**A-Level Paper 1 Personal Learning Checklist**

**Measurements and Errors**

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

**Particles**

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| **Learning Objectives:** | **Confidence** | | |
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| Recall the model of the atom, including the proton, neutron and electron. |  |  |  |
| Recall the charge and mass of the proton, neutron and electron in SI units and relative units. |  |  |  |
| Understand what is meant by the atomic mass unit (amu). |  |  |  |
| Calculate the specific charge of the proton and the electron, and of nuclei and ions. |  |  |  |
| Use nuclide notation, and understand what Z and A stand for in this notation. |  |  |  |
| Define isotope. |  |  |  |
| Use isotopic data in calculations. |  |  |  |
| Describe the strong nuclear force. |  |  |  |
| Explain the role of the strong nuclear force in keeping the nucleus stable. |  |  |  |
| Describe alpha and beta decay. |  |  |  |
| Write equations for alpha and beta decay. |  |  |  |
| Explain the need for the neutrino in beta decay. |  |  |  |
| Describe what is meant by the term ‘antiparticle’. |  |  |  |
| Compare particles and antiparticles in terms of their mass, charge and rest energy in MeV. |  |  |  |
| State the antiparticles of the electron, proton, neutron and neutrino. |  |  |  |
| State what is meant by a ‘photon’. |  |  |  |
| Understand how energy of a photon is related to the frequency of radiation. |  |  |  |
| Use the following equation: E = hf = hc / λ |  |  |  |
| Describe the process of annihilation. |  |  |  |
| Describe the process of pair production. |  |  |  |
| Describe and calculate the energies involved in annihilation and pair production. |  |  |  |
| State the four fundamental interactions. |  |  |  |
| Describe the four fundamental interactions and their exchange particles. |  |  |  |
| State what is meant by exchange particles. |  |  |  |
| ***Draw Feynman diagrams for the following interactions:*** | | | |
| * β− decay. |  |  |  |
| * β+ decay. |  |  |  |
| * electron capture. |  |  |  |
| * electron – proton collision |  |  |  |
| * neutron – neutrino. |  |  |  |
| Describe how we can classify particles into two groups: hadrons and leptons. |  |  |  |
| Describe the two classes of hadrons: baryons and mesons. |  |  |  |
| Conserve baryon number. |  |  |  |
| Describe what kaons are. |  |  |  |
| Describe what kaons can decay into. |  |  |  |
| Conserve lepton number. |  |  |  |
| State when strange particles are produced. |  |  |  |
| State when strangeness is conserved and not conserved. |  |  |  |
| Apply all the conservation rules (charge, baryon number, lepton number and strangeness, if necessary) to be able to predict products of interactions. |  |  |  |
| Appreciate that particle physics relies on the collaborative efforts of large teams of scientists and engineers to validate new knowledge. |  |  |  |
| Understand what quarks are. |  |  |  |
| Describe the properties of quarks and antiquarks. |  |  |  |
| State how many quarks are needed in a baryon and how many needed in a meson. |  |  |  |
| Be able to identify the quark make up of particles in terms of the following quarks: up (u), down (d) and straneg (s). |  |  |  |
| State what a neutron decays into. |  |  |  |
| Describe the change in quark character in in β− and in β+ decay. |  |  |  |
| State that energy and momentum are conserved in all interactions. |  |  |  |

**Quantum**

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| **Learning Objectives:** | **Confidence** | | |
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| Describe the photoelectric effect. |  |  |  |
| State what is meant by the threshold frequency. |  |  |  |
| Explain how the presence of a threshold frequency was evidence for photon theory. |  |  |  |
| State what is meant by the work function, φ. |  |  |  |
| Explain what a stopping potential is. |  |  |  |
| Understand and use the photoelectric equation: hf = φ + Ek(max) |  |  |  |
| Explain why the kinetic energy in the photoelectric equation is a maximum. |  |  |  |
| ***State what is meant by the following words:*** |  |  |  |
| * ionisation |  |  |  |
| * excitation |  |  |  |
| * ground state |  |  |  |
| * de-excitation |  |  |  |
| * electron volt |  |  |  |
| Describe how electrons can be ionised or excited. |  |  |  |
| Describe what happens when an electron is de-excited. |  |  |  |
| Describe what happens in a fluorescent tube. |  |  |  |
| Convert from eV to joules and vice versa. |  |  |  |
| Describe what a line spectra shows. |  |  |  |
| Explain how a line spectra is evidence for transitions between discrete energy levels. |  |  |  |
| Understand and use the following equation: hf = E1 – E2 |  |  |  |
| Explain what electron diffraction is and how it suggests that particles possess wave properties. |  |  |  |
| Calculate de Broglie wavelength using the equation 𝜆 = h /(𝑚𝑣) |  |  |  |
| Explain how and why the amount of diffraction changes when the momentum of the particle is changed. |  |  |  |
| Appreciate knowledge and understanding of the nature of matter changes over time. |  |  |  |
| Appreciate that such changes need to be evaluated through peer review and validated by the scientific community. |  |  |  |

**Progressive and Stationary Waves**

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| **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| Define what a progressive wave is. |  |  |  |
| ***Define the following words and state their units:*** | | | |
| * amplitude |  |  |  |
| * frequency |  |  |  |
| * wavelength |  |  |  |
| * speed |  |  |  |
| * phase |  |  |  |
| * phase difference |  |  |  |
| * time period |  |  |  |
| Carry out calculations using the wave equation, c = fλ. |  |  |  |
| Carry out calculations using the time period equation, T= 1/f. |  |  |  |
| Describe a transverse wave and give examples. |  |  |  |
| Describe a longitudinal wave and give examples. |  |  |  |
| Compare transverse waves and longitudinal waves. |  |  |  |
| State common features of all electromagnetic waves. |  |  |  |
| Define polarisation. |  |  |  |
| Explain why polarisation can only happen for transverse waves. |  |  |  |
| Describe uses of polarisers, including Polaroid material and the alignment of aerials. |  |  |  |
| Define what a stationary wave is. |  |  |  |
| Explain how a stationary wave is formed from two progressive waves travelling in opposite directions towards each other. |  |  |  |
| Draw a stationary wave. |  |  |  |
| Define nodes and antinodes. |  |  |  |
| Label nodes and antinodes onto a graphical depiction of a standing wave. |  |  |  |
| Explain what harmonics are. |  |  |  |
| Calculate the first harmonic using the equation. |  |  |  |
| Calculate further harmonics by understanding what happens to the frequency as the order of the harmonic increases. |  |  |  |
| Describe how standing waves are formed in different scenarios including on a string and in a microwave. |  |  |  |
| ***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. |  |  |  |

**Refraction, Diffraction and Interference**

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| **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| Define the term path difference. |  |  |  |
| Define coherence. |  |  |  |
| State an example of monochromatic light. |  |  |  |
| Explain constructive and destructive interference. |  |  |  |
| Describe diffraction. |  |  |  |
| Describe the pattern produced when coherent light is passed through a double-slit. (Young’s double slit experiment). |  |  |  |
| Explain how the pattern is produced in a double-slit experiment. |  |  |  |
| Describe the safety issues associated with using lasers. |  |  |  |
| Understand and use the following equation w = λD/s. |  |  |  |
| Describe and explain what the pattern would look like if using white light. |  |  |  |
| Describe the interference produced with sound and electromagnetic waves. |  |  |  |
| Appreciate how knowledge and understanding of nature of electromagnetic radiation has changed over time. |  |  |  |
| Describe the pattern produced when monochromatic light is shone through a single slit. |  |  |  |
| Describe the pattern produced when white light is shone through a single slit. |  |  |  |
| State and explain how the variation of the width of the central diffraction maximum is affected by wavelength and slit width. |  |  |  |
| Derive and use dsinθ = nλ |  |  |  |
| Describe the pattern produced by a plane transmission diffraction grating at normal incidence. |  |  |  |
| Describe the uses of application gratings. |  |  |  |
| Understand what refraction is and what causes refraction. |  |  |  |
| Understand and use the equation for the refractive index of a substance: n = c / cs |  |  |  |
| State the refractive index of air. |  |  |  |
| Understand and use Snell’s law of refraction for a boundary: n1sin θ1 = n2sin θ2 |  |  |  |
| Describe what total internal reflection is. |  |  |  |
| Explain when total internal reflection occurs with reference to the critical angle. |  |  |  |
| Be able to calculate the critical angle for a medium: sin θc = n2 / n1 |  |  |  |
| Explain how simple fibre optics work. |  |  |  |
| Explain the function of cladding in optical fibres. |  |  |  |
| Describe what is meant by material dispersion. |  |  |  |
| Describe what is meant by modal dispersion. |  |  |  |
| Describe the principles of pulse broadening and absorption. |  |  |  |
| Describe the consequences of pulse broadening and absorption. |  |  |  |
| ***Core Practical*** | | | |
| Investigation of interference effects to include the Young’s slit experiment and interference by a diffraction grating. |  |  |  |

**Vectors, Forces and Moments**

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| **Learning Objectives:** | **Confidence** | | |
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| State what is meant by the term scalar. |  |  |  |
| State what the term vector means. |  |  |  |
| Give examples of vectors and scalars. |  |  |  |
| Calculate the resultant vector numerically or by scale drawing. (Calculations will be limited to two vectors at right angles). |  |  |  |
| Resolve vectors into two components at right angles to each other (vertically and horizontally). |  |  |  |
| Resolve vectors into two components that are along and perpendicular to an inclined plane. |  |  |  |
| State what is meant by the term coplanar. |  |  |  |
| State the conditions for equilibrium for two forces acting at a point. |  |  |  |
| State the conditions for equilibrium for three coplanar forces acting at a point. |  |  |  |
| Describe the motion of an object that is in equilibrium. |  |  |  |
| State what ‘moment’ means. |  |  |  |
| Calculate the moment of a force about a point. |  |  |  |
| State what ‘couple’ means. |  |  |  |
| Calculate the moment of a couple. |  |  |  |
| State the principle of moments. |  |  |  |
| Apply the principle of moments to a given context. |  |  |  |
| State what is meant by centre of mass. |  |  |  |
| Explain why the centre of mass of a uniform regular object is at its centre. |  |  |  |

**Motion and Momentum**

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| **Learning Objectives:** | **Confidence** | | |
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| ***Define the following words:*** | | | |
| * displacement |  |  |  |
| * speed |  |  |  |
| * velocity |  |  |  |
| * acceleration |  |  |  |
| Apply the equations for velocity and acceleration, including average and instantaneous speeds and velocities. |  |  |  |
| Represent uniform and non-uniform acceleration on graphs. |  |  |  |
| Deduce what the area under an acceleration-time graph represents. |  |  |  |
| Draw a velocity-time graph. |  |  |  |
| Deduce what the gradient and area under a velocity-time graph represents. |  |  |  |
| Apply and use the equations for uniform acceleration (SUVAT) for one-dimension one-direction problems. |  |  |  |
| Apply and use the equations for uniform acceleration (SUVAT) for one-dimension problems. |  |  |  |
| Understand the independent effect of motion in the horizontal and vertical directions in a uniform gravitational field. |  |  |  |
| Apply and use the equations for uniform acceleration (SUVAT) for two dimension problems. |  |  |  |
| Describe the effect of friction. |  |  |  |
| Describe the effect of lift and drag forces. |  |  |  |
| Explain what is meant by terminal speed and when it occurs. |  |  |  |
| Describe what happens to air resistance with increased speed. |  |  |  |
| Explain what effect air resistance has on the trajectory of a projectile. |  |  |  |
| State the factors that affect the maximum speed of a vehicle. |  |  |  |
| State the three laws of motion |  |  |  |
| Apply the three laws of motion to appropriate situations. |  |  |  |
| Understand and use F=ma in situations where the mass is constant. |  |  |  |
| Define momentum as mass x velocity. |  |  |  |
| State the conservation of linear momentum. |  |  |  |
| Apply the conservation of linear momentum to problems in one dimension. |  |  |  |
| State force as the rate of change of momentum and apply the equation F = Δmv / Δt. |  |  |  |
| Define impulse. |  |  |  |
| Deduce what the area under a force-time graph represents. |  |  |  |
| Explain how impact forces are related to contact time (eg kicking a football, crumple zones, packaging). |  |  |  |
| State what is meant by an elastic and inelastic collision. |  |  |  |
| Carry out calculations involving elastic and inelastic collisions. |  |  |  |
| Carry out calculations involving explosions. |  |  |  |
| Appreciate the use of momentum conservation issues in the context of ethical transport design. |  |  |  |
| ***Core Practical*** | | | |
| Determination of g by a free-fall method. |  |  |  |

**Work, Energy and Power**

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| **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| Calculate the energy transferred using the equation: W = Fs cosθ |  |  |  |
| State what is meant by the term ‘power’. |  |  |  |
| Calculate the power using P = ΔW / Δt = Fv |  |  |  |
| Explain what would happen to power if the force was not constant. |  |  |  |
| Deduce what the area under a force-displacement graph represents. |  |  |  |
| State what is meant by the term efficiency. |  |  |  |
| Calculate efficiency using efficiency = useful output power / input power. |  |  |  |
| Express efficiency as a percentage. |  |  |  |
| State what the principle of conservation of energy is. |  |  |  |
| Apply the principle of conservation of energy. |  |  |  |
| Calculate change in gravitational potential energy. |  |  |  |
| Calculate kinetic energy. |  |  |  |
| Describe and explain applications of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces. |  |  |  |

**Materials**

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| **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| State what is meant by density. |  |  |  |
| Calculate density using ρ = m / V. |  |  |  |
| State Hooke’s law. |  |  |  |
| State what is meant by elastic limit. |  |  |  |
| Understand and apply F = kΔL to an example. |  |  |  |
| Define tensile strain. |  |  |  |
| Define tensile stress. |  |  |  |
| Calculate tensile strain. |  |  |  |
| Calculate tensile stress. |  |  |  |
| Calculate the elastic strain energy using the equation. |  |  |  |
| Deduce the elastic strain energy from a force-extension graph. |  |  |  |
| Calculate breaking stress. |  |  |  |
| ***Describe the following words:*** | | | |
| * plastic behaviour |  |  |  |
| * fracture |  |  |  |
| * brittle behaviour |  |  |  |
| Link the above words to force- extension graphs. |  |  |  |
| Quantitative and qualitative application of energy conservation to examples involving elastic strain energy and energy to deform. |  |  |  |
| Convert from elastic potential energy to kinetic and gravitational potential energy. |  |  |  |
| Interpret stress-strain curves. |  |  |  |
| Appreciate use of energy conservation issues in the context of ethical transport design. |  |  |  |
| Define Young’s modulus. |  |  |  |
| Calculate Young’s modulus as stress/strain. |  |  |  |
| Use a stress-strain graph to deduce Young’s modulus. |  |  |  |
| ***Core practical*** | | | |
| Determination of the Young modulus by a simple method. |  |  |  |

**Electrical Properties**

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| **Learning Objectives:** | **Confidence** | | |
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| ***Define the following terms:*** | | | |
| * Current |  |  |  |
| * Charge |  |  |  |
| * Potential difference |  |  |  |
| * Resistance |  |  |  |
| ***Calculate quantities using the following equations:*** | | | |
| * I = ΔQ / Δt |  |  |  |
| * V = W / Q |  |  |  |
| * R = V / I |  |  |  |
| 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) |  |  |  |
| State Ohm’s law. |  |  |  |
| Recognise that Ohm’s law is a special case where I is directly proportional to V under constant physical conditions. |  |  |  |
| Describe why ammeters must be connected in series and voltmeters in parallel. (Ammeters and voltmeters should be treated as ideal unless specifically stated) |  |  |  |
| Define resistivity. |  |  |  |
| Suggest reasons why resistivity is a better quantity to state than resistance. |  |  |  |
| Understand and use the resistivity equation: ρ = RA / L |  |  |  |
| Describe and explain the effect of temperature on the resistance of metal conductors. |  |  |  |
| Describe the effect of temperature on the resistance of thermistors. (Only negative temperature coefficient, ntc, thermistors will be considered). |  |  |  |
| Describe application of thermistors, including in temperature sensors. |  |  |  |
| Explain what ‘superconductor’ means. |  |  |  |
| Describe how superconductors can be used to produce strong magnetic fields and to reduce energy losses in the transmission of electric power. |  |  |  |
| ***Core Practical*** | | | |
| Determination of resistivity of a wire using a micrometer, ammeter, and voltmeter. |  |  |  |

**Circuits**

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| **Learning Objectives:** | **Confidence** | | |
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| Calculate the value for total resistance when resistors are connected in series. |  |  |  |
| Calculate the value for total resistance when resistors are connected in parallel. |  |  |  |
| Calculate values for resistance when components are connected in a combination of series and parallel. |  |  |  |
| Calculate electrical energy using the equation, E = IVt. |  |  |  |
| Calculate electrical power using: P = IV = I2R = V2/R. |  |  |  |
| State Kirchhoff’s first law. |  |  |  |
| Explain why current into a junction must equal the current exiting a junction. |  |  |  |
| Calculate current in a series or parallel circuit. |  |  |  |
| State Kirchhoff’s second law. |  |  |  |
| Define potential difference. |  |  |  |
| Define electromotive force. |  |  |  |
| Calculate the potential difference of components in series or parallel circuits. |  |  |  |
| Explain what happens to cells that are combined in series. |  |  |  |
| Explain what happens to cells that are combined in parallel. |  |  |  |
| Describe what a potential divider does. |  |  |  |
| Describe the purpose of a negative temperature coefficient (ntc) thermistor and draw the circuit symbol. |  |  |  |
| Describe the purpose of a light dependent resistor (LDR) and draw the circuit symbol. |  |  |  |
| Derive the equation for a potential divider. |  |  |  |
| 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. |  |  |  |
| Understand what internal resistance is. |  |  |  |
| Define terminal potential difference. |  |  |  |
| **Apply the following equations to a circuit:** | | | |
| * ε = E/Q |  |  |  |
| * ε = I (R + r) |  |  |  |
| Preform calculations for circuits where the internal resistance is **not** negligible. |  |  |  |
| ***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. |  |  |  |

**Periodic Motion (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
|  |  |  |
| Describe the motion in a circular path at constant speed. |  |  |  |
| Explain why motion in circular path requires a centripetal force. |  |  |  |
| Estimate the acceleration and centripetal force in situations that involve rotation. |  |  |  |
| State the centripetal force in a situation. |  |  |  |
| Calculate the magnitude of angular speed using ω = v / r = 2πf. |  |  |  |
| Convert between radians and degrees. |  |  |  |
| Calculate centripetal acceleration using a = v2/r = ω2r. |  |  |  |
| Derive and use the equation for centripetal force F = mv2/r= mω2r. |  |  |  |
| Describe simple harmonic motion. |  |  |  |
| Explain the characteristics of simple harmonic motion. |  |  |  |
| State the conditions for simple harmonic motion. |  |  |  |
| Define an equation for simple harmonic motion a = - ω2x and x = A cos 𝜔t and v = ±ω √(A2 − x2) |  |  |  |
| ***Sketch the following graphs:*** | | | |
| * x against t. |  |  |  |
| * v against t. |  |  |  |
| * a against t. |  |  |  |
| * kinetic energy against x. |  |  |  |
| * kinetic energy against t. |  |  |  |
| * potential energy against x. |  |  |  |
| * potential energy against t. |  |  |  |
| * total energy against x. |  |  |  |
| * total energy against t. |  |  |  |
| 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. |  |  |  |
| Calculate maximum speed using ωA. |  |  |  |
| Calculate maximum acceleration using ω2A |  |  |  |
| Study the mass-spring system and use the equation for time period of this system. |  |  |  |
| Study the simple pendulum and use the equation for time period of this system. |  |  |  |
| Explain why we use the small angle approximation in the derivation of the time period formula. |  |  |  |
| Apply simple harmonic motion to other contexts (eg liquid in a U-tube). |  |  |  |
| Describe the effect of damping on oscillations. , |  |  |  |
| State what free vibrations mean. |  |  |  |
| State what is meant by forced vibrations. |  |  |  |
| State what resonance is. |  |  |  |
| Describe the effect of damping on the sharpness of resonance. |  |  |  |
| Apply knowledge of resonance to mechanical systems and situations involving stationary waves. |  |  |  |
| ***Core Practical*** | | | |
| Investigation into simple harmonic motion using a mass-springsystem and a simple pendulum. |  |  |  |