

Mapping grid showing how the AQA AS Level Physics A specification is covered by
Boardworks AS Physics

Unit 1. Particles, Quantum Phenomena and Electricity	
Topic 3.1.1: Particles and Radiation	Boardworks AS Physics presentation title
<p>3.1.1a: Constituents of the atom Proton, neutron, electron. Their charge and mass in SI units and relative units. Specific charge of nuclei and of ions. Atomic mass unit is not required. Proton number Z, nucleon number A, nuclide notation, isotopes.</p>	<ul style="list-style-type: none"> • Particle Physics
<p>3.1.1b: Stable and unstable nuclei The strong nuclear force; its role in keeping the nucleus stable; short-range attraction to about 3 fm, very-short range repulsion below about 0.5 fm; equations for alpha decay and β^- decay including the neutrino.</p>	<ul style="list-style-type: none"> • Particle Physics
<p>3.1.1c: Particles, antiparticles and photons Candidates should know that for every type of particle, there is a corresponding antiparticle. They should know that the positron, the antiproton, the antineutron and the antineutrino are the antiparticles of the electron, the proton, the neutron and the neutrino respectively. Comparison of particle and antiparticle masses, charge and rest energy in MeV. Photon model of electromagnetic radiation, the Planck constant, $E = hf = hc/\lambda$ Knowledge of annihilation and pair production processes and the respective energies involved. The use of $E = mc^2$ is not required in calculations.</p>	<ul style="list-style-type: none"> • Particle Physics • Quantum Physics
<p>3.1.1d: Particle interactions Concept of exchange particles to explain forces between elementary particles The electromagnetic force; virtual photons as the exchange particle. The weak interaction limited β^-, β^+ decay, electron capture and electron–proton collisions; W^+ and W^- as the exchange particles. Simple Feynman diagrams to represent the above reactions or interactions in terms of particles going in and out and exchange particles.</p>	<ul style="list-style-type: none"> • Particle Physics

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Boardworks AS Physics**

<p>3.1.1e: Classification of particles Hadrons: baryons (proton, neutron) and antibaryons (antiproton and antineutron) and mesons (pion, kaon). Hadrons are subject to the strong nuclear force. Candidates should know that the proton is the only stable baryon into which other baryons eventually decay; in particular, the decay of the neutron should be known. Leptons: electron, muon, neutrino (electron and muon types). Leptons are subject to the weak interaction. Candidates will be expected to know baryon numbers for the hadrons. Lepton numbers for the leptons will be given in the data booklet.</p>	<ul style="list-style-type: none"> • Particle Physics
<p>3.1.1f: Quarks and antiquarks Up (u), down (d) and strange (s) quarks only. Properties of quarks: charge, baryon number and strangeness. Combinations of quarks and antiquarks required for baryons (proton and neutron only), antibaryons (antiproton and antineutron only) and mesons (pion and kaon) only. Change of quark character in β^- and β^+ decay. Application of the conservation laws for charge, baryon number, lepton number and strangeness to particle interactions. The necessary data will be provided in questions for particles outside those specified.</p>	<ul style="list-style-type: none"> • Particle Physics

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Topic 3.1.2: Electromagnetic Radiation and Quantum Phenomena	Boardworks AS Physics presentation title
<p>3.1.2a: The photoelectric effect Work function ϕ, photoelectric equation $hf = \phi + E_k$; the stopping potential experiment is not required.</p>	<ul style="list-style-type: none"> • Quantum Physics
<p>3.1.2b: Collisions of electrons with atoms The electron volt. Ionisation and excitation; understanding of ionization and excitation in the fluorescent tube.</p>	<ul style="list-style-type: none"> • Quantum Physics
<p>3.1.2c: Energy levels and photon emission Line spectra (e.g. of atomic hydrogen) as evidence of transitions between discrete energy levels in atoms. $hf = E_1 - E_2$</p>	<ul style="list-style-type: none"> • Quantum Physics
<p>3.1.2d: Wave-particle duality Candidates should know that electron diffraction suggests the wave nature of particles and the photoelectric effect suggests the particle nature of electromagnetic waves; details of particular methods of particle diffraction are not expected. de Broglie wavelength $\lambda = h/(mv)$, where mv is the momentum.</p>	<ul style="list-style-type: none"> • Quantum Physics

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Topic 3.1.3: Current Electricity	Boardworks AS Physics presentation title
<p>3.1.3a: Charge, current and potential difference Electric current as the rate of flow of charge; potential difference as work done per unit charge. $I = \Delta Q / \Delta t$ and $V = Q/W$. Resistance is defined by $R = V/I$.</p>	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
<p>3.1.3b: Current / voltage characteristics For an ohmic conductor, a semiconductor diode and a filament lamp; candidates should have experience of the use of a current sensor and a voltage sensor with a data logger to capture data from which to determine $V-I$ curves. Ohm's law as a special case where $I \propto V$.</p>	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
<p>3.1.3c: Resistivity $\rho = RA/L$ Description of the qualitative effect of temperature on the resistance of metal conductors and thermistors. Applications (e.g. temperature sensors). Superconductivity as a property of certain materials which have zero resistivity at and below a critical temperature which depends on the material. Applications (e.g. very strong electromagnets, power cables).</p>	<ul style="list-style-type: none"> • Resistance and Resistivity • Simple Circuits
<p>3.1.3d: Circuits Resistors in series; $R_T = R_1 + R_2 + R_3 + \dots$ Resistors in parallel; $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \dots$ energy $E = I V t$, $P = IV$, $P = I^2 R$; application, e.g. Understanding of high current requirement for a starter motor in a motor car. Conservation of charge and energy in simple d.c. circuits. The relationships between currents, voltages and resistances in series and parallel circuits, including cells in series and identical cells in parallel. Questions will not be set which require the use of simultaneous equations to calculate currents or potential differences.</p>	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
<p>3.1.3e: Potential divider The potential divider used to supply variable pd e.g. application as an audio 'volume' control. Examples should include the use of variable</p>	<ul style="list-style-type: none"> • Using Electricity

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resistors, thermistors and L.D.R.'s.	
<p>3.1.3f: Electromotive force and internal resistance $\varepsilon = E/Q$ $\varepsilon = I(R + r)$ Applications; e.g. low internal resistance for a car battery.</p>	<ul style="list-style-type: none"> Resistance and Resistivity
<p>3.1.3g: Alternating currents Sinusoidal voltages and currents only; root mean square, peak and peak-to-peak values for sinusoidal waveforms only. $I_{\text{rms}} = I_0/\sqrt{2}$ $V_{\text{rms}} = V_0/\sqrt{2}$ Application to calculation of mains electricity peak and peak-to-peak voltage values.</p>	<ul style="list-style-type: none"> Using Electricity
<p>3.1.3h: Oscilloscope Use of an oscilloscope as a d.c. and a.c. voltmeter, to measure time intervals and frequencies and to display a.c. waveforms. No details of the structure of the instrument is required but familiarity with the operation of the controls is expected.</p>	<ul style="list-style-type: none"> Using Electricity

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Unit 2. Mechanics, Materials and Waves	
Topic 3.2.1: Mechanics	Boardworks AS Physics presentation title
<p>3.2.1a: Scalars and vectors The addition of vectors by calculation or scale drawing. Calculations will be limited to two perpendicular vectors. The resolution of vectors into two components at right angles to each other; examples should include the components of forces along and perpendicular to an inclined plane. Conditions for equilibrium for two or three coplanar forces acting at a point; problems may be solved either by using resolved forces or by using a closed triangle.</p>	<ul style="list-style-type: none"> • Vectors • Kinematics
<p>3.2.1b: Moments Moment of a force about a point defined as force \times perpendicular distance from the point to the line of action of the force; torque. Couple of a pair of equal and opposite forces defined as force \times perpendicular distance between the lines of action of the forces. The principle of moments and its applications in simple balanced situations. Centre of mass; calculations of the position of the centre of mass of a regular lamina are not expected.</p>	<ul style="list-style-type: none"> • Moments and Centre of Gravity
<p>3.2.1c: Motion along a straight line Displacement, speed, velocity and acceleration. $v = \Delta s / \Delta t$ $a = \Delta v / \Delta t$ Representation by graphical methods of uniform and non-uniform acceleration; interpretation of velocity-time and displacement-time graphs for uniform and nonuniform acceleration; significance of areas and gradients. Equations for uniform acceleration; $v = u + at$, $s = (u+v)t/2$ $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$ Acceleration due to gravity, g; detailed experimental methods of measuring g are not required. Terminal speed.</p>	<ul style="list-style-type: none"> • Vectors • Kinematics
<p>3.2.1d: Projectile motion Independence of vertical and horizontal motion; problems will be soluble from first principles.</p>	<ul style="list-style-type: none"> • Kinematics

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<p>The memorising of projectile equations is not required.</p>	
<p>3.2.1e: Newton's laws of motion Knowledge and application of the three laws of motion in appropriate situations. For constant mass, $F = ma$.</p>	<ul style="list-style-type: none"> • Dynamics
<p>3.2.1f: Work, energy and power $W = F_s \cos \theta$ $P = \Delta W / \Delta t$ $P = Fv$</p>	<ul style="list-style-type: none"> • Work, Energy and Power
<p>3.2.1g: Conservation of energy Principle of conservation of energy, applied to examples involving gravitational potential energy, kinetic energy and work done against resistive forces. $\Delta E_p = mg\Delta h$ $E_k = \frac{1}{2}mv^2$</p>	<ul style="list-style-type: none"> • Work, Energy and Power

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Topic 3.2.2: Materials	Boardworks AS Physics presentation title
<p>3.2.2a: Bulk properties of solids Density $\rho = m/V$ Hooke's law, elastic limit, experimental investigations. $F = k\Delta L$ Tensile strain and tensile stress. Elastic strain energy, breaking stress. Derivation of <i>energy stored</i> = $\frac{1}{2}F\Delta L$. Description of plastic behaviour, fracture and brittleness; interpretation of simple stress-strain curves.</p>	<ul style="list-style-type: none"> • Materials
<p>3.2.2b: The Young modulus The Young modulus = <i>tensile stress/tensile strain</i> = $FL/(A\Delta L)$ One simple method of measurement. Use of stress-strain graphs to find the Young modulus.</p>	<ul style="list-style-type: none"> • Materials

**Mapping grid showing how the AQA AS Level Physics A specification is covered by
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Topic 3.2.3: Waves	Boardworks AS Physics presentation title
<p>3.2.3a: Progressive Waves Oscillation of the particles of the medium; amplitude, frequency, wavelength, speed, phase, path difference. $c = f\lambda$</p>	<ul style="list-style-type: none"> • Waves
<p>3.2.3b: Longitudinal and transverse waves Characteristics and examples, including sound and electromagnetic waves. Polarisation as evidence for the nature of transverse waves; applications e.g. Polaroid sunglasses, aerial alignment for transmitter and receiver.</p>	<ul style="list-style-type: none"> • Waves
<p>3.2.3c: Refraction at a plane surface Refractive index of a substance s, $n = c/c_s$ Candidates are not expected to recall methods for determining refractive indices. Law of refraction for a boundary between two different substances of refractive indices n_1 and n_2 in the form $n_1 \sin \theta_1 = n_2 \sin \theta_2$. Total internal reflection including calculations of the critical angle at a boundary between a substance of refractive index n_1 and a substance of lesser refractive index n_2 or air; $\sin \theta_c = n_2/n_1$ Simple treatment of fibre optics including function of the cladding with lower refractive index around central core limited to step index only; application to communications.</p>	<ul style="list-style-type: none"> • Optics • Waves
<p>3.2.3d: Superposition of waves, stationary waves The formation of stationary waves by two waves of the same frequency travelling in opposite directions; no mathematical treatment required. Simple graphical representation of stationary waves, nodes and antinodes on strings.</p>	<ul style="list-style-type: none"> • Waves
<p>3.2.3e: Interference The concept of path difference and coherence The laser as a source of coherent monochromatic light used to demonstrate interference and diffraction; comparison with non-laser light; awareness of safety issues. Candidates will not be required to describe how</p>	<ul style="list-style-type: none"> • Waves • Optics

**Mapping grid showing how the AQA AS Level Physics A specification is covered by
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<p>a laser works. Requirements of two source and single source double-slit systems for the production of fringes. The appearance of the interference fringes produced by a double slit system, <i>fringe spacing</i> $w = \lambda D/s$, where s is the slit separation.</p>	
<p>3.2.3f: Diffraction Appearance of the diffraction pattern from a single slit. The plane transmission diffraction grating at normal incidence; optical details of the spectrometer will not be required. Derivation of $d\sin\theta = n\lambda$, where n is the order number. Applications; e.g. to spectral analysis of light from stars.</p>	<ul style="list-style-type: none"> • Waves • Optics

Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks AS Physics

Unit 1. Physics on the go	
Topic 1.3 Mechanics	Boardworks AS Physics presentation title
<p>1. Use the equations for uniformly accelerated motion in one dimension:</p> $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$	<ul style="list-style-type: none"> • Kinematics
<p>2. Demonstrate an understanding of how ICT can be used to collect data for, and display, displacement/time and velocity/time graphs for uniformly accelerated motion and compare this with traditional methods in terms of reliability and validity of data.</p>	
<p>3. Identify and use the physical quantities derived from the slopes and areas of displacement/time and velocity/time graphs, including cases of non-uniform acceleration.</p>	<ul style="list-style-type: none"> • Kinematics
<p>4. Investigate, using primary data, recognise and make use of the independence of vertical and horizontal motion of a projectile moving freely under gravity.</p>	<ul style="list-style-type: none"> • Kinematics
<p>5. Distinguish between scalar and vector quantities and give examples of each.</p>	<ul style="list-style-type: none"> • Vectors • Kinematics
<p>6. Resolve a vector into two components at right angles to each other by drawing and by calculation.</p>	<ul style="list-style-type: none"> • Vectors
<p>7. Combine two coplanar vectors at any angle to each other by drawing, and at right angles to each other by calculation.</p>	<ul style="list-style-type: none"> • Vectors
<p>8. Draw and interpret free-body force diagrams to represent forces on a particle or on an extended but rigid body, using the concept of <i>centre of gravity</i> of an extended body.</p>	<ul style="list-style-type: none"> • Dynamics
<p>9. Investigate, by collecting primary data, and use $\Sigma F = ma$ in situations where m is constant (Newton's first law of motion ($a = 0$) and second law of motion)</p>	<ul style="list-style-type: none"> • Dynamics

**Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks
AS Physics**

<p>10. Use the expressions for gravitational field strength $g = F/m$ and weight $W = mg$.</p>	<ul style="list-style-type: none"> • Dynamics
<p>11. Identify pairs of forces constituting an interaction between two bodies (Newton's third law of motion).</p>	<ul style="list-style-type: none"> • Dynamics
<p>12. Use the relationship $E_k = \frac{1}{2}mv^2$ for the kinetic energy of a body.</p>	<ul style="list-style-type: none"> • Work, Energy and Power
<p>13. Use the relationship $\Delta E_{grav} = mg\Delta h$ for the gravitational potential energy transferred near the Earth's surface.</p>	<ul style="list-style-type: none"> • Work, Energy and Power
<p>14. Investigate and apply the principle of conservation of energy including use of work done, gravitational potential energy and kinetic energy.</p>	<ul style="list-style-type: none"> • Work, Energy and Power
<p>15. Use the expression for work $\Delta W = F\Delta s$ including calculations when the force is not along the line of motion.</p>	<ul style="list-style-type: none"> • Work, Energy and Power
<p>16. Understand some applications of mechanics, for example to safety or to sports.</p>	
<p>17. Investigate and calculate power from the rate at which work is done or energy transferred.</p>	<ul style="list-style-type: none"> • Work, Energy and Power

Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks AS Physics

Topic 1.4 Materials	Boardworks AS Physics presentation title
<p>18. Understand and use the terms <i>density</i>, <i>laminar flow</i>, <i>streamline flow</i>, <i>terminal velocity</i>, <i>turbulent flow</i>, <i>upthrust</i> and <i>viscous drag</i>, for example, in transport design or in manufacturing.</p>	<ul style="list-style-type: none"> • Materials • Dynamics
<p>19. Recall, and use primary or secondary data to show that the rate of flow of a fluid is related to its viscosity.</p>	
<p>20. Recognise and use the expression for Stokes's Law, $F = 6\pi\eta rv$ and upthrust = weight of fluid displaced.</p>	
<p>21. Investigate, using primary or secondary data, and recall that the viscosities of most fluids change with temperature. Explain the importance of this for industrial applications.</p>	
<p>22. Obtain and draw force-extension, force-compression, and tensile/compressive stress-strain graphs. Identify the <i>limit of proportionality</i>, <i>elastic limit</i> and <i>yield point</i>.</p>	<ul style="list-style-type: none"> • Materials
<p>23. Investigate and use Hooke's law, $F = k\Delta x$, and know that it applies only to some materials.</p>	<ul style="list-style-type: none"> • Materials
<p>24. Explain the meaning and use of, and calculate <i>tensile/compressive stress</i>, <i>tensile/compressive strain</i>, <i>strength</i>, <i>breaking stress</i>, <i>stiffness</i> and <i>Young Modulus</i>. Obtain the Young modulus for a material.</p>	<ul style="list-style-type: none"> • Materials
<p>25. Investigate elastic and plastic deformation of a material and distinguish between them.</p>	<ul style="list-style-type: none"> • Materials
<p>26. Explore and explain what is meant by the terms <i>brittle</i>, <i>ductile</i>, <i>hard</i>, <i>malleable</i>, <i>stiff</i> and <i>tough</i>. Use these terms, give examples of materials exhibiting such properties and explain how these properties are used in a variety of applications, for example, safety clothing, foodstuffs.</p>	<ul style="list-style-type: none"> • Materials
<p>27. Calculate the elastic strain energy E_{el} in a deformed material sample, using the expression $E_{el} = \frac{1}{2}Fx$, and from the area under the force/extension graph.</p>	<ul style="list-style-type: none"> • Materials

Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks AS Physics

Unit 2. Physics at Work	
Topic 2.3 Waves	Boardworks AS Physics presentation title
28. Understand and use the terms <i>amplitude, frequency, period, speed</i> and <i>wavelength</i> .	<ul style="list-style-type: none"> • Waves
29. Identify the different regions of the electromagnetic spectrum and describe some of their applications.	<ul style="list-style-type: none"> • Optics
30. Use the wave equation $v = f\lambda$.	<ul style="list-style-type: none"> • Waves
31. Recall that a sound wave is a longitudinal wave which can be described in terms of the displacement of molecules.	<ul style="list-style-type: none"> • Waves
32. Use graphs to represent transverse and longitudinal waves, including standing waves.	<ul style="list-style-type: none"> • Waves
33. Explain and use the concepts of wavefronts, coherence, path difference, superposition and phase.	<ul style="list-style-type: none"> • Waves • Optics
34. Recognise and use the relationship between phase difference and path difference.	<ul style="list-style-type: none"> • Waves • Optics
35. Explain what is meant by a <i>standing (stationary) wave</i> , investigate how such a wave is formed, and identify nodes and antinodes.	<ul style="list-style-type: none"> • Waves
36. Recognise and use the expression for refractive index ${}_1\mu_2 = \sin i / \sin r = v_1 / v_2$, determine refractive index for a material in the laboratory, and predict whether total internal reflection will occur at an interface using critical angle.	<ul style="list-style-type: none"> • Optics
37. Investigate and explain how to measure refractive index.	<ul style="list-style-type: none"> • Optics
38. Discuss situations that require the accurate determination of refractive index.	
39. Investigate and explain what is meant by <i>plane polarized light</i> .	<ul style="list-style-type: none"> • Waves
40. Investigate and explain how to measure the rotation of the plane of polarization.	<ul style="list-style-type: none"> • Waves

**Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks
AS Physics**

<p>41. Investigate and recall that waves can be diffracted and that substantial diffraction occurs when the size of the gap or obstacle is similar to the wavelength of the wave.</p>	<ul style="list-style-type: none"> • Optics
<p>42. Explain how diffraction experiments provide evidence for the wave nature of electrons.</p>	<ul style="list-style-type: none"> • Waves • Optics
<p>43. Discuss how scientific ideas may change over time, for example, our ideas on the particle/wave nature of electrons.</p>	<ul style="list-style-type: none"> • Quantum Physics
<p>44. Recall that, in general, waves are transmitted and reflected at an interface between media.</p>	<ul style="list-style-type: none"> • Optics
<p>45. Explain how different media affect the transmission/reflection of waves travelling from one medium to another.</p>	<ul style="list-style-type: none"> • Optics
<p>46. Explore and explain how a pulse-echo technique can provide details of the position and/or speed of an object and describe applications that use this technique.</p>	
<p>47. Explain qualitatively how the movement of a source of sound or light relative to an observer/detector gives rise to a shift in frequency (Doppler effect) and explore applications that use this effect.</p>	
<p>48. Explain how the amount of detail in a scan may be limited by the wavelength of the radiation or by the duration of the pulses.</p>	
<p>49. Discuss the social and ethical issues that need to be considered, eg, when developing and trialling new medical techniques on patients or when funding a space mission.</p>	

Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks AS Physics

Topic 2.4 DC Electricity	Boardworks AS Physics presentation title
50. Describe electric current as the rate of flow of charged particles and use the expression $I = \Delta Q/\Delta t$.	<ul style="list-style-type: none"> • Simple Circuits
51. Use the expression $V = W/Q$	<ul style="list-style-type: none"> • Simple Circuits
52. Recognise, investigate and use the relationships between current, voltage and resistance, for series and parallel circuits, and know that these relationships are a consequence of the conservation of charge and energy.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
53. Investigate and use the expressions $P = VI$, $W = VI t$. Recognise and use related expressions eg $P = I^2 R$ and $P = V^2/R$.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
54. Use the fact that resistance is defined by $R = V/I$ and that Ohm's law is a special case when $I \propto V$.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
55. Demonstrate an understanding of how ICT may be used to obtain current-potential difference graphs, including non-ohmic materials and compare this with traditional techniques in terms of reliability and validity of data.	
56. Interpret current-potential difference graphs, including non-ohmic materials.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
57. Investigate and use the relationship $R = \rho l/A$.	<ul style="list-style-type: none"> • Resistance and Resistivity
58. Investigate and explain how the potential along a uniform current-carrying wire varies with the distance along it and how this variation can be made use of in a potential divider.	<ul style="list-style-type: none"> • Using Electricity
59. Define and use the concepts of emf and internal resistance and distinguish between emf and terminal potential difference.	<ul style="list-style-type: none"> • Resistance and Resistivity
60. Investigate and recall that the resistance of metallic conductors increases with increasing temperature and that the resistance of negative temperature coefficient thermistors decreases with increasing temperature.	<ul style="list-style-type: none"> • Resistance and Resistivity

**Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks
AS Physics**

61. Use $I = nqvA$ to explain the large range of resistivities of different materials.	<ul style="list-style-type: none">• Using Electricity
62. Explain, qualitatively, how changes of resistance with temperature may be modelled in terms of lattice vibrations and number of conduction electrons.	<ul style="list-style-type: none">• Resistance and Resistivity

Mapping grid showing how the Edexcel AS Level Physics specification is covered by Boardworks AS Physics

Topic 2.5 Nature of Light	Boardworks AS Physics presentation title
63. Explain how the behaviour of light can be described in terms of waves and photons.	<ul style="list-style-type: none"> • Quantum Physics
64. Recall that the absorption of a photon can result in the emission of a photoelectron.	<ul style="list-style-type: none"> • Quantum Physics
65. Understand and use the terms threshold frequency and work function and recognise and use the expressions $hf = \phi + \frac{1}{2}mv_{max}^2$.	<ul style="list-style-type: none"> • Quantum Physics
66. Use the non-SI unit, the electronvolt (eV) to express small energies.	<ul style="list-style-type: none"> • Quantum Physics • Particle Physics
67. Recognise and use the expression $E = hf$ to calculate the highest frequency of radiation that could be emitted in a transition across a known energy band gap or between known energy levels.	<ul style="list-style-type: none"> • Quantum Physics
68. Explain atomic line spectra in terms of transitions between discrete energy levels.	<ul style="list-style-type: none"> • Quantum Physics
69. Define and use radiation flux as power per unit area.	<ul style="list-style-type: none"> • Quantum Physics
70. Recognise and use the expression efficiency = [useful energy (or power) output]/[total energy (or power) input].	<ul style="list-style-type: none"> • Work, Energy and Power • Using Electricity
71. Explain how waves and photon models have contributed to the understanding of the nature of light.	<ul style="list-style-type: none"> • Quantum Physics
72. Explore how science is used by society to make decisions, for example, the viability of solar cells as a replacement for other energy resources, the uses of remote sensing.	

**Mapping grid showing how the OCR AS Level A Physics specification is covered by
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Unit G481. Mechanics	
Module 1.1: Motion	Boardworks AS Physics presentation title
1.1.1 Physics quantities and units	
1.1.1a: Explain that some physical quantities consist of a numerical magnitude and a unit.	<ul style="list-style-type: none"> • Vectors
1.1.1b: Use units correctly.	
1.1.1c: Use correctly the following prefixes and their symbols to indicate decimal sub-multiples or multiples of units: pico (p), nano (n), micro (μ), milli (m), centi (c), kilo (k), mega (M), giga (G), tera (T).	<ul style="list-style-type: none"> • Vectors
1.1.1d: Make suitable estimates of physical quantities and give examples.	
1.1.2a: Define <i>scalar</i> and <i>vector</i> quantities and give examples.	<ul style="list-style-type: none"> • Vectors
1.1.2 Scalars and vectors	
1.1.2b: Draw and use a vector triangle to determine the resultant of two coplanar vectors such as displacement, velocity and force.	<ul style="list-style-type: none"> • Vectors
1.1.2c: Calculate the resultant of two perpendicular vectors such as displacement, velocity and force.	<ul style="list-style-type: none"> • Vectors
1.1.2d: Resolve a vector such as displacement, velocity and force into two perpendicular components.	<ul style="list-style-type: none"> • Vectors

**Mapping grid showing how the OCR AS Level A Physics specification is covered by
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1.1.3 Kinematics	
1.1.3a: Define <i>displacement, instantaneous speed, average speed, velocity</i> and <i>acceleration</i> .	<ul style="list-style-type: none"> • Vectors • Kinematics
1.1.3b: Select and use the relationships average speed = distance/time acceleration = change in velocity/time to solve problems.	<ul style="list-style-type: none"> • Kinematics
1.1.3c: Apply graphical methods to represent displacement, speed, velocity and acceleration.	<ul style="list-style-type: none"> • Kinematics
1.1.3d: Determine velocity from the gradient of a displacement against time graph.	<ul style="list-style-type: none"> • Kinematics
1.1.3e: Determine displacement from the area under a velocity against time graph.	<ul style="list-style-type: none"> • Kinematics
1.1.3f: Determine acceleration from the gradient of a velocity against time graph.	<ul style="list-style-type: none"> • Kinematics
1.1.4 Linear motion	
1.1.4a: Derive the equations of motion for constant acceleration in a straight line from a velocity against time graph.	<ul style="list-style-type: none"> • Kinematics
1.1.4b: Select and use the equations of motion for constant acceleration in a straight line: $v = u + at$, $s = \frac{1}{2}(u + v)t$, $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$.	<ul style="list-style-type: none"> • Kinematics
1.1.4c: Apply the equations for constant acceleration in a straight line, including the motion of bodies falling in the Earth's uniform gravitational field without air resistance.	<ul style="list-style-type: none"> • Kinematics
1.1.4d: Explain how experiments carried out by Galileo overturned Aristotle's ideas of motion.	<ul style="list-style-type: none"> • Kinematics
1.1.4e: Describe an experiment to determine the acceleration of free fall g using a falling body.	
1.1.4f: Apply the equations of constant acceleration to describe and explain the motion of an object due to a uniform velocity in one direction and a constant acceleration in a perpendicular direction.	<ul style="list-style-type: none"> • Kinematics

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Module 1.2: Forces in action	Boardworks AS Physics presentation title
1.2.1 Force	
1.2.1a: Solve problems using the relationship: net force = mass \times acceleration ($F = ma$) appreciating that acceleration and the net force are always in the same direction.	<ul style="list-style-type: none"> • Dynamics
1.2.1b: Define the <i>Newton</i> .	<ul style="list-style-type: none"> • Dynamics
1.2.1c: Apply the equations for constant acceleration and $F = ma$ to analyse the motion of objects.	<ul style="list-style-type: none"> • Dynamics
1.2.1d: Recall that according to the special theory of relativity, $F = ma$ cannot be used for a particle travelling at very high speeds because its mass increases.	<ul style="list-style-type: none"> • Dynamics
1.2.2 Nonlinear motion	
1.2.2a: Explain that an object travelling in a fluid experiences a resistive or a frictional force known as drag.	
1.2.2b: State the factors that affect the magnitude of the drag force.	
1.2.2c: Determine the acceleration of an object in the presence of drag.	
1.2.2d: State that the weight of an object is the gravitational force acting on the object.	<ul style="list-style-type: none"> • Kinematics • Work, Energy and Power
1.2.2e: Select and use the relationship weight = mass \times acceleration of free fall ($W = mg$)	<ul style="list-style-type: none"> • Dynamics • Work, Energy and Power
1.2.2f: Describe the motion of bodies falling in a uniform gravitational field with drag.	<ul style="list-style-type: none"> • Dynamics
1.2.2g: Use and explain the term <i>terminal velocity</i> .	<ul style="list-style-type: none"> • Dynamics

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1.2.3 Equilibrium	
1.2.3a: Draw and use a triangle of forces to represent the equilibrium of three forces acting at a point in an object.	<ul style="list-style-type: none"> • Dynamics
1.2.3b: State that the <i>centre of gravity</i> of an object is a point where the entire weight of an object appears to act.	<ul style="list-style-type: none"> • Moments and Centre of Gravity
1.2.3c: Describe a simple experiment to determine the centre of gravity of an object.	<ul style="list-style-type: none"> • Moments and Centre of Gravity
1.2.3d: Explain that a couple is a pair of forces that tends to produce rotation only.	<ul style="list-style-type: none"> • Moments and Centre of Gravity
1.2.3e: Define and apply the <i>torque of a couple</i> .	<ul style="list-style-type: none"> • Moments and Centre of Gravity
1.2.3f: Define and apply the <i>moment of force</i> .	<ul style="list-style-type: none"> • Moments and Centre of Gravity
1.2.3g: Explain that both the net force and net moment on an extended object in equilibrium is zero.	<ul style="list-style-type: none"> • Dynamics • Moments and Centre of Gravity
1.2.3h: Apply the principle of moments to solve problems, including the human forearm.	<ul style="list-style-type: none"> • Moments and Centre of Gravity
1.2.3i: Select and use the equation for density: $\rho = m/V$.	<ul style="list-style-type: none"> • Materials
1.2.3j: Select and use the equation for pressure: $p = F/A$, where F is the force normal to area A .	
1.2.4 Car safety	
1.2.4a: Define <i>thinking distance</i> , <i>braking distance</i> and <i>stopping distance</i> .	
1.2.4b: Analyse and solve problems using the terms thinking distance, braking distance and stopping distance.	
1.2.4c: Describe the factors that affect thinking distance and braking distance.	
1.2.4d: Describe and explain how air bags, seat belts and crumple zones in cars reduce impact forces in accidents.	
1.2.4e: Describe how air bags work, including the triggering mechanism.	
1.2.4f: Describe how the trilateration technique is used in GPS (global positioning system) for cars.	

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Module 1.3: Work and energy	Boardworks AS Physics presentation title
1.3.1 Work and conservation of energy	
1.3.1a: Define <i>work done</i> by a force.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.1b: Define the <i>joule</i> .	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.1c: Calculate the work done by a force using $W = Fx$ and $W = Fx\cos\theta$	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.1d: State the principle of conservation of energy.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.1e: Describe examples of energy in different forms, its conversion and conservation, and apply the principle of energy conservation to simple examples.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.1f: Apply the idea that work done is equal to the transfer of energy to solve problems.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.2 Kinetic and potential energies	
1.3.2a: Select and apply the equation for kinetic energy $E_k = \frac{1}{2}mv^2$.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.2b: Apply the definition of work done to derive the equation for the change in gravitational potential energy.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.2c: Select and apply the equation for the change in gravitational potential energy near the Earth's surface $E_p = mgh$.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.2d: Analyse problems where there is an exchange between gravitational potential energy and kinetic energy.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.2e: Apply the principle of conservation of energy to determine the speed of an object falling in the Earth's gravitational field.	<ul style="list-style-type: none"> • Work, Energy and Power

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1.3.3 Power	
1.3.3a: Define <i>power</i> as the rate of work done.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.3b: Define the <i>watt</i> .	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.3c: Calculate power when solving problems.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.3d: State that the efficiency of a device is always less than 100% because of heat losses.	
1.3.3e: Select and apply the relationship for efficiency <i>efficiency = useful output energy/total input energy × 100%</i>	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.3f: Interpret and construct Sankey diagrams.	<ul style="list-style-type: none"> • Work, Energy and Power
1.3.4 Behaviour of springs and materials	
1.3.4a: Describe how deformation is caused by a force in one dimension and can be tensile or compressive.	<ul style="list-style-type: none"> • Materials
1.3.4b: Describe the behaviour of springs and wires in terms of force, extension, elastic limit, Hooke's law and the force constant (ie force per unit extension or compression).	<ul style="list-style-type: none"> • Materials
1.3.4c: Select and apply the equation $F = kx$, where k is the force constant of the spring or the wire.	<ul style="list-style-type: none"> • Materials
1.3.4d: Determine the area under a force against extension (or compression) graph to find the work done by the force.	<ul style="list-style-type: none"> • Materials • Work, Energy and Power
1.3.4e: Select and use the equations for elastic potential energy $E = \frac{1}{2}Fx$ and $E = \frac{1}{2}kx^2$.	<ul style="list-style-type: none"> • Materials
1.3.4f: Define and use the terms <i>stress</i> , <i>strain</i> , <i>Young modulus</i> and <i>ultimate tensile strength</i> (<i>breaking stress</i>).	<ul style="list-style-type: none"> • Materials
1.3.4g: Describe an experiment to determine the Young modulus of a metal in the form of a wire.	<ul style="list-style-type: none"> • Materials
1.3.4h: Define the terms <i>elastic deformation</i> and <i>plastic deformation</i> of a material.	<ul style="list-style-type: none"> • Materials
1.3.4i: Describe the shapes of the stress against strain graphs for typical ductile, brittle and polymeric materials.	<ul style="list-style-type: none"> • Materials

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Unit G482. Electrons, Waves and Photons	
Module 2.1 Electric current	Boardworks AS Physics presentation title
2.1.1 Electric current	
2.1.1a: Explain that electric current is a net flow of charged particles.	<ul style="list-style-type: none"> • Simple Circuits
2.1.1b: Explain that electric current in a metal is due to the movement of electrons, whereas in an electrolyte the current is due to the movement of ions.	<ul style="list-style-type: none"> • Simple Circuits
2.1.1c: Explain what is meant by conventional current and electron flow.	<ul style="list-style-type: none"> • Simple Circuits
2.1.1d: Select and use the equation $\Delta Q = I\Delta t$.	<ul style="list-style-type: none"> • Simple Circuits
2.1.1e: Define the coulomb.	<ul style="list-style-type: none"> • Using Electricity
2.1.1f: Describe how an ammeter may be used to measure the current in a circuit.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.1.1g: Recall and use the elementary charge $e = 1.6 \times 10^{-19}\text{C}$	<ul style="list-style-type: none"> •
2.1.1h: Describe Kirchhoff's first law and appreciate that this is a consequence of conservation of charge.	<ul style="list-style-type: none"> • Simple Circuits
2.1.1i: State what is meant by the term <i>mean drift velocity</i> of charge carriers.	<ul style="list-style-type: none"> • Simple Circuits
2.1.1j: Select and use the equation $I = Anev$.	<ul style="list-style-type: none"> • Using Electricity
2.1.1k: Describe the difference between conductors, semiconductors and insulators in terms of the number density n .	<ul style="list-style-type: none"> • Resistance and Resistivity

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Module 2.2 Resistance	Boardworks AS Physics presentation title
2.2.1 Circuit symbols	
2.2.1a: Recall and use appropriate circuit symbols.	<ul style="list-style-type: none"> • Simple Circuits
2.2.1b: Interpret and draw circuit diagrams using these symbols.	<ul style="list-style-type: none"> • Simple Circuits
2.2.2 E.m.f. and p.d.	
2.2.2a: Define <i>potential difference</i> (p.d.).	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.2.2b: Select and use the equation $W = VQ$	<ul style="list-style-type: none"> • Simple Circuits
2.2.2c: Define the <i>volt</i> .	<ul style="list-style-type: none"> • Simple Circuits
2.2.2d: Describe how a voltmeter may be used to determine the p.d. across a component.	<ul style="list-style-type: none"> • Simple Circuits
2.2.2e: Define <i>electromotive force</i> (e.m.f) of a source such as a cell or a power supply.	<ul style="list-style-type: none"> • Resistance and Resistivity
2.2.2f: Describe the difference between e.m.f. and p.d. in terms of energy transfer.	<ul style="list-style-type: none"> • Resistance and Resistivity
2.2.3 Resistance	
2.2.3a: Define <i>resistance</i> .	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.2.3b: Select and use the equation for resistance $R = V/I$.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.2.3c: Define the <i>ohm</i> .	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.2.3d: State and use Ohm's law.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.2.3e: Describe the I–V characteristics of a resistor at constant temperature, filament lamp and light-emitting diode (LED).	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.2.3f: Describe an experiment to obtain the I–V characteristics of a resistor at constant temperature, filament lamp and light-emitting diode (LED).	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.2.3g: Describe the uses and benefits of using light-emitting diodes (LEDs).	

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2.2.4 Resistivity	
2.2.4a: Define <i>resistivity</i> of a material.	<ul style="list-style-type: none"> • Resistance and Resistivity
2.2.4b: Select and use the equation $R = \rho L/A$.	<ul style="list-style-type: none"> • Resistance and Resistivity
2.2.4c: Describe how the resistivities of metals and semiconductors are affected by temperature.	<ul style="list-style-type: none"> • Resistance and Resistivity
2.2.4d: Describe how the resistance of a pure metal wire and of a negative temperature coefficient (NTC) thermistor is affected by temperature.	<ul style="list-style-type: none"> • Resistance and Resistivity
2.2.5 Power	
2.2.5a: Describe power as the rate of energy transfer.	<ul style="list-style-type: none"> • Work, Energy and Power • Using Electricity
2.2.5b: Select and use power equations $P = VI$, $P = I^2R$ and $P = V^2/R$.	<ul style="list-style-type: none"> • Using Electricity
2.2.5c: Explain how a fuse works as a safety device.	
2.2.5d: Determine the correct fuse for an electrical device.	
2.2.5e: Select and use the equation $W = IVt$.	
2.2.5f: Define the kilowatt-hour (kWh) as a unit of energy.	<ul style="list-style-type: none"> • Using Electricity
2.2.5g: Calculate energy in kWh and the cost of this energy when solving problems.	<ul style="list-style-type: none"> • Using Electricity

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Module 2.3 DC circuits	Boardworks AS Physics presentation title
2.3.1 Series and parallel circuits	
2.3.1a: State Kirchhoff's second law and appreciate that this is a consequence of conservation of energy.	<ul style="list-style-type: none"> • Simple Circuits
2.3.1b: Apply Kirchhoff's first and second laws to circuits.	<ul style="list-style-type: none"> • Simple Circuits
2.3.1c: Select and use the equation for the total resistance of two or more resistors in series.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.3.1d: Recall and use the equation for the total resistance of two or more resistors in parallel.	<ul style="list-style-type: none"> • Simple Circuits • Resistance and Resistivity
2.3.1e: Solve circuit problems involving series and parallel circuits with one or more sources of e.m.f..	<ul style="list-style-type: none"> • Resistance and Resistivity
2.3.1f: Explain that all sources of e.m.f. have an internal resistance.	<ul style="list-style-type: none"> • Resistance and Resistivity
2.3.1g: Explain the meaning of the term <i>terminal p.d.</i> .	<ul style="list-style-type: none"> • Resistance and Resistivity
2.3.1h: Select and use the equations e.m.f. = $I(R + r)$ and e.m.f. = $V + Ir$	<ul style="list-style-type: none"> • Resistance and Resistivity
2.3.2 Practical circuits	
2.3.2a: Draw a simple potential divider circuit.	<ul style="list-style-type: none"> • Using Electricity
2.3.2b: Explain how a potential divider circuit can be used to produce a variable p.d..	<ul style="list-style-type: none"> • Using Electricity
2.3.2c: Recall and use the potential divider equation $V_{\text{out}} = R_2/(R_1 + R_2) \times V_{\text{in}}$.	<ul style="list-style-type: none"> • Using Electricity
2.3.2d: Describe how the resistance of a light-dependent resistor (LDR) depends on the intensity of light.	<ul style="list-style-type: none"> • Using Electricity
2.3.2e: Describe and explain the use of thermistors and light-dependent resistors in potential divider circuits.	<ul style="list-style-type: none"> • Using Electricity
2.3.2f: Describe the advantages of using data-loggers to monitor physical changes.	

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Module 2.4 Waves	Boardworks AS Physics presentation title
2.4.1 Wave motion	
2.4.1a: Describe and distinguish between progressive longitudinal and transverse waves.	<ul style="list-style-type: none"> • Waves
2.4.1b: Define and use the terms <i>displacement, amplitude, wavelength, period, phase difference, frequency</i> and <i>speed of a wave</i> .	<ul style="list-style-type: none"> • Waves
2.4.1c: Derive from the definitions of speed, frequency and wavelength, the wave equation $v = f\lambda$.	<ul style="list-style-type: none"> • Waves
2.4.1d: Select and use the wave equation $v = f\lambda$.	<ul style="list-style-type: none"> • Waves
2.4.1e: Explain what is meant by reflection, refraction and diffraction of waves such as sound and light.	<ul style="list-style-type: none"> • Optics

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2.4.2 Electromagnetic waves	
2.4.2a: State typical values for the wavelengths of the different regions of the electromagnetic spectrum from radio waves to γ -rays.	<ul style="list-style-type: none"> • Optics
2.4.2b: State that all electromagnetic waves travel at the same speed in a vacuum.	<ul style="list-style-type: none"> • Waves • Optics
2.4.2c: Describe differences and similarities between different regions of the electromagnetic spectrum.	<ul style="list-style-type: none"> • Optics
2.4.2d: Describe some of the practical uses of electromagnetic waves.	<ul style="list-style-type: none"> • Optics
2.4.2e: Describe the characteristics and dangers of UV-A, UV-B and UV-C radiations and explain the role of sunscreen.	
2.4.2f: Explain what is meant by plane polarised waves and understand the polarisation of electromagnetic waves.	<ul style="list-style-type: none"> • Waves
2.4.2g: Explain that polarisation is a phenomenon associated with transverse waves only.	<ul style="list-style-type: none"> • Waves
2.4.2h: State that light is partially polarised on reflection.	<ul style="list-style-type: none"> • Waves
2.4.2i: Recall and apply Malus's law for transmitted intensity of light from a polarising filter.	<ul style="list-style-type: none"> • Waves

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2.4.3 Interference	
2.4.3a: State and use the principle of superposition of waves.	<ul style="list-style-type: none"> • Waves
2.4.3b: Apply graphical methods to illustrate the principle of superposition.	<ul style="list-style-type: none"> • Waves
2.4.3c: Explain the terms <i>interference</i> , <i>coherence</i> , <i>path difference</i> and <i>phase difference</i> .	<ul style="list-style-type: none"> • Waves • Optics
2.4.3d: State what is meant by constructive interference and destructive interference.	<ul style="list-style-type: none"> • Waves
2.4.3e: Describe experiments that demonstrate two source interference using sound, light and microwaves.	<ul style="list-style-type: none"> • Waves
2.4.3f: Describe constructive interference and destructive interference in terms of path difference and phase difference.	<ul style="list-style-type: none"> • Waves • Optics
2.4.3g: Use the relationships, intensity = power/cross-sectional area intensity \propto amplitude ² .	
2.4.3h: Describe the Young double-slit experiment and explain how it is a classical confirmation of the wave-nature of light.	<ul style="list-style-type: none"> • Waves
2.4.3i: Select and use the equation $\lambda = ax/D$ for electromagnetic waves.	<ul style="list-style-type: none"> • Waves
2.4.3j: Describe an experiment to determine the wavelength of monochromatic light using a laser and a double slit.	<ul style="list-style-type: none"> • Waves
2.4.3k: Describe the use of a diffraction grating to determine the wavelength of light (the structure and use of a spectrometer are not required).	<ul style="list-style-type: none"> • Optics
2.4.3l: Select and use the equation $d\sin\theta = n\lambda$.	<ul style="list-style-type: none"> • Optics
2.4.3m: Explain the advantages of using multiple slits in an experiment to find the wavelength of light.	<ul style="list-style-type: none"> • Optics

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2.4.4 Stationary waves	
2.4.4a: Explain the formation of stationary (standing) waves using graphical methods.	<ul style="list-style-type: none"> • Waves
2.4.4b: Describe the similarities and differences between progressive and stationary waves.	<ul style="list-style-type: none"> • Waves
2.4.4c: Define the terms <i>nodes</i> and <i>antinodes</i> .	<ul style="list-style-type: none"> • Waves
2.4.4d: Describe experiments to demonstrate stationary waves using microwaves, stretched strings and air columns.	<ul style="list-style-type: none"> • Waves
2.4.4e: Determine the standing wave patterns for stretched string and air columns in closed and open pipes.	<ul style="list-style-type: none"> • Waves
2.4.4f: Use the equation: separation between adjacent nodes (or antinodes) = $\lambda/2$.	<ul style="list-style-type: none"> • Waves
2.4.4g: Define and use the terms <i>fundamental mode of vibration</i> and <i>harmonics</i> .	<ul style="list-style-type: none"> • Waves
2.4.4h: Determine the speed of sound in air from measurements on stationary waves in a pipe closed at one end.	<ul style="list-style-type: none"> • Waves

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Module 2.5 Quantum Physics	Boardworks AS Physics presentation title
2.5.1 Energy of a photon	
2.5.1a: Describe the particulate nature (photon model) of electromagnetic radiation.	<ul style="list-style-type: none"> • Particle Physics • Quantum Physics
2.5.1b: State that a photon is a quantum of energy of electromagnetic radiation.	<ul style="list-style-type: none"> • Quantum Physics
2.5.1c: Select and use the equations for the energy of a photon: $E = hf$ and $E = hc/\lambda$.	<ul style="list-style-type: none"> • Quantum Physics
2.5.1d: Define and use the electronvolt (eV) as a unit of energy.	<ul style="list-style-type: none"> • Quantum Physics • Particle Physics
2.5.1e: Use the transfer equation $eV = \frac{1}{2}mv^2$ for electrons and other charged particles.	
2.5.1f: Describe an experiment using LEDs to estimate the Planck constant h using the equation $eV = hc/\lambda$.	
2.5.2 The photoelectric effect	
2.5.2a: Describe and explain the phenomenon of the photoelectric effect.	<ul style="list-style-type: none"> • Quantum Physics
2.5.2b: Explain that the photoelectric effect provides evidence for a particulate nature of electromagnetic radiation while phenomena such as interference and diffraction provide evidence for a wave nature.	<ul style="list-style-type: none"> • Quantum Physics
2.5.2c: Define and use the terms <i>work function</i> and <i>threshold frequency</i> .	<ul style="list-style-type: none"> • Quantum Physics
2.5.2d: State that energy is conserved when a photon interacts with an electron.	<ul style="list-style-type: none"> • Quantum Physics
2.5.2e: Select, explain and use Einstein's photoelectric equation $hf = \phi + KE_{\max}$;	<ul style="list-style-type: none"> • Quantum Physics
2.5.2f: Explain why the maximum kinetic energy of the electrons is independent of intensity and why the photoelectric current in a photocell circuit is proportional to intensity of the incident radiation.	<ul style="list-style-type: none"> • Quantum Physics

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2.5.3 Wave-particle duality	
2.5.3a: Explain electron diffraction as evidence for the wave nature of particles like electrons.	<ul style="list-style-type: none"> • Quantum Physics
2.5.3b: Explain that electrons travelling through polycrystalline graphite will be diffracted by the atoms and the spacing between the atoms.	<ul style="list-style-type: none"> • Quantum Physics
2.5.3c: Select and apply the de Broglie equation $\lambda = h/mv$.	<ul style="list-style-type: none"> • Quantum Physics
2.5.3d: Explain that the diffraction of electrons by matter can be used to determine the arrangement of atoms and the size of nuclei.	
2.5.4 Energy levels in atoms	
2.5.4a: Explain how spectral lines are evidence for the existence of discrete energy levels in isolated atoms, ie in a gas discharge lamp.	<ul style="list-style-type: none"> • Quantum Physics
2.5.4b: Describe the origin of emission and absorption line spectra.	<ul style="list-style-type: none"> • Quantum Physics
2.5.4c: Use the relationships $hf = E_1 - E_2$ and $hc/\lambda = E_1 - E_2$.	<ul style="list-style-type: none"> • Quantum Physics