PHYSICS

Paper 9702/01

Multiple Choice

Question Number	Key	Question Number	Key
1	C	21	C
2	D	22	A
3	A	23	D
4	C	24	D
5	A	25	C
6	D	26	D
7	C	27	A
8	A	28	D
9	B	29	A
10	B	30	B
11	B	31	D
12	B	32	A
13	B	33	C
14	C	34	A
15	A	35	C
16	C	36	C
17	C	37	C
18	B	38	A
19	A	39	D
20	B	40	C

General comments

This paper proved to be a good test. To get the paper completed in the hour means that hard concentrated work is essential. Even so, the mean mark out of 40 was 26.4 and the standard deviation was 6.7. The results showed that fewer than 20% of candidates scored less than 20/40 and that there were 76 candidates who scored 39 or 40. The implication of these figures is that the able candidates could show their ability and that the less able candidates still had something positive to do, and were not disillusioned by the paper.

There were a few questions which were very easy and which resulted in high facility. Only **Questions 5** and **6** had more than 90% of candidates getting the correct answer. Ten other questions proved rather easy, with more than 80% correct answers. These were 1, 2, 14, 15, 16, 25, 28, 30, 32 and 39. Some easy questions are useful to test basic facts and to get candidates to start to think about a new physics topic.

Careless mistakes are very easy to make when answering multiple choice questions. Candidates need to work their answers through in writing and preferably before looking at the 4 options. The most unreliable way of answering is by fiddling with the numbers given on a calculator. Candidates must check their work as they go. There will be little time to check work at the end of the examination, and by that time they will have forgotten what any question was about.

Questions that proved to be difficult were –

Question 23, where far too many candidates assumed that the wave was a stationary wave rather than realising that at maximum displacement in simple harmonic motion there will be maximum acceleration. Only 25% gave **D**; 57% gave **B** as the answer.

Question 37. Here 25% gave **C** and 31% gave **B**. A good deal of guessing was going on here. Many were hurrying at this stage to get the paper finished in time.

Question 40, where only 9% got the correct answer **C**, 66% thought that **D** was correct. It is the *q/m* ratio that is important, and this has the lowest value for the lithium nucleus. Even with this question however, it was the able candidates who scored well, giving the question positive discrimination. There were no questions on the paper with negative discrimination. That is a question where able candidates were less likely to get the right answer than the less able candidates.

Other questions that deserve some comment were as follows.

Question 9, where too many candidates think that *g* is gravity.

Question 10, where candidates needed to appreciate that p_2 will itself be negative.

PHYSICS

Paper 9702/02
AS Structured Questions

General comments

The paper gave rise to a wide spread of marks. Some parts of questions were recall but elsewhere, candidates were expected to apply their knowledge and understanding to unfamiliar situations. Thus, the paper provided ample opportunity for candidates to demonstrate their various skills.

There were some excellent scripts where candidates showed a sound understanding of the concepts across the whole of the syllabus. It was saddening to see other scripts where the candidate scored less than 30% of the total marks.

There were some calculations in this paper where candidates appeared to be doing well but they then made a careless mistake, such as a power-of-ten or inverting a ratio. A moment of reflection on the answer obtained could have alerted the candidate to such a simple mistake and hence given rise to a higher mark.

The overall impression was that candidates had sufficient time to complete their answers.

Comments on specific questions

Question 1

Answers to this question were very disappointing with many candidates scoring no marks.

(a) (i) Candidates were expected to calibrate the scale at 20×10^3 cm^3 intervals. Many produced a linear scale or did not mark all the intervals up to 80×10^3 cm^3.

(ii) Only a minority were able to mark, within reasonable limits, a possible position for 1.0×10^5 cm^3.

(b) There were many references to accuracy and it was apparent that candidates did not appreciate the difference between accuracy and sensitivity. Frequently, any discussion did not mention to which part of the scale (i.e. the low-volume end) they were referring.

Question 2

(a) Of those who did include a reference to a ratio, many did not mention that it is the force per unit *positive* charge. The use of units in definitions such as this should be actively discouraged. Candidates should realise that electric field strength is not defined as potential gradient.

(b) There were many correct answers. The most common error was to substitute the separation measured in cm into the equation for potential gradient. Some did substitute the length of the plates, rather than their separation.

(c) (i) There were many correct responses although a minority attempted the calculation using equations for linear motion. The specification of the direction frequently left much to be desired. 'Upwards' was a very common answer, rather than the more precise 'upwards and normal to the positive plate'.

(ii) There were many correct answers to this simple problem. Surprisingly, a significant minority who had given the correct direction in **(i)**, now assumed the electron would accelerate horizontally.

(d) The usual correct approaches to this calculation were either to determine the time to travel from the central region to the top plate or to determine the distance moved vertically during the time between the plates. This time or distance was then compared with data previously calculated or provided in order to reach a conclusion.

There were some very good, clearly expressed answers. A common error amongst those candidates who appreciated what they had to do was to find the time to move 1.5 cm vertically, rather than 0.75 cm. In order for credit to be given, any conclusion had to be justified by a calculation.

Question 3

(a) There were many correct responses. However, a minority did not indicate that a ratio is involved or gave units in the definition. 'Mass of 1 m^3' is not credit-worthy.

(b) (i) With few exceptions, the correct relation was given.

(ii) Candidates were instructed to explain their working. There were some very good, clearly expressed answers. However, approximately one half of all candidates gave their answers in symbols and with no explanation.

Where candidates are told to explain their working, then it is expected that, for full credit, symbols will be explained.

(c) (i) The vast majority of candidates gave the answer as either 1600 or 1/1600. For those who gave the answer as 1/1600, it would have been worthwhile for them to reflect on the answer they had written down. Liquid water expands when it evaporates and so the answer must be greater than 1!

(ii) There were very few correct answers involving the cube root. Many candidates just wrote down the same answer they had given in **(i)**.

(d) (i) Frequently, the question was paraphrased, rather than given in terms of macroscopic evidence for the molecular behaviour. It was common for an answer to be based on 'the separations are about equal' rather than to consider density or change in volume on melting.

(ii) The strong forces may be indicated by the fact that the volume is fixed whereas rigid forces are indicated by fixed shape. Frequently, candidates were unable to distinguish between the two, giving an answer such as 'hard to compress' for rigid forces. This answer is not only inappropriate but also applies to liquids as well as solids.

Question 4

(a) (i) The majority of candidates gave the correct answer to two or three significant figures. A minority used a value of 10 m s^{-2} for g. This should be discouraged. In general, the data as provided on page 2 of the question paper should be used.

(ii) A frequent error here was to calculate the kinetic energy of the stone at a speed of 18 m s^{-1} but then fail to add on the change in potential energy as a result of its change in height.

A minority attempted to calculate, quite wrongly, the final speed using an equation for linear motion with an initial speed of 18 m s^{-1} and accelerated at 9.8 m s^{-2} for 16 m.

(b) Interestingly, candidates who had calculated only the initial kinetic energy in **(i)** frequently went on to find, quite correctly, the final speed.

(c) Usually, the correct answer was given. However, amongst weaker students there was confusion between the horizontal velocity and the magnitude of the final velocity.

(d) (i) Having determined the magnitudes of the horizontal and the final velocities, it was expected that the basic shape of the diagram would cause few problems. This was not the case. Diagrams where the shape could be recognised were in a minority.

(ii) Those candidates who had drawn a recognisable shape in **(i)** usually gave an answer for the angle within acceptable limits. However, there were many incorrect answers.

Question 5

(a) Candidates were assisted with their definitions in that they were instructed to consider the direction of propagation of energy. However, many failed to make any distinction between a progressive wave and polarisation.

Candidates did not explain that, for a transverse wave, the vibrations are in any direction in a plane normal to the direction of propagation. Many wrote about one direction. For polarisation, the most common answer was that the oscillations are in one plane, rather than in one direction in a plane normal to the direction of propagation.

(b) (i) Frequently, candidates wrote at length about the formation of a stationary wave, rather than its properties. It appeared that, from a significant proportion of answers, some candidates had not seen this effect demonstrated and were quite unaware of the fact that the dust would settle at the nodes.

(ii) Only a minority realised that the distance would be 2.5λ. Many thought that it would be either 5λ or 6λ.

(c) Candidates were told to consider the formation of a stationary wave. There were some good descriptions but many did not make it clear that the stationary wave is formed by superposition of the wave travelling down the tube and the wave reflected from the closed end. There were some answers that showed a lack of understanding of the situation. These included 'the speed of the wave' and 'the speed at which the nodes are formed'.

Question 6

(a) (i) Most candidates gave the correct answer for the total resistance. However, a surprisingly small number gave the answer of $(14 - E)$ or $(E - 14)$ for the total e.m.f. Some gave a numerical value equal to the 'lost volts' whilst many gave the answer of $(E + 14)$.

(ii) In general, those who gave correct answers in **(i)** were successful with this calculation. However, there were many answers where it was clear that the candidates did not appreciate the situation.

(b) (i) With few exceptions, a correct expression was given and the calculation was completed successfully.

(ii) Although most candidates wrote down a correct expression, many substituted the e.m.f. of the battery, rather than that of the charger.

(iii) In some scripts, a relevant expression was not provided. In others, only part of the total internal resistance in the circuit was considered.

(c) It was common to find that what was calculated was the percentage of the energy dissipated in the internal resistance in the circuit.

Question 7

(a) With few exceptions the correct answer was quoted.

(b) It was pleasing to note that most answers were given with an explanation. The answer that was expected was γ-radiation because this would not affect either the nucleon number or the proton number. However, some candidates had spotted that, for α-decay, the nucleon number would be reduced by four and that this could not be represented on Fig. 7.1. This latter approach, if explained, was given credit.

PHYSICS

Paper 9702/31
Advanced Practical Skills 1

General comments

The general standard of the work done by the candidates was similar to last year, with a reasonable spread of marks. **Question 1** was relatively straightforward, although some of the weaker candidates found the analysis section challenging. Poor candidates found the first part of **Question 2** confusing. All candidates attempted the evaluation section but found it difficult to obtain many marks. As in previous years, there was a significant variation in performance between Centres. It would be helpful to all candidates if attention could be drawn to the published mark schemes.

The majority of Centres had no problem in providing the equipment required for use by the candidates. Some help was given to candidates from Supervisors in setting up the apparatus in **Question 1**. Supervisors are reminded that under **no circumstances** should help be given with the recording of results, graphical work or analysis.

Candidates seemed not to be short of time. Most candidates were more confident in the generation and handling of data than they were with the critical evaluation of their experimental skills. Both questions were attempted, although the last section in **Question 2** was poorly answered.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the inverse of the voltage across a resistor depends on the number of resistors placed in series in the circuit.

(a)   Most of the candidates were able to set up the equipment without help from the Supervisor. Weaker candidates needing help only lost 1 mark.

(b)   Most candidates were able to tabulate six sets of readings of V and n correctly with V to one or two decimal places. With eleven resistors available, it was expected that candidates would use values from at least $n = 2$ to $n = 10$. Occasionally the values of V were clearly wrong, either because of an incorrectly connected circuit or mis-reading the units/scales on the voltmeter. A minority of candidates had V increasing as n increased as a result of connecting the voltmeter incorrectly.

(b)   Many candidates were able to use the appropriate number of significant figures in the $1/V$ value relative to the raw value of V_1. However many candidates quoted two significant figures in $1/V$ value when their V values were written to three significant figures. It is expected that the significant figures in the derived quantity $1/V$ are the same or one better than the significant figures in the corresponding values of V. This oversight often led to losing the quality mark later, because the plotted points provided too much scatter about the line of best fit.

(b)   Many candidates were awarded the column heading mark. The most common error was in the $1/V$ column.

(c) (i) Candidates were required to plot a graph of $1/V$ against n. Many candidates used suitable scales, however some had a gap of four squares along the y-axis. Many candidates had plots extending over half of the graph grid available, but compressed scales (plots extending only over five large squares or less) were common and were penalised. It is expected that the plots extend over six squares or more in the y-direction and four squares or more in the x-direction. A few candidates used scales that resulted in points lying beyond the grid area. Any plots off the grid are discounted. Few candidates used awkward scales. Most candidates plotted points correctly, although a few misread plots. It is expected that candidates do not use one large square to represent three or a multiple of three as this gives rise to mis-plots or mis-read points later in the gradient section. It is expected that candidates can plot and read values to the nearest half a small square. Many plots were plotted as 'blobs', that is dots greater than half a square in diameter and in some cases greater than a square in diameter. This was unacceptable in both cases.

(ii) Most candidates were able to draw an acceptable line of best fit as results provided little scatter around the line of best fit. The quality mark was only awarded if five or more plots lay on the line of best fit. A few lines were drawn with blunt pencils, providing a thickness greater than half a square or lines were drawn with a kink (by using a ruler which was too small) and failed to gain credit.

Many candidates used triangles greater than half the length of the line drawn to determine the gradient. A few candidates used triangles smaller than half the length of the line. Often, the same candidates who mis-plotted points, went on to mis-read gradient points. That said, if a candidate had mis-plotted a point which later was replotted by the Examiner onto the line of best fit, there was still a chance that the candidate could score the quality mark. A small number of candidates assessed the graph gradient by square counting, thereby ignoring the scales and ending up with wildly incorrect values for E and R_1/R_2.

Many candidates read off the y-intercept at $x = 0$ successfully. Some candidates used substitution into $y = mx + c$ in the determination of the y-intercept.

(d) In the analysis section many candidates were able to equate the gradient with R_1/ER_2 and the y-intercept with $1/E$. Many candidates correctly gave the answer for E and R_1/R_2 to two or three significant figures and gave the correct units E(V) and R_1/R_2(no units). $E = 5$ was penalised, while $E = 5.0$ V was credited. The E value was gained by many candidates, whilst R_1/R_2 was gained by fewer candidates as the candidate was expected to manipulate the equation $R_1/ER_2 =$ gradient. Inaccuracies earlier did result in answers being out of range and penalised. Many candidates incorrectly choose substitution of known points to find E and R_1/R_2 instead of using the gradient and y-intercept in **(c)(iii)** as it states in the question.

Question 2

(a) (iii) Most candidates gave a position of the centre of mass to the nearest cm or mm, however some candidates did not have an appropriate unit, e.g. 56 m, and this was penalised.

(b) (i)(ii) Many candidates gave a value of position of centre of mass when displaced downwards and a
(d) position of centre of mass at maximum height when released. For small displacements $h < x$ (small bob on spring system) and for large displacements $h \gg x$ (catapult system). Some candidates gave positions for the displacement and maximum height which are both on the same side of the equilibrium position, meaning that the ball never got back up to the equilibrium position after being released. This lost a quality mark and an observation of reading mark. Some candidates struggled to record appropriate data leading to difficulty in calculating x and h.

(b) (i)(iii) Many candidates correctly calculated a value for x and h although there were arithmetic errors in
(d) the subtraction e.g. 63.6 – 59.0 = 4.9 as a result of candidates carrying out the sum in their head. Some candidates quoted all measurements in metres, using standard form in a haphazard way, leading to confusion in the subtraction e.g. 0.058 – 0.054 = 4 cm, not 4 mm. A few candidates calculated x and h from the displaced position and not the equilibrium position.

(b) (iii)(d) The determination of the centre of mass at the maximum height was a tricky reading and it was expected that the candidate appreciate the need to repeat their readings. Only a few did this. A minority of students repeated the experiment, using many different values of x. This was not credited.

(c)   Since the position at the maximum height was difficult to obtain, an error of 1 mm in *h* was too small given the size and motion of the bob. There is a misconception that candidates should equate uncertainty with the smallest division on the scale, without looking at the limitations of the experiment. A tolerance of 2-10 mm was acceptable here and many candidates failed to appreciate this. Most candidates knew and applied $\Delta h/h \times 100\%$ = uncertainty.

(e)   Many candidates worked out a constant of proportionality for each of the results and correctly stated a conclusion. Many showed a flawed understanding of how close the values of *k* needed to be for the case to be made for proportionality e.g. *k* = 0.12 and *k* = 0.14 would not necessarily mean that $h \propto x^2$ as the *k*'s are 14% different, however they look similar. In this experiment, if the *k*'s differed by more than 10%, then the variables *h* and x^2 were not considered to be proportional. Some candidates worked out a constant of proportionality and substituted their value of *k* to find their second value of *h.* This method was accepted. Many candidates did not work out any values and stated that as *h* increases, so too *does x or x^2. This qualitative approach was not credited. A few candidates incorrectly used $h = x^2$.*

(f) (i)(ii) The evaluation proved to be the hardest section on which to score marks. This was probably owing to the fact that candidates were unfamiliar with this style of question. The key is to identify specific problems for this particular experiment and then come up with practical solutions (not just change the experiment itself). Clarity of thought, experience and good expression is needed here to produce a better experiment, not a different one. Outlined below are some answers quoted by candidates that gained credit followed by those that failed to gain credit.

Credited problem: 'Uncertainty in the measurement of the centre of mass of the ball.' (common)
Credited solution: 'Mark the centre of the ball.'
No credit: 'Get an apparatus/vernier calliper/micrometer screwguage that measures the centre of mass.'

Credited problem: 'It was difficult to release the ball so that it rose vertically.'
Credited solution: 'Use an iron ball and electromagnet to release it.'
No credit: 'When the ball is released, you have a big chance to make an error.'

Credited problem: 'Difficult to measure *h* as the bob is moving.'
Credited solution: 'Use a video camera with slow motion feature to measure *h* accurately.'
No credit: 'Get an electronic ruler/device/light sensor that measures displacement.'
No credit: 'Human error when reading the maximum height.'

Credited problem: 'Two values of *x* and *h* are not enough.' (Surprisingly uncommon)
Credited solution: 'Record different values of *h* and *x*, plotting *h* against x^2.' (Rarer still)
No credit: 'Repeat the readings in *x*.' (Very common)
No credit: 'Use different mass/length/thickness of rubber.'

Many candidates seemed to report on the rubber band slipping between the blocks but unless this was evident in the results, it was not credited.

The 'no credit' points were common and penalised for not providing enough detail or not supported with a reason. Candidates needed to be much more specific and consciously state the method needed. Further examples can be found in the mark scheme. The most common credited answers made reference to parallax errors and locating the centre of the ball. The average score for this evaluation section was between two and three out of eight.

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General comments

The general standard of the work done by the candidates was similar to last year, with a reasonable spread of marks. Most candidates were more confident in the generation and handling of data than they were with the critical evaluation of their experimental skills. **Question 1** was relatively straightforward, although some of the weaker candidates found the analysis section challenging. Candidates attempted the evaluation section of **Question 2** but found it difficult to score many marks. As in previous years, there was a significant variation in performance between Centres. It would be helpful to candidates generally if attention could be drawn to the published mark schemes.

Centres had no problem in providing the equipment required for use by the candidates.

Supervisors helped some candidates to set up the apparatus in **Question 1**, but a few candidates produced no readings and should have asked for help with the circuit. Supervisors are reminded that although they can assist with setting up apparatus, under no circumstances should help be given with the recording of results, graphical work or analysis.

Candidates had enough time to complete the tasks and both questions were attempted.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

This was a well-structured practical task for which nearly all candidates were well prepared. They were required to measure the current in a parallel branch of a resistor network as the resistance of the branch was changed.

(a) Most of the candidates were able to set up the equipment without help from the Supervisor. Weaker candidates needing help only lost 1 mark.

Most of the values recorded for the cell e.m.f. were sensible.

(b) Most candidates presented the required six sets of readings in a clear table, but not all included a correct unit for the $1/I$ column.

Examiners were looking for a good range of values for R_3, including one of the lowest and one of the highest resistances provided. Although it was intended that only single resistors be used, some candidates apparently chose to use resistor combinations for R_3.

Most candidates' values for I had consistent numbers of decimal places, but they were penalised if meaningless zeros had been added at the end of all values. There were many cases where a 'power of ten' error was introduced by, for example, recording mA values as A.

Significant figures in the calculated values ($1/I$) also presented problems – examiners expected the same number of s.f. (or one more) as the s.f. in I, even if this meant that not all $1/I$ values had the same number of decimal places.

The quality of results was generally very good, with the graph showing little scatter about the best-fit line.

(c) (i) Candidates were required to plot a graph of $1/I$ against R_3.

Most graphs were drawn to a high standard with good use of the grid area, but a few candidates chose very awkward scales in order to achieve this. The preferred scales use multiples of 1, 2, 5, 10 or 4 units to each large square so that points are easy to plot. Most points were plotted accurately, but some used unacceptably large dots.

(ii) Most candidates were able to draw an acceptable line of best fit. A few lines were drawn with blunt pencils (providing a thickness greater than half a square) or lines were drawn with a kink (by using a ruler which was too small) and failed to gain credit.

(iii) Most candidates found the gradient accurately, but some used a triangle with a hypotenuse less than half the length of their line, or counted squares instead of using the scales.

Most found the *y*-intercept accurately, although a few ignored a false origin and read a value from the *y*-axis when they should have calculated the intercept using $y = mx + c$ or a similar method.

(d) In the analysis section many candidates were able to equate the intercept with $1/E$ and the gradient with $(R_1 + R_2)/ER_2$ and carry out the analysis correctly, but many lost the available marks because their values were out of range ($\pm$ 20% was allowed) or because units were omitted or there were too many significant figures (2 or 3 were allowed).

A few candidates offered no analysis and just stated the nominal values of R_1 and R_2. It was assumed that they had looked at the hidden colour codes and so no credit was given.

Question 2

This question required candidates to reach a conclusion about the coefficient of restitution of a table-tennis ball, based on only two sets of readings in a simple bounce-height experiment. The instructions were not as detailed as in **Question 1** and candidates were expected to make some decisions for themselves and to describe what they had done. They were also asked to evaluate the experiment and suggest improvements (this section proved particularly difficult).

(a) (ii) The drop height *d* was expected to be less than 40 cm but some candidates chose a higher value and were penalised. It was not easy to judge the rebound height *h* and so values to the nearest cm or mm were acceptable.

(iii) Not many candidates described a good procedure for finding the rebound height as accurately as possible. Examiners were expecting a process involving a marker (e.g. a set square) being adjusted towards a final refined value using repeated drops.

(iv) Candidates were expected to take repeated readings for *h* and a mark was given in **(b)** to those who showed some evidence of this. They were expected to use half of their range as the absolute uncertainty when calculating the percentage uncertainty.

If there were no repeat readings then absolute uncertainties from 2 to 10 mm were accepted for the calculation (many used $\pm$ 1 mm which was considered to be too optimistic).

(v) The value for *e* was usually correctly calculated to the expected two or three significant figures.

(b) Most candidates gained the quality mark (their values for e had to be within 10% of each other).

(c) Well-reasoned comments on whether the two experimental values for *e* suggested that *e* is a constant were very rare. Examiners expected the variation in the experimental values to be compared with the percentage uncertainty already calculated for *h*.

(d)   Candidates found it hard to score marks in this section.

The main problems with the experiment were:

Two experimental values for *e* are not sufficient to draw a conclusion (improvement: use several values of *d* and *plot a graph* of √*h* against √*d* to look for proportionality).

It is hard to judge the rebound height <u>because it happens quickly</u> (improvement: record on video and <u>play back slowly</u>, or use a position sensor <u>above the ball</u>).

Parallax error (improvement: ensure measurement taken is at eye level, or use an assistant <u>to drop the ball,</u> or use an adjustable marker).

It is difficult to release the ball without applying a force or an initial velocity (improvement: use a remotely operated clamp to release ball).

The rule may not be vertical (improvement: use a set square to check rule is vertical).

The bounce is inconsistent in height (improvement: use a flat surface).

The bounce is inconsistent in direction (improvement: turn off fans).

The improvements described above are only examples but they indicate the level of detail expected from candidates. Vague descriptions or impractical suggestions such as '*h* was difficult to measure', 'use a second person', 'take more readings', 'use a camera', 'use a light gate' or 'do the experiment in a vacuum' were not accepted, and neither were suggestions which changed the experiment such as 'use a heavier ball'.

PHYSICS

General comments

This was the first examination of the revised Paper 4 that now encompasses the replacement for the Options.

The general standard of *Section A* was similar to that seen previously for Paper 4. There were some very good scripts where candidates had been prepared well for the examination. Conversely, there were some candidates who had very little knowledge of the bookwork and who had little or no appreciation of the concepts being assessed.

In general, those candidates who achieved a good standard in *Section A* also did well in *Section B*. However, there was a very clear indication that, on average, candidates were not as well prepared for *Section B* as they were for *Section A*. This was apparent, not only from inferior knowledge but also what they wrote did show serious failures of understanding.

A significant number of low-scoring candidates did not attempt *Section B*. There is evidence that, as for the situation when Options were assessed, *Section B* material is not receiving due attention. It must be remembered that topics in *Section B* have a similar emphasis and weighting as topics in *Section A*.

Comments on specific questions

Section A

Question 1

(a)   Definitions frequently lacked precision. There were many references to 'an object experiencing a force'. Gravitation is concerned with forces on masses. Some defined gravitational field strength. Very few seemed to realise that a field marks out a region where a force is experienced.

(b) (i)   Most candidates gave a mathematical expression, without adequate explanation, from which the given expression was derived. The impression gained was that many would not have arrived at the correct expression if it had not been given to them.

(ii)   There were very few problems with this derivation.

(c) (i)   The great majority equated the two expressions and arrived at the correct answer for the mass.

(ii)   There were many trivial answers such as 'no energy losses' or 'changes in kinetic energy and potential energy are equal'. Such responses are inadequate for A Level. A reference to energy conservation should include how energy is lost from the system. A number of candidates made reference to the possibility of another large mass giving rise to a force on the rocket.

Question 2

(a)   More able candidates made reference to the bonds between molecules and then went on to discuss changes in potential and kinetic energy of the molecules. Frequently, there was no mention of either potential energy or kinetic energy.

(b) (i) A minority thought that the final temperature would be room temperature. However, most candidates could give correct equations, but frequently incorrect values for the masses were used.

(ii) There were many answers where a vague statement about heat losses/gains was made, followed by a conclusion that could not be justified. Very few made a clear statement that ice would be melted by the heat gained from the atmosphere, resulting in an increased mass and a reduced value for the specific latent heat.

Question 3

(a) The great majority of answers were, simply, *V/d*. This was, of course, quite incorrect since *V* was defined as a potential and *d* as a distance. This was a serious misunderstanding. Very few gave the answer as the field strength equal to the negative potential gradient.

(b) There was a pleasing number of correct answers. A significant number approximated the area to a number of rectangles and triangles but in so doing, lost the necessary accuracy. Others determined the area within acceptable limits but assumed the area, in cm^2, was numerically equal to the potential difference.

(c) This calculation was completed successfully by most candidates.

(d) (i) The most common answer was 4.0 cm. Those giving the answer as 'zero' were few in number.

(ii) The majority of candidates gave an incorrect answer in that they identified the acceleration with the gradient of the graph, rather than with the value of *E*.

Question 4

(a) Very few candidates failed to give a correct expression for the turns ratio. However, it was disappointing to find that many candidates either failed to recognise that the two voltages were not both r.m.s. values or used the factor of $\sqrt{2}$ incorrectly.

(b) (i) Most candidates could give the correct symbol for a diode. However, those who could connect the diodes correctly into the circuit, regardless of polarity at the load, were in a minority.

(ii) Of those who did include a capacitor, most were correct. However, there were many scripts where the capacitor was not included.

(c) (i) The great majority of candidates correctly identified the time interval.

(ii) Acceptable sketches were in a minority. Many graphs did not show the peaks for the reduced ripple as occurring at the same positions as those on Fig. 4.2. Many showed ripple with a reduced peak value.

Question 5

(a) (i) Although most answers included a reference to a quantum or 'packet' of energy, many did not include a mention of electromagnetic radiation. Indeed, some identified the photon as the electron!

(ii) With few exceptions, the result was derived. However, some answers lacked explanation. Candidates should realise that, where an answer is given, then the marks are awarded for a clear derivation. In this particular case, substitution of all numerical values into an equation was required.

(iii) As expected, the answers of 0.5 and 2.0 were seen in approximately equal numbers.

(b)(i) It was expected that candidates would make reference to the minimum energy required to remove an electron from the surface of the metal. Of those answers that were recognisable as being concerned with photoelectric emission, many did not include a mention of *minimum* energy.

(ii) There were some good answers here. Despite the instruction that a quantitative answer was required, a significant minority did not attempt to convert an energy from eV to J or *vice versa*. A surprisingly large number of candidates made an appropriate calculation and then made a correct statement, without mentioning that the photon energy must be in excess of the work function.

Question 6

(a) The basic concept that decay constant is the probability of decay of a nucleus per unit time is still appreciated by only a small minority of candidates.

(b) There were many scripts where it was clear that this type of calculation had been rehearsed in that even weaker students were able to score full credit on **(i)** and **(ii)**. There were, regrettably, a small number of candidates who did not understand how to approach the problem.

(i) A small number of candidates failed either to calculate correctly the number of seconds in one year or they determined λ in yr^{-1}. Significantly, there were some candidates who gave the number of days in one year as (30×12).

(ii) With few exceptions, the number of nuclei in the sample was calculated correctly. However, when determining the mass, it was common to find that either the Avogadro constant or the molar mass was omitted. Some very large, or very small, values were found that did not raise any comment.

(iii) Generally, the expression for density was known. However, the astronomic volumes that were sometimes generated did not raise comment.

(c) Most candidates made a reference to inhaling the radioactive material even when the calculated volume was very large. Very few realised that the small volume of radioactive material would have a large activity or that, because the volume is small, the dust could come become contaminated easily.

Question 7

(a)(i) It was common to find amongst weaker candidates that it was not made clear where the change in flux was taking place or where the e.m.f. was being induced. Very few answers included a clear statement that thermal energy would be dissipated in the load and that this energy is derived from the oscillations of the magnet. Many merely stated that an e.m.f. would be induced and that this would lead to damping.

(ii) The majority of answers were correct.

(b) In general, the sketches were disappointing. In many instances, successive half-periods were shown to increase and/or decrease quite randomly. In those sketches where the period was acceptable, then the vast majority showed increased, rather than decreased damping.

(c)(i) As in **(b)**, sketches tended to be poor. The majority did draw a peaked curve but frequently, the peak did not occur at $1.0\omega_0$.

(ii) Although a majority did recognise 'resonance', there was a significant minority where the answer given was 'damping'.

(iii) Candidates were asked to 'describe briefly'. Therefore, mere naming of examples was insufficient to score credit. Candidates needed to put the example in context. For example 'microwave cooking' was not considered to be adequate. However, some candidates then mentioned heating as a result of hydrogen atoms/molecules resonating at the microwave frequency.

Section B

Question 8

(a) Generally, candidates either scored three marks or none in this section.

(b) (i) Although candidates were asked to identify the type of feedback, many gave the answer as some form of amplifier circuit.

(ii) The calculation of the gain was completed successfully in the majority of scripts. However, there was a significant minority where this calculation was not attempted.

There was some confusion as to which formula to use for the calculation of the resistance. Of those who did give a recognisable equation, opinion was equally divided between the gain formula for an inverting and a non-inverting amplifier.

(iii) The majority of candidates made a reference to 'output increases'. Only a minority considered either the gain or the bandwidth of the amplifier.

Question 9

(a) A significant number of candidates did not read the question carefully and, as a result, described in detail the production of X-rays. Others gave confusing accounts whereby the X-rays were detected after reflection from boundaries.

(b) There was widespread confusion between CT scanning and MRI. Very few candidates appreciated that, in CT scanning, two-dimensional images of many separate slices are obtained. These images are then combined to give a three-dimensional image.

Question 10

(a) A surprisingly large number of candidates were unable to translate four-bit digital numbers into decimal numbers. Of those candidates who did plot points on Fig. 10.2, many joined the points with a continuous curve, rather than create steps.

(b) There were many correct answers here although a minority quoted the Nyquist condition.

Question 11

(a) This was poorly answered with a minority giving the correct solution. It was disappointing to note the large number of scripts where impossible situations were given. For example, a box labelled 'cellular exchange'.

(b) Again, the great majority of answers were disappointing. The answers indicated that many candidates did not have any real understanding of the situation. There was widespread confusion between the roles of the base station and the cellular exchange. Furthermore, many appeared not to be able to distinguish between carrier frequency and signal.

PHYSICS

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Paper 9702/05

Planning, Analysis and Evaluation

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General comments

This was the first time that this paper has been taken on this revised specification. The paper was very similar to the specimen paper. Few candidates scored full marks for **Question 1**; often answers lacked detail. More candidates scored full marks for **Question 2**. It was apparent that a large number of candidates had been prepared for this paper. There was also evidence that a significant number of candidates were unaware of how to deal with errors. It should be noted that the treatment of errors accounts for five out of the thirty marks available for this paper.

Candidates should be encouraged to clearly present their answers, particularly when calculations are involved. Marks are often awarded when a clear (correct) method is seen. It is essential that plans contain all the necessary detail; there are four additional detail marks on **Question 1**. This is a practical examination and thus it cannot be stressed too strongly that the skills required for this paper are best taught through a coherent practical course where the skills required for this paper are developed and practised over a period of time with a 'hands-on' approach. To assist Centres, CIE have produced two booklets – Teaching AS Physics Practical Skills and Teaching A2 Physics Practical Skills.

Comments on specific questions

Question 1

Candidates were required to design a laboratory experiment to investigate whether the terminal velocity of a small steel ball is directly proportional to the square of its radius.

The majority of the candidates understood the problem, and most were able to explain that the radii of the steel spheres would be changed and that there would be a method of determining the terminal velocity. Sometimes these points were stated in terms of independent and dependent variables. Candidates should also be considering the variables that are to be controlled, for example, in this experiment, temperature. Good candidates wrote an explicit statement such as "the temperature will be kept constant". Some candidates stated that they would keep the mass of the small steel balls constant.

Five marks were available for the methods of data collection. One mark was awarded for a <u>labelled</u> diagram of a workable arrangement. It was expected that the balls would be able to fall a reasonable distance. Methods which involved ticker tape or the ball being attached to another material did not gain credit. There was a mark available for determining the radius of the steel ball. Good candidates measured the diameter using a micrometer screw gauge and stated how the radius would then be determined. Two marks were available for the determination of the terminal velocity. It was expected that candidates would explain that a distance would be measured and how the terminal velocity would then be calculated. Candidates who suggested the use of light gates or other data collection methods were expected to explicitly state that the distance the two light gates were apart should have been measured. The final mark in this section was available for candidates who realised that the ball needed to fall a reasonable distance for it to reach terminal velocity. Many candidates just measured the time for the ball to fall through the depth of liquid. Candidates who discussed using the equations of uniform acceleration could not gain this mark.

Most candidates suggested plotting a graph of v against r^2 for one mark. For the second mark candidates were expected to state that if the relationship given is valid, the graph should be a straight line passing through the origin. This latter point was often omitted. Candidates should be making this point explicitly. Some candidates discussed plotting an appropriate logarithmic graph stating that the gradient would be equal to two – this gained full credit. Calculation methods did not gain credit.

There was one mark available for describing an appropriate safety precaution for this particular experiment. Vague answers did not gain credit. It is important that candidates relate their safety precautions to the experiment that they are planning. Standard laboratory rules do not gain credit.

There were four marks available for additional detail. Candidates should be encouraged to write their plans adding appropriate detail. Examples of creditworthy points included:

allow oil to stand so that air bubbles escape/ball may trap air bubbles
wash and dry steel balls/handle steel balls with tweezers/gloves
distance marks should be as far apart as possible or use long tube
large distance to reduce percentage uncertainty
wide tube to reduce edge effects/method to keep long tube vertical
discussion of parallax for stop watch methods
method of ensuring that terminal velocity has been reached
retrieve steel balls using a magnet
use clear oil
repeat diameter measurements and average
an additional variable kept constant.

Question 2

In this data analysis question candidates were given data on how the resistance of a fixed volume of conducting putty varied with its length.

Part **(a)** asked candidates to explain why plotting a graph of R against l^2 would enable the relationship to be confirmed. To gain credit candidates were expected to rearrange the given equation into the form $y = mx + c$ and give details of the gradient and y-intercept. Many candidates could not rearrange the formula. Other disappointing answers stated that R was directly proportional to l^2 or the line would pass through the origin.

Candidates were then asked to calculate and record values of l^2 including the absolute errors in l^2. Almost all candidates correctly labelled the column in the table and the majority of candidates correctly calculated l^2. Some candidates did not gain a mark since their values were not calculated to an appropriate number of significant figures. It is expected that the number of significant figures in calculated quantities should be the same or one more than the number of significant figures in the raw data; in this case 3 or 4 significant figures were expected apart from the first row of the table. A significant number of candidates could not calculate the absolute errors in l^2. Common errors were all the values as ± 0.4 or ± 0.8 or ± 0.16.

In a large number of cases the graph plotting in part **(c)** was good with very neat plots and lines. The Examiners did check all the plots. The best-fit straight line mark was often lost because candidates 'forced' their best fit line through the origin. A surprisingly large number of candidates plotted vertical error bars. The worst acceptable line varied widely in quality. It should be either the steepest possible line or the shallowest possible line that passes through the error bars of all the data points. It is important that candidates do distinguish clearly the lines on their graph. A common error with the worst acceptable line was to draw a line almost parallel to the best-fit line.

Part **(c)(iii)** was answered well. Candidates who had correctly plotted the points and drawn an appropriate best-fit line were expected to have calculated a gradient within a specified range. Some candidates did not use a sensibly sized triangle for their gradient calculation. Other errors included using plotted points that did not lie on the best-fit line. To determine the absolute error in the gradient candidates were expected to find the difference between the gradient of the best-fit line and the gradient of the worst acceptable line. Weaker candidates just stated their earlier calculated error bars.

In part **(d)** candidates were expected to have used their gradient value to determine the resistivity of the conducting putty. There were many cases where candidates used a substitution method. Another common error in this part was the wrong unit for resistivity (Ω cm). If Ω m was given, examiners expected to see an appropriate conversion. Often an incorrect unit was given; some candidates gave the unit for density. Candidates should have determined the error in their value for resistivity by using either the error in the gradient or their worst acceptable gradient value. Finally there were two 'quality' marks available for candidates who gave the resistivity (one mark) and the error correctly within an acceptable range. Part **(d)** was generally poorly answered with many candidates struggling to score many marks.