A-Level Paper 1 Personal Learning Checklist

1. Measurements and Errors				
LO	**Learning Objectives:**	**Confidence**		
1.01	Recall the fundamental (base) units for: mass, length, time, amount of substance, temperature and electric current.			
1.02	Derive the SI units for other quantities.			
1.03	Recall and use the prefixes: T, G, M, k, c, m, μ, n, p and f.			
1.04	Convert between units of the same quantity for example J, eV and kW h.			
1.05	Identify random and systematic errors in a practical.			
1.06	Suggest ways to reduce random and systematic errors in a practical.			
	Understand and use the following terms correctly:			
1.07	• precision			
1.08	• repeatability			
1.09	• reproducibility			
1.10	• resolution			
1.11	• accuracy			
1.12	State a quantity to the appropriate number of significant figures based on the value and its associated uncertainty.			
	Calculate the following:			
1.13	• absolute uncertainty			
1.14	• fractional uncertainty			
1.15	• percentage uncertainty			
1.16	• combination of absolute and percentage uncertainties			
1.17	• combining uncertainties in cases where the measurements have been added, subtracted, multiplied, divided, or raised to powers.			
1.18	Draw error bars on a graph relating to the uncertainty in a data point.			
1.19	Calculate the uncertainty in the gradient of a straight-line graph.			
1.20	Calculate the uncertainty in the y-intercept of a straight-line graph.			
1.21	Explain why individual points on a graph may or may not have associated error bars.			
1.22	Estimate approximate values of physical quantities to the nearest order of magnitude.			
1.23	Use common estimates and knowledge of physics to produce further derived estimates to the nearest order of magnitude.			

2. Particles and Radiation				
LO	**Learning Objectives:**	**Confidence**		
2.01	Recall the model of the atom, including the proton, neutron and electron.			
2.02	Recall the charge and mass of the proton, neutron and electron in SI units and relative units.			
2.03	Understand what is meant by the atomic mass unit (amu).			
2.04	Calculate the specific charge of the proton and the electron, and of nuclei and ions.			
2.05	Use nuclide notation, and understand what Z and A stand for in this notation.			
2.06	Define isotope.			
2.07	Use isotopic data in calculations.			

2.08	Describe the strong nuclear force.			
2.09	Explain the role of the strong nuclear force in keeping the nucleus stable.			
2.10	Describe alpha and beta decay.			
2.11	Write equations for alpha and beta decay.			
2.12	Explain the need for the neutrino in beta decay.			
2.13	Describe what is meant by the term ‘antiparticle’.			
2.14	Compare particles and antiparticles in terms of their mass, charge and rest energy in MeV.			
2.15	State the antiparticles of the electron, proton, neutron and neutrino.			
2.16	State what is meant by a ‘photon’.			
2.17	Understand how energy of a photon is related to the frequency of radiation.			
2.18	Use the following equation: $E = hf = hc / \lambda$			
2.19	Describe the process of annihilation.			
2.20	Describe the process of pair production.			
2.21	Describe and calculate the energies involved in annihilation and pair production.			
2.22	State the four fundamental interactions.			
2.23	Describe the four fundamental interactions and their exchange particles.			
2.24	State what is meant by exchange particles.			
	Draw Feynman diagrams for the following interactions:			
2.25	• $\beta-$ decay.			
2.26	• $\beta+$ decay.			
2.27	• electron capture.			
2.28	• electron – proton collision			
2.29	• neutron – neutrino.			
2.30	Describe how we can classify particles into two groups: hadrons and leptons.			
2.31	Describe the two classes of hadrons: baryons and mesons.			
2.32	Conserve baryon number.			
2.33	Describe what kaons are.			
2.34	Describe what kaons can decay into.			
2.35	Conserve lepton number.			
2.36	State when strange particles are produced.			
2.37	State when strangeness is conserved and not conserved.			
2.38	Apply all the conservation rules (charge, baryon number, lepton number and strangeness, if necessary) to be able to predict products of interactions.			
2.39	Appreciate that particle physics relies on the collaborative efforts of large teams of scientists and engineers to validate new knowledge.			
2.40	Understand what quarks are.			
2.41	Describe the properties of quarks and antiquarks.			
2.42	State how many quarks are needed in a baryon and how many needed in a meson.			
2.43	Be able to identify the quark make up of particles in terms of the following quarks: up (u), down (d) and straneg (s).			
2.44	State what a neutron decays into.			
2.45	Describe the change in quark character in in $\beta-$ and in $\beta+$ decay.			
2.46	State that energy and momentum are conserved in all interactions.			
2.47	Describe the photoelectric effect.			
2.48	State what is meant by the threshold frequency.			
2.49	Explain how the presence of a threshold frequency was evidence for photon theory.			
2.50	State what is meant by the work function, φ.			

2.51	Explain what a stopping potential is.			
2.52	Understand and use the photoelectric equation: $hf = \varphi + E_{k(max)}$			
2.53	Explain why the kinetic energy in the photoelectric equation is a maximum.			
	State what is meant by the following words:			
2.54	• ionisation			
2.55	• excitation			
2.56	• ground state			
2.57	• de-excitation			
2.58	• electron volt			
2.59	Describe how electrons can be ionised or excited.			
2.60	Describe what happens when an electron is de-excited.			
2.61	Describe what happens in a fluorescent tube.			
2.62	Convert from eV to joules and vice versa.			
2.63	Describe what a line spectra shows.			
2.64	Explain how a line spectra is evidence for transitions between discrete energy levels.			
2.65	Understand and use the following equation: $hf = E_1 - E_2$			
2.66	Explain what electron diffraction is and how it suggests that particles possess wave properties.			
2.67	Calculate de Broglie wavelength using the equation $\lambda = h/(mv)$			
2.68	Explain how and why the amount of diffraction changes when the momentum of the particle is changed.			
2.69	Appreciate knowledge and understanding of the nature of matter changes over time.			
2.70	Appreciate that such changes need to be evaluated through peer review and validated by the scientific community.			

3. Waves

LO	**Learning Objectives:**	**Confidence**		
3.01	Define what a progressive wave is.			
	Define the following words and state their units:			
3.02	• amplitude			
3.03	• frequency			
3.04	• wavelength			
3.05	• speed			
3.06	• phase			
3.07	• phase difference			
3.08	• time period			
3.09	Carry out calculations using the wave equation, $c = f\lambda$.			
3.10	Carry out calculations using the time period equation, $T= 1/f$.			
3.11	Describe a transverse wave and give examples.			
3.12	Describe a longitudinal wave and give examples.			
3.13	Compare transverse waves and longitudinal waves.			
3.14	State common features of all electromagnetic waves.			
3.15	Define polarisation.			
3.16	Explain why polarisation can only happen for transverse waves.			
3.17	Describe uses of polarisers, including Polaroid material and the alignment of aerials.			
3.18	Define what a stationary wave is.			

3.19	Explain how a stationary wave is formed from two progressive waves travelling in opposite directions towards each other.			
3.20	Draw a stationary wave.			
3.21	Define nodes and antinodes.			
3.22	Label nodes and antinodes onto a graphical depiction of a standing wave.			
3.23	Explain what harmonics are.			
3.24	Calculate the first harmonic using the equation.			
3.25	Calculate further harmonics by understanding what happens to the frequency as the order of the harmonic increases.			
3.26	Describe how standing waves are formed in different scenarios including on a string and in a microwave.			
3.27	***Core Practical: Investigation into the variation of the frequency of stationary waves on a string with length, tension, and mass per unit length of the string.***			
3.28	Define the term path difference.			
3.29	Define coherence.			
3.30	State an example of monochromatic light.			
3.31	Explain constructive and destructive interference.			
3.32	Describe diffraction.			
3.33	Describe the pattern produced when coherent light is passed through a double-slit. (Young's double slit experiment).			
3.34	Explain how the pattern is produced in a double-slit experiment.			
3.35	Describe the safety issues associated with using lasers.			
3.36	Understand and use the following equation $w = \lambda D/s$.			
3.37	Describe and explain what the pattern would look like if using white light.			
3.38	Describe the interference produced with sound and electromagnetic waves.			
3.39	Appreciate how knowledge and understanding of nature of electromagnetic radiation has changed over time.			
3.40	Describe the pattern produced when monochromatic light is shone through a single slit.			
3.41	Describe the pattern produced when white light is shone through a single slit.			
3.42	State and explain how the variation of the width of the central diffraction maximum is affected by wavelength and slit width.			
3.43	Derive and use $d\sin\theta = n\lambda$			
3.44	Describe the pattern produced by a plane transmission diffraction grating at normal incidence.			
3.45	Describe the uses of application gratings.			
3.46	Understand what refraction is and what causes refraction.			
3.47	Understand and use the equation for the refractive index of a substance: $n = c / c_s$			
3.48	State the refractive index of air.			
3.49	Understand and use Snell's law of refraction for a boundary: $n_1\sin\theta_1 = n_2\sin\theta_2$			
3.50	Describe what total internal reflection is.			
3.51	Explain when total internal reflection occurs with reference to the critical angle.			
3.52	Be able to calculate the critical angle for a medium: $\sin\theta_c = n_2 / n_1$			
3.53	Explain how simple fibre optics work.			
3.54	Explain the function of cladding in optical fibres.			
3.55	Describe what is meant by material dispersion.			
3.56	Describe what is meant by modal dispersion.			
3.57	Describe the principles of pulse broadening and absorption.			
3.58	Describe the consequences of pulse broadening and absorption.			
3.59	***Core Practical: Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating.***			

4. Mechanics and Materials				
LO	Learning Objectives:	Confidence		
4.01	State what is meant by the term scalar.			
4.02	State what the term vector means.			
4.03	Give examples of vectors and scalars.			
4.04	Calculate the resultant vector numerically or by scale drawing. (Calculations will be limited to two vectors at right angles).			
4.05	Resolve vectors into two components at right angles to each other (vertically and horizontally).			
4.06	Resolve vectors into two components that are along and perpendicular to an inclined plane.			
4.07	State what is meant by the term coplanar.			
4.08	State the conditions for equilibrium for two forces acting at a point.			
4.09	State the conditions for equilibrium for three coplanar forces acting at a point.			
4.10	Describe the motion of an object that is in equilibrium.			
4.11	State what ‘moment’ means.			
4.12	Calculate the moment of a force about a point.			
4.13	State what ‘couple’ means.			
4.14	Calculate the moment of a couple.			
4.15	State the principle of moments.			
4.16	Apply the principle of moments to a given context.			
4.17	State what is meant by centre of mass.			
4.18	Explain why the centre of mass of a uniform regular object is at its centre.			
	Define the following words:			
4.19	• displacement			
4.20	• speed			
4.21	• velocity			
4.22	• acceleration			
4.23	Apply the equations for velocity and acceleration, including average and instantaneous speeds and velocities.			
4.24	Represent uniform and non-uniform acceleration on graphs.			
4.25	Deduce what the area under an acceleration-time graph represents.			
4.26	Draw a velocity-time graph.			
4.27	Deduce what the gradient and area under a velocity-time graph represents.			
4.28	Apply and use the equations for uniform acceleration (SUVAT) for one-dimension one-direction problems.			
4.29	Apply and use the equations for uniform acceleration (SUVAT) for one-dimension problems.			
4.30	Understand the independent effect of motion in the horizontal and vertical directions in a uniform gravitational field.			
4.31	Apply and use the equations for uniform acceleration (SUVAT) for two dimension problems.			
4.32	Describe the effect of friction.			
4.33	Describe the effect of lift and drag forces.			
4.34	Explain what is meant by terminal speed and when it occurs.			
4.35	Describe what happens to air resistance with increased speed.			
4.36	Explain what effect air resistance has on the trajectory of a projectile.			
4.37	State the factors that affect the maximum speed of a vehicle.			
4.38	State the three laws of motion			

4.39	Apply the three laws of motion to appropriate situations.			
4.40	Understand and use F=ma in situations where the mass is constant.			
4.41	Define momentum as mass x velocity.			
4.42	State the conservation of linear momentum.			
4.43	Apply the conservation of linear momentum to problems in one dimension.			
4.44	State force as the rate of change of momentum and apply the equation $F = \Delta mv / \Delta t$.			
4.45	Define impulse.			
4.46	Deduce what the area under a force-time graph represents.			
4.47	Explain how impact forces are related to contact time (eg kicking a football, crumple zones, packaging).			
4.48	State what is meant by an elastic and inelastic collision.			
4.49	Carry out calculations involving elastic and inelastic collisions.			
4.50	Carry out calculations involving explosions.			
4.51	Appreciate the use of momentum conservation issues in the context of ethical transport design.			
4.52	***Core Practical: Determination of g by a free-fall method.***			
4.53	Calculate the energy transferred using the equation: $W = Fs\cos\theta$			
4.54	State what is meant by the term ‘power’.			
4.55	Calculate the power using $P = \Delta W / \Delta t = Fv$			
4.56	Explain what would happen to power if the force was not constant.			
4.57	Deduce what the area under a force-displacement graph represents.			
4.58	State what is meant by the term efficiency.			
4.59	Calculate efficiency using efficiency = useful output power / input power.			
4.60	Express efficiency as a percentage.			
4.61	State what the principle of conservation of energy is.			
4.62	Apply the principle of conservation of energy.			
4.63	Calculate change in gravitational potential energy.			
4.64	Calculate kinetic energy.			
4.65	Describe and explain applications of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces.			
4.66	State what is meant by density.			
4.67	Calculate density using $\rho = m / V$.			
4.68	State Hooke’s law.			
4.69	State what is meant by elastic limit.			
4.70	Understand and apply $F = k\Delta L$ to an example.			
4.71	Define tensile strain.			
4.72	Define tensile stress.			
4.73	Calculate tensile strain.			
4.74	Calculate tensile stress.			
4.75	Calculate the elastic strain energy using the equation.			
4.76	Deduce the elastic strain energy from a force-extension graph.			
4.77	Calculate breaking stress.			
	Describe the following words:			
4.78	• plastic behaviour			
4.79	• fracture			
4.80	• brittle behaviour			
4.81	Link the above words to force- extension graphs.			

4.82	Quantitative and qualitative application of energy conservation to examples involving elastic strain energy and energy to deform.			
4.83	Convert from elastic potential energy to kinetic and gravitational potential energy.			
4.84	Interpret stress-strain curves.			
4.85	Appreciate use of energy conservation issues in the context of ethical transport design.			
4.86	Define Young's modulus.			
4.87	Calculate Young's modulus as stress/strain.			
4.88	Use a stress-strain graph to deduce Young's modulus.			
4.89	***Core practical: Determination of the Young modulus by a simple method.***			

5. Electricity

LO	Learning Objectives:	Confidence		
	Define the following terms:			
5.01	• Current			
5.02	• Charge			
5.03	• Potential difference			
5.04	• Resistance			
	Calculate quantities using the following equations:			
5.05	• $I = \Delta Q / \Delta t$			
5.06	• $V = W / Q$			
5.07	• $R = V / I$			
5.08	Interpret current – voltage graphs and distinguish between the characteristics for an ohmic conductor, a semiconductor diode and a filament lamp. (I or V can be on the x-axis)			
5.09	State Ohm's law.			
5.10	Recognise that Ohm's law is a special case where I is directly proportional to V under constant physical conditions.			
5.11	Describe why ammeters must be connected in series and voltmeters in parallel. (Ammeters and voltmeters should be treated as ideal unless specifically stated)			
5.12	Define resistivity.			
5.13	Suggest reasons why resistivity is a better quantity to state than resistance.			
5.14	Understand and use the resistivity equation: $\rho = RA / L$			
5.15	Describe and explain the effect of temperature on the resistance of metal conductors.			
5.16	Describe the effect of temperature on the resistance of thermistors. (Only negative temperature coefficient, ntc, thermistors will be considered).			
5.17	Describe application of thermistors, including in temperature sensors.			
5.18	Explain what 'superconductor' means.			
5.19	Describe how superconductors can be used to produce strong magnetic fields and to reduce energy losses in the transmission of electric power.			
5.20	***Core Practical: Determination of resistivity of a wire using a micrometer, ammeter, and voltmeter.***			
5.21	Calculate the value for total resistance when resistors are connected in series.			
5.22	Calculate the value for total resistance when resistors are connected in parallel.			
5.23	Calculate values for resistance when components are connected in a combination of series and parallel.			
5.24	Calculate electrical energy using the equation, $E = IVt$.			
5.25	Calculate electrical power using: $P = IV = I^2R = V^2/R$.			
5.26	State Kirchhoff's first law.			
5.27	Explain why current into a junction must equal the current exiting a junction.			

5.28	Calculate current in a series or parallel circuit.			
5.29	State Kirchhoff's second law.			
5.30	Define potential difference.			
5.31	Define electromotive force.			
5.32	Calculate the potential difference of components in series or parallel circuits.			
5.33	Explain what happens to cells that are combined in series.			
5.34	Explain what happens to cells that are combined in parallel.			
5.35	Describe what a potential divider does.			
5.36	Describe the purpose of a negative temperature coefficient (ntc) thermistor and draw the circuit symbol.			
5.37	Describe the purpose of a light dependent resistor (LDR) and draw the circuit symbol.			
5.38	Derive the equation for a potential divider.			
5.39	Explain what happens to the output voltage of a potential divider when changes are made to the circuit, including circuits with a thermistor and LDR.			
5.40	Understand what internal resistance is.			
5.41	Define terminal potential difference.			
	Apply the following equations to a circuit:			
5.42	• $\varepsilon = E/Q$			
5.43	• $\varepsilon = I(R + r)$			
5.44	Preform calculations for circuits where the internal resistance is **not** negligible.			
5.45	***Core Practical: Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of the cell with current in it.***			

6A. Further Mechanics

LO	Learning Objectives:	Confidence		
6A.01	Describe the motion in a circular path at constant speed.			
6A.02	Explain why motion in circular path requires a centripetal force.			
6A.03	Estimate the acceleration and centripetal force in situations that involve rotation.			
6A.04	State the centripetal force in a situation.			
6A.05	Calculate the magnitude of angular speed using $\omega = v / r = 2\pi f$.			
6A.06	Convert between radians and degrees.			
6A.07	Calculate centripetal acceleration using $a = v^2/r = \omega^2 r$.			
6A.08	Derive and use the equation for centripetal force $F = mv^2/r = m\omega^2 r$.			
6A.09	Describe simple harmonic motion.			
6A.10	Explain the characteristics of simple harmonic motion.			
6A.11	State the conditions for simple harmonic motion.			
6A.12	Define an equation for simple harmonic motion $a = -\omega^2 x$ and $x = A \cos \omega t$ and $v = \pm\omega \sqrt{(A^2 - x^2)}$			
	Sketch the following graphs:			
6A.13	• x against t.			
6A.14	• v against t.			
6A.15	• a against t.			
6A.16	• kinetic energy against x.			
6A.17	• kinetic energy against t.			
6A.18	• potential energy against x.			
6A.19	• potential energy against t.			
6A.20	• total energy against x.			

6A.21	• total energy against t.			
6A.22	Appreciate that the v-t graph is derived from the gradient of the x-t graph and that the a-t graph is derived from the gradient of the v-t graph.			
6A.23	Calculate maximum speed using ωA.			
6A.24	Calculate maximum acceleration using $\omega^2 A$			
6A.25	Study the mass-spring system and use the equation for time period of this system.			
6A.26	Study the simple pendulum and use the equation for time period of this system.			
6A.27	Explain why we use the small angle approximation in the derivation of the time period formula.			
6A.28	Apply simple harmonic motion to other contexts (eg liquid in a U-tube).			
6A.29	Describe the effect of damping on oscillations. ,			
6A.30	State what free vibrations mean.			
6A.31	State what is meant by forced vibrations.			
6A.32	State what resonance is.			
6A.33	Describe the effect of damping on the sharpness of resonance.			
6A.34	Apply knowledge of resonance to mechanical systems and situations involving stationary waves.			
6A.35	***Core Practical: Investigation into simple harmonic motion using a mass-spring system and a simple pendulum.***			