SL + HL / V2.1



FIVE THEMES. ONE CLEARER PICTURE.

IB PHYSICS

Ultimate Conceptual Checklist

Current syllabus | First assessment 2025

- A Space, time and motion
- B The particulate nature of matter
- C Wave behavior
- D Fields
- E Nuclear and quantum physics

Don’t just read it. Prove it.

RECALL / APPLY / TRANSFER

287 skills | Evidence tests | Linked simulations | Printable checkboxes

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PRINT. CHECK. REVISIT.

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Your revision dashboard

Tick one box per skill: 1 recall; 2 familiar application; 3 unfamiliar transfer. Leave untested skills blank. A higher level includes the earlier levels. Test without notes before ticking 3.

★ Start-here stars flag foundational revision priorities, not measured exam frequency or a prediction of the next paper.

Theme	My current position	
A Space, time and motion	☐ Revise ☐ Developing ☐ Secure	3
B The particulate nature of matter	☐ Revise ☐ Developing ☐ Secure	5
C Wave behavior	☐ Revise ☐ Developing ☐ Secure	7
D Fields	☐ Revise ☐ Developing ☐ Secure	9
E Nuclear and quantum physics	☐ Revise ☐ Developing ☐ Secure	11

My next three priorities

Write a weak area and one next revision action on each line after reviewing your ratings.

1 _____

2 _____

3 _____

Jump to a topic

A.1 Kinematics
A.2 Forces and Momentum
A.3 Work, Energy and Power
A.4 Rigid Body Mechanics
A.5 Relativity
B.1 Thermal Energy Transfers
B.2 Greenhouse Effect
B.3 Gas Laws
B.4 Thermodynamics
B.5 Current and Circuits
C.1 Simple Harmonic Motion
C.2 Wave Model
C.3 Wave Phenomena
C.4 Standing Waves and Resonance
C.5 Doppler Effect
D.1 Gravitational Fields
D.2 Electric and magnetic fields
D.3 Motion in fields
D.4 Induction
E.1 Structure of the Atom
E.2 Quantum Physics
E.3 Radioactive Decay
E.4 Fission
E.5 Fusion and Stars

Maths skills **Data** **Paper 1A** **Paper 1B** **Paper 2**

This is your printable reference. Mark the boxes by hand and revisit your ratings as you improve. On-screen links open topic pages and matching simulations; the checkboxes are for printing.

Exam readiness Explain concepts without notes; identify SL/HL scope; select unfamiliar models; connect equations, graphs and diagrams; use the data booklet; justify Paper 1A choices, analyse Paper 1B evidence and write reasoned Paper 2 answers. Check equation conditions and plan your three weakest areas. This is not a grade prediction.

A.1 Kinematics

		1	2	3
COMMON CONTENT | SL + HL				
1	Distinguish position, distance and displacement; use scalar/vector language correctly.	☐	☐	☐
2	Determine average and instantaneous speed, velocity and acceleration from data, equations and graphs.	☐	☐	☐
3	Interpret displacement-time and velocity-time graphs, including gradients and areas where physically meaningful.	☐	☐	☐
★ 4	Recognize uniform versus non-uniform acceleration and use SUVAT only when acceleration is constant or can be legitimately modelled as constant.	☐	☐	☐
★ 5	Resolve projectile motion into independent horizontal and vertical components; handle launches horizontally, above the horizontal and below the horizontal.	☐	☐	☐
6	Use constant g near Earth and recognize that quantitative projectile calculations assume fluid resistance is absent or negligible.	☐	☐	☐
7	Explain qualitatively how fluid resistance changes trajectory, time of flight, velocity, acceleration, range and terminal speed.	☐	☐	☐
8	Distinguish “constant speed” from “constant velocity” and recognize that curved motion can have non- zero acceleration at constant speed.	☐	☐	☐

Prove it before selecting 3 Predict two ground-level launches at equal speed but complementary angles. Compare range and flight time without drag; explain which prediction fails when drag is added.

Practice labs: Projectile motion

A.2 Forces and Momentum

		1	2	3
COMMON CONTENT | SL + HL				
1	State and apply Newton’s three laws and identify when translational equilibrium gives resultant force zero.	☐	☐	☐
★ 2	Draw and interpret free-body diagrams in one and two dimensions; label actual interactions, not “centripetal force” as an extra force.	☐	☐	☐
3	Use normal force, static/dynamic friction, tension, Hooke restoring force, Stokes drag, buoyancy and field forces in appropriate models.	☐	☐	☐
4	Distinguish limiting static friction from friction below the limiting value.	☐	☐	☐
★ 5	Use momentum conservation only when external resultant force / external impulse is negligible over the interaction.	☐	☐	☐
6	Relate impulse to change in momentum and interpret force-time area as impulse.	☐	☐	☐
7	Distinguish elastic and inelastic collisions and explain the energy changes without implying total energy is destroyed.	☐	☐	☐
8	Analyse explosions and recoil using momentum conservation.	☐	☐	☐
★ 9	Relate circular motion to radial acceleration, angular speed, period and a resultant force directed toward the centre.	☐	☐	☐
10	Analyse uniform and non-uniform circular motion in horizontal/vertical contexts within syllabus limits.	☐	☐	☐
HL APPLICATION				
11	Solve quantitative collision and explosion problems in two dimensions using vector momentum components.	☐	☐	☐

Prove it before selecting 3 Increase a force through the static-friction limit, then reduce it while the block is sliding. Explain both the resultant force and acceleration direction.

Practice labs: Friction **Circular motion**

Scope note SL quantitative collisions and explosions are one-dimensional; HL includes two-dimensional problems. Vertical-circle force calculations are limited to top and bottom; banked-surface calculations are not required.

A.3 Work, Energy and Power

		1	2	3
COMMON CONTENT | SL + HL				
★ 1	Apply conservation of energy and distinguish stored energy from transferred energy.	☐	☐	☐
2	Interpret and construct Sankey diagrams for energy transfers.	☐	☐	☐
3	Calculate work by a constant force at an angle and identify positive, negative and zero work.	☐	☐	☐
4	Use translational kinetic energy, near-Earth gravitational potential energy and elastic potential energy.	☐	☐	☐
★ 5	Recognize when mechanical energy is conserved and when non-conservative work changes total mechanical energy.	☐	☐	☐
6	Relate resultant work to the change in energy of a system.	☐	☐	☐
7	Relate power to energy transfer rate; use $P = Fv$ only with the correct force component.	☐	☐	☐
8	Calculate and interpret efficiency using energy or power ratios.	☐	☐	☐
9	Use energy density to compare fuel sources in context.	☐	☐	☐

Prove it before selecting 3 Two blocks descend the same vertical height on different slopes. Compare final kinetic energy with and without friction, stating the system and energy transfers.

Practice labs: Incline model

A.4 Rigid Body Mechanics

		1	2	3
HL ONLY				
1	Calculate torque about an axis using the perpendicular component / lever arm and identify clockwise versus anticlockwise sense.	☐	☐	☐
2	Apply rotational equilibrium: resultant torque equals zero.	☐	☐	☐
3	Relate unbalanced torque to angular acceleration and distinguish angular displacement, angular speed and angular acceleration.	☐	☐	☐
4	Use the rotational equations of motion for uniform angular acceleration.	☐	☐	☐
5	Explain how moment of inertia depends on mass distribution and calculate I for systems of point masses.	☐	☐	☐
★ 6	Use $\tau = I\alpha$ as the rotational analogue of Newton's second law.	☐	☐	☐
★ 7	Calculate angular momentum $L = I\omega$; conserve it only when external resultant torque is zero.	☐	☐	☐
8	Use angular impulse: $\Delta L = \tau \Delta t = \Delta(I\omega)$ for constant torque.	☐	☐	☐
9	Calculate rotational kinetic energy and connect it to angular momentum when appropriate.	☐	☐	☐
10	Analyse rolling without slipping as simultaneous translational and rotational motion.	☐	☐	☐
11	Predict how changing moment of inertia changes angular speed when angular momentum is conserved.	☐	☐	☐

Prove it before selecting 3 Release a ring and a solid sphere from equal heights. Predict which is faster at the bottom, then account for translational and rotational energy.

Practice labs: Rolling bodies

Scope note Specific-body moment-of-inertia relationships will be supplied when required; calculations for point-mass systems are expected.

A.5 Galilean and Special Relativity

		1	2	3
HL ONLY				
1	Define reference frames and inertial frames and state Galilean relativity for Newtonian mechanics.	☐	☐	☐
2	Apply Galilean transformations for position/time and Galilean velocity addition.	☐	☐	☐
3	State the two postulates of special relativity and explain why they require a new transformation between inertial frames.	☐	☐	☐

A.5 Galilean and Special Relativity continued

		1	2	3
HL ONLY				
★ 4	Use the Lorentz factor and Lorentz transformations for event coordinates.	☐	☐	☐
5	Use relativistic velocity addition.	☐	☐	☐
★ 6	Distinguish proper time from dilated time and proper length from contracted length.	☐	☐	☐
7	Explain relativity of simultaneity using events and reference frames.	☐	☐	☐
8	Work with invariant spacetime intervals.	☐	☐	☐
9	Interpret spacetime diagrams and worldlines with physically meaningful gradients.	☐	☐	☐
10	Connect muon-decay observations to time dilation / length contraction as complementary frame descriptions.	☐	☐	☐
11	Check that relativistic results approach Galilean predictions in the limit $v \ll c$.	☐	☐	☐

Prove it before selecting 3 Two events occur at the same place in a moving clock's frame. Identify the proper time, transform their separation and explain why time dilation applies.

Scope note Transformation derivations are not required. Spacetime worldlines are restricted to constant velocity; the time axis is labelled ct.

B.1 Thermal Energy Transfers

		1	2	3
COMMON CONTENT | SL + HL				
1	Describe solids, liquids and gases using molecular structure and particle motion.	☐	☐	☐
2	Use density and absolute-temperature ideas, including Kelvin/Celsius conversion where appropriate.	☐	☐	☐
3	Relate mean particle kinetic energy to absolute temperature using $\overline{E_k} = \frac{3}{2}k_B T$.	☐	☐	☐
★ 4	Distinguish internal energy, temperature and thermal energy transfer.	☐	☐	☐
5	Explain phase changes at particle level: temperature may remain constant while intermolecular potential energy changes.	☐	☐	☐
★ 6	Calculate specific heat capacity and specific latent heat problems and choose the correct relationship for the process.	☐	☐	☐
7	Explain conduction, convection and radiation in appropriate physical contexts.	☐	☐	☐
8	Use emissivity, Stefan-Boltzmann and Wien relationships for thermal radiation.	☐	☐	☐
9	Distinguish luminosity from apparent brightness and use inverse-square spreading where appropriate.	☐	☐	☐
★ 10	Use conduction rate $\frac{\Delta Q}{\Delta t} = kA\frac{\Delta T}{\Delta x}$; compare material, area and gradient.	☐	☐	☐

Prove it before selecting 3 Double conductor length and temperature difference together, holding material and area fixed. Predict the heat-transfer rate before testing; explain the gradient.

Practice labs: Thermal conduction **Blackbody radiation**

B.2 Greenhouse Effect

		1	2	3
COMMON CONTENT | SL + HL				
★ 1	Apply conservation of energy to planetary energy-balance models.	☐	☐	☐
★ 2	Use albedo and emissivity correctly and distinguish reflected, absorbed and emitted radiation.	☐	☐	☐
3	Explain the factor of four when comparing intercepted solar power with average incident power over a spherical planet.	☐	☐	☐
4	Calculate equilibrium temperature from incoming and outgoing radiation in simplified models.	☐	☐	☐

B.2 Greenhouse Effect continued

		1	2	3
COMMON CONTENT | SL + HL				
5	Identify major greenhouse gases and distinguish the natural greenhouse effect from the enhanced greenhouse effect.	☐	☐	☐
6	Connect molecular energy levels/resonance to infrared absorption and re-emission.	☐	☐	☐
7	Explain why “greenhouse gases reflect infrared” is an oversimplification.	☐	☐	☐
8	Analyse surface-atmosphere energy flows and predict the effect of changing albedo/emissivity in a stated model.	☐	☐	☐

Prove it before selecting 3 A model planet becomes more reflective with solar intensity and emissivity fixed. Construct its energy balance and predict the equilibrium-temperature change.

B.3 Gas Laws

		1	2	3
COMMON CONTENT | SL + HL				
1	State ideal-gas assumptions and identify when real gases most closely approximate the ideal model.	☐	☐	☐
2	Use pressure as force per unit area and relate pressure to molecular collisions with container walls.	☐	☐	☐
★ 3	Use amount of substance, particle number and the ideal-gas equation with temperature in kelvin.	☐	☐	☐
★ 4	Apply Boyle, Charles and pressure-temperature relationships only under their stated fixed-variable conditions.	☐	☐	☐
5	Use the combined gas law for the same fixed amount of gas between equilibrium states.	☐	☐	☐
6	Interpret pressure-volume graphs and distinguish process constraints before choosing equations.	☐	☐	☐
7	Calculate internal energy of a monatomic ideal gas and connect changes in U to changes in absolute temperature.	☐	☐	☐
8	Explain why simply “doubling Celsius temperature” is not a valid gas-law statement.	☐	☐	☐
9	Connect gas pressure, density and mean-square molecular speed using $P = \frac{1}{3}\rho\overline{v^2}$.	☐	☐	☐

Prove it before selecting 3 At fixed temperature, double both the amount of gas and its volume. Predict pressure and explain the result using particle collisions.

Practice labs: Gas laws

B.4 Thermodynamics

		1	2	3
HL ONLY				
★ 1	Apply $Q = \Delta U + W$: heat into the system is positive; work done by the system is positive.	☐	☐	☐
2	Use $W = P\Delta V$ at constant pressure; interpret work as area on a pressure-volume graph.	☐	☐	☐
3	Calculate ΔU for a monatomic ideal gas from the change in absolute temperature.	☐	☐	☐
4	Distinguish isovolumetric, isobaric, isothermal and adiabatic processes and state what becomes zero/constant in each.	☐	☐	☐
5	For an isothermal ideal-gas process, use $\Delta U = 0$ to relate heat transfer and work.	☐	☐	☐
6	For an adiabatic process, use $Q = 0$ and explain why temperature can change.	☐	☐	☐
★ 7	Analyse a complete cycle: the state returns to its start, so net $\Delta U = 0$.	☐	☐	☐
8	Explain the second law using entropy and the spontaneous direction of real processes.	☐	☐	☐
9	Calculate entropy changes in syllabus contexts and distinguish reversible from irreversible processes.	☐	☐	☐
10	Analyse heat-engine cycles and calculate thermal efficiency.	☐	☐	☐
11	Use Carnot efficiency as the theoretical maximum between two reservoirs and use kelvin temperatures.	☐	☐	☐

B.4 Thermodynamics continued

		1	2	3
HL ONLY				
12	Explain why a heat engine operating between finite reservoirs cannot be 100% efficient.	☐	☐	☐

Prove it before selecting 3 Sketch a clockwise pressure-volume cycle. Identify net work and net heat transfer, and explain why a full cycle has no net internal-energy change.

B.5 Current and Circuits

		1	2	3
COMMON CONTENT | SL + HL				
1	Distinguish current, charge flow, potential difference and emf as separate quantities.	☐	☐	☐
2	Draw and interpret circuit diagrams using the required standard component symbols.	☐	☐	☐
3	Model current as rate of charge flow and relate electrical energy transfer to charge and potential difference.	☐	☐	☐
4	Use ideal ammeter and voltmeter assumptions and recognize what non-ideal meter resistance would change.	☐	☐	☐
★ 5	Use $R = \frac{V}{I}$ at an operating point; distinguish this definition from Ohm's law.	☐	☐	☐
6	Use resistivity and predict how resistance changes with wire length, cross-sectional area and material.	☐	☐	☐
7	Interpret ohmic and non-ohmic I-V behaviour, including heating effects.	☐	☐	☐
★ 8	Solve series and parallel resistor networks using current, p.d. and equivalent-resistance relationships.	☐	☐	☐
9	Calculate electrical power using $P = IV = I^2R = \frac{V^2}{R}$ where appropriate.	☐	☐	☐
★ 10	Model internal resistance using emf and terminal behaviour, including the open-circuit limit.	☐	☐	☐
11	Use thermistors, LDRs and potentiometers as variable resistors and interpret potential-divider behaviour.	☐	☐	☐

Prove it before selecting 3 Build a potential divider with a thermistor, then add a load across its output. Explain why heating and loading can each change the measured voltage.

Practice labs: Circuit builder

Scope note AC circuit analysis is not required in this topic. Unless stated otherwise, treat meters as ideal.

C.1 Simple Harmonic Motion

		1	2	3
COMMON CONTENT | SL + HL				
★ 1	Recognize the defining condition for SHM: acceleration is proportional to displacement and directed toward equilibrium.	☐	☐	☐
2	Interpret $a = -\omega^2 x$ and explain the physical meaning of the negative sign.	☐	☐	☐
3	Relate amplitude, displacement, period, frequency and angular frequency.	☐	☐	☐
★ 4	Calculate periods for ideal mass-spring and simple-pendulum systems within model assumptions.	☐	☐	☐
5	Track kinetic and potential energy qualitatively through one oscillation.	☐	☐	☐
6	Interpret displacement-time, velocity-time, acceleration-time and acceleration-displacement graphs.	☐	☐	☐
7	Identify equilibrium and extreme positions and the corresponding speed/acceleration conditions.	☐	☐	☐
HL EXTENSION				
8	Use phase angle (in radians) to describe SHM.	☐	☐	☐
9	Solve quantitative SHM problems using $x(t)$, $v(t)$ and the speed-displacement relationship.	☐	☐	☐
10	Calculate total, potential and kinetic energy quantitatively in SHM.	☐	☐	☐

C.1 Simple Harmonic Motion continued

		1	2	3
HL EXTENSION				
11	Use phase relationships between displacement, velocity and acceleration to interpret unfamiliar graphs.	☐	☐	☐

Prove it before selecting 3 With no damping, double the initial extension of a spring oscillator. Predict period, maximum speed and total energy; distinguish common and HL depth.

Practice labs: Spring oscillator

C.2 Wave Model

		1	2	3
COMMON CONTENT | SL + HL				
1	Distinguish transverse and longitudinal travelling waves by particle motion relative to propagation.	☐	☐	☐
★ 2	Interpret displacement-position and displacement-time representations without confusing the two axes.	☐	☐	☐
★ 3	Define wavelength, frequency, period, amplitude and wave speed; use $v = f\lambda$.	☐	☐	☐
4	Explain energy transfer by travelling waves without net transport of the medium.	☐	☐	☐
5	Distinguish mechanical waves from electromagnetic waves and recognize that EM waves can travel through vacuum.	☐	☐	☐
6	Use approximate electromagnetic-spectrum wavelength scales qualitatively.	☐	☐	☐

Prove it before selecting 3 Double frequency at fixed wave speed. Predict wavelength, then distinguish one particle's displacement-time graph from a snapshot of the medium.

Practice labs: Wave particles

C.3 Wave Phenomena

		1	2	3
COMMON CONTENT | SL + HL				
1	Use rays and wavefronts to describe waves in two and three dimensions.	☐	☐	☐
2	Explain reflection, refraction and transmission at boundaries.	☐	☐	☐
3	Predict/sketch diffraction around obstacles and through apertures.	☐	☐	☐
★ 4	Apply Snell's law, critical angle and the two conditions required for total internal reflection.	☐	☐	☐
5	Use superposition for pulses and waves.	☐	☐	☐
6	Recognize that double-source interference requires coherent sources.	☐	☐	☐
★ 7	Use path difference for constructive and destructive interference.	☐	☐	☐
★ 8	Use Young's double-slit relationship and interpret fringe spacing when parameters change.	☐	☐	☐
9	Use small-angle approximations only when their conditions are satisfied.	☐	☐	☐
HL EXTENSION				
10	Analyse single-slit diffraction intensity patterns and use the first-minimum relation.	☐	☐	☐
11	Explain qualitatively how slit width changes the single-slit pattern.	☐	☐	☐
12	Explain how the single-slit diffraction envelope modulates double-slit interference.	☐	☐	☐
13	Analyse multiple-slit and diffraction-grating patterns using $n\lambda = d\sin\theta$.	☐	☐	☐
14	Compare patterns produced by white light and by different monochromatic wavelengths.	☐	☐	☐

Prove it before selecting 3 Core: double slit separation and predict fringe spacing. HL: increase slit width and explain why outer maxima fade without confusing the two changes.

Practice labs: Double slit **Two sources** **Refraction**

Scope note Use normal incidence for interference and diffraction. The single-slit discussion is restricted to monochromatic light and rectangular slits.

C.4 Standing Waves and Resonance

		1	2	3
COMMON CONTENT | SL + HL				
1	Explain standing-wave formation from two identical waves travelling in opposite directions.	☐	☐	☐
★ 2	Identify displacement nodes and antinodes and compare amplitudes/phase at different points.	☐	☐	☐
★ 3	Apply boundary conditions for strings with fixed/free ends and pipes with open/closed ends.	☐	☐	☐
4	Identify the first, second and nth harmonic; distinguish harmonic number from allowed mode order.	☐	☐	☐
5	Relate harmonic number, wavelength, frequency, length and wave speed.	☐	☐	☐
6	Explain resonance in terms of driving frequency and natural frequency.	☐	☐	☐
7	Interpret amplitude-versus-driving-frequency graphs.	☐	☐	☐
8	Distinguish light, critical and heavy damping and their effect on the response.	☐	☐	☐
9	Explain useful and destructive resonance examples.	☐	☐	☐

Prove it before selecting 3 Predict whether the centre of a string's second harmonic is a node. Select particles in neighbouring loops and use the time slider to justify their phase difference.

Practice labs: Standing waves

Scope note Use first harmonic rather than fundamental/overtone terminology. Discuss pipe motion through displacement nodes and antinodes; pressure nodes and end corrections are not required.

C.5 Doppler Effect

		1	2	3
COMMON CONTENT | SL + HL				
1	Explain the Doppler effect for sound and electromagnetic waves using relative motion and wavefront spacing.	☐	☐	☐
2	Use wavefront diagrams for a moving source or a moving observer.	☐	☐	☐
★ 3	Predict whether observed frequency/wavelength increases or decreases for approach and recession.	☐	☐	☐
4	Use the low-speed electromagnetic Doppler approximation when the speed of light is much greater than relative speed.	☐	☐	☐
5	Use spectral shifts to infer radial motion of astronomical objects and distinguish redshift from blueshift.	☐	☐	☐
HL EXTENSION				
6	Solve quantitative sound/mechanical-wave Doppler problems for a moving source.	☐	☐	☐
7	Solve quantitative sound/mechanical-wave Doppler problems for a moving observer.	☐	☐	☐
★ 8	Choose signs by physical reasoning (approach must raise observed frequency; recession must lower it).	☐	☐	☐

Prove it before selecting 3 Predict a received-frequency graph as an approaching source slows to rest. HL: justify the trend using a sound-Doppler relationship and its sign convention.

Practice labs: Doppler effect

Scope note Quantitative sound-wave problems consider either the source or the observer moving, not both simultaneously.

D.1 Gravitational Fields

		1	2	3
COMMON CONTENT | SL + HL				
1	State Kepler's three laws and use them qualitatively in orbital contexts.	☐	☐	☐
2	Use Newton's universal law of gravitation for point masses and appropriate spherical-mass models.	☐	☐	☐
★ 3	Define gravitational field strength as force per unit mass and use radial/uniform field models.	☐	☐	☐
4	Superpose gravitational fields along the line joining two bodies within syllabus limits.	☐	☐	☐
★ 5	Relate gravitational force to centripetal resultant force in circular orbital motion.	☐	☐	☐

D.1 Gravitational Fields continued

		1	2	3
COMMON CONTENT | SL + HL				
6	Sketch and interpret gravitational field lines.	☐	☐	☐
HL EXTENSION				
7	Use gravitational potential and potential energy with zero potential defined at infinity.	☐	☐	☐
8	Relate gravitational field strength to the potential gradient and interpret equipotential surfaces.	☐	☐	☐
9	Calculate work/energy changes when moving masses through gravitational potential differences.	☐	☐	☐
10	Use orbital-speed and escape-speed relationships in circular-orbit/escape contexts.	☐	☐	☐
11	Analyse energy changes when a satellite changes orbit and conditions for escape.	☐	☐	☐
12	Explain qualitatively how small atmospheric drag affects orbital height and speed.	☐	☐	☐

Prove it before selecting 3 Place unequal point masses on a line and predict where their fields cancel. HL: compare escape speeds when source mass is quadrupled at fixed radius.

Practice labs: Gravitational field

D.2 Electric and Magnetic Fields

		1	2	3
COMMON CONTENT | SL + HL				
1	Predict force direction between positive and negative charges and apply Coulomb's law for point charges.	☐	☐	☐
2	Use conservation and quantization of charge, including the role of Millikan's experiment.	☐	☐	☐
3	Explain charge transfer by friction, contact and electrostatic induction, including grounding.	☐	☐	☐
★ 4	Define electric field strength and sketch/interpret field patterns, including parallel plates and point charges.	☐	☐	☐
5	Interpret field-line density qualitatively as field strength.	☐	☐	☐
6	Use $E = \frac{V}{d}$ for an approximately uniform field between parallel plates.	☐	☐	☐
7	Sketch/interpret magnetic fields of a bar magnet, straight current, circular coil and air-core solenoid.	☐	☐	☐
8	Use the right-hand rule to determine magnetic-field direction around a straight current-carrying conductor.	☐	☐	☐
HL EXTENSION				
9	Use electric potential energy for two point charges and recognize its sign.	☐	☐	☐
10	Define electric potential as a scalar, zero at infinity; use $V = \frac{kQ}{r}$.	☐	☐	☐
★ 11	Relate electric field to electric potential gradient.	☐	☐	☐
12	Calculate work done moving charge through a potential difference and express energy in J or eV as appropriate.	☐	☐	☐
13	Interpret equipotential surfaces and their perpendicular relationship to electric field lines.	☐	☐	☐
14	Recognize equipotential/field patterns for point charges, conducting spheres and parallel plates.	☐	☐	☐

Prove it before selecting 3 Compare the midpoint field for two equal positive charges and for a dipole. HL: distinguish zero field from zero potential and justify both predictions.

Practice labs: Electric field **Millikan**

D.3 Motion in Electromagnetic Fields

		1	2	3
COMMON CONTENT | SL + HL				
1	Describe and calculate motion of charged particles in uniform electric fields.	☐	☐	☐
2	Calculate the magnitude and direction of magnetic force using $F = qvB\sin\theta$.	☐	☐	☐

D.3 Motion in Electromagnetic Fields continued

			1	2	3
COMMON CONTENT | SL + HL					
★	3	Explain why a magnetic field does no work on a moving charge and therefore does not change its kinetic energy.	☐	☐	☐
	4	Analyse circular motion of a charge entering a uniform B-field perpendicular to its velocity.	☐	☐	☐
	5	Use particle trajectories to determine charge-to-mass ratio.	☐	☐	☐
★	6	Analyse crossed perpendicular electric and magnetic fields, including undeflected velocity-selector conditions.	☐	☐	☐
	7	Calculate force on a current-carrying conductor in a magnetic field.	☐	☐	☐
	8	Calculate force per unit length between parallel current-carrying wires and identify attraction for same- direction currents.	☐	☐	☐

Prove it before selecting 3 Set crossed fields for an undeflected particle, then reverse its charge sign. Predict the selected speed and explain both force directions.

Practice labs: Velocity selector **Magnetic motion** **Electric motion**

D.4 Induction

			1	2	3
HL ONLY					
	1	Define magnetic flux $\Phi = BA\cos\theta$; measure the angle to the area normal.	☐	☐	☐
★	2	Use Faraday's law to relate induced emf to the rate of change of magnetic flux linkage.	☐	☐	☐
★	3	Apply Lenz's law to determine direction and connect it to conservation of energy.	☐	☐	☐
	4	Analyse motional emf in a straight conductor moving perpendicular to a uniform magnetic field.	☐	☐	☐
	5	Analyse rectangular coils moving into/out of field regions and relate changing flux to emf.	☐	☐	☐
	6	Explain sinusoidally varying emf from a coil rotating in a uniform magnetic field.	☐	☐	☐
	7	Relate generator frequency / rotation frequency to the induced-emf waveform.	☐	☐	☐
	8	Predict how increasing rotation frequency affects peak induced emf.	☐	☐	☐
	9	Recognize the phase relationship between magnetic flux and induced emf for a rotating coil.	☐	☐	☐
	10	Explain self-induction qualitatively in terms of a changing current and induced emf.	☐	☐	☐
	11	Identify situations where flux is non-zero but constant and therefore induced emf is zero.	☐	☐	☐

Prove it before selecting 3 Move a magnet in, stop it and withdraw it. Use the flux-time gradient to predict emf sign and magnitude, including an instant with nonzero flux but zero emf.

Practice labs: Induction

Scope note Self-induction is qualitative. Inductance and resistance-inductor circuit calculations are not required.

E.1 Structure of the Atom

			1	2	3
COMMON CONTENT | SL + HL					
	1	Interpret Geiger-Marsden-Rutherford scattering observations and conclusions qualitatively.	☐	☐	☐
	2	Use nuclear notation correctly and distinguish nucleon number from proton number.	☐	☐	☐
★	3	Explain why emission and absorption spectra provide evidence for discrete atomic energy levels.	☐	☐	☐
★	4	Relate photon emission and absorption to atomic transitions using $\Delta E = hf$.	☐	☐	☐
	5	Use spectral lines to infer chemical composition.	☐	☐	☐
HL EXTENSION					
	6	Use nuclear-radius scaling $R = R_0 A^{1/3}$ and explain approximately constant nuclear density.	☐	☐	☐
	7	Explain deviations from Rutherford scattering at high energies.	☐	☐	☐

E.1 Structure of the Atom continued

		1	2	3
HL EXTENSION				
8	Use energy conservation to determine distance of closest approach in head-on Rutherford scattering.	☐	☐	☐
9	Use Bohr hydrogen energy levels $E_n = -\frac{13.6}{n^2}\,\text{eV}$.	☐	☐	☐
10	Use angular momentum quantisation $mvr = \frac{nh}{2\pi}$ to explain quantised Bohr orbits.	☐	☐	☐
11	Connect atomic energy-level differences to emitted/absorbed photon wavelength and frequency.	☐	☐	☐

Prove it before selecting 3 Core: explain why only certain incident photons are absorbed. HL: distinguish a bound-state excitation from ionisation, accounting for excess photon energy.

Practice labs: Atomic energy levels **Rutherford**

Scope note Qualitative scattering and spectral evidence are common content. Nuclear-radius scaling, closest approach, high-energy deviations and the quantitative Bohr model are HL additions.

E.2 Quantum Physics

		1	2	3
HL ONLY				
1	Explain the photoelectric effect as evidence for the particle nature of light and identify classical-wave failures.	☐	☐	☐
2	Use photon energy $E = hf$, threshold frequency and work function.	☐	☐	☐
★ 3	Use Einstein's photoelectric equation to determine maximum photoelectron kinetic energy.	☐	☐	☐
★ 4	Interpret photoelectric graphs and distinguish effects of changing intensity from changing frequency.	☐	☐	☐
5	Use stopping potential to connect electric potential energy to maximum photoelectron kinetic energy.	☐	☐	☐
6	Explain particle diffraction as evidence for the wave nature of matter.	☐	☐	☐
7	Use de Broglie wavelength $\lambda = \frac{h}{p}$ and connect wavelength to momentum.	☐	☐	☐
8	Describe wave-particle duality without treating "wave" and "particle" as mutually exclusive classical identities.	☐	☐	☐
9	Explain Compton scattering as evidence for photon momentum.	☐	☐	☐
10	Use the Compton wavelength-shift relationship with the scattered-photon angle.	☐	☐	☐
11	Interpret diffraction minima using de Broglie wavelength in stated experimental geometries.	☐	☐	☐

Prove it before selecting 3 Above threshold, vary photon arrival rate without changing frequency. Predict saturation current and stopping potential, then explain why they respond differently.

Practice labs: Photoelectric effect **Compton** **Matter waves**

Scope note Derivation of the Compton wavelength-shift equation is not required.

E.3 Radioactive Decay

		1	2	3
COMMON CONTENT | SL + HL				
1	Define isotopes and use mass-energy equivalence in nuclear contexts.	☐	☐	☐
★ 2	Calculate mass defect and binding energy, including use of u and MeV conversion factors.	☐	☐	☐
3	Interpret binding-energy-per-nucleon curves and relate greater binding to nuclear stability trends.	☐	☐	☐
4	Describe the strong nuclear force as short-range and attractive between nucleons.	☐	☐	☐
5	Describe random and spontaneous radioactive decay.	☐	☐	☐
★ 6	Distinguish alpha, beta-minus, beta-plus and gamma decay and complete nuclear equations.	☐	☐	☐

E.3 Radioactive Decay continued

		1	2	3
COMMON CONTENT | SL + HL				
7	Explain the role of neutrinos/antineutrinos in beta processes at the required level.	☐	☐	☐
8	Compare penetration and ionizing ability of α, β and γ radiation.	☐	☐	☐
9	Distinguish activity from detector count rate and correct measured count rate for background.	☐	☐	☐
★ 10	Use integer half-lives to track changes in number/activity/count rate.	☐	☐	☐
HL EXTENSION				
11	Explain evidence for the strong nuclear force and the role of neutron-to-proton ratio in stability.	☐	☐	☐
12	Interpret the roughly constant binding energy per nucleon above nucleon number $A \approx 60$.	☐	☐	☐
13	Use discrete α/γ spectra as evidence for discrete nuclear energy levels.	☐	☐	☐
14	Use the continuous β spectrum as evidence for the neutrino.	☐	☐	☐
15	Use decay constant and the exponential law $N = N_0 e^{-\lambda t}$ for arbitrary intervals.	☐	☐	☐
16	Use $\mathcal{A} = \lambda N$ and relate activity to exponential decay.	☐	☐	☐
17	Use $T_{1/2} = \dfrac{\ln 2}{\lambda}$ and distinguish half-life from mean lifetime.	☐	☐	☐
18	Interpret $\lambda \Delta t$ as the approximate decay probability when $\lambda \Delta t \ll 1$.	☐	☐	☐

Prove it before selecting 3 After three half-lives, determine the fractions of parent remaining and stable daughter produced. State the initial-composition assumption and how background counts affect measurements.

E.4 Fission

		1	2	3
COMMON CONTENT | SL + HL				
1	Explain spontaneous and induced nuclear fission.	☐	☐	☐
2	Calculate energy release from changes in nuclear mass / binding energy.	☐	☐	☐
3	Explain how emitted neutrons make a chain reaction possible.	☐	☐	☐
★ 4	Distinguish a sustained/critical chain reaction from subcritical or uncontrolled behaviour qualitatively.	☐	☐	☐
★ 5	Describe the function of moderators (slow neutrons) and control rods (absorb neutrons).	☐	☐	☐
6	Describe roles of coolant, heat exchanger and shielding in reactor systems.	☐	☐	☐
7	Discuss fission products and long-term radioactive-waste management using physically relevant considerations.	☐	☐	☐
8	Connect reactor energy release to momentum/energy conservation and the binding-energy curve.	☐	☐	☐

Prove it before selecting 3 Explain why a moderator and control rods are not interchangeable. Predict the effect of inserting control rods further into a steady reactor.

E.5 Fusion and Stars

		1	2	3
COMMON CONTENT | SL + HL				
1	Explain fusion as a process in which light nuclei combine and energy is released through increased binding.	☐	☐	☐
2	Identify the high-temperature and confinement/density conditions needed to overcome electrostatic repulsion sufficiently for fusion.	☐	☐	☐
3	Calculate energy released in fusion reactions using mass-energy equivalence.	☐	☐	☐
4	Explain main-sequence stars as fusion-powered systems in hydrostatic equilibrium.	☐	☐	☐
★ 5	Interpret Hertzsprung-Russell diagrams and identify main sequence, giants/supergiants and white dwarfs.	☐	☐	☐

E.5 Fusion and Stars continued

		1	2	3
COMMON CONTENT | SL + HL				
6	Recognize that the temperature axis on a standard HR diagram decreases from left to right.	☐	☐	☐
7	Use AU, light-year and parsec appropriately and explain stellar parallax as a distance method.	☐	☐	☐
8	Use Wien's law and intensity-wavelength spectra to infer stellar surface temperature.	☐	☐	☐
9	Use absorption spectra to infer stellar composition.	☐	☐	☐
★ 10	Use luminosity and surface temperature with Stefan-Boltzmann to calculate/compare stellar radius.	☐	☐	☐
11	Explain why a red giant can be cool at the surface yet highly luminous because of its large radius.	☐	☐	☐
12	Relate stellar mass qualitatively to lifetime/evolution where required by the course context.	☐	☐	☐
13	Locate the instability strip and interpret lines of constant radius on an H-R diagram.	☐	☐	☐

Prove it before selecting 3 At constant luminosity, a star's surface temperature decreases. Predict its radius change, locate the motion on the H-R diagram and explain your reasoning.

Practice labs: H-R diagram

Scope note Interpret the instability strip and constant-radius lines; Cepheid-variable detail is not required.

Maths skills

		1	2	3
COMMON CONTENT | SL + HL				
★ 1	Convert units confidently, use SI prefixes correctly and check dimensional consistency.	☐	☐	☐
★ 2	Read gradients, areas, intercepts, maxima/minima and trends from graphs and connect them to physical meaning.	☐	☐	☐
★ 3	Use proportional reasoning, limiting cases and order-of-magnitude checks before reaching for a calculator.	☐	☐	☐
4	Manipulate equations without losing signs, powers, vector directions or units.	☐	☐	☐
5	Distinguish scalar quantities from vectors and resolve/add vectors in the allowed two-dimensional contexts.	☐	☐	☐
6	Interpret and construct free-body diagrams, field lines, ray diagrams, wavefronts and circuit diagrams.	☐	☐	☐
7	Use the Physics data booklet efficiently and check the conditions behind an equation before applying it.	☐	☐	☐

Prove it before selecting 3 Take one unfamiliar graph. State what its gradient and area mean, check units and a limiting case, then choose whether a numerical calculation is necessary.

SK-DATA Data & Experimental Reasoning

		1	2	3
COMMON CONTENT | SL + HL				
1	Identify independent, dependent and controlled variables and explain why controls matter.	☐	☐	☐
2	Choose an appropriate measuring instrument and justify its resolution/range.	☐	☐	☐
★ 3	Distinguish random error, systematic error and zero error; explain what repetition can and cannot improve.	☐	☐	☐
4	Recognize anomalies without automatically deleting them and justify inclusion/exclusion.	☐	☐	☐
★ 5	Use absolute, fractional and percentage uncertainty language appropriately.	☐	☐	☐
6	Plot data clearly, select sensible scales and draw/interpret a best-fit line or curve.	☐	☐	☐
★ 7	Interpret gradient/intercept physically and use widely separated points where practical for gradient calculation.	☐	☐	☐
8	Assess accuracy, precision, reliability and validity rather than treating them as synonyms.	☐	☐	☐

SK-DATA Data & Experimental Reasoning continued

		1	2	3
COMMON CONTENT | SL + HL				
9	Evaluate limitations and propose specific, realistic improvements with a mechanism for improvement.	☐	☐	☐

Prove it before selecting 3 Design a pendulum measurement of gravitational acceleration. Identify controls, propagate uncertainties and decide whether a reported result agrees with a reference value.

SK-P1A Paper 1A Thinking

		1	2	3
COMMON CONTENT | SL + HL				
★ 1	Read the exact quantity, condition and qualifier being asked before calculating.	☐	☐	☐
★ 2	Use units, signs, limiting cases and order of magnitude to eliminate options.	☐	☐	☐
3	Identify distractors built from common conceptual misconceptions.	☐	☐	☐
4	Know when qualitative reasoning or a diagram is faster than calculation.	☐	☐	☐
5	Treat every option as a physics claim that must satisfy the model and its assumptions.	☐	☐	☐

Prove it before selecting 3 Write one correct claim and three plausible incorrect claims about a chosen lab. Reject each distractor using a condition, diagram, unit or limiting case.

Practice labs: Collision example

SK-P1B Paper 1B Thinking

		1	2	3
COMMON CONTENT | SL + HL				
1	Extract relevant information from tables, graphs, diagrams and experimental descriptions.	☐	☐	☐
2	Track variables, units and uncertainties across multiple stages of a data-based problem.	☐	☐	☐
★ 3	Use evidence from the data rather than unsupported conclusions.	☐	☐	☐
4	Distinguish correlation, proportionality and causal explanation.	☐	☐	☐
★ 5	Connect a data feature to the underlying physical model and state any required assumptions.	☐	☐	☐

Prove it before selecting 3 Plan a graph that linearises an unfamiliar relation. Explain its slope, intercept, error bars and one apparatus limitation that could produce a systematic offset.

SK-P2 Paper 2 Thinking

		1	2	3
COMMON CONTENT | SL + HL				
1	Decode the command term before writing.	☐	☐	☐
2	State a result briefly when only a statement is requested.	☐	☐	☐
3	Show enough working for calculations to make the method visible.	☐	☐	☐
★ 4	Explain using a connected chain of physical reasoning, not just a formula.	☐	☐	☐
★ 5	Justify conclusions with explicit evidence or a physical principle.	☐	☐	☐
6	Draw and label diagrams when they communicate the physics more clearly.	☐	☐	☐
7	Keep final answers with units, appropriate significant figures and direction where required.	☐	☐	☐

Prove it before selecting 3 Choose a mixed-topic calculation. Show the model, conditions, linked reasoning, labelled diagram and units so that another student can follow your method.