GCE

Rewarding Learning

Chief Examiner's Report

Physics

Summer Series 2023

Foreword

This booklet outlines the performance of candidates in all aspects of this specification for the Summer 2023 series.

CCEA hopes that the Chief Examiner's and/or Principal Moderator's report(s) will be viewed as a helpful and constructive medium to further support teachers and the learning process.

This booklet forms part of the suite of support materials for the specification. Further materials are available from the specification's microsite on our website at www.ccea.org.uk.

Contents

GCE PHYSICS

Chief Examiner's Report

Subject Overview

Candidates' performance was similar to last year in terms of the wide range of marks achieved. As commented on in 2022, the performance of candidates at the top grades was comparable to previous years but the overall range of marks achieved appeared to be considerably higher with lower grade candidates on a lower raw mark than previously would have been the case.

Handwriting and sentence structure in written responses is a weakness for many candidates. Candidates should be aware that they should score out and write fresh answers rather than overwriting numbers, as it is difficult for examiners to decipher overwritten numbers when the paper has been scanned. Unorganised layout of working in unstructured calculations continues to create problems. Where the correct answer has not been achieved and examiners are trying to award credit for candidates working it is difficult on scripts where the working is unclear. Points on graphs or lines on grids should be clearly marked so that they can be identified after the scanning process.

Candidates should be reminded that while past papers and their mark schemes are useful tools, they should not be reliant upon the mark schemes for learning answers. Knowledge must be applied to the specific question asked. Evidence of careful reading and interpretation of the question was missing in many responses. When a definition is required, candidates should ensure that their responses are unambiguous and can not be interpreted in a different way than they intend.

When performing calculations using given data it is expected that candidates should quote their answer to a suitable number of significant figures. While not doing so will not be penalised in every question it is expected as good practice and will, on occasions where relevant, be penalised. Answers should also be given on the answer line rather than working out shown leading to an answer and the answer line left blank.

In questions where candidates are asked to 'show that..' there should be a clear starting point from first principles and it should be obvious at each step what the candidate is doing. There should be no jumps or skipping steps. Even though it may be obvious that the candidate knows what they are doing, the purpose of these questions is to assess whether they can explain the physics behind the calculation or derivation. Lack of structure will result in loss of marks. If there is a numerical value being 'shown' in a question of this type, the value should be quoted to one more significant figure than the value given in the question.

Assessment Unit AS 1 Forces, Energy and Electricity

Unit Overview

In general, candidates performed well in this paper. There was a very wide range in marks from candidates of an extremely high standard to those who found the paper extremely challenging.

The paper was accessible to almost all candidates and most candidates demonstrated a sound understanding of the Physics involved in this unit. There was no evidence to suggest that candidates had insufficient time to complete the paper. The paper appeared well balanced and addressed most topics on the AS1 specification. Definitions were not always accurately known. Questions involving calculations were generally answered better than questions that required some sort of explanation.

Poor handwriting and poorly structured work still occasionally present difficulties awarding marks for some candidates. The level of language used in the examination appeared to be appropriate for all candidates.

The questions that were the most discriminating were Parts 1(c), 3 (c), 5 (b)(i), 5 (b)(ii), 6 (a)(i), 6 (b), 7 (b) and 9(b). The paper was, however, successful in allowing candidates of differing abilities to respond positively to most of the questions.

Q1 **(a)** This was generally well answered but some candidates did not give a clear definition of base units. A very small number confused the definition with that for scalars/vectors.

(b) Most candidates accessed the first three marks in this question. The most common mistake was to incorrectly combine the indices for seconds.

(c) Most candidates correctly calculated the mass of the sphere in Part (i). However, Part (ii) was more challenging. Most candidates correctly calculated 52% of the mass but struggled to access any other marks. Dealing with the mass of one mole and Avogadro's constant caused difficulties for many candidates. A good discriminator.

Q2 **(a)** This question was very well attempted by most candidates.

(b) Some candidates forgot to square the velocity in Part (b)(i). In Part (b)(ii), some candidates did not read the stem of the question and used conservation of energy rather than momentum.

Q3 **(a)** The definition of the moment of a force was not always accurately and fully stated. It was either very well stated or one of the two marking points were omitted due to lack of clarity as to the perpendicular distance from the force to the point. A few candidates confused this definition with the principle of moments.

(b) This was well done by many. However, a significant number of candidates gave the base units instead of the SI unit.

(c) This question was challenging for many candidates. The majority knew how to take moments about a point. A small number forgot to convert mass to weight. Many did not correctly calculate the distance to the force F. cSome did not correctly resolve F into a vertical component. ECF benefitted many candidates in this question. A good discriminator.

(d) Most candidates correctly identified the increased time leading to a reduced force but very few stated that the impulse was equal to the change in momentum which remained constant.

Q4 **(a)** The vast majority of candidates sketched the velocity-time graph correctly and gained 2 marks.

(b) Most candidates stated the correct equation of motion and were able to obtain the correct value for the acceleration of the pod. Some answered in terms of use of gradient and gained full marks.

(c) This part was generally very well done. A few candidates forgot to multiply the distance travelled in the first 6.25 s by two in order to obtain the distance travelled during the last 6.25 s of the motion.

(d) This was very well completed by most candidates.

Q5 **(a)** It was common for candidates to achieve 2 out of 3 marks for their Newton's 2nd Law definition by often forgetting to include the word resultant or the direction of the acceleration.

(b) Only some candidates correctly calculated the mass of the person in Part (i). There was generally a poor understanding of the appropriate force vectors to create the upwards acceleration of 0.8 m s^{-2}. Many were unable to apply F=ma correctly to the lift. Candidates benefitted from and ecf in Part (II). However, it was sometimes unclear if they knew that R = mg due the acceleration of the lift being equal to zero. A good discriminator.

Q6 **(a)** The vector diagram caused difficulties for many candidates. Vectors V_a and V_r were often mixed up. If vectors were drawn from a point, they often did not form a right angle and the first marking point was not awarded. Some candidates incorrectly drew V_w being perpendicular to V_a rather than V_r. Incorrect vector diagrams in Part (i) sometimes meant that candidates were not able to score marks in Part (ii) but many did benefit from and ecf in this part and also in Part (ii). Part (i) was a good discriminator. Part (iv) was well done by many and again, some benefitted from an ecf in this part.

(b) This was surprisingly poorly completed by many candidates. Many drew a curve in the wrong direction and could not access the first marking point. Several candidates drew a straight line rather than a parabola. A good discriminator.

Q7 **(a)** This was very well answered by almost all candidates.

(b) This part caused difficulties for a significant number of candidates. Many started with an EMF of 2V, while others did not divide their r value by 3 to get r for each cell. A good discriminator.

Q8 **(a)** Many candidates incorrectly applied V=IR and P = VI in Part (i) and assumed that the voltage given in the stem was the voltage across the bulb. Part (ii) also presented difficulties however, many benefitted from an ecf in this part and scored 4 marks. A number of candidates correctly calculated the voltage across the bulb but did not subtract this from 6V to obtain the voltage across the box.

(b) A significant number of candidates correctly drew a curve with decreasing gradient but incorrectly extended the decrease to horizontal or beyond and scored 1 mark. The answers to Part (ii) were variable. The first 2 points were obtained by most candidates, but many talked about particles and atoms instead of ions and did not score the third marking point. Some candidates talked about extra charge carriers being released.

(c) Part (i) was well done by most candidates. In part (ii) some candidates did not answer the question as to whether the bulb was on or off. They stated "no" and could not access the two marks available.

Q9 **(a)** In Part (i), if candidates talked about the deformation of the wire, they either talked about length or area but very few candidates talked about both.

Part (ii) was well answered by most candidates, possibly since no conversion of units was required. Most correctly recalled the formula for resistivity.

(b) Many candidates calculated the resistance across both the strain gauge and the buzzer was 50 Ω but stopped short of completing the question. Others were unable to substitute into the potential divider equation correctly. Only those who fully understood the physics of the circuit were able to obtain full marks in the question. A good discriminator.

Assessment Unit AS 2 Assessing Waves, Photons and Astronomy

Unit Overview

The paper covered all sections of the specification and facilitated a broad range of outcomes. Candidates of all abilities accessed all questions on the paper, with no evidence of poor time management and little evidence of blank answer spaces. Most answers were clearly written and in general, calculations were laid out in an appropriate manner. In questions where recall of facts or definitions was required, there was a surprising lack of clarity in many cases, with absence or misunderstanding of key words or phrases even when stimulus material was provided. When asked to explain differences between two types of imaging, many candidates did not provide an answer that adequately made a comparison between the two. Completion of the ray diagram was generally well done, with straight lines and arrows on rays. Generally, candidates were more successful in questions involving calculations than in those parts where written explanations or definitions were required.

Q1 **(a)** Candidates were successful in identifying examples of transverse and longitudinal waves. The majority were successful in distinguishing between the two types of wave, the most common error being a failure to identify the 'vibrations/ oscillations' in relation to the direction of the wave.

(b) These parts were generally well answered; candidates correctly identified and labelled the amplitude, most were measuring across more than 1 waveform to find the period and making correct use of the wave equation to calculate wavelength. There was a lot of variation in the care taken and the detail of the sketched waveforms, the more successful candidates had marked crossing points on the x-axis and positions of crests and troughs.

Q2 **(a)** Sketches varied in quality, at times the 'object' was not adequately labelled or the metre-rule was not included.

(b) Few answers included the point that a minimum of five sets of readings should be taken.

(c) The most common answer was a graph of 1/u against 1/v.

(d) Of these there were a good number who explained how to find a value for f from an intercept, with fewer referencing finding an average value. Many incorrectly referenced using the gradient.

Q3 **(a)** Most candidates gave acceptable answers to distinguish between the Doppler and cosmological red-shift. A small number who referenced sound waves could not gain credit.

(b) The calculation was generally well done, candidates recognised the equations required from their formula sheet. A standard error was division by the longer wavelength rather than the true value, leading to a value of 3.99×10^6 m s^{-1} for two out of three marks. Candidates followed on to correctly calculate a distance, but a very small number gave a correct explanation for this being an estimate – the majority commented on the expansion of space.

Q4 **(a)** A good number of candidates correctly stated that the laser light is in phase, although many incorrectly used constant phase 'difference'. Many added information related to frequency and wavelength.

(b) Candidates were nearly all confident in applying the correct equation, with standard errors following from incorrect values of 'y'. the m ⇨ mm conversion was correctly made in most cases.

Q5 **(a)** The required marking points were achieved by most candidates, linking the power to the focal length and converting 0.5 m to 50cm. The three properties of the image were listed by many candidates, with some writing sentences to describe the formation of the image but not always using the required language. For Part (iii) there was some discrimination between those who could correctly use the lens equation (or otherwise) to calculate the far point with the glasses in place.

(b) A good number of candidates achieved full marks for their ray diagram. Common errors included failure to add arrows to the rays, or failing to draw the first ray as if it was coming from the focus F, many drawing the ray coming from the point marked O instead. For those candidates who attempted a ray diagram as if the lens were a converging lens, the maximum mark was 1, for the ray through the optical centre of the lens.

Q6 **(a)** There was great variation in the attempts made by candidates to explain the photoelectric effect. Many neglected to mention the minimum energy/ frequency requirement. Many referenced electron release from 'atoms' rather than metal or metal surface.

(b) A good number of candidates did calculate the required value of 4.31 eV as the work function. In some cases, candidates attempted to work from Einstein's photoelectric equation, without identifying the work function. In their attempt to answer Part (ii), most candidates failed to take account of the information and labelling of **Fig. 6.1** and were not accurate in their explanation of the range of kinetic energies of emitted particles – many referenced electron positions/levels within an atom rather than relative to the surface of the metal.

Q7 **(a)** There was a lack of clarity and accuracy in many explanations of the negative energy values for levels within the atom, despite the mark-scheme being developed to include an alternative answer.

(b) Calculations were mainly correctly done by candidates and the transition between C and B was identified by the majority. A small number stated from B to C to lose the final mark. In Part (ii) only a minority could explain correctly why the transition could not occur, though most achieved the first mark.

(c) It was surprising how many candidates could not correctly define 'CT' scanning. In comparing CT and X-ray imaging, while most were aware of properties of CT, there was an evident lack of skill in making the comparison between the two in order to achieve the marks for this question type.

Q8 **(a)** Both parts were well answered by most candidates.

(b) The majority were correct in stating that the wavelength and aperture width should be equal, with some losing the mark for 'similar' in size or approximately equal, for example.

(c) There was a range of marks awarded across both parts – accuracy was lacking in many descriptions of how the pattern would change (no reference to the circular pattern) and more able candidates gave full explanations of why this occurred. The calculation challenged many candidates, and standard errors included incorrect conversion from m^{-1} to mm^{-1}, failure to calculate the number of lines from the d value, failure to identify that n=2. A number of candidates attempted to calculate a value of n from the equation.

Q9 **(a)** A complete and correct expression of Snell's Law was not given by many candidates, some defined refractive index for example.

(b) Many candidates got two marks here, a good number had to define the refractive index used in their equation and move from ${}_{g}n_{a}$ to ${}_{a}n_{g}$ in order to reach the required answer.

(c) Challenging parts for candidates here – a good number correctly calculated the speed of light in the core material, but only the most able reached the correct answer in Part (ii) – the first mark was rarely awarded for those who did not get the correct answer, and there was no follow from Part (i).

Q10 **(a)** This was not well answered by candidates, with few achieving two marks. A very small number referred to the driver frequency matching the natural frequency, most who gained a mark mentioned formation of a standing wave and the more able explained in terms of superposition.

(b) The majority of candidates labelled the A and N positions correctly, but there were many inaccurate descriptions of wave behaviour at those points – primarily use of 'minimum' displacement and maximum 'displacement'. In Parts (iii) and (iv) there was discrimination between candidates who recognised the first and second positions of resonance as a quarter wavelength and three-quarters of a wave-length and those who did not, with little opportunity for achieving part marks.

Assessment Unit AS 3A Practical Techniques and Data Analysis

Unit Overview

In general candidates performed well in this paper. The questions allowed most candidates to respond positively to at least part of each question. There were some issues in a minority of centres where apparatus lists/set-up instructions had not been followed and this resulted in candidates having answers outside the range, or to a different number of decimal places in meter readings than given in the mark scheme. Where possible, centres should set up as apparatus as instructed to ensure that their candidates are not disadvantaged. Uncertainties in measuring instruments were correctly quoted to ± the smallest division by the majority of candidates.

Q1 **(a)** Most candidates were able to access between 5-7 marks in this question. The most common error was to ignore the conversion from mA in the resistance calculation. Layout of the table was generally well done with candidates almost all using a solidus and including correct units in the table heading. A small number of candidates did not appear to be able to set up a correct circuit and their readings were incorrect. They could still access many of the marks if they showed the skills of recording results correctly.

(b) This was quite well answered by most candidates. Weaker candidates gave confused explanations or couldn't relate the results to what they had been asked to do. Most scored the first mark.

Q2 **(a)** This was well answered with most candidates achieving full marks. Some included an extra decimal place when averaging the tension in Part (iii) and were penalised.

(b) This was well answered. Candidates were not penalised here if they made an error for which a penalty had been applied in Part (a).

(c) This question discriminated well, top grade candidates showed clear working and used both sets of results to achieve full marks. Weaker candidates usually scored part marks for some of the steps in the calculation.

Q3 **(a)** The table of results was completed by candidates and all seemed to get the correct trend of the larger diameter when h increased. A few recorded values in mm and some averaging was done incorrectly. In Part (ii) there were a few vague statements about reliability and averaging rather than a correct explanation.

(b) This was well done by top grade candidates but many weaker candidates seemed to struggle with the power of 4 being unfamiliar to them. Conclusions were well explained by those who could work with the equation to find a k value.

Q4 **(a)** Full mark were award to the majority of candidates. A few had valued greater than 100g and had included the mass of the beaker.

(b) The temperature values were recorded to the nearest degree by the majority of candidates and uncertainty correctly given as ±1°C. Some candidates did not double the uncertainty in Part (ii)

(c) Substitution into the equation was well done here but few candidates quoted their answer to the correct number of significant figures based on their temperature values and were not awarded the second mark.

Assessment Unit AS 3B Practical Techniques and Data Analysis

Unit Overview

Candidates' performance in this paper varied widely. Many scored highly but a significant number showed a lack of skills in data analysis and interpreting information successfully. The format of the paper was similar to previous years but the novel context of some the questions proved difficult for weaker candidates.

Q1 Drawing a graph from given points was done well by most candidates although plenty struggled with the negative temperature axis. The Mark Scheme on this question is by now well established so marks were accessed easily by candidates who had prepared well. A significant number lost marks for the points not covering more than half of the available grid.

Q2 **(a)** The majority of candidates correctly calculated the 3% value, some then subtracted this rather than added. The other common error was not to quote the time to 0.001 s.

(b) This was well answered by top grade candidates. Weaker candidates struggled to interpret what they were trying to calculate.

(c) This question discriminated well, top grade candidates had no problem and displayed a variety of methods to achieve the correct answer. Weaker candidates got confused and often did not progress far towards the correct answer.

Q3 **(a)** Most candidates were able to name a suitable experiment and go on to explain that by using more LED's their choice of best fit line could be better. Some gave vague statements here about repeating and averaging.

(b) The gradient was usually correctly calculated but most candidates could not cope with the power and lost 1 mark. In Part (ii) those candidates who could map the equation successfully had no problem getting the correct answer. Others tried to substitute into the equation and couldn't get a successful outcome.

Q4 **(a)** Recognition that the value had been correctly quoted to the nearest angle/2 significant figures was common and most candidates were able to explain it in terms of the uncertainty in the protractor used or the values that were averaged.

(b) This was quite poorly answered by a significant number of candidates. Explanations were vague in both Part (i) and (ii) for many. Top grade candidates showed clear understanding of the concept. A few candidates did not complete the table with values in Part (iii) and possibly missed this part and did not check their work carefully at the end to ensure they had answered all questions. The majority had measurements within the accepted range. Uncertainties were well answered to the smallest divisions of the instruments.

(c) Most drew the curve well but some had incorrectly plotted points, usually plotting 8.5 on the axis as 9.0 and others ignored the first point on the graph at (0,0). The H value was usually correct.

Q5 **(a)** This was well done by many candidates. Common errors were to use °C or ignore the power of 4, losing 1 mark.

(b) This was well answered by the majority of candidates. Weaker candidates sometimes multiplied the uncertainties together and didn't score but most either got full marks or lost 1 for omitting to multiply the T uncertainty by 4.

Assessment Unit A2 1 Deformation of Solids, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

Unit Overview

Overall, the paper had excellent specification coverage and sufficient range of questions to test candidates of all abilities. The standard of answers was generally good, and candidates displayed a noticeable improvement in knowledge of course content and development of mathematical skills compared to 2022. There were also some very high-quality answers and excellent levels of understanding of physics concepts. Very few candidates were unable to perform mathematical operations on their calculator or round correctly. However, knowledge of prefixes and unit conversions for area and volumes were still not well known.

The paper was, successful in allowing candidates of differing abilities to respond positively to most of the questions posed. Questions which were handled well by most candidates were Questions 1, 2 (a) and (b), 3, 6, 7 (a) and 8. Questions 2 (c) & (d), 4 (a), 4 (b), 5 (a), 5 (b)(i), 7 (b) & 9 provided the most difficulty. Candidates' handwriting did in some instances cause some concern. Written responses sometimes lacked the depth of language and understanding to gain full marks. The synoptic element of the paper was not always well recalled.

Q1 **(a)** The first question provided a gentle introduction to the paper with most candidates scoring full marks.

(b) There was an element of challenge in this question with some candidates incorrectly using the atomic number to calculate the radius of the nucleus. Most students were able to correctly complete the calculation.

Q2 **(a)** This proved straight forward with many candidates scoring all 4 marks for the decay equation.

(b) The written explanations for the purpose of a moderator and critical size were well done by most. A common issue was neglecting to mention smallest amount of fuel when defining critical size.

(c) While most candidates realised burning coal resulted in a larger carbon footprint, a surprising number failed to mention carbon dioxide specifically. Some candidates seemed to think that the fission process produced "some" carbon emission. Very few candidates discussed the carbon dioxide released due to mining and transport of both fuels. A common incorrect response was to discuss the radioactive waste associated with nuclear fission.

(d) Candidates struggled with this section. Many candidates incorrectly used $E=mc^2$ in both parts, resulting in wrong physics. The conversion from MeV to J in Part (ii) was usually well done.

Q3 **(a)** This was poorly answered. Only a minority of candidates correctly answered Part (i) in terms of amplitude. The most common mistake was to draw the graph of displacement for a lightly damped system. Parts (ii) and (iii) were well attempted but some descriptions in Part (iii) lacked reference to the maximum frequency calculated in Part (ii).

(b) While most candidates clearly understood the difference between a node and an antinode, the language used to distinguish between them were not precise enough. Part (ii) was poorly done with many students not making the link between the length of the hacksaw blade and the wavelength.

Q4 **(a)** This question part provided a lot of discrimination. Some candidates answered poorly by drawing sine or cosine graphs. Others gained a mark for drawing a straight line through the origin and a further mark for recall of the negative slope. Very few accessed the last mark by determining the value for the maximum and minimum amplitude from the equation and applying it correctly to their sketch.

(b) Very few candidates were able to state that $a_{max} = \omega^2 A$ and use it to obtain a correct answer.

Q5 **(a)** This definition was well answered.

(b) Some candidates found it difficult to interpret the diagram to obtain the correct value for the resultant force and incorrectly included the downward weight of the person. Other candidates lacked the mathematical knowledge required to resolve forces and obtain a resultant value. Candidates were able to obtain full marks in Part (ii) even if they had an incorrect value for v. The most common errors in Part (iii) were in the use of their calculated frequency or time period to calculate revolutions per minute.

Q6 **(a)** Most candidates could recall that the Young modulus was ratio of stress over strain but very few stated that this was only "up to the limit of proportionality". A large number of candidates stated that the elastic limit was a point and failed to link this to a "maximum" force.

(b) This part was generally well answered. The most common mistakes were a power of ten error for an incorrectly calculated area or Giga conversion. A significant number of candidates confused "strain" with "strain energy" in Part (iii).

Q7 **(a)** Candidates generally scored well in this question, both for the diagram and the procedure. Some candidates omitted the fact that the temperature must be in Kelvin. The diagram for Part (ii) was well drawn although, sometimes not well labelled. Several candidates included a foot pump linked to a pressure gauge. A small number of candidates drew the set up for Charles Law. Descriptions in Part (iii) were very well written with many candidates scoring 6 marks. Common omissions included not stating that 5 or more different readings were required and for a directly proportional graph, the line through the origin must be straight.

(b) Only a few candidates were able to score 6 marks in this part. Some were only able to score 2 marks for writing the formula and substituting values. The common mistakes were not converting the temperatures to kelvin or using 1/6 V as the final volume. A significant number of candidates could not complete the last stage to find the percentage change.

Q8 **(a)** Generally, well answered.

(b) Most candidates scored 3 or 4 in Part (i). Conversion of cm^3 to m^3 was the most common error along with confusion with N (number of molecules) and n (number of moles). Many candidates were able to access all 3 marks in Part (ii). Some candidates however forgot to square root their answer for <c2> and lost the last mark.

Q9 **(a)** The vast majority of candidates could not articulate the difference between spontaneous and random.

(b) The definition of activity was generally well understood, decay constant less so. Most candidates were able to correctly calculate the correct numeric values for the intercept and gradient. The unit mark proved more challenging with very few scoring all 5 marks due to incorrectly including units for the intercept or day-1 for the gradient.

Assessment Unit A2 2 Fields, Capacitors and Particle Physics

Unit Overview

The paper was accessible to all candidates and the majority of candidates were able to demonstrate a sound understanding of the subject knowledge and skills involved in this unit. Some of the written questions highlighted misconceptions among candidates and these were only answered well by high achieving candidates. Candidates, as would generally be the case, coped better with the calculation-based questions while the more unstructured ones proved difficult for some.

Q1 **(a)** This was very well answered by most candidates.

(b) Top grade candidates scored full marks in this question and there was a range of responses from other candidates. Most managed to achieve at least 1 or 2 marks, most commonly getting the electron correct.

(c) Most candidates performed the necessary steps to get to the correct answer here. Some did not have the G conversion correct and others did not convert to Joules.

Q2 **(a)** The angular velocity was correctly completed by the majority of candidates. In Part (ii) only top-grade candidates achieved full marks. There were a number of common errors such as, not converting to m and not subtracting the radius of the Earth. A few candidates did not know where to start and were unable to access any marks.

(b) This was very well answered by the majority of candidates.

Q3 **(a)** A minority of candidates answered this part well. Some confused magnetic and electric fields.

(b) This calculation was well done in part by many. A common error was to omit the weight of the spider in the calculation.

(c) This question challenged weaker candidates. It discriminated well with a range of marks being awarded. The synoptic nature may have caused weaker candidates difficulty.

Q4 **(a)** This was answered well by most candidates who knew the equation and were able to correctly use it. Some used relative charge in the equation. In Part (ii) the majority of candidates scored both marks, some did not get the second for the explanation.

(b) Most candidates were able to score at least one mark in Part (i) for calculating the wavelength. Some did not use the de Broglie equation despite it being on the data sheet. The kinetic energy calculation was generally well done.

Q5 **(a)** This was answered well by top grade candidates but others struggled. Responses showed clear misconceptions around capacitor physics. Many referred to positive and negative plates before charging started and some described charge carriers moving through the capacitor from one plate to the other. Electrons were often not named as the charge carriers.

(b) This was very well answered. The majority of candidates achieved full marks in both parts. Weaker candidates may not have known the required equations and could not access marks in Part (ii).

(c) Top grade candidates scored highly in this question. The majority of candidates were able to answer Part (i) and in Part (ii) most could use the equation to calculate the new current value. Some did not do the subtraction for the final mark.

Q6 **(a)** This was quite well answered although some candidates wrote very vague statements most still managed to be awarded the mark.

(b) This was poorly answered and indicated a common weakness in this area. Many candidates failed to register that the coils were connected and discussed transformers. In Part (ii) top grade candidates recognized resonance and got full marks from their description.

(c) For candidates who chose the correct equation from the data sheet these marks were easily accessible. Many used incorrect equations which resulted in only achieving the conversion mark for the area in some cases.

Q7 **(a)** The majority of candidates scored highly in this part. The mark that was most commonly omitted was the clear location of the step-up transformer. Most candidates scored at least 4 out of 6 in this part.

(b) This question caused few problems. It was very well answered by almost all candidates and most gave the correct direction of the force.

Q8 **(a)** This question was answered well by many candidates. Some did not answer in terms of the effect of the acceleration and misunderstood the question.

(b) Most candidates managed this calculation well. Weaker candidates could not equate the equations and lost marks. In Part (ii) most candidates scored the first mark but often explanations were incomplete and lacked detail.

(c) The calculation was done well by the majority of candidates and most clearly showed their substitution and awarded part marks even if they made calculation errors. A common error was to forget to square on the bottom line. A significant number did not quote the answer to the correct number of significant figures.

Assessment Unit A2 3A Practical Techniques and Data Analysis

Unit Overview

The paper allowed for discrimination between candidates of different abilities with a wide range of attainment between candidates. Most candidates were able to access both questions and demonstrate data analysis skills to reasonable extent. The overall standard of responses seemed lower than in previous years and this may reflect the omission of the practical component at AS-Level for the majority of candidates.

There were some issues in a minority of centres where apparatus lists/set-up instructions had not been followed and this resulted in candidates having answers outside the range, or to a different number of decimal places in meter readings than given in the mark scheme. Where possible centres should set up as instructed to ensure that their candidates are not disadvantaged by incorrect set-ups. Uncertainties in measuring instruments were correctly quoted to ± the smallest division by the majority of candidates.

Q1 **(a)** A number of candidates failed to record the values for h to the nearest mm as should be the case when measuring these distances with a metre rule. A few candidates failed to use multiple oscillations or failed to record their values of T to 2 dcp.

(b) The majority of candidates were able to multiple the bracket out correctly and map the equation to y = mx+c

(c) **(i)** Many candidates failed to give the correct unit in their heading for their values of root h and a number failed to give their values to a consistent number of significant figures.

(ii) Graphs tended to be well drawn but a number of candidates failed to correctly scale their axis to ensure the data took up more than half the axis.

(d) **(i)** Some candidates failed to use a large enough triangle when calculating their gradient, a larger number of candidates were unable to calculate a gradient than in previous years.

(ii) Some candidates struggled to rearrange the equation correctly to calculate g.

(iii) Most candidates who correctly answered Part (ii) were able to gain full marks in Part (iii), however, a number of candidates failed to divide by the correct value of g when calculating their percentage error.

Q2 **(a)** **(i)** The vast majority of candidates were able to answer this question correctly.

(ii) Most candidates were able to record their values correctly with a few failing to give their averages to the correct number of significant figures. Some failed to read the question correctly and did not take 5 readings in total.

(b) **(i)** Most pupils were able to show the derivation correctly.

(ii) The vast majority of candidates correctly answered this question.

(c) **(i)** Most candidates were able to correctly calculate the values, some candidates failed to give the values the required number of decimal places or made rounding errors when doing so.

(ii) Most candidates were able to draw the graph correctly although a few pupils chose a poor scale for their y-axis which caused them problems when plotting points. Lines of best fit were well drawn in general.

(d) Very few candidates achieved full marks in this question, with a number making power of ten errors or making a mistake with the units. Some candidates failed to use the intercept to find R_F trying instead to use the gradient. Although, it was possible to achieve full marks using this method, very few candidates were able to complete all the steps correctly to come the correct answer.

Assessment Unit A2 3B Practical Techniques and Data Analysis

Unit Overview

The paper was successful in accommodating candidates of differing abilities offering opportunities for both stronger and weaker candidates to respond positively in most questions. In general, candidates performed well with many obtaining high marks. However, some candidates showed a lack of preparation or knowledge of the skills and techniques tested in this examination and this may reflect on the lack of testing on practical techniques the majority of this cohort undertook both at AS and at GCSE level due to the pandemic.

Q1 **(a)** Most candidates answered this question correctly. Some candidates were unable to identify the base units for Force. Some candidates did not provide enough detailed steps required to award full marks for a show question.

(b) **(i)** Most candidates were able to identify the 2nd reading as anomalous but some candidates did not specify that this value was not used in calculating the average.

(ii) The vast majority of candidates drew the correct best fit line. A few candidates forced their line of best fit through the origin despite the data dictating that this was not the case.

(iii) Most candidates correctly answered this question however, some showed a lack of understanding of the term zero error.

(iv) This question was correctly answered by the majority of candidates.

(c) **(i)** Some candidates failed to use a large enough triangle while calculating their gradient. Some candidates used the origin as their second point despite the fact that their line of best fit did not go through the origin. A number of candidates were unable to work out the correct units for their answer.

(ii) Most candidates answered this question correctly, some candidates were not able to identify how the gradient of the graph would be used to calculate C_{L-}.

(iii) Most candidates were able to identify that the zero error did not affect the gradient. Some candidates focused on the fact that C_L was a constant as their reasoning and this did not allow any marks to be awarded.

Q2 **(a)** Very few candidates achieved full marks in this question. Many candidates either failed to measure the time period across a number of oscillations or incorrectly used the entire length of the screen without being able to correctly identify the total number of waves present. Candidates found it difficult to correctly calculate a percentage error consistent with their measurements with pupils using +/- 1% rather than considering how their measurement was made.

(b) The majority of candidates were correctly able to convert from g to kg but failed to give the value of T to a consistent number of significant figures. Some candidates did not know to double the percentage uncertainty in f due it being squared in the equation.

Q3 **(a)** **(i)** The majority of candidates were able to correctly identify P_o. Some candidates incorrectly stated that it was the 'initial pressure' rather than the pressure at sea-level.

(ii) Some candidates were unable to work with natural logs to rearrange the equation correctly. Some candidates were unable to separate out the -h/k term to correctly identify the gradient.

(iii) The majority of candidates were able to correctly calculate lnP but a large number of candidates did not include the correct units inside the brackets of their natural log.

(b) **(i)** The majority of candidates were able to plot the graph correctly although, many failed to correctly scale their y-axis.

(ii) The vast majority of candidates were able to correctly read their y-intercept but some candidates were unable to use this value to correctly calculate $P_{o\neg}$.

(iii) Most candidates were able to draw a correct extreme fit line but some drew a line much too steep or shallow that had no correlation to the points on the graph. A number of candidates were unable to use their extreme intercept to correctly calculate the absolute uncertainty in P_o.

Q4 **(a)** A large number of candidates only achieved 1 mark in this question although, some candidates identified the need to both repeat and average and average across multiple oscillations.

(b) **(i)** Most candidates correctly answered this question.

(ii) Some candidates struggled to use the correct terminology to describe the difference between the actual and expected graphs in clear enough language to allow the awarding of a mark.

(iii) As in Part (ii) some candidates struggled to use the correct terminology to clearly describe the difference between the actual and expected graphs to allow the awarding of a mark. It was clear from some candidates' responses that they did not know what shape a square root graph would produce.

(c) The majority of candidates correctly calculated K. Many candidates did not use at least two points from the graph to calculate a reliable value of K. Some candidates incorrectly tried using the gradient of the graph and were not awarded marks.

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