

3.6 Circular and periodic motion (International A-level only)

3.7 Gravitational fields and satellites (International A-level only)

3.8 Electric fields and capacitance (International A-level only)

3.9 Exponential change (International A-level only)

3.10 Magnetic fields (International A-level only)

3.11 Thermal physics (International A-level only)

3.12 Nuclear energy (International A-level only)

3.13 Energy sources (International A-level only)

2.2 International AS

Assessments

Unit 1: Mechanics, materials and atoms	+	Unit 2: Electricity, waves and particles
What's assessed Content: 3.1 Measurements and their errors 3.2 Mechanics and materials 3.3 Particles, radiation and radioactivity		**What's assessed** Content: 3.4. Electricity 3.5. Oscillations and waves Although content-led questions will not be set on topics from Unit 1, questions may draw on the physics principles specified for Unit 1
How it's assessed Written exam: 2 hours 80 marks 50% of the International AS assessment 20% of the International A-level		**How it's assessed** Written exam: 2 hours 80 marks 50% of the International AS assessment 20% of the International A-level
Questions Section A: Short and long questions on Sections 3.1 – 3.3 – 50 marks Section B: Data analysis and application questions drawing on Sections 3.1 – 3.3 – 16 marks Section C: Multiple choice on Sections 3.1 – 3.3 – 14 marks The balance of marks in Section A will be about 15 marks in 4 – 7 short questions and 35 marks in 3 – 5 long questions		**Questions** Section A: Short and long questions on Sections 3.4 and 3.5 – 50 marks Section B: Data analysis and application questions drawing on Sections 3.1 – 3.5 – 16 marks Section C: Multiple choice on Sections 3.4 and 3.5 – 14 marks The balance of marks in Section A will be about 15 marks in 4 – 7 short questions and 35 marks in 3 – 5 long questions

2.3 International A2

Assessments

Unit 3: Fields and their consequences	Unit 4: Energy and Energy resources	Unit 5: Physics in practice
What's assessed	**What's assessed**	**What's assessed**
Content: 3.6 Circular and periodic motion 3.7 Gravitational fields and satellites 3.8 Electric fields and capacitance 3.9 Exponential change 3.10 Magnetic fields Although content-led questions will not be set on topics from Units 1 or 2, questions may draw on the physics principles specified for Units 1 or 2	Content: 3.11. Thermal physics 3.12. Nuclear energy 3.13. Energy sources Although content-led questions will not be set on topics from Units 1 – 3, questions may draw on the physics principles specified for Units 1 – 3.	3.14. Practical and analytical skills Any content from topics 3.1 – 3.13
How it's assessed	**How it's assessed**	**How it's assessed**
Written exam: 2 hours 80 marks 20% of International A-level	Written exam: 2 hours 80 marks 20% of International A-level	Written exam: 2 hours 80 marks 20% of International A-level
Questions	**Questions**	**Questions**
Section A: 6 – 9 questions – 65 marks Section B: Multiple choice – 15 marks	Section A: 6 – 9 questions – 65 marks Section B: Multiple choice – 15 marks	Section A: Practical and data analysis skills – 36 marks Section B: Synoptic (International AS and A2) – 44 marks

AS + A2 = A-level

3 Subject content

Sections 3.1 to 3.5 will be assessed in the International AS exams. All content will be assessed in the full International A-level.

The specification includes **required practicals**. Students can be examined on the principles and techniques required when carrying out these practicals.

3.1 Measurements and their errors

Content in this section is a continuing study for a student of physics. A working knowledge of the specified fundamental (base) units of measurement is vital. Likewise, practical work in the subject needs to be underpinned by an awareness of the nature of measurement errors and of their numerical treatment. The ability to carry through reasonable estimations is a skill that is required throughout the course and beyond.

3.1.1 Use of SI units and their prefixes

Fundamental (base) units.

Use of mass, length, time, amount of substance, temperature, electric current and their associated SI units.

SI units derived.

Knowledge and use of the SI prefixes ($\mathrm{T, G, M, k, c, m, \mu, n, p, f}$), values and standard form.

The fundamental unit of light intensity, the candela, is not required.

Students are not expected to recall definitions of the fundamental quantities.

Dimensional analysis is not required.

Students should be able to convert between different units of the same quantity, eg J and eV, J and $\mathrm{kW\,h}$.

3.1.2 Limitation of physical measurements

Identification and suggestions for removal of random and systematic errors.

Precision, repeatability, reproducibility, resolution and accuracy.

Use of absolute, fractional and percentage uncertainties to represent uncertainty in the final answer for a quantity.

Combination of absolute and percentage uncertainties where measurements are added, subtracted, multiplied, divided, or raised to powers.

Combinations involving trigonometric or logarithmic functions will not be required.

Representation of uncertainty in a data point on a graph using error bars.

Determine the uncertainties in the gradient and intercept of a straight-line graph for graphs with or without associated error bars.

In practical work students should understand the link between the number of significant figures in the value of a quantity and its associated uncertainty.

3.1.3 Estimation of physical quantities

Estimation of approximate values of physical quantities to the nearest order of magnitude.

Use of these estimates together with their knowledge of physics to produce further derived estimates also to the nearest order of magnitude.

3.2 Mechanics and materials

Vectors and their treatment are introduced followed by development of the student's knowledge and understanding of forces, energy and momentum. A study of materials is considered in terms of their bulk properties including elastic and plastic behaviour, the Young modulus and tensile strength.

3.2.1 Scalars and vectors

Nature of scalars and vectors.

Examples should include: velocity/speed, mass, force/weight, acceleration, displacement/distance.

Addition of vectors by calculation or scale drawing.

Conditions for equilibrium for two or three coplanar forces acting at a point.

Appreciation that objects at rest or moving with constant velocity are in equilibrium.

3.2.2 Moments

Moment of a force about a point.

Moment defined as *force × perpendicular distance from the point to the line of action of the force*.

Couple as a pair of equal and opposite coplanar forces.

Moment of couple defined as *force × perpendicular distance between the lines of action of the forces.*

Principle of moments.

Centre of mass.

Knowledge that the position of the centre of mass of uniform regular solid is at its centre.

3.2.3 Motion along a straight line

Displacement, speed, velocity, acceleration. $v = \frac{\Delta s}{\Delta t} \quad a = \frac{\Delta v}{\Delta t}$

Calculations may include average and instantaneous speeds and velocities.

Representation by graphical methods of uniform and non-uniform acceleration eg motion of a bouncing ball.

Significance and calculation of areas in velocity–time and acceleration–time graphs.

Significance and calculation of gradients in displacement–time and velocity–time graphs.

Equations for uniform acceleration: $v = u + at \quad s = \left(\frac{u+v}{2}\right)t \quad s = ut + \frac{1}{2}at^2 \quad v^2 = u^2 + 2as$

Acceleration due to gravity, g

Required practical 1	Determination of g by a freefall method. Procedures should include determination of g from graph (eg from graph of s against t^2)

3.2.4 Projectile motion

Independent effect of motion in horizontal and vertical directions of a uniform gravitational field. Problems will be solvable using the equations of uniform acceleration.

Qualitative treatment of friction.

Distinctions between static and dynamic friction will not be tested.

Qualitative treatment of lift force and drag force.

Terminal speed.

Knowledge that air resistance increases with speed.

Qualitative understanding of the effect of air resistance on the trajectory of a projectile and on the factors that affect the maximum speed of a vehicle.

3.2.5 Newton's laws of motion

Knowledge and application of the three laws of motion.

Use of $F = ma$ in situations where the mass is constant.

3.2.6 Momentum

momentum = mass × velocity; $p = mv$

Conservation of linear momentum.

Principle applied quantitatively to problems in one dimension.

Elastic and inelastic collisions; explosions.

Force as the rate of change of momentum, $F = \frac{\Delta(mv)}{\Delta t}$

Impulse = change in momentum.

$F\Delta t = \Delta \ mv$, where F is constant.

Significance of the area under a force–time graph.

Quantitative questions may be set on forces that vary with time.

Relationship between impact forces and contact times (eg kicking a football, crumple zones, packaging).

3.2.7 Work, energy and power

Energy transferred, $W = Fs \cos \theta$

where θ is the angle between F and s

Significance of the area under a force–displacement graph.

Power = rate of doing work = rate of energy transfer, $P = \frac{\Delta W}{\Delta t} = Fv$

Quantitative questions may be set on variable forces.

$$Efficiency = \frac{useful\ output\ power}{input\ power}$$

Efficiency may be expressed as a percentage.

3.2.8 Conservation of energy

Principle of conservation of energy.

$\Delta E_p = mg\Delta h$ and $E_k = \frac{1}{2}mv^2$

Quantitative and qualitative application of energy conservation to examples involving gravitational potential energy, kinetic energy, elastic potential energy and work done against resistive forces.

3.2.9 Bulk properties of solids

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

Hooke's law, elastic limit.

$F = k\Delta L$, k as either stiffness and spring constant.

Tensile strain and tensile stress.

Elastic strain energy, breaking stress.

$$energy\ stored = \frac{1}{2}F\Delta L\ = area\ under\ force-extension\ graph$$

Description of plastic behaviour, fracture and brittle behaviour, linked to force–extension graphs.

Quantitative and qualitative application of energy conservation to examples involving elastic strain energy and energy to deform.

Elastic potential energy in spring transformed to kinetic and gravitational potential energy.

Interpretation of simple stress–strain curves.

3.2.10 The Young modulus

$$\textit{Young modulus } E = \frac{\textit{tensile stress}}{\textit{tensile strain}} = \frac{FL}{A\Delta L}$$

Use of stress–strain graphs to determine the Young modulus.

Required practical 2	Investigation of load-extension graph for a wire and determination of the Young modulus for the material of the wire.

3.3 Particles, radiation and radioactivity

In this section students will study microscopic nature of matter and the basics of radioactive decay. They will gain an appreciation of the range of elementary particles and their interactions.

3.3.1 Constituents of the atom

Simple model of the atom, including the proton, neutron and electron.

Evidence for a nucleus: Rutherford scattering.

Appreciation of how knowledge and understanding of the structure of the nucleus has changed over time.

Charge and mass of the proton, neutron and electron in SI units and relative units.

Use of the atomic mass unit (amu) is not required at International AS (see Section 3.12.2).

Specific charge of the proton and the electron, and of nuclei and ions.

Proton number Z, nucleon number A, nuclide notation. Students should be familiar with the ${}^{A}_{Z}\mathrm{X}$ notation.

3.3.2 Elementary particles

Classification of particles:

For every type of particle, there is a corresponding antiparticle.

Students should know that the positron, antiproton, antineutron and antineutrino are the antiparticles of the electron, proton, neutron and neutrino respectively.

Knowledge of annihilation and pair production and the energies involved.

Comparison of particle and antiparticle masses, charge and rest energy in MeV.

The use of $E = mc^2$ is not required in calculations.

3.3.3 Radioactivity

Possible decay modes of unstable nuclei including α, β^-, β^+

Equations for α, β^-, β^+ decays including neutrinos and antineutrinos.

The existence of the neutrino was hypothesised to account for conservation of momentum and energy in beta decay.

The decay of a free neutron should be known.

Half-life; Determination of half-life from graphical decay data including decay; Simple calculations involving times that are whole numbers of the half-life.

Use of equations for exponential decay will be required at International A2 only, (see Section 3.9).

Existence of nuclear excited states; γ ray emission; application eg use of technetium-99m as a source in medical diagnosis.

Properties of α, β, and γ radiation and experimental identification of these using simple absorption experiments; applications eg to relative hazards of exposure to humans.

Applications also include thickness measurements of aluminium foil, paper and steel.

Inverse-square law for γ radiation: $I = \frac{I_o}{r^2}$

Experimental verification of inverse-square law.

Applications eg to safe handling of radioactive sources.

Background radiation; examples of its origins and experimental elimination from calculations.

3.4 Electricity

This section builds on, and develops, knowledge and understanding of electricity from prior study. It provides opportunities for the development of practical skills and lays the groundwork for later study of the many electrical applications that are important to society.

3.4.1 Basics of electricity

Electric current as the rate of flow of charge; potential difference as work done per unit charge.

$$I = \frac{\Delta Q}{\Delta t} \quad V = \frac{W}{Q}$$

Resistance defined as $R = \frac{V}{I}$

3.4.2 Current–voltage characteristics

Characteristics for an ohmic conductor, semiconductor diode, and filament lamp.

Ohm's law as a special case where $I \propto V$ under constant physical conditions.

Unless specifically stated in questions, ammeters and voltmeters should be treated as ideal (having zero and infinite resistance respectively).

Questions can be set where either I or V is on the horizontal axis of the characteristic graph.

3.4.3 Resistivity

Resistivity $\rho = \frac{RA}{L}$

Description of the qualitative effect of temperature on the resistance of metal conductors and thermistors.

Only negative temperature coefficient (ntc) thermistors will be considered.

Applications of thermistors to include temperature sensors and resistance–temperature graphs.

Superconductivity as a property of certain materials which have zero resistivity at and below a critical temperature which depends on the material.

Applications of superconductors to include the production of strong magnetic fields and the reduction of energy loss in transmission of electric power.

Critical field will not be assessed.

3.4.4 Circuits

Resistors:

in series, $R_T = R_1 + R_2 + R_3 + \ldots$

in parallel, $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} +$

Energy and power equations: $E = IVt$; $P = IV = I^2 R = \frac{V^2}{R}$

The relationships between current, voltage and resistance in series and parallel circuits, including cells in series and identical cells in parallel.

Conservation of charge and conservation of energy in dc circuits.

3.4.5 Potential divider

The potential divider used to supply constant or variable potential difference from a power supply.

The use of the potentiometer as a measuring instrument is not required.

Examples should include the use of variable resistors, thermistors, and light dependent resistors (LDR) in the potential divider.

3.4.6 Electromotive force and internal resistance

emf: $\varepsilon = \frac{E}{Q}$; $\varepsilon = I\left(R + r\right)$

Effect of internal resistance on terminal pd.

Students will be expected to understand and perform calculations for circuits in which the internal resistance of the supply is not negligible.

Required practical 3	Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of a cell or battery with current.

3.5 Oscillations and waves

The earlier study of mechanics is developed further with a study of examples of systems undergoing oscillations. This is followed by a study of the characteristics, properties, and applications of travelling waves and stationary waves and concludes with a study of refraction, diffraction, superposition and interference. They will also study evidence for wave-particle duality of electromagnetic radiation and moving particles.

3.5.1 Oscillating systems

Mass-spring system: $T = 2\pi\sqrt{\frac{m}{k}}$

Simple pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$

Variation of E_k, E_p, and total energy with both displacement and time.

Effects of damping on oscillations.

Required practical 4	Investigation into simple harmonic systems using a mass-spring system and a simple pendulum.

3.5.2 Forced vibrations and resonance

Qualitative treatment of free and forced vibrations.

Resonance and the effects of damping on the sharpness of resonance.

Examples of these effects in mechanical systems and situations involving stationary waves.

3.5.3 Progressive waves

Oscillation of the particles of the medium;

amplitude, frequency, wavelength, speed, phase, phase difference, $c = f\lambda$ $f = \frac{1}{T}$

Phase difference measured as angles (radians or degrees) or as fractions of a cycle.

3.5.4 Longitudinal and transverse waves

Nature of longitudinal and transverse waves.

Examples to include: sound, electromagnetic waves, and waves on a string.

Students will be expected to know the direction of displacement of particles/fields relative to the direction of energy propagation and that all electromagnetic waves travel at the same speed in a vacuum.

Use of ultrasound in medicine.

Polarisation as evidence for the nature of transverse waves.

Applications of polarisers to include Polaroid material and the alignment of aerials for transmission and reception.

Malus's law will not be expected.

3.5.5 Principle of superposition of waves and formation of stationary waves

Stationary waves.

Nodes and antinodes on strings.

$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ for the first harmonic

The formation of stationary waves by two waves of the same frequency travelling in opposite directions.

A graphical explanation of formation of stationary waves will be expected.

Stationary waves formed on a string and those produced with microwaves and sound waves should be considered.

Stationary waves on strings will be described in terms of harmonics.

The terms fundamental (for first harmonic) and overtone will not be used.

Knowledge of experiments that investigate the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string.

3.5.6 Interference

Path difference. Coherence.

Interference and diffraction using a laser as a source of monochromatic light.

Young's double-slit experiment: the use of two coherent sources or the use of a single source with double slits to produce an interference pattern.

Fringe spacing $w = \frac{\lambda D}{s}$

Production of interference pattern using white light.

Students are expected to show awareness of safety issues associated with using lasers.

Students will not be required to describe how a laser works.

Students will be expected to describe and explain interference produced with sound and electromagnetic waves.

Required practical 5	Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating.

3.5.7 Diffraction

Appearance of the diffraction pattern from a single slit using monochromatic and white light.

Qualitative treatment of the variation of the width of the central diffraction maximum with wavelength and slit width. The graph of intensity against angular separation is not required.

Plane transmission diffraction grating at normal incidence. Derivation of $d \sin\theta = n\lambda$

Use of the spectrometer will not be tested.

Applications of diffraction gratings.

3.5.8 Refraction at a plane surface

Refractive index of a substance, $n = \frac{c}{c_s}$

Students should recall that the refractive index of air is approximately 1.

Snell's law of refraction for a boundary $n_1 \sin \theta_1 = n_2 \sin \theta_2$

Total internal reflection $\sin\theta_c = \frac{n_2}{n_1}$

Simple treatment of fibre optics including the function of the cladding.

Optical fibres will be limited to step index only.

Material and modal dispersion.

Students are expected to understand the principles and consequences of pulse broadening and absorption.

3.5.9 Collisions of electrons with atoms

Ionisation and excitation; understanding of ionisation and excitation in the fluorescent tube.

The electron volt.

Line spectra (eg of atomic hydrogen) as evidence for transitions between discrete energy levels in atoms.

$hf = \mathrm{E}_1 - E_2$

Characteristic and line spectrum for X-rays and use of X-rays in medical applications.

Students should know the basic structure and operation of an X-ray tube.

In questions energy levels may be given in eV or J. Students will be expected to be able to convert eV into J and vice versa.

3.5.10 Photoelectric effect

Photon model of electromagnetic radiation, the Planck constant.

$$E = h\boldsymbol{f} = \frac{hc}{\lambda}$$

Photoelectric effect: threshold frequency; photon explanation of threshold frequency.

Work function ϕ, stopping potential.

Photoelectric equation: $hf = \phi + E_{k\,(max)}$

$E_{k\,(max)}$ is the maximum kinetic energy of the photoelectrons.

The experimental determination of stopping potential is not required.

3.5.11 Wave particle duality

Students should know that electron diffraction suggests that particles possess wave properties and the photoelectric effect suggests that electromagnetic waves have a particulate nature.

Details of particular methods of particle diffraction are not expected.

de Broglie equation $\lambda = \frac{h}{mv}$ where mv is the momentum.

Students should be able to explain how and why the amount of diffraction changes when the momentum of the particle is changed.

Appreciation of how knowledge and understanding of the nature of matter changes over time.

3.6 Circular and periodic motion (International A-level only)

3.6.1 Circular motion

Motion in a circle at constant speed implies an acceleration and the need for a centripetal force.

Angular speed $\omega = \frac{v}{r} = 2\pi f$

Centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

Centripetal force $F = \frac{mv^2}{r} = m\omega^2 r$

The derivation of $a = \frac{v^2}{r}$ will not be examined.

3.6.2 Simple harmonic motion

Characteristic features of simple harmonic motion

Condition for SHM: $a = -\omega^2 x$

$x = A\cos\omega t$ and $v = \pm\,\omega\sqrt{(A^2 - x^2)}$

Graphical representations linking x, v, a and t.

Velocity as gradient of the displacement time graph.

Acceleration as the gradient of the velocity time graph.

Maximum speed = ωA

Maximum acceleration = $\omega^2 A$

Derivation of formulae for the period of a mass-spring system and a simple pendulum

$$T = 2\pi\sqrt{\frac{m}{k}} \quad T = 2\pi\sqrt{\frac{l}{g}}$$

Graphs of variation of E_k, E_p and total energy with displacement, and with time

Total energy of the oscillator = $\frac{1}{2} m\omega^2 A^2$

3.7 Gravitational fields and satellites (International A-level only)

3.7.1 Newton's gravitational law

Gravity as a universal attractive force acting between all matter.

Force between point masses

$F = \frac{Gm_1 m_2}{r^2}$ where G is the gravitational constant

3.7.2 Gravitational field strength

Concept of a force field as a region in which a body experiences a force.

Representation by gravitational field lines

g as force per unit mass defined by $g = \frac{F}{m}$

Magnitude of g in a radial field given by $g = \frac{GM}{r^2}$

3.7.3 Gravitational potential

Understanding of definition of gravitational potential including zero potential at infinity and gravitational potential difference.

Work done in moving mass: $\Delta W = m\Delta v$

Gravitational potential in a radial field: $V = -\frac{GM}{r}$

Equipotential surfaces: appreciation that no work is done when moving a mass along an equipotential surface.

Graphical representations of the variations of g and V with r

V related to g by $g = -\frac{\Delta V}{\Delta r}$

3.7.4 Orbits of planets and satellites

Orbital period and speed related to radius of circular orbit.

Energy considerations for an orbiting satellite.

Significance of a geosynchronous orbit.

3.8 Electric fields and capacitance (International A-level only)

3.8.1 Coulomb's law

Force between point charges in a vacuum:

$F = \frac{1}{4\pi\varepsilon_o}\frac{Q_1 Q_2}{r^2}$ where ε_o is the permittivity of free space.

Appreciation that air can be treated as a vacuum when calculating force between charges.

For a charged sphere, charge may be considered to be at the centre.

Comparison of magnitude of gravitational and electrostatic forces between subatomic particles.

3.8.2 Electric field strength

Representation of electric fields by electric field lines.

Electric field strength E as force per unit charge defined by $E = \frac{F}{Q}$

Magnitude of E in a uniform field: $E = \frac{V}{d}$

Derivation from work done moving charge between plates: $Fd = Q\Delta V$

Trajectory of moving charged particle entering a uniform electric field initially at right angles.

Magnitude of E in a radial field given by $E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$

3.8.3 Electric potential

Understanding of definition of absolute electric potential, including zero value at infinity, and of electric potential difference.

Work done in moving charge Q given by $\Delta W = Q \Delta V$

Equipotential surfaces. Appreciations that no work is done moving charge along an equipotential surface.

Magnitude of V in a radial field given by $V = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r}$

Graphical representations of variations of E and V with r.

V related to E by $E = \frac{\Delta V}{\Delta r}$

ΔV from the area under graph of E against r.

3.8.4 Capacitors

Definition of capacitance: $C = \frac{Q}{V}$

For a parallel plate capacitor: $C = \frac{A\varepsilon_o \varepsilon_r}{d}$

Relative permittivity and dielectric constant.

Dielectric action in a capacitor: Students should be able to describe the action of a simple polar molecule that rotates in the presence of an electric field.

Energy stored from area under a graph of charge against pd: $E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

3.9 Exponential change (International A-level only)

3.9.1 Capacitor charge and discharge

Graphical representation of charging and discharging of capacitors through resistors.

Corresponding graphs for Q, V and I against time for charging and discharging.

Interpretation of gradients and areas under graphs where appropriate.

Time constant = RC

Calculation of time constants including their determination from graphical data.

Time to halve, $T_{½} = \ln 2RC$

Quantitative treatment of capacitor discharge, $Q = Q_o e^{-\frac{t}{RC}}$

Use of the corresponding equations for V and I

Quantitative treatment of capacitor charge $Q = Q_o\left(1 - e^{-\frac{t}{RC}}\right)$

Required practical 6	Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant, RC.

3.9.2 Exponential changes in radioactivity

Random nature of radioactive decay; constant decay probability of a given nucleus;

$$\frac{\Delta N}{\Delta t} = -\lambda N; \; N = N_o e^{-\lambda t}$$

Use of activity, $A = \lambda N$

Modelling with constant decay probability.

Questions may be set which require students to use $A = A_o e^{-\lambda t}$

Questions may also involve use of molar mass or the Avogadro constant.

Half-life equation

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

Determination of half-life from graphical decay data including decay curves and log graphs.

3.10 Magnetic fields (International A-level only)

3.10.1 Magnetic flux density

Force on a current-carrying wire in a magnetic field: $F = BIL$ when field is perpendicular to current.

Fleming's left hand rule.

Magnetic flux density B and definition of the tesla.

3.10.2 Moving charges in a magnetic field

Force on charged particles moving in a magnetic field: $F = BQv$ when the field is perpendicular to velocity.

Direction of force on positive and negative charged particles.

Circular path of particles; application in devices such as the cyclotron.

3.10.3 Magnetic flux and flux linkage

Magnetic flux defined by $\Phi = BA$ where B is perpendicular to A.

Flux linkage as $N\Phi$ where N is the number of turns.

Flux and flux linkage passing through a rectangular coil rotated in a magnetic field:

Flux linkage $N\Phi = BAN\cos\theta$

3.10.4 Electromagnetic induction

Simple experimental phenomena.

Faraday's and Lenz's laws.

Magnitude of induced emf = rate of change of flux linkage: $\varepsilon = \frac{\Delta \Phi}{\Delta t}$

Applications such as a straight conductor moving in a magnetic field.

Production of eddy currents.

Emf induced in a coil rotating uniformly in a magnetic field: $\varepsilon = BAN\omega \sin \omega t$

3.10.5 Alternating currents

Sinusoidal voltages and currents only; root mean square, peak and peak-to-peak values for sinusoidal waveforms only.

$I_{rms} = \frac{I_o}{\sqrt{2}}$; $V_{rms} = \frac{V_o}{\sqrt{2}}$

Application to the calculation of mains electricity peak and peak-to-peak voltage values.

Use of an oscilloscope as a dc and ac voltmeter, to measure time intervals and frequencies, and to display ac waveforms.

No details of the structure of an oscilloscope are required but familiarity with the operation of the controls is expected.

3.10.6 The operation of a transformer

The transformer equation $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

Transformer efficiency = $\frac{I_S V_S}{I_P V_P}$

Causes of in efficiencies in a transformer.

Transmission of electrical power at high voltage including calculations of power and voltage losses in transmission lines.

Required practical 7	Investigation of the efficiency of a transformer.

3.11 Thermal physics (International A-level only)

In Sections 3.11 – 3.13, students will study alternative energy sources. They must be able to use their knowledge of the advantages and disadvantages of each to make a judgment of appropriate sources to be used in different situations. The latter parts of this section brings together ideas from other parts of the specification.

3.11.1 Energy transfer by heating and doing work

Internal energy is the sum of the randomly distributed kinetic energies and potential energies of the particles in a body.

The internal energy of a system is increased when energy is transferred to it by heating or when work is done on it (and vice versa).

The first law of thermodynamics: $\Delta U = Q + W$ where Q is the energy input to the system by heating and W is the work done ON the system.

Appreciation that during a change of state the potential energies of the particle ensemble are changing but not the kinetic energies.

Calculations involving transfer of energy including continuous flow systems:

For a change of temperature: $Q = mc\ \Delta\theta$ where c is specific heat capacity.

For a change of state $Q = ml$ where l is the specific latent heat.

Required practical 8	Determination of specific heat capacity by an electrical method.

3.11.2 Energy transfer by conduction

Rate of energy transfer by conduction = $\dfrac{kA\Delta\theta}{L}$ where k is the thermal conductivity.

Use of U–values to calculate energy losses for parallel surfaces only.

Rate of energy transfer = $UA\ \ \Delta\theta$ where $U = \dfrac{k}{L}$

3.11.3 Ideal gases

Gas laws as experimental relationships between p, V, T and the mass of the gas.

Concept of absolute zero of temperature.

Ideal gas equation: $pV = nRT$ for n moles and $pV = N\,kT$ for N molecules.

Work done $= p\Delta V$

Avogadro constant N_A, molar gas constant R, Boltzmann constant k

Molar mass and molecular mass.

Required practical 9	Investigation of Boyle's law (constant temperature) and Charles's law (constant pressure) for a gas.

3.11.4 Kinetic theory of gases

Brownian motion as evidence for existence of atoms.

Explanation of relationships between p, V and T in terms of a simple molecular model.

Students should understand that the gas laws are empirical in nature whereas the kinetic theory model arises from theory.

Assumptions leading to $pV = \frac{1}{3} Nm \left(c_{\text{rms}}\right)^2$: Calculations using the formula are expected.

Appreciation that for an ideal gas, internal energy is kinetic energy of the atoms.

Use of average molecular kinetic energy $= \frac{1}{2} m \left(c_{\text{rms}}\right)^2 = \frac{3}{2} kT = \frac{3}{2} \frac{RT}{N_A}$

3.12 Nuclear energy (International A-level only)

3.12.1 Radius of the nucleus

Estimate of radius from closest approach of alpha particles and determination of radius from electron diffraction.

Knowledge of typical values for nuclear radius.

Students will need to be familiar with the Coulomb equation for the closest approach estimate.

Dependence of radius on nucleon number:

$R = R_o \mathrm{A}^{1/3}$ derived from experimental data.

Interpretation of equation as evidence for constant density of nuclear material.

Calculation of nuclear density.

Students should be familiar with the graph of intensity against angle for electron diffraction by a nucleus.

3.12.2 Mass and energy

Appreciation that $E = mc^2$ applies to all energy changes.

Simple calculations involving mass difference, binding energy and mass defect.

Atomic mass unit, u.

Conversion of units; 1 u = 931.5 MeV.

Fission and fusion processes.

Simple calculations from nuclear masses of energy released in fission and fusion reactions.

Graph of average binding energy per nucleon against nucleon number.

Students may be expected to identify, on the plot, the regions where nuclei will release energy when undergoing fission/fusion.

3.12.3 Induced fission

Fission induced by thermal neutrons; possibility of a chain reaction; critical mass.

The functions of the moderator, control rods, and coolant in a thermal nuclear reactor.

Details of particular reactors are not required.

Students should have studied a simple mechanical model of moderation by elastic collisions.

Factors affecting the choice of materials for the moderator, control rods and coolant. Examples of materials used for these functions.

3.12.4 Safety aspects nuclear reactors

Fuel used, remote handling of fuel, shielding, emergency shut-down.

Production, remote handling, and storage of radioactive waste materials.

Appreciation of balance between risk and benefits in the development of nuclear power.

3.12.5 Nuclear fusion

Knowledge of suitable nuclei for use in a fusion reactor.

Estimation of kinetic energy of nuclei necessary for fusion to take place and of the temperature of the plasma.

Energy release from fusion of two nuclei.

Solar fusion cycle limited to the hydrogen cycle.

Appreciation of the problems that have to be overcome to produce a practical nuclear reactor.

3.13 Energy sources (International A-level only)

3.13.1 Rotational motion

$I = mr^2$ for a point mass. $I = \Sigma mr^2$ for an extended object.

Qualitative knowledge of the factors that affect the moment of inertia of a rotating object.

Expressions for moment of inertia will be given where necessary.

Angular displacement, angular speed, angular velocity and angular acceleration.

Equations for uniform angular acceleration

$$\omega = \omega_o + \alpha t \qquad \theta = \frac{(\omega_0 + \omega)}{2} t \qquad \theta = \omega_0 t + \frac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_o{}^2 + 2\alpha\,\theta$$

Torque = $Fr = I\alpha$

Angular momentum $I\omega$

Conservation of angular momentum

Rotational kinetic energy $E_{\mathrm{k(rot)}} = \frac{1}{2} I\omega^2$

Work $W = T\theta$ and power $P = T\omega$

Students should be aware of the analogy between rotational and translational dynamics.

3.13.2 Wind energy

Maximum power available from a wind turbine $E = \frac{1}{2}\pi r^2 \rho v^3$ where ρ is the density of air.

Appreciation why all this energy cannot be used.

Wind shadows determine arrangement of turbines in a wind farm.

Environmental factors in the use of wind turbines.

3.13.3 Solar energy

Intensity of energy from the Sun at the Earth's surface.

Use of inverse square law to determine intensity at different distances from the Sun: $I = \frac{P}{4\pi r^2}$

V-I characteristic and maximum power for a solar cell.

Arrangement of cells in solar arrays.

Required practical 10	Investigation of the inverse square law for light using an LDR and a point source.

3.13.4 Hydroelectric power and pumped storage

Components of a hydroelectric power station: Turbine and generator.

Transfer of gravitational potential energy to kinetic energy.

Maximum power available from flow of water through a turbine $E = \frac{1}{2}\pi r^2 \rho v^3$ where ρ is the density of water.

Idea of base-power stations and back-up power stations.

Principles of operation pumped storage systems.

4 Scheme of assessment

Find mark schemes, and specimen papers for new courses, on our website at **oxfordaqa.com/9630**

These qualifications are modular. The full International A-level is intended to be taken over two years. The specification content for the International AS is half that of an International A-level.

The International AS can be taken as a stand-alone qualification or it can count towards the International A-level. To complete the International A-level, students can take the International AS in their first year and the International A2 in their second year or they can take all the units together in the same examination series at the end of the two year course.

The International AS content will be 50% of the International A-level content. International AS assessments contribute 40% of the total marks for the full International A-level qualification. The remaining 60% comes from the International A2 assessments.

The specification provides an opportunity for students to produce extended responses either in words or using open-ended calculations.

The specification content will be split across units and will include some synoptic assessment. This allows students to draw together different areas of knowledge from across the full course of study.

All materials are available in English only.

Our International AS and A-level exams in Physics include questions that allow students to demonstrate their ability to:

- demonstrate knowledge and understanding of scientific, mathematical and practical techniques, principles and concepts
- apply their knowledge and understanding of scientific, mathematical and practical techniques, principles and concepts.

4.1 Availability of assessment units and certification

Exams and certification for this specification are available as follows:

	Availability of units		Availability of certification	
	International AS	International A2	International AS	International A-level
June 2017	✓		✓	
January 2018	✓		✓	
June 2018	✓	✓	✓	✓
January 2019 onwards	✓	✓	✓	✓
June 2019 onwards	✓	✓	✓	✓

4.2 Aims

Science is more than facts and information. It is stimulating and helps us to make sense of the world around us in a way that no other subject allows.

Courses based on this specification should encourage students to:

- develop a deep appreciation, enjoyment and enthusiasm for science
- appreciate the breadth of the subject
- allows a depth of treatment that prepares students for further study in physics
- understand the tentative nature of science and understand the importance of critical thinking
- apply scientific knowledge and understanding in novel contexts
- develop practical, mathematical and communication skills.

4.3 Assessment Objectives

The exams will measure how students have achieved the following assessment objectives.

- AO1: Knowledge and understanding of scientific principles and concepts.
- AO2: Application of knowledge and understanding of scientific principles and concepts in both familiar and novel contexts.
- AO3: The ability to describe, analyse, interpret and evaluate scientific information presented in different forms.
- AO4: The ability to select, describe and evaluate scientific procedures.

Quality of Written Communication (QWC)

Students must:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Questions in the papers for this specification do not include specific marks for QWC. However, poor written communication may lead to lower marks due to lack of clarity in answers.

4.3.1 Assessment Objective weightings for International AS Physics

Assessment objectives	Unit Weightings (%)		Overall weighting of AOs (%)
	Unit 1	Unit 2	
AO1	14	14	28
AO2	18	18	36
AO3	14	14	28
AO4	4	4	8
Overall weighting of units (%)	50	50	100

4.3.2 Assessment Objective weightings for International A-level Physics

Assessment Objectives (AOs)	Unit weightings (approx %)					Overall weighting (approx %)
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	
AO1	5.6	5.6	5	5	3	24
AO2	7.2	7.2	9	9	7	40
AO3	5.6	5.6	5	5	7	28
AO4	1.6	1.6	1	1	3	8
Overall weighting of units	20	20	20	20	20	100

4.4 Assessment weightings

The raw marks awarded on each unit will be transferred to a uniform mark scale (UMS) to meet the weighting of the units and to ensure comparability between units sat in different exam series. Students' final grades will be calculated by adding together the uniform marks for all units. The maximum raw and uniform marks are shown in the table below.

Unit	Maximum raw mark	Percentage weighting A-level (AS)	Maximum uniform mark
1	80	20 (50)	100
2	80	20 (50)	100
3	80	20	100
4	80	20	100
5	80	20	100
Qualification			
International AS (Unit 1 + Unit 2)	–	40 (100)	200
International A-level (Unit 1 + Unit 2 + Unit 3 + Unit 4 + Unit 5)	–	100	500

For more detail on UMS, see Section 5.3.

5 General administration

We are committed to delivering assessments of the highest quality and have developed practices and procedures to support this aim. To ensure all students have a fair experience, we have worked with other awarding bodies in England to develop best practice for maintaining the integrity of exams. This is published through the Joint Council for Qualifications (JCQ). We will maintain the same high standard through their use for OxfordAQA Exams.

More information on all aspects of administration is available at **oxfordaqa.com/exams-administration**

For any immediate enquiries please contact **info@oxfordaqa.com**

Please note: We aim to respond to all email enquiries within two working days.

Our UK office hours are Monday to Friday, 8am – 5pm local time.

5.1 Entries and codes

You should use the following subject award entry codes:

Qualification title	OxfordAQA Exams entry code
OxfordAQA International Advanced Subsidiary Physics	9631
OxfordAQA International Advanced Level Physics	9632

Please check the current version of the Entry Codes book and the latest information about making entries on **oxfordaqa.com/exams-administration**

You should use the following unit entry codes:

Unit 1 – PH01

Unit 2 – PH02

Unit 3 – PH03

Unit 4 – PH04

Unit 5 – PH05

A unit entry will not trigger certification. You will also need to make an entry for the overall subject award in the series that certification is required.

Exams will be available May/June and in January.

5.2 Overlaps with other qualifications

There is overlapping content in the International AS and A-level specifications. This helps you teach the International AS and A-level together.

5.3 Awarding grades and reporting results

The International AS qualification will be graded on a five-point scale: A, B, C, D and E.

The International A-level qualification will be graded on a six-point scale: A*, A, B, C, D and E. To be awarded an A*, students will need to achieve a grade A on the full A-level qualification and 90% of the maximum uniform mark on the aggregate of the A2 units.

Students who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

We will publish the minimum raw mark needed for each grade in each unit when we issue students' results. We will report a student's unit results to schools in terms of uniform marks and unit grades and we will report qualification results in terms of uniform marks and grades.

The relationship between uniform marks and grades is shown in the table below.

	Uniform mark range per unit and per qualification						
Grade	**Unit 1**	**Unit 2**	**International AS Physics**	**Unit 3**	**Unit 4**	**Unit 5**	**International A-level Physics**
Maximum uniform mark	100	100	200	100	100	100	500
A*							* See note below
A	80–100	80–100	160–200	80–100	80–100	80–100	400–500
B	70–79	70–79	140–159	70–79	70–79	70–79	350–399
C	60–69	60–69	120–139	60–69	60–69	60–69	300–349
D	50–59	50–59	100–119	50–59	50–59	50–59	250–299
E	40–49	40–49	80–99	40–49	40–49	40–49	200–249

* For the award of grade A*, a student must achieve grade A in the full A-level qualification and a minimum of 270 uniform marks in the aggregate of units 3, 4 and 5.

5.4 Resits

Unit results remain available to count towards certification, whether or not they have already been used, provided the specification remains valid. Students can resit units as many times as they like, as long as they're within the shelf-life of the specification. The best result from each unit will count towards the final qualification grade. Students who wish to repeat a qualification may do so by resitting one or more units.

To be awarded a new subject grade, the appropriate subject award entry, as well as the unit entry/entries, must be submitted.

5.5 Previous learning and prerequisites

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools.

5.6 Access to assessment: equality and inclusion

Our general qualifications are designed to prepare students for a wide range of occupations and further study and assess a wide range of competences.

The subject criteria have been assessed to ensure that they test specific competences and the skills or knowledge required do not disadvantage particular groups of students.

For students with disabilities and special educational needs, exam access arrangements are available to allow these students to demonstrate their knowledge and ability. We comply with the *UK Equality Act 2010* to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student. Information about the access arrangements that are available will be issued to schools when they become OxfordAQA centres.

5.7 Working with OxfordAQA for the first time

You will need to apply to become an OxfordAQA centre to offer our specifications to your students. Find out how at **oxfordaqa.com/centreapprovals**

5.8 Private candidates

Centres may accept private candidates for examined units/components only with the prior agreement of OxfordAQA. If you are an approved OxfordAQA centre and wish to accept private candidates, please contact OxfordAQA at: **info@oxfordaqa.com**

As some of the marks in the AS and A-level papers will relate to practical work, students undertaking this specification must carry out the required practical activities in section 6.1 of the specification.

Centres accepting private candidates must ensure they have carried out this minimum requirement. Private candidates may also enter for examined only units via the British Council; please contact your local British Council office for details.

6 Practical assessment

Practical work is at the heart of science and we expect students taking this course to have a rich diet of practical work. This will allow them to fully appreciate the practical nature of science and to understand the methods that scientists use to investigate the world around us.

As schools around the world have very different circumstances, particularly around access to practical equipment, there is no direct assessment of practical work for this qualification. This allows teachers to choose the best ways to introduce practical work to their students. It also allows meaningful discussion of practical work in a way that is separated from the artificial rigors of coursework or other exam board set assessments.

To be able to answer the questions on the papers for this specification, students must have had hands-on experience of the following required practicals. Questions may be set on these practicals directly, or on the skills contained within the practicals.

These skills could include, but are not limited to:

- planning experiments, including identifying and understanding how to control variables
- choosing equipment, or evaluating the use of specified pieces of equipment
- skills required for carrying out experiments such as taking readings or recording data
- choosing, constructing and interpreting appropriate graphical displays for data
- analysing and interpreting data, including carrying out calculations on data
- evaluating experimental procedures.

6.1 Required practical activities

International AS practical activities	International A2 practical activities
Students must carry out the practical activities listed below. The International AS written papers test knowledge and understanding of the procedures involved and require evaluation of the techniques adopted. Students may need to interpret specimen results. **Practical activity** **1.** Determination of g by a freefall method. Procedures should include determination of g from graph (eg from graph of s against t^2). **2.** Investigation of load-extension graph for a wire and determination of the Young modulus for the material of the wire. **3.** Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of a cell or battery with current. **4.** Investigation into simple harmonic systems using a mass-spring system and a simple pendulum. **5.** Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating.	Students must carry out the practical activities listed below. The International A2 written papers test knowledge and understanding of the procedures involved and require evaluation of the techniques adopted. Students may need to interpret specimen results. **Practical activity** **6.** Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant, RC. **7.** Investigation of the efficiency of a transformer. **8.** Determination of specific heat capacity using an electrical method. **9.** Investigation of Boyle's law (constant temperature) and Charles's law (constant pressure). **10.** Investigation of the inverse square law for light using an LDR and a point source.

6.2 Practical and analytical skills

By undertaking the required practical activities students should develop competence in the necessary practical and analytical skills.

6.2.1 Practical skills

Students should know how to:

- use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings
- use appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance, mass)
- use methods to increase accuracy of measurements, such as timing over multiple oscillations, use of fiduciary marker, use of set square and plumb line
- use stopwatch and light gates for timing
- use calipers and micrometers for small distances, using digital and vernier scales
- correctly construct circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important
- design, construct and check circuits using DC power supplies, cells, and a range of circuit components
- use signal generator and oscilloscope, including volts/division and time-base
- generate and measure waves, using microphone and loudspeaker, ripple tank, vibration transducer and a microwave/radio wave source
- use laser and light source to investigate characteristics of light, including interference and diffraction
- use ICT for computer modelling and to process data
- use data logger with sensors to collect data.

Students should be able to:

- design an experiment to test the relationship between two physical quantities
- evaluate practical procedures and techniques and suggest improvements that would improve reliability.

6.2.2 Data analysis skills

Plotting of labelled graphs with suitable scales and units.

Comparison of data for a linear graph with the general formula $y = mx + c$; determination of gradients and intercepts when a graph shows a true origin or a false origin.

Appreciation that:

- a straight line graph through the origin with a positive gradient indicates that the quantities show direct proportionality
- a straight line graph with an intercept indicates that the quantities vary linearly with one another
- a graph with a negative gradient indicates that the quantities are indirectly proportional.

Use of ratios to test power relationships

International A2 only

Use of a log-log or ln–ln graph to determine the constants k and n in a relationship of the form

$y = kx^n$

Use of a ln-linear graph to determine the constants k and n in a relationship of the form $y = ke^{nx}$

7 Mathematical requirements

Bold statements will be assessed in International A2 units only.

1. Carry out calculations in decimal and standard form, using an appropriate number of significant figures.
2. Recognise and use appropriate units in calculations.
3. Use fractions, ratios and percentages.
4. Use power functions.
5. Use trigonometric functions $\sin x$, $\cos x$, $\tan x$.
6. Use angles in degrees and radians and translate between the two forms.
7. Calculate arithmetic means.
8. Understand and use appropriately the terms 'chance' and 'probability'.
9. Make estimates and order of magnitude calculations.
10. Identify and determine uncertainties in measurements, including calculating uncertainties in derived measurements and data (limited to data combined by addition, subtraction, multiplication, division and raising to powers).
11. Understand the symbols = , $<$,$<<$,$>>$, $>$, $\propto$, $\approx$, $\not\approx$, Δ
12. Change the subject of, substitute numbers into, or solve, algebraic equations, including quadratic equations and other non-linear equations.
13. **Solve simultaneous equations.**
14. Translate information between graphical, numerical and algebraic forms.
15. Plot graphs, draw lines of best fit on linear and non-linear graphs and extrapolate lines.
16. Understand and use $y = mx + c$ and determine the slope and intercept of a linear graph.
17. Calculate rate of change from linear and non-linear graphs, using tangents as required.
18. Distinguish between instantaneous rate of change and average rate of change.
19. Understand the possible physical significance of gradients, tangents and areas under graphs and calculate or estimate them as appropriate, using non-calculus methods.
20. Interpret logarithmic plots.
21. **Use logarithmic and exponential functions.**
22. **Use logarithmic plots to test exponential and power law variations.**
23. **Use log-log or ln-ln graphs to determine the constants k and n in a relationship of the form $y=kx^n$**
24. **Use of a ln-linear graph to determine the constants k and n**
25. Sketch graphs of linear, quadratic, trigonometric, **exponential, $\sin^2 x$ and $\cos^2 x$ relationships.**
26. Visualise, represent and use angles in 2D and 3D structures and 2D representations of 3D structures.
27. Calculate areas, perimeters and volumes of simple shapes.

28. Use Pythagoras' theorem and the angle sum of a triangle.

29. Use of the sine rule and cosine rule.

30. Use of small angle approximations including $\sin\theta \approx \theta$, $\cos\theta \approx \theta$, $\tan\theta \approx 1$ where appropriate.

OXFORD AQA
INTERNATIONAL QUALIFICATIONS

Fairness *first*

Thank you for choosing OxfordAQA, the international exam board that puts fairness first.

Benchmarked to UK standards, our exams only ever test subject ability, not language skills or cultural knowledge.

This gives every student the best possible chance to show what they can do and get the results they deserve.

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or email *info@oxfordaqa.com*