**A-Level Paper 3 Personal Learning Checklist**

**Practical Skills**

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| **Learning Objectives:** | **Confidence** | | |
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| Solve problems set in practical contexts |  |  |  |
| Apply scientific knowledge to practical contexts |  |  |  |
| Comment on experimental design |  |  |  |
| Evaluate scientific methods. |  |  |  |
| Present data in appropriate ways |  |  |  |
| Evaluate results. |  |  |  |
| Draw conclusions with reference to measurement uncertainties and errors. |  |  |  |
| Identify variables including those that must be controlled |  |  |  |
| Plot and interpret graphs |  |  |  |
| Process and analyse data using appropriate mathematical skills as exemplified in the mathematical appendix. |  |  |  |
| Consider margins of error, accuracy and precision of data |  |  |  |
| Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification |  |  |  |
| ***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. |  |  |  |
| Investigation of interference effects to include the Young’s slit experiment and interference by a diffraction grating. |  |  |  |
| Determination of g by a free-fall method |  |  |  |
| Determination of the Young modulus by a simple method. |  |  |  |
| Determination of resistivity of a wire using a micrometer, ammeter and voltmeter. |  |  |  |
| 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. |  |  |  |
| Investigation into simple harmonic motion using a mass-spring system and a simple pendulum. |  |  |  |
| Investigation of Boyle’s (constant temperature) law and Charles’s (constant pressure) law for a gas. |  |  |  |
| Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant RC. |  |  |  |
| Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance. |  |  |  |
| Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction. |  |  |  |
| Investigation of the inverse-square law for gamma radiation. |  |  |  |

**Turning Points (A-Level only)**

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| **Learning Objectives:** | **Confidence** | | |
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| State what is meant by a cathode ray. |  |  |  |
| Describe the structure of a discharge tube. |  |  |  |
| Explain how cathode rays are produced in a discharge tube. |  |  |  |
| Describe thermionic emission. |  |  |  |
| Calculate the work done in accelerating an electron through a potential difference using 1/mv2 = eV |  |  |  |
| Determine the specific charge of an electron. |  |  |  |
| Explain the significance of Thomson’s determination of the specific charge of an electron. |  |  |  |
| Compare the specific charge of an electron to a hydrogen ion. |  |  |  |
| State the conditions for holding a charged oil droplet stationary between two oppositely charged parallel plates. |  |  |  |
| Understand and use QV / d = mg |  |  |  |
| Describe the motion of a falling oil droplet without an electric field. |  |  |  |
| Describe the motion of a falling oil droplet with an electric field. |  |  |  |
| Use the terminal speed to determine the mass and charge of the droplet. |  |  |  |
| State Stokes’ law. |  |  |  |
| Understand and use F = 6πηrv |  |  |  |
| Explain the significance of Millikan’s results. |  |  |  |
| Explain why charge is considered quantised. |  |  |  |
| State what is meant by wave-particle duality. |  |  |  |
| Describe Huygen’s wave theory in general terms. |  |  |  |
| Describe Newton’s corpuscular theory of the light. |  |  |  |
| Compare Huygen’s wave theory to Newton’s corpuscular theory of light. |  |  |  |
| Explain why Newton’s theory was preferred. |  |  |  |
| Explanation of fringes in Young’s double slit experiment. (No calculations expected here). |  |  |  |
| Explain why there was a delayed acceptance of Huygen’s wave theory of light. |  |  |  |
| Describe the nature of electromagnetic waves. |  |  |  |
| Calculate the speed of electromagnetic waves in a vacuum using Maxwell’s formula: c = 1 / √(0ε0) |  |  |  |
| Appreciate that 0 relates to the electric field strength due to a charged object in free space and ε0 relates to the magnetic flux density due to a current-carrying wire in free space. |  |  |  |
| Describe how Hertz discovered radio waves. |  |  |  |
| Describe how Hertz was able to take measurements to find the speed of radio waves. |  |  |  |
| Describe Fizeau’s determination of the speed of light |  |  |  |
| Explain the implications of Fizeau’s determination of the speed of light |  |  |  |
| Describe the ultraviolet catastrophe. |  |  |  |
| Describe the black-body radiation. |  |  |  |
| Explain Planck’s interpretation of photoelectricity in terms of quanta. |  |  |  |
| Explain why classical wave theory failed to explain the observations of photoelectricity. |  |  |  |
| Explain Einstein’s explanation of photoelectricity. |  |  |  |
| Describe the significance of Einstein’s explanation of photoelectricity in terms of the nature of electromagnetic radiation. |  |  |  |
| State de Broglie’s hypothesis: p = h / λ; λ = h / √(2meV) |  |  |  |
| Describing low-energy electron diffraction experiments. |  |  |  |
| Explain the effect of a change of electron speed on the diffraction pattern. |  |  |  |
| Estimate the anode voltage needed to produce wavelengths of the order of the size of the atom. |  |  |  |
| Describe the principles of operation of the transmission electron microscope (TEM). |  |  |  |
| Describe the principles of operation of the scanning tunneling microscope (STM). |  |  |  |
| Describe the principles of the Michelson-Morley interferometer. |  |  |  |
| Outline of the experiment as a means of detecting absolute motion. |  |  |  |
| Explain the significance of the failure to detect absolute motion. |  |  |  |
| State the invariance of the speed of light. |  |  |  |
| Describe the concept of an inertial frame of reference. |  |  |  |
| State the two postulates of Einstein’s theory of special relativity. |  |  |  |
| Explain the difference between proper time and time dilation as a consequence of special relativity. |  |  |  |
| Calculate the time dilation using: t = t0 / √ (1 – (v2 / c2)) |  |  |  |
| Describe the evidence for time dilation from muon decay. |  |  |  |
| Calculate length contraction using: l = l0√ (1 – (v2 / c2)) |  |  |  |
| Calculate the equivalence of mass and energy using: E = mc2 and E = m0c2/ √ (1 – (v2 / c2)) |  |  |  |
| Sketch a graph of mass against speed. |  |  |  |
| Sketch a graph of kinetic energy with speed. |  |  |  |
| Describe Bertozzi’s experiement. |  |  |  |
| Explain how Bertozzi’s experiment is direct evidence for the variation of kinetic energy with speed. |  |  |  |