Mapping grid showing how the AQA A2 Level Physics A specification is covered by Boardworks A2 Physics

Unit 4. Fields and Further Mechanics

Topic 3.4.1: Further Mechanics	Boardworks A2 Physics presentation title
3.4.1a: Momentum concepts Force as the rate of change of momentum $F = \Delta(mv) / \Delta t$ Impulse $F\Delta t = \Delta mv$ Significance of area under a force-time graph. Principle of conservation of linear momentum applied to problems in one dimension. Elastic and inelastic collisions; explosions.	• Momentum and Collisions
3.4.1b: Circular motion Motion in a circular path at constant speed implies there is an acceleration and requires a centripetal force. Angular speed $\omega = v / r = 2\pi f$ Centripetal acceleration $a = v^2 / r = \omega^2 r$ Centripetal force $F = mv^2 / r = m\omega^2 r$ The derivation of $a = v^2 r$ will not be examined.	• Circular Motion
3.4.1c: Simple harmonic motion Characteristic features of simple harmonic motion. Condition for shm: $a = -(2\pi f)^2 x$ $x = A\cos 2\pi ft$ and $v = \pm 2\pi f \sqrt{A^2 - x^2}$ Graphical representations linking x, v, a and t. Velocity as gradient of displacement-time graph. Maximum speed = $2\pi fA$. Maximum acceleration = $(2\pi f)^2 A$.	• Oscillations
3.4.1d: Simple harmonic systems Study of mass-spring system. $T = 2\pi\sqrt{(m / k)}$ Study of simple pendulum. $T = 2\pi\sqrt{(l / k)}$ Variation of E_k, E_p and total energy with displacement, and with time.	• Oscillations
3.4.1e: Forced vibrations and resonance Qualitative treatment of free and forced vibrations. Resonance and the effects of damping on the sharpness of resonance. Phase difference between driver and driven displacements. Examples of these effects in mechanical systems and stationary wave situations.	• Oscillations

Mapping grid showing how the AQA A2 Level Physics A specification is covered by Boardworks A2 Physics

Topic 3.4.2: Gravitation	Boardworks A2 Physics presentation title
3.4.2a: Newton's law Gravity as a universal attractive force acting between all matter. Force between point masses $F = Gm_1m_2 / r^2$ where G is the gravitational constant.	• Gravitation
3.4.2b: 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 $g = F / m$ Magnitude of g in a radial field given by $g = GM / r^2$	• Gravitation
3.4.2c: Gravitational potential Understanding of the definition of gravitational potential, including zero value at infinity, and of gravitational potential difference. Work done in moving mass m given by $\Delta W = m\Delta V$ Magnitude of V in a radial field given by $V = -GM / r$ Graphical representations of variations of g and V with r. V related to g by $g = -\Delta V / \Delta r$	• Gravitation
3.4.2d: 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.	• Gravitation

Mapping grid showing how the AQA A2 Level Physics A specification is covered by Boardworks A2 Physics

Topic 3.4.3: Electric Fields	Boardworks A2 Physics presentation title
3.4.3a: Coulomb's law Force between point charges in a vacuum $F = 1 / 4\pi\varepsilon_0 \, Q_1Q_2 / r^2$ where ε_0 is the permittivity of free space.	• Electric Fields
3.4.3b: Electric field strength E as force per unit charge defined by $E = F / Q$ Representation by electric field lines. Magnitude of E in a radial field given by $E = 1 / 4\pi\varepsilon_0 \, Q / r^2$ Magnitude of E in a uniform field given by $E = V / d$	• Electric Fields
3.4.3c: 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 $\Delta W = Q\Delta V$ Magnitude of V in a radial field given by $E = 1 / 4\pi\varepsilon_0 \, Q / r$ Graphical representations of variations of E and V with r.	• Electric Fields
3.4.3d: Comparison of electric and gravitational fields Similarities; inverse square law fields having many characteristics in common. Differences; masses always attract but charges may attract or repel.	• Electric Fields • Gravitation

Mapping grid showing how the AQA A2 Level Physics A specification is covered by Boardworks A2 Physics

Topic 3.4.4: Capacitance	Boardworks A2 Physics presentation title
3.4.4a: Capacitance Definition of capacitance; $C = V / Q$	• Capacitors
3.4.4b: Energy stored by a capacitor Derivation of $E = ½QV$ and interpretation of area under a graph of charge against p.d. $E = ½QV = ½CV^2 = ½Q^2 / C$	• Capacitors
3.4.4c: Capacitor discharge Graphical representation of charging and discharging of capacitors through resistors Time constant = RC Calculation of time constants including their determination from graphical data, Quantitative treatment of capacitor discharge, $Q = Q_o e^{-t/RC}$ Candidates should have experience of the use of a voltage sensor and datalogger to plot discharge curves for a capacitor.	• Capacitors

Mapping grid showing how the AQA A2 Level Physics A specification is covered by Boardworks A2 Physics

Topic 3.4.5: Magnetic Fields	Boardworks A2 Physics presentation title
3.4.5a: Magnetic flux discharge 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	• Magnetic Fields
3.4.5b: Moving charges in a magnetic field Force on charged particles moving in a magnetic field. $F = BQv$ when the field is perpendicular to velocity. Circular path of particles; application in devices such as the cyclotron.	• Magnetic Fields
3.4.5c: Magnetic flux and flux linkage Magnetic flux defined by $\phi = BA$ where B is normal to A. Flux linkage as $N\phi$ where N is the number of turns cutting the flux. Flux and flux linkage passing through a rectangular coil rotated in a magnetic field: flux linkage $N\phi = BAN \cos\theta$ where θ is the angle between the normal to the plane of the coil and the magnetic field.	• Magnetic Fields
3.4.5d: Electromagnetic induction Simple experimental phenomena. Faraday's and Lenz's laws. Magnitude of induced emf = rate of change of flux linkage = $N \Delta\varphi / \Delta t$ Applications such as a moving straight conductor. Emf induced in a coil rotating uniformly in a magnetic field: $\varepsilon = BAN\omega \sin\omega t$ The operation of a transformer; The transformer equation $N_s / N_p = V_s / V_p$ Transformer efficiency = $I_s V_s / I_p V_p$ Causes of inefficiency of a transformer. Transmission of electrical power at high voltage.	• Magnetic Fields

Unit 5. Nuclear Physics, Thermal Physics and [an Optional Topic]

Topic 3.5.1: Radioactivity	Boardworks A2 Physics presentation title
3.5.1a: Evidence for the nucleus Qualitative study of Rutherford scattering.	• Radioactive Decay
3.5.1b: α, β and γ radiation Their properties and experimental identification using simple absorption experiments; applications e.g. to relative hazards of exposure to humans. The inverse square law for γ radiation, $I = k / x^2$, including its experimental verification; applications, e.g. to safe handling of radioactive sources. Background radiation; examples of its origins and experimental elimination from calculations.	• Radioactive Decay
3.5.1c: Radioactive decay Random nature of radioactive decay; constant decay probability of a given nucleus; $\Delta N / \Delta t = -\lambda N = N_o e^{-\lambda t}$ Use of activity $A = \lambda N$ Half life, $T_{1/2} = \ln 2 / \lambda$; determination from graphical decay data including decay curves and log graphs; applications e.g. relevance to storage of radioactive waste, radioactive dating.	• Radioactive Decay
3.5.1d: Nuclear instability Graph of N against Z for stable nuclei. Possible decay modes of unstable nuclei including α, β^+, β^- and electron capture. Changes of *N* and *Z* caused by radioactive decay and representation in simple decay equations. Existence of nuclear excited states; γ ray emission; application e.g. use of technetium-99m as a γ source in medical diagnosis.	• Radioactive Decay
3.5.1e: Nuclear radius Estimate of radius from closest approach of alpha particles and determination of radius from electron diffraction; knowledge of typical values. Dependence of radius on nucleon number $R = r_o A^{1/3}$ derived from experimental data. Calculation of nuclear density.	• Radioactive Decay

Topic 3.5.2: Nuclear Energy	Boardworks A2 Physics presentation title
3.5.2a: Mass and energy Appreciation that $E = mc^2$ applies to all energy changes. Simple calculations on mass difference and binding energy. Atomic mass unit, u; Conversion of units; $1u = 931.3$ MeV. Graph of average binding energy per nucleon against nucleon number. Fission and fusion processes. Simple calculations from nuclear masses of energy released in fission and fusion reactions.	• Nuclear Energy
3.5.2b: Induced fission Induced fission by thermal neutrons; possibility of a chain reaction; critical mass. The functions of the moderator, the control rods and the coolant in a thermal nuclear reactor; factors affecting the choice of materials for the moderator, the control rods and the coolant and examples of materials used; details of particular reactors are not required.	• Nuclear Energy
3.5.2c: Safety aspects Fuel used, shielding, emergency shut-down. Production, handling and storage of radioactive waste materials.	• Nuclear Energy

Topic 3.5.3: Thermal Physics	Boardworks A2 Physics presentation title
3.5.3a: Thermal energy Calculations involving change of energy. 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 specific latent heat.	• Thermal Physics
3.5.3b: Ideal gases Gas laws as experimental relationships between p, V, T and mass. Concept of absolute zero of temperature. Ideal gas equation as $pV = nRT$ for n moles and as $pV = NkT$ for N molecules. Avogadro constant N_A, molar gas constant R, Boltzmann constant k. Molar mass and molecular mass.	• Thermal Physics
3.5.3c: Molecular kinetic theory model Explanation of relationships between p, V and T in terms of a simple molecular model. Assumptions leading to and derivation of $pV = 1/3\ Nmc^2_{rms}$ Average molecular kinetic energy $1/2mc^2_{rms} = 3/2kT = 3RT / 2N_A$.	• Thermal Physics

Unit 4. Physics on the Move

Topic 4.3 Further mechanics	Boardworks A2 Physics presentation title
73 use the expression $p = mv$	• Momentum and Collisions
74 investigate and apply the principle of conservation of linear momentum to problems in one dimension	• Momentum and Collisions
75 investigate and relate net force to rate change of momentum in situations where mass is constant (Newton's second law of motion)	• Momentum and Collisions
76 derive and use the expression $E_k = p^2 / 2m$ for the kinetic energy of a non-relativistic particle	• Momentum and Collisions
77 analyse and interpret data to calculate the momentum of (non-relativistic) particles and apply the principle of conservation of linear momentum to problems in one and two dimensions	• Momentum and Collisions
78 explain and apply the principle of conservation of energy, and determine whether a collision is elastic or inelastic	• Momentum and Collisions
79 express angular displacement in radians and in degrees, and convert between those units	• Circular Motion
80 explain the concept of angular velocity, and recognise and use the relationships $v = \omega r$ and $\omega = 2\omega / \omega$	• Circular Motion
81 explain that a resultant force (centripetal force) is required to produce and maintain circular motion	• Circular Motion
82 use the expression for centripetal force $F = ma = mv^2 / r$ and hence derive and use the expressions for centripetal acceleration $a = v^2 / r$ and $a = r\omega^2$.	• Circular Motion

Topic 4.4 Electric and magnetic fields	Boardworks A2 Physics presentation title
83 explain what is meant by an electric field and recognise and use the expression electric field strength $E = F / Q$	• Electric Fields
84 draw and interpret diagrams using lines of force to describe radial and uniform electric fields qualitatively	• Electric Fields
85 use the expression $F = kQ_1Q_2 / r^2$, where $k = 1 / 4\pi\varepsilon_0$, and derive and use the the force between two charges expression $E = kQ / r^2$ for the electric field due to a point charge	• Electric Fields
86 investigate and recall that applying a potential difference to two parallel plates produces a uniform electric field in the central region between them, and recognise and use the expression $E = V / d$	• Electric Fields
87 investigate and use the expression $C = Q / V$	• Capacitors
88 recognise and use the expression $W = ½QV$ for the energy stored by a capacitor, derive the expression from the area under a graph of charge stored against potential difference, and derive and use related expressions, for example, $W = ½QV^2$	• Capacitors
89 investigate and recall that the growth and decay curves for resistor-capacitor circuits are exponential, and know the significance of the time constant RC	• Capacitors
90 recognise and use the expression $Q = Q_0e^{-t/RC}$ and derive and use related expressions, for exponential discharge in RC circuits, for example, $I = I_0\ e^{-t/RC}$	• Capacitors
91 explore and use the terms magnetic flux density B, flux ϕ, and flux linkage $N\phi$	• Magnetic Fields
92 investigate, recognise and use the expression $F = BIl\sin\theta$ and apply Fleming's left hand rule to currents	• Magnetic Fields
93 recognise and use the expression $F = Bqv\sin\theta$ and apply Fleming's left hand rule to charges	• Magnetic Fields

94 investigate and explain qualitatively the factors affecting the emf induced in a coil when there is relative motion between the coil and a permanent magnet and when there is a change of current in a primary coil linked with it.	• Magnetic Fields
95 investigate, recognise and use the expression $\varepsilon = -d(N\phi) / dt$ and explain how it is a consequence of Faraday's and Lenz's laws	• Magnetic Fields

Mapping grid showing how the Edexcel A2 Level Physics specification is covered by Boardworks A2 Physics

Topic 4.5 Particle physics	Boardworks A2 Physics presentation title
96 use the terms nucleon number (mass number) and proton number (atomic number)	• Radioactive Decay
97 describe how large-angle alpha particle scattering gives evidence for a nuclear atom	• Radioactive Decay
98 recall that electrons are released in the process of thermionic emission and explain how they can be accelerated by electric and magnetic fields	• Magnetic Fields
99 explain the role of electric and magnetic fields in particle accelerators (linac and cyclotron) and detectors (general principles of ionisation and deflection only)	• Magnetic Fields
100 recognise and use the expression $r = p / BQ$ for a charged particle in a magnetic field	• Magnetic Fields
101 recall and use the fact that charge, energy and momentum are always conserved in interactions between particles and hence interpret records of particle tracks	
102 explain why high energies are required to break particles into their constituents and to see fine structure	
103 recognise and use the expression $\Delta E = c^2 \Delta m$ in situations involving the creation and annihilation of matter and antimatter particles	
104 use the non-SI units MeV and GeV (energy) and MeV / c^2, GeV / c^2 (mass) and atomic mass unit u, and convert between these and SI units	
105 be aware of relativistic effects and that these need to be taken into account at speeds near that of light (use of relativistic equations not required)	• Momentum and Collisions

106 recall that in the standard quark-lepton model each particle has a corresponding antiparticle, that baryons (eg neutrons and protons) are made from three quarks, and mesons (eg pions) from a quark and an antiquark, and that the symmetry of the model predicted the top and bottom quark	• *Boardworks AS Physics, Particle Physics*
107 write and interpret equations using standard nuclear notation and standard particle symbols (eg π^+, e^-)	• *Boardworks AS Physics, Particle Physics*
108 use de Broglie's wave equation $\lambda = h / p$	• *Boardworks AS Physics, Quantum Physics*

Unit 5. Physics from Creation to Collapse

Topic 5.3 Thermal energy	Boardworks A2 Physics presentation title
109 investigate, recognise and use the expression $\Delta E = mc\Delta\theta$	• Thermal Physics
110 explain the concept of internal energy as the random distribution of potential and kinetic energy amongst molecules	• Thermal Physics
111 explain the concept of absolute zero and how the average kinetic energy of molecules is related to the absolute temperature	• Thermal Physics
112 recognise and use the expression $\frac{1}{2} m\langle c^2\rangle = 3/2\ kT$	• Thermal Physics
113 use the expression $pV = NkT$ as the equation of state for an ideal gas	• Thermal Physics

Topic 5.4 Nuclear decay	Boardworks A2 Physics presentation title
114 show an awareness of the existence and origin of background radiation, past and present	• Radioactive Decay
115 investigate and recognise nuclear radiations (alpha, beta and gamma) their penetrating power and ionising ability	• Radioactive Decay
116 describe the spontaneous and random nature of nuclear decay	• Radioactive Decay
117 determine the half lives of radioactive isotopes graphically and recognise and use the expressions for radioactive decay: $\mathrm{d}N / \mathrm{d}t = -\lambda N$, $\lambda = \ln 2/t_{1/2}$ and $N = N_0 e^{-\lambda t}$	• Radioactive Decay
118 discuss the applications of radioactive materials, including ethical and environmental issues	• Radioactive Decay

Topic 5.5 Oscillations	Boardworks A2 Physics presentation title
119 recall that the condition for simple harmonic motion is $F = -kx$, and hence identify situations in which simple harmonic motion will occur	• Oscillations
120 recognise and use the expressions $a = -\omega^2 x$, $a = -A\omega^2 \cos \omega t$, $v = A\omega \sin \omega t$, $x = A\cos \omega t$ and $T = 1 / f = 2\pi / \omega$ as applied to a simple harmonic oscillator	• Oscillations
121 obtain a displacement-time graph for an oscillating object and recognise that the gradient at a point gives the velocity at that point	• Oscillations
122 recall that the total energy of an undamped simple harmonic system remains constant and recognise and use expressions for total energy of an oscillator	• Oscillations
123 distinguish between free, damped and forced oscillations	• Oscillations
124 investigate and recall how the amplitude of a forced oscillation changes at and around the natural frequency of a system and describe, qualitatively, how damping affects resonance	• Oscillations
125 explain how damping and the plastic deformation of ductile materials reduce the amplitude of oscillation	• Oscillations

Mapping grid showing how the Edexcel A2 Level Physics specification is covered by Boardworks A2 Physics

Topic 5.6 Astrophysics and cosmology	Boardworks A2 Physics presentation title
126 use the expression $F = Gm_1m_2 / r^2$	• Gravitation
127 derive and use the expression $g = -Gm / r^2$ for the gravitational field due to a point mass	• Gravitation
128 recall similarities and differences between electric and gravitational fields	• Electric Fields
129 recognise and use the expression relating flux, luminosity and distance $F = L / 4\pi d^2$ application to standard candles	• Astrophysics
130 explain how distances can be determined using trigonometric parallax and by measurements on radiation flux received from objects of known luminosity (standard candles)	• Astrophysics
131 recognise and use a simple Hertzsprung-Russell diagram to relate luminosity and temperature. Use this diagram to explain the life cycle of stars	• Astrophysics
132 recognise and use the expression $L = \sigma T^4 \times$ surface area, (for a sphere $L = 4\pi r^2 \sigma T^4$) (Stefan-Boltzmann law) for black body radiators	• Astrophysics
133 recognise and use the expression: $\lambda_{max} = 2.898 \times 10^{-3}$ m K (Wien's law) for black body radiators	• Astrophysics
134 recognise and use the expressions $z = \Delta\lambda / \lambda \approx f / f \approx v / c$ for a source of electromagnetic radiation moving relative to an observer and $v = H_0 d$ for objects at cosmological distances	• Astrophysics
135 be aware of the controversy over the age and ultimate fate of the universe associated with the value of the Hubble Constant and the possible existence of dark matter	
136 explain the concept of nuclear binding energy, and recognise and use the expression $\Delta E = c^2 \Delta m$ and use the non-SI atomic mass unit (u) in calculations of nuclear mass (including mass deficit) and energy	• Nuclear Energy

137 describe the processes of nuclear fusion and fission	• Nuclear Energy
138 explain the mechanism of nuclear fusion and the need for high densities of matter and high temperatures to bring it about and maintain it	• Nuclear Energy

Unit G484. The Newtonian World

Module 4.1: Newton's laws and momentum	Boardworks A2 Physics presentation title
4.1.1 Newton's laws of motion	
4.1.1a: state and use each of Newton's three laws of motion	• Momentum and Collisions
4.1.1b: define *linear momentum* as the product of mass and velocity and appreciate the vector nature of momentum	• Momentum and Collisions
4.1.1c: define *net force on a body* as equal to rate of change of its momentum	• Momentum and Collisions
4.1.1d: select and apply the equation $F = \Delta p / \Delta t$ to solve problems	• Momentum and Collisions
4.1.1e: explain that $F = ma$ is a special case of Newton's second law when mass m remains constant	• Momentum and Collisions
4.1.1f: define *impulse of a force*	• Momentum and Collisions
4.1.1g: recall that the area under a force against time graph is equal to impulse	• Momentum and Collisions
4.1.1h: recall and use the equation impulse = change in momentum.	• Momentum and Collisions
4.1.2 Collisions	
4.1.2a: state the principle of conservation of momentum	• Momentum and Collisions
4.1.2b: apply the principle of conservation of momentum to solve problems when bodies interact in one dimension	• Momentum and Collisions
4.1.2c: define a *perfectly elastic collision* and an *inelastic collision*	• Momentum and Collisions
4.1.2d: explain that whilst the momentum of a system is always conserved in the interaction between bodies, some change in kinetic energy usually occurs.	• Momentum and Collisions

Mapping grid showing how the OCR A2 Level Physics A specification is covered by Boardworks A2 Physics

Module 4.2: Circular motion and oscillations	Boardworks A2 Physics presentation title
4.2.1 Circular motion	
4.2.1a: define the *radian*	• Circular Motion
4.2.1b: convert angles from degrees into radians and vice versa	• Circular Motion
4.2.1c: explain that a force perpendicular to the velocity of an object will make the object describe a circular path	• Circular Motion
4.2.1d: explain what is meant by centripetal acceleration and centripetal force	• Circular Motion
4.2.1e: select and apply the equations for speed $v = 2\pi r / T$ and centripetal acceleration $a = v^2 / r$	• Circular Motion
4.2.1f: select and apply the equation for centripetal force.	• Circular Motion
4.2.2 Gravitational fields	
4.2.2a: describe how a mass creates a gravitational field in the space around it	
4.2.2b: define gravitational field strength as force per unit mass	• Gravitation
4.2.2c: use gravitational field lines to represent a gravitational field	• Gravitation
4.2.2d: state Newton's law of gravitation	• Gravitation
4.2.2e: select and use the equation $F = -GMm / r^2$ for the force between two point or spherical objects	• Gravitation
4.2.2f: select and apply the equation $g = -GM / r^2$ for the gravitational field strength of a point mass	• Gravitation
4.2.2g: select and use the equation $g = -GM / r^2$ to determine the mass of the Earth or another similar object	• Gravitation

4.2.2h: explain that close to the Earth's surface the gravitational field strength is uniform and approximately equal to the acceleration of free fall	• Gravitation
4.2.2i: analyse circular orbits in an inverse square law field by relating the gravitational force to the centripetal acceleration it causes	• Gravitation
4.2.2j: define and use the *period* of an object describing a circle	• Circular Motion
4.2.2k: derive the equation $T^2 = (4\pi^2 / GM)r^3$ from first principles	• Gravitation
4.2.2l: select and apply the equation $T^2 = (4\pi^2 / GM)r^3$ for planets and satellites (natural and artificial)	• Gravitation
4.2.2m: select and apply Kepler's third law $T^2 \propto r^3$ to solve problems	• Gravitation
4.2.2n: define *geostationary orbit* of a satellite and state the uses of such satellites.	• Gravitation
4.2.3 Simple harmonic oscillations	
4.2.3a: describe simple examples of free oscillations	• Oscillations
4.2.3b: define and use the terms *displacement*, *amplitude*, *period*, *frequency*, *angular frequency* and *phase difference*	• Oscillations
4.2.3c: select and use the equation *period* = 1 / *frequency*	• Circular Motion
4.2.3d: define *simple harmonic motion*	• Oscillations
4.2.3e: select and apply the equation $a = -(2\pi f)^2 x$ as the defining equation of simple harmonic motion	• Oscillations
4.2.3f: select and use $x = A\cos(2\pi ft)$ or $x = A\sin(2\pi ft)$ as solutions to the equation $a = -(2\pi f)^2 x$	• Oscillations
4.2.3g: select and apply the equation $v_{max} = (2\pi f)A$ for the maximum speed of a simple harmonic oscillator	• Oscillations
4.2.3h: explain that the period of an object with simple harmonic motion is independent of its amplitude	• Oscillations

4.2.3i: describe, with graphical illustrations, the changes in displacement, velocity and acceleration during simple harmonic motion	• Oscillations
4.2.3j: describe and explain the interchange between kinetic and potential energy during simple harmonic motion	• Oscillations
4.2.3k: describe the effects of damping on an oscillatory system	• Oscillations
4.2.3l: describe practical examples of forced oscillations and resonance	• Oscillations
4.2.3m: describe graphically how the amplitude of a forced oscillation changes with frequency near to the natural frequency of the system	• Oscillations
4.2.3n: describe examples where resonance is useful and other examples where resonance should be avoided.	• Oscillations

Mapping grid showing how the OCR A2 Level Physics A specification is covered by Boardworks A2 Physics

Module 4.3: Thermal physics	Boardworks A2 Physics presentation title
4.3.1 Solid, liquid and gas	
4.3.1a: describe solids, liquids and gases in terms of the spacing, ordering and motion of atoms or molecules	
4.3.1b: describe a simple kinetic model for solids, liquids and gases	• Thermal Physics
4.3.1c: describe an experiment that demonstrates Brownian motion and discuss the evidence for the movement of molecules provided by such an experiment	
4.3.1d: define the term *pressure* and use the kinetic model to explain the pressure exerted by gases	• Thermal Physics
4.3.1e: define *internal energy* as the sum of the random distribution of kinetic and potential energies associated with the molecules of a system	• Thermal Physics
4.3.1f: explain that the rise in temperature of a body leads to an increase in its internal energy	• Thermal Physics
4.3.1g: explain that a change of state for a substance leads to changes in its internal energy but not its temperature	• Thermal Physics
4.3.1h: describe using a simple kinetic model for matter the terms melting, boiling and evaporation.	• Thermal Physics
4.3.2 Temperature	
4.3.2a: explain that thermal energy is transferred from a region of higher temperature to a region of lower temperature	• Thermal Physics
4.3.2b: explain that regions of equal temperature are in thermal equilibrium	• Thermal Physics
4.3.2c: describe how there is an absolute scale of temperature that does not depend on the property of any particular substance (ie the thermodynamic scale and the concept of absolute zero)	• Thermal Physics

4.3.2d: convert temperatures measured in kelvin to degrees Celsius (or vice versa): T (K) = θ (°C) + 273.15	• Thermal Physics
4.3.2e: state that absolute zero is the temperature at which a substance has minimum internal energy.	• Thermal Physics
4.3.3 Thermal properties of materials	
4.3.3a: define and apply the concept of specific heat capacity	• Thermal Physics
4.3.3b: select and apply the equation $E = mc\Delta\theta$	• Thermal Physics
4.3.3c: describe an electrical experiment to determine the specific heat capacity of a solid or a liquid	• Thermal Physics
4.3.3d: describe what is meant by the terms *latent heat of fusion* and *latent heat of vaporisation*.	• Thermal Physics
4.3.4 Ideal gases	
4.3.4a: state Boyle's law	• Thermal Physics
4.3.4b: select and apply $p\ V\ /\ T$ = constant	• Thermal Physics
4.3.4c: state the basic assumptions of the kinetic theory of gases	• Thermal Physics
4.3.4d: state that one mole of any substance contains 6.02×10^{23} particles and that 6.02×10^{23} mol^{-1} is the Avogadro constant N_A	• Thermal Physics
4.3.4e: select and solve problems using the ideal gas equation expressed as $pV = NkT$ and $pV = nRT$, where N is the number of atoms and n is the number of moles	• Thermal Physics
4.3.5f: explain that the mean translational kinetic energy of an atom of an ideal gas is directly proportional to the temperature of the gas in kelvin	• Thermal Physics
4.3.4g: select and apply the equation $E = 3/2\ kT$ for the mean translational kinetic energy of atoms.	• Thermal Physics

Unit G485. Fields, Particles and Frontiers of Physics

Module 5.1 Electric and magnetic fields	Boardworks A2 Physics presentation title
5.1.1 Electric fields	
5.1.1a: state that electric fields are created by electric charges	• Electric Fields
5.1.1b: define *electric field strength* as force per unit positive charge	• Electric Fields
5.1.1c: describe how electric field lines represent an electric field	• Electric Fields
5.1.1d: select and use Coulomb's law in the form $F = Qq / 4\pi\varepsilon_0 r^2$	• Electric Fields
5.1.1e: select and apply $E = Q / 4\pi\varepsilon_0 r^2$ for the electric field strength of a point charge	• Electric Fields
5.1.1f: select and use $E = V / d$ for the magnitude of the uniform electric field strength between charged parallel plates	• Electric Fields
5.1.1g: explain the effect of a uniform electric field on the motion of charged particles	• Electric Fields
5.1.1h: describe the similarities and differences between the gravitational fields of point masses and the electric fields of point charges.	• Electric Fields
5.1.2 Magnetic fields	
5.1.2a: describe the magnetic field patterns of a long straight current-carrying conductor and a long solenoid	• Magnetic Fields
5.1.2b: state and use Fleming's left-hand rule to determine the force on current conductor placed at right angles to a magnetic field	• Magnetic Fields
5.1.2c: select and use the equations $F = BIL$ and $F = BIL\sin\theta$	• Magnetic Fields
5.1.2d: define *magnetic flux density* and the *tesla*	• Magnetic Fields
5.1.2e: select and use the equation $F = BQv$ for the force on a charged particle travelling at right angles to a uniform magnetic field	• Magnetic Fields

5.1.2f: analyse the circular orbits of charged particles moving in a plane perpendicular to a uniform magnetic field by relating the magnetic force to the centripetal acceleration it causes	• Magnetic Fields
5.1.2g: analyse the motion of charged particles in both electric and magnetic fields	• Magnetic Fields
5.1.2h: explain the use of deflection of charged particles in the magnetic and electric fields of a mass spectrometer.	• Magnetic Fields
5.1.3 Electromagnetism	
5.1.3a: define *magnetic flux*	• Magnetic Fields
5.1.3b: define the *weber*	• Magnetic Fields
5.1.3c: select and use the equation for magnetic flux $\phi = BA\cos\theta$	• Magnetic Fields
5.1.3d: define *magnetic flux linkage*	• Magnetic Fields
5.1.3e: state and use Faraday's law of electromagnetic induction	• Magnetic Fields
5.1.3f: state and use Lenz's law	• Magnetic Fields
5.1.3g: select and use the equation: induced e.m.f. = –rate of change of magnetic flux linkage	• Magnetic Fields
5.1.3h: describe the function of a simple ac generator	• Magnetic Fields
5.1.3i: describe the function of a simple transformer	• Magnetic Fields
5.1.3j: select and use the turns-ratio equation for a transformer	• Magnetic Fields
5.1.3k: describe the function of step-up and step-down transformers.	• Magnetic Fields

Mapping grid showing how the OCR A2 Level Physics A specification is covered by Boardworks A2 Physics

Module 5.2 Capacitors and exponential decay	Boardworks A2 Physics presentation title
5.2.1 Capacitors	
5.2.1a: define *capacitance* and the *farad*	• Capacitors
5.2.1b: select and use the equation $Q = VC$	• Capacitors
5.2.1c: state and use the equation for the total capacitance of two or more capacitors in series	• Capacitors
5.2.1d: state and use the equation for the total capacitance of two or more capacitors in parallel	• Capacitors
5.2.1e: solve circuit problems with capacitors involving series and parallel circuits	• Capacitors
5.2.1f: explain that the area under a potential difference against charge graph is equal to energy stored by a capacitor	• Capacitors
5.2.1g: select and use the equations $W = 1/2QV$ and $W = 1/2CV^2$ for a charged capacitor	• Capacitors
5.2.1h: sketch graphs that show the variation with time of potential difference, charge and current for a capacitor discharging through a resistor	• Capacitors
5.2.1i: define the *time constant* of a circuit	• Capacitors
5.2.1j: select and use *time constant* = CR	• Capacitors
5.2.1k: analyse the discharge of capacitor using equations of the form $x = x_0e^{-t/CR}$	• Capacitors
5.2.1l: explain exponential decays as having a constant-ratio property	
5.2.1m: describe the uses of capacitors for the storage of energy in applications such as flash photography, lasers used in nuclear fusion and as back-up power supplies for computers (HSW 6a).	• Capacitors

Mapping grid showing how the OCR A2 Level Physics A specification is covered by Boardworks A2 Physics

Module 5.3 Nuclear physics	Boardworks A2 Physics presentation title
5.3.1 The nuclear atom	
5.3.1a: describe qualitatively the alpha-particle scattering experiment and the evidence this provides for the existence, charge and small size of the nucleus (HSW 1, 4c)	• Radioactive Decay
5.3.1b: describe the basic atomic structure of the atom and the relative sizes of the atom and the nucleus	• Radioactive Decay
5.3.1c: select and use Coulomb's law to determine the force of repulsion, and Newton's law of gravitation to determine the force of attraction, between two protons at nuclear separations and hence the need for a short-range, attractive force between nucleons (HSW 1, 2, 4)	• Radioactive Decay
5.3.1d: describe how the strong nuclear force between nucleons is attractive and very short-ranged	• Radioactive Decay
5.3.1e: estimate the density of nuclear matter	• Radioactive Decay
5.3.1f: define *proton* and *nucleon number*	• Radioactive Decay
5.3.1g: state and use the notation ${}^{A}_{Z}X$ for the representation of nuclides	• Radioactive Decay
5.3.1h: define and use the term *isotopes*	
5.3.1i: use nuclear decay equations to represent simple nuclear reactions	
5.3.1j: state the quantities conserved in a nuclear decay.	
5.3.2 Fundamental particles	
5.3.2a: explain that since protons and neutrons contain charged constituents called quarks they are, therefore, not fundamental particles	• *Boardworks AS Physics, Particle Physics*
5.3.2b: describe a simple quark model of hadrons in terms of up, down and strange quarks and their respective antiquarks, taking into account their charge, baryon number and strangeness	• *Boardworks AS Physics, Particle Physics*

5.3.2c: describe how the quark model may be extended to include the properties of charm, topness and bottomness	• *Boardworks AS Physics, Particle Physics*
5.3.2d: describe the properties of neutrons and protons in terms of a simple quark model	• *Boardworks AS Physics, Particle Physics*
5.3.2e: describe how there is a weak interaction between quarks and that this is responsible for β decay	• *Boardworks AS Physics, Particle Physics*
5.3.2f: state that there are two types of β decay	• Radioactive Decay
5.3.2g: describe the two types of β decay in terms of a simple quark model	• *Boardworks AS Physics, Particle Physics*
5.3.2h: state that (electron) neutrinos and (electron) antineutrinos are produced during β+ and β- decays, respectively	• *Boardworks AS Physics, Particle Physics*
5.3.2i: state that a β- particle is an electron and a β+ particle is a positron	• Radioactive Decay
5.3.2j: state that electrons and neutrinos are members of a group of particles known as leptons.	• *Boardworks AS Physics, Particle Physics*
5.3.3 Radioactivity	
5.3.3a: describe the spontaneous and random nature of radioactive decay of unstable nuclei	• Radioactive Decay
5.3.3b: describe the nature, penetration and range of α-particles, β-particles and γ-rays	• Radioactive Decay
5.3.3c: define and use the quantities *activity* and *decay constant*	• Radioactive Decay
5.3.3d: select and apply the equation for activity $A = \lambda N$	• Radioactive Decay
5.3.3e: select and apply the equations $A = A_0 e^{-\lambda t}$ and $N = N_0 e^{-\lambda t}$ where A is the activity and N is the number of undecayed nuclei	• Radioactive Decay
5.3.3f: define and apply the term *half-life*	• Radioactive Decay
5.3.3g: select and use the equation $\lambda t_{1/2} = 0.693$	• Radioactive Decay
5.3.3h: compare and contrast decay of radioactive nuclei and decay of charge on a capacitor in a C–R circuit (HSW 5b)	• Capacitors • Radioactive Decay
5.3.3i: describe the use of radioactive isotopes in smoke alarms (HSW 6a)	• Radioactive Decay

5.3.3j: describe the technique of radioactive dating (ie carbon-dating).	• Radioactive Decay
5.3.4 Nuclear fission and fusion	
5.3.4a: select and use Einstein's mass–energy equation $\Delta E = \Delta mc^2$	• Nuclear Energy
5.3.4b: define *binding energy* and *binding energy per nucleon*	• Nuclear Energy
5.3.4c: use and interpret the binding energy per nucleon against nucleon number graph	• Nuclear Energy
5.3.4d: determine the binding energy of nuclei using $\Delta E = \Delta mc^2$ and masses of nuclei	• Nuclear Energy
5.3.4e: describe the process of induced nuclear fission	• Nuclear Energy
5.3.4f: describe and explain the process of nuclear chain reaction	• Nuclear Energy
5.3.4g: describe the basic construction of a fission reactor and explain the role of the fuel rods, control rods and the moderator (HSW 6a and 7c)	• Nuclear Energy
5.3.4h: describe the use of nuclear fission as an energy source (HSW 4 and 7c)	• Nuclear Energy
5.3.4i: describe the peaceful and destructive uses of nuclear fission (HSW 4 and 7c)	
5.3.4j: describe the environmental effects of nuclear waste (HSW 4, 6a and b, 7c)	
5.3.4k: describe the process of nuclear fusion	• Nuclear Energy
5.3.4l: describe the conditions in the core of stars that make fusion possible	• Astrophysics
5.3.4m: calculate the energy released in simple nuclear reactions.	• Nuclear Energy

Mapping grid showing how the OCR A2 Level Physics A specification is covered by Boardworks A2 Physics

Module 5.4 Medical imaging	Boardworks A2 Physics presentation title
5.4.1 X-rays	
5.4.1a: describe the nature of X-rays	• Medical Imaging
5.4.1b: describe in simple terms how X-rays are produced	• Medical Imaging
5.4.1c: describe how X-rays interact with matter (limited to photoelectric effect, Compton Effect and pair production)	
5.4.1d: define *intensity* as the power per unit cross-sectional area	• Radioactive Decay
5.4.1e: select and use the equation $I = I_0 e^{-\mu x}$ to show how the intensity I of a collimated X-ray beam varies with thickness x of medium	• Medical Imaging
5.4.1f: describe the use of X-rays in imaging internal body structures including the use of image intensifiers and of contrast media (HSW 3, 4c and 6)	• Medical Imaging
5.4.1g: explain how soft tissues like the intestines can be imaged using barium meal	• Medical Imaging
5.4.1h: describe the operation of a computerised axial topography (CAT) scanner	• Medical Imaging
5.4.1i: describe the advantages of a CAT scan compared with an X-ray image (HSW 4c, 6).	• Medical Imaging
5.4.2 Diagnostic methods in medicine	
5.4.2a: describe the use of medical tracers like technetium-99m to diagnose the function of organs	• Radioactive Decay
5.4.2b: describe the main components of a gamma camera	• Radioactive Decay
5.4.2c: describe the principles of positron emission tomography (PET)	• Medical Imaging
5.4.2d: outline the principles of magnetic resonance, with reference to precession of nuclei, Larmor frequency, resonance and relaxation times	• Medical Imaging
5.4.2e: describe the main components of an MRI scanner	• Medical Imaging

5.4.2f: outline the use of MRI (magnetic resonance imaging) to obtain diagnostic information about internal organs (HSW 3, 4c and 6a)	• Medical Imaging
5.4.2g: describe the advantages and disadvantages of MRI (HSW 4c & 6a)	• Medical Imaging
5.4.2h: describe the need for non-invasive techniques in diagnosis (HSW 6a)	• Medical Imaging
5.4.2i: explain what is meant by the Doppler effect	• Astrophysics
5.4.2j: explain qualitatively how the Doppler effect can be used to determine the speed of blood.	
5.4.3 Ultrasound	
5.4.3a: describe the properties of ultrasound	• Medical Imaging
5.4.3b: describe the piezoelectric effect	• Medical Imaging
5.4.3c: explain how ultrasound transducers emit and receive high-frequency sound	• Medical Imaging
5.4.3d: describe the principles of ultrasound scanning	• Medical Imaging
5.4.3e: describe the difference between A-scan and B-scan	• Medical Imaging
5.4.3f: calculate the acoustic impedance using the equation $Z = \rho c$	• Medical Imaging
5.4.3g: calculate the fraction of reflected intensity using the equation $I_r / I_0 = (Z_2 - Z_1)^2 / (Z_2 + Z_1)^2$	• Medical Imaging
5.4.3h: describe the importance of impedance matching	• Medical Imaging
5.4.3i: explain why a gel is required for effective ultrasound imaging techniques.	• Medical Imaging

Mapping grid showing how the OCR A2 Level Physics A specification is covered by Boardworks A2 Physics

Module 5.5 Modelling the universe	Boardworks A2 Physics presentation title
5.5.1 Structure of the universe	
5.5.1a: describe the principal contents of the universe, including stars, galaxies and radiation	• Astrophysics
5.5.1b: describe the solar system in terms of the Sun, planets, planetary satellites and comets	
5.5.1c: describe the formation of a star, such as our Sun, from interstellar dust and gas	• Astrophysics
5.5.1d: describe the Sun's probable evolution into a red giant and white dwarf	• Astrophysics
5.5.1e: describe how a star much more massive than our Sun will evolve into a super red giant and then either a neutron star or black hole	• Astrophysics
5.5.1f: define distances measured in astronomical units (AU), parsecs (pc) and light-years (ly)	• Astrophysics
5.5.1g: state the approximate magnitudes in metres, of the parsec and light-year	• Astrophysics
5.5.1h: state Olbers' paradox	
5.5.1i: interpret Olbers' paradox to explain why it suggests that the model of an infinite, static universe is incorrect (HSW 7)	
5.5.1j: select and use the equation $\Delta\lambda / \lambda = v / c$	• Astrophysics
5.5.1k: describe and interpret Hubble's redshift observations	• Astrophysics
5.5.1l: state and interpret Hubble's law (HSW 1 & 2)	• Astrophysics
5.5.1m: convert the Hubble constant H_0 from its conventional units (km s^{-1} Mpc^{-1}) to SI (s^{-1})	• Astrophysics
5.5.1n: state the cosmological principle	
5.5.1o: describe and explain the significance of the 3K microwave background radiation (HSW 1).	• Astrophysics

5.5.2 The evolution of the universe	
5.5.2a: explain that the standard (hot big bang) model of the universe implies a finite age for the universe (HSW 1, 2, 7)	• Astrophysics
5.5.2b: select and use the expression age of universe ≈ $1/H_0$	• Astrophysics
5.5.2c: describe qualitatively the evolution of universe 10^{-43} s after the big bang to the present	• Astrophysics
5.5.2d: explain that the universe may be 'open', 'flat' or 'closed', depending on its density (HSW 7)	
5.5.2e: explain that the ultimate fate of the universe depends on its density	
5.5.2f: define the term *critical density*	
5.5.2g: select and use the expression for critical density of the universe $P_0 = 3H_0^2 / 8\pi G$	
5.5.2h: explain that it is currently believed that the density of the universe is close to, and possibly exactly equal to, the critical density needed for a 'flat' cosmology (HSW 7).	