PHYSICS

Paper 9702/01
Multiple Choice

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

General comments

As in June 2007, this paper proved to be a good test. The mean mark out of 40 was 24.8, which is a little lower than last June and the standard deviation was 7.4, which is a little higher. The results showed that fewer than 20% of candidates scored less than 18/40 and that there were 66 of the 7918 candidates who scored 39 and 23 candidates who scored 40. To get through 40 questions in an hour and not make a single mistake is really impressive. A very small percentage of the candidates had considerable difficulty; under 4% of candidates scored less than 12 marks.

There were a few questions which were found to be easy but no question where more than 90% of the answers were correct. **Questions 5, 8, 10, 13, 21, 28** and **30** were the only questions where more than 80% correct answers were received. This seems about the right number of easy questions for a paper that has 40 questions to be answered in an hour. All of these questions required straightforward answering with no subtle twists for the candidate to worry about or to ignore. There is little time for checking answers when doing one of these tests so candidates must make sure that their approach to answering is reliable.

It was obviously too easy for 24% of candidates to get as far as option B in **Question 1** and find it correct. Unfortunately, if they had also considered C, they would have found that to be correct too. Then they might have realised that although B seemed correct it was not in base units, so C is the only possible answer to satisfy the question. This does take time but 73% did find the correct answer.

Questions similar to **Question 2** always seem to cause problems. Too much guesswork was apparent here with only 29% getting the correct answer, A. Having some benchmarks for physical quantities is really useful: such as 'an atom has a diameter around 10^{-10} m'; and a nucleus has a diameter only about 1/100 000 that of an atom.

Other questions that proved to be very difficult were as follows:

- **Question 7**, where 40% of candidates appeared to believe that *g* is gravity.

- **Question 20**, where 35% gave C, which is the total area under the graph, but of course the extension is only 0.20 m.

- **Question 25**, where 46% got the correct answer, but there was a good deal of guessing by the weaker candidates.

- **Question 37**, where only 22% of candidates gave the answer C. Candidates appear to have difficulty with 'not' questions.

All of the questions showed positive discrimination. There were no questions where able candidates were less likely to obtain the correct answer than the less able candidates.

PHYSICS

Paper 9702/02

AS Structured Questions

General comments

As always, there were some very good scripts with candidates maintaining a high standard throughout the whole paper. However, there were many scripts where what was written revealed that there was very little understanding of the fundamental principles of physics on which the answers should have been based.

Questions 3 and **7** proved to be the lowest scoring and **Question 2** the highest. Good scores were achieved by many candidates in **Questions 1** or **5** or **6** but these scores were very Centre-dependent.

Many candidates lost marks needlessly. Time was wasted copying out either large sections of the questions or the results from calculators to ten significant figures where data in the question was given to either two or three significant figures. In other scripts, answers were given with no working. When such answers are incorrect, then no credit can be given even though the error may be purely arithmetical.

It is appreciated that, for many candidates, English is not their first language. However, candidates do need to ensure that answers are sufficiently detailed and unambiguous. For example, in **Question 5(c)**, statements such as 'the fringes increased' do not indicate whether the candidate is referring to an increase in fringe width or in number or in intensity/contrast.

Apart from very weak candidates, there was no evidence for a shortage of time to complete their answers.

Comments on specific questions

Section A

Question 1

(a) Candidates chose various criteria by which to distinguish between systematic and random errors. Arguments based on instrumental/experimental errors, constant/scattered errors or reducible/irreducible by averaging were all acceptable. The quoting of examples of errors, without further explanation, was unacceptable.

(b) It was pleasing to note that most candidates had some idea as to how to determine the uncertainty. Generally, the fractional uncertainties in V and L were found. Many then either added these fractional uncertainties, rather than calculating the difference, or failed to halve their result to find the fractional uncertainty in R. Most did convert correctly their calculated fractional uncertainty into the absolute uncertainty. However, there was considerable confusion as to how to express the final answer. The uncertainty should be given to one significant figure and the value of R to the corresponding number of decimal places.

Question 2

(a) Correctly answered by most candidates.

(b) (i) Most candidates did calculate the distance travelled by the boy while accelerating. Only a small minority assumed constant speed.

(ii) It was disappointing to note that many candidates failed to read the question carefully. A common error was to use T seconds, rather than (T – 5) seconds, as the time travelling at constant speed.

(c) This section was answered poorly by many candidates. Many failed to recognise that, when the boy caught up with the girl, both would have travelled the same distance from rest. Consequently, the sum of the answers given in **(b)(i)** and **(b)(ii)** should be equated to the answer in **(a)**. Many who gave an incorrect answer in **(b)(ii)** managed to obtain an answer by simply ignoring the negative sign that appeared in the calculation of T.

(d) (i) There were many correct answers to this relatively simple calculation.

(ii) A correct expression for power was quoted in most scripts. However, only a minority summed the accelerating force and the resistive force. Some substituted either one force or the other. A significant minority used the difference between the two forces.

Question 3

(a) (i) The majority of candidates attempted in some way to define *gravitational* potential energy, often using the equation $E_P = mgh$. Comparatively few dealt with the more fundamental concepts of stored energy that is available to do work.

(ii) Explanations based on either the position of one mass relative to another or the position of a mass in a gravitational field were equally acceptable but many answers were incomplete. Answers such as 'height of a body above the Earth' were common. Some candidates confused gravitational potential with gravitational potential energy.
Most candidates could associate elastic potential energy with some form of deformation of a body. However, descriptions were frequently very general and lacking scientific precision.

(b) (i) Most candidates did attempt to use an appropriate formula for change in gravitational potential energy. However, relatively few were able to calculate correctly the height through which the sphere had been raised. Many candidates used the vertical distance of the sphere below the point of support.

(ii) Some candidates confused *moment* and *momentum.* When calculating the moment, there were relatively few correct answers. Most candidates used the distance of the sphere either from the pivot or vertically below the pivot.

Question 4

(a) The large majority stated correctly that the material is brittle.

(b) Almost all candidates attempted to find the ratio *stress/strain* and most chose a suitable range of values on the graph over which to determine this ratio. The most common errors were to fail either to take the reciprocal of the gradient or to omit the 10^8 factor.

(c) Most candidates did quote a relevant expression relating stress, force and area. Many went on to calculate an area based on the breaking stress and the given force. With few exceptions, this was then stated to be the maximum area of cross-section of the bubble.

(d) Answers here were very disappointing, with few candidates considering the extension of the 'outer' edge and the compression of the 'inner' edge as the rod bends and then concluding that the thick rod would break more easily because the extension and the compression would be greater.
Many candidates defined *stress* and then concluded that, for a given force, the stress is inversely proportional to the area of the rod and therefore it follows that a thin rod can bend more. Others claimed that the Young modulus for a thin rod is different from that for a thick rod of the same material.

Question 5

(a) Most sketches showed a wave with an appropriate phase difference. However, less than half showed a wave with an amplitude close to 0.7 of the amplitude of the original wave, as was necessary for a wave of half the intensity. Most commonly, waves were drawn with one-half the amplitude.

(b) With few exceptions, an appropriate expression was quoted. There were, however, frequent inconsistencies in the units. Moreover, there were numerous instances where, having calculated the fringe separation in metres, the candidate multiplied by 10^{-3} to obtain the separation in millimetres.

(c) There were many complete and entirely correct answers. However, the question did reveal a lack of understanding on the part of a sizeable minority of candidates who concluded that the wavelength of the light would change or that the slits would move closer to the screen.
In many answers to **(i)**, it was concluded that the fringes would be brighter. Candidates need to distinguish between bright fringes and dark fringes. In this case, there was no change in brightness of the dark fringes.

Question 6

(a) With few exceptions, the numerical substitution into the relevant formula for current was shown clearly.

(b)(i) It was surprising to find that, although the question asked for the resistance of the cable, very few candidates attempted to determine the potential difference across the cable. Instead, they used either the supply voltage or the potential difference across the shower.

(ii) In most scripts, an expression for resistivity was stated clearly. However, very few candidates considered that there are two wires in the cable. When determining the area of cross-section, they failed to use either double the length of the cable or half the cable resistance. A minority thought that the two wires in the cable would be connected in parallel.

(c)(i) Disappointingly few candidates suggested that, with constant resistance, the power would be proportional to the square of the potential difference. Many arrived at the correct result by assuming a constant value for the resistance (which was frequently the resistance of the cable) and then calculating currents *en route* to the calculation of the power. Others assumed that the current would be constant.
A significant number of answers were left as fractions with unacceptably large numbers in the numerator and the denominator. Unless otherwise stated, the ratio should be given as a decimal.

(ii) Most candidates realised that there would be increased power loss and related problems such as fire risk but many did not explain why the increased heating would occur. Others thought that the resistance would increase as a result of increased resistivity or that the effect of a thinner wire would be an increased current.

Question 7

(a) A significant number of candidates discussed the conclusions that could be drawn from the experiment rather than state the results. Many did summarise the results very clearly. However, there were more who failed to appreciate the importance of the relative numbers of particles that are deflected either only slightly or through an angle greater than 90°.

(b) There were many acceptable estimates for the diameters of the atom and of the nucleus. It was apparent, however, that a significant minority of candidates had no appreciation of the numbers involved. Estimates for the nuclear diameter varied from 10^{-54} m to many metres.

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** and the first part of **Question 2** was relatively straightforward. 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 candidates. Experiments are designed with the view that Centres will have the apparatus as outlined in the syllabus available for use. 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 did not seem 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** scored poorly.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question, candidates were required to investigate how the potential difference across a length of wire depends on the length / cross-sectional area ratio in order to find the current in the circuit.

Successful collection of data

(a) Few candidates were able to read the micrometer screw gauge accurately and carry out repeat readings.

(b) Many candidates were able to set up the equipment without help from the Supervisor. Help setting up the whole circuit lost just 2 marks, while minor changes to the circuit lost just 1 mark.

(c) Most candidates were able to tabulate 6 sets of readings of V and I. Occasionally the values of V were too small because the resistor was wrongly connected (or not connected at all) or the voltage reading showed the wrong trend, indicating that the candidate read the scale starting from 100 cm and not from 0 cm.

Range and distribution of marks

(c) It was expected that candidates would use a range of lengths of 70 cm or more, given that candidates were supplied with at least 100 cm of wire.

Presentation of data and observations

Table

(c) Many candidates were awarded the column heading mark. The most common error was in the *l/A/m*$^{-1}$ column and almost half the candidates failed to gain this mark.

Many candidates were able to use the appropriate number of decimal places in the *l* value. The number of significant figures used in the *l/A* quantity was expected to relate to the number of significant figures used for the diameter or length (whichever was less). Many candidates gained this mark but some were penalised for using five or more significant figures. It is expected that the number of significant figures used in *l/A* is the same or one better than the significant figures in the corresponding values of *l* or diameter.

Graph

(d) (i) Candidates were required to plot a graph of *V* against *l/A*. Many candidates used suitable scales and not many candidates compressed their scales. Some candidates used awkward scales. The majority of errors were in the plotting and reading of plots. It is expected that candidates can plot and read values to the nearest half a smallest square. Some plots were plotted as 'blobs', that is dots greater than half a square in diameter and failed to gain credit.

(ii) Most candidates were able to draw an acceptable line of best fit. The quality mark was only awarded if all the plotted points lay close to the best fit line.

Analysis, conclusions and evaluation

Interpretation of graph

(iii) Many candidates used triangles with the hypotenuse greater than half the length of the line drawn to determine the gradient. A few candidates used smaller triangles and lost the gradient mark. 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 re-plotted by the Examiner onto the line of best fit, there was still a chance that the candidate could score the quality mark.

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

Drawing conclusions

(e) In the analysis section many candidates were able to equate the gradient with ρI and the *y*-intercept with *k*. Many candidates correctly gave the answer for *k* with the correct units. The correct value and unit of *I* was more difficult to obtain. Some candidates incorrectly chose substitution of known points to find *k* and *I* instead of using the gradient and *y*-intercept in **(d)(iii)** as it states in the question. Incorrect calculation of the area of cross-section of the wire and power-of-ten errors in the evaluation of *l/A* often led to the answer for *I* being out of range.

Question 2

Successful collection of data

(a) (iii) Most candidates gave an equilibrium position of the end of rule to the nearest cm or mm.

(b) (i)(ii) Often candidates recorded the lowest position of the rule rather than the value of *d* as indicated on the diagram. The value of *d* was generally within the specified range. The reading for the maximum height was then recorded. The majority of candidates were able to choose a different value of *d* and measure the new maximum height. Repeated readings were expected for the measurement of the highest point as this was the most unreliable reading. This was rarely done.

Quality

(b), (d) Often candidates obtained a value of *x* that was equal or bigger than *d*, which was not expected, and failed to gain this quality mark. It was expected that a larger value of *d* would yield a larger *x*.

Presentation of data and observations

Display of calculation and reasoning

(b), (d) Most candidates were able to work out the first and second value of *x*. Generally, those candidates who failed to get this mark did not use the equilibrium position.

(e) A large number of candidates failed to calculate the two values of the ratio *x/d* so did not gain this mark.

Analysis, conclusions and evaluation

(e) It was expected that candidates would give their judgement on whether the relationship holds or not <u>based on their ratio calculation</u>. This was poorly answered. If the candidate stated that they felt the ratio for each experiment was the same and therefore the relationship holds then credit was given provided the ratios were within a certain percentage of one another. It was deemed for this experiment that 10% was feasible. This is not a strict rule. The candidate could choose their own limit or they could use the percentage uncertainty they calculated from part **(c)**.

Estimating uncertainties

(c) Once again, 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 in the uncertainty of *x* and many candidates failed to appreciate this.

(f) (i)(ii) The evaluation proved to be the hardest section on which to score marks. This was probably because candidates were unfamiliar with this style of question. The key is to identify specific problems for <u>this particular experiment</u> 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 <u>better</u> experiment, not a different one. Outlined below are some common answers that gained credit and some which failed to gain credit.

- Credited problem: 'Difficult to apply the same force during the <u>release</u> of the ruler.'
  Credited solution: 'Use an electromagnetic device to release the mass of the ruler.'

- Credited problem: 'Problem with parallax in taking the readings.'
  Credited solution: 'Get eye in right place so that readings are taken at eye level.'
  No credit: 'Repeated readings and average.'

- Credited problem: 'Difficult to measure the highest position as the ruler is <u>moving</u>.'
  Credited solution: 'Use a video camera with slow motion feature to measure maximum height accurately.'
  Credited solution: 'Use a pin at the end of the oscillating rule.'
  No credit: 'Human error when reading the maximum height / reaction time error.'
  No credit: 'Use a pointer.' – detail such as where the pointer is placed is also needed.

- Credited problem: 'Two values of *x* and *d* are not enough.'
  Credited solution: 'Record different values of *x* and *d*, and plot a graph of *x* against *d*.'
  No credit: 'Repeat the readings in *x*.' (Very common.)
  No credit: 'Use different mass/length of ruler.'

Many candidates seemed to report on the equilibrium position changing 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 if not supported with a reason. Candidates needed to be much more specific and consciously state the <u>method</u> needed for this particular experiment. Further examples can be found in the mark scheme.

PHYSICS

Paper 9702/32
Advanced Practical Skills 2

General comments

The standard of the candidates' work was similar to last year, with a good spread of marks. **Question 1** and the first parts of **Question 2** were relatively straightforward, with most candidates confident in the generation and handling of data. Although all candidates attempted the last part of **Question 2** (critical evaluation of the experiment), many 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 candidates if attention was drawn to the published mark schemes.

Experiments are designed to use apparatus from the list specified in the syllabus, and most Centres had no problems in providing the equipment required.

In some cases candidates were helped by their Supervisors to set up the apparatus in **Question 1** and incurred a small mark penalty, but had the benefit of being able to continue with the experiment. Supervisors are reminded that under no circumstances should help be given with taking readings or with the analysis.

There was no evidence in the scripts that candidates were short of time. Those that attempted **Question 2** first and found that they had some time available would have been able to plan their selection of resistances and draw up a results table while they waited to use the apparatus for **Question 1**.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates were required to set up a metre bridge and investigate how the balance length varied as one of the resistances was changed, and to use this data to find the value of the resistance in the other arm. This question was generally well answered.

Successful collection of data

(a) Most candidates were able to connect the circuit without help from their Supervisor. Those that were helped were penalised by 1 or 2 marks.

(b) Nearly all candidates were able to make a clear table with 6 sets of readings of R_2 and l. Some gave one or more impossible values for R_2, usually through miscalculating the value of a combination of the four 10Ω resistors provided.

Many candidates gained a mark for good quality readings – these gave a graph with the correct trend and little scatter.

Range and distribution of values

(b) Examiners expected a good range of values for R_2, including the highest possible (40Ω) and a low value (5Ω or less), and many candidates achieved this.

Table

(a) Many candidates gave an incorrect unit for the column heading $(1/l)/\text{cm}^{-1}$, or missed out this unit.

(b) Nearly all candidates gave consistent readings for *l*, i.e. all to the nearest mm or the nearest cm. Values for $(1/l)$ were usually calculated correctly, but about half the candidates gave them to too few significant figures (Examiners expected the same as, or one more than, the s.f. in *l*).

Graph

(c) (i) Graphs were generally well produced, though a few candidates plotted points as large 'blobs' (greater than half a small square in diameter), and some chose awkward scales.

(ii) Best fit lines were usually good (Examiners expected at least 5 of the points to be included in the judgement).

Interpretation of graph

(iii) Nearly all candidates knew how to calculate the gradient, and nearly all used a suitably large triangle (one that used at least half the length of the graph line), but a few mis-read the coordinates.
Many candidates calculated the y-intercept (which was acceptable) even though it could have been read directly from the graph.

Drawing conclusions

(d) A significant number of candidates used the equation provided to calculate the value of R_1 by substituting the coordinates of points from their graph. This was not acceptable as they were instructed to use their gradient value. Others were not credited because they omitted a unit, or because they gave too many significant figures (2 or 3 s.f. was accepted).

The constant *k* was usually correctly equated to the intercept, but again in many cases the unit or too many s.f. led to a penalty**,** as did a value out of range (0.005 to 0.015 cm^{-1} was accepted).

Question 2

This question required candidates to time the fall of a paper cone over a measured distance and then calculate the terminal velocity. After repeating with a smaller cone, a reasoned comment on the relationship between cone size and terminal velocity was requested. Although the instructions were deliberately less detailed than in the first question, these sections were answered reasonably well.

The last section required evaluation of the experiment and suggestions for improvement, and this proved difficult for many candidates.

Successful collection of data

(b) (ii) All candidates measured the diameter of the first cone, although a few quoted their measurement to too great a precision (i.e. to 0.1 mm).

(c) (ii) A significant number of candidates mis-read the stop-clock when timing the fall (e.g. recording 65s or 0.0065s instead of 0.65s). An error of this type was only penalised once.

(f) (ii) The diameter of the second cone was expected to be less than that of the first (most were credited here).

(f) (ii) Candidates were expected to take the average of repeated measurements for each time, but the majority of candidates failed to show any evidence of this.

Display of calculation and reasoning

(e) When calculating the values of terminal velocity, many candidates used equations of motion with acceleration, rather than *h*/*t*. This error was only penalised once.

(f) (ii) The quality mark required that the smaller cone fell with greater velocity (if candidates' calculated velocities were wrong, Examiners used corrected values).

(g) When testing whether terminal velocity was inversely proportional to diameter, Examiners expected candidates to calculate values of *vd* for the two cones, or to calculate the ratios v_1/v_2 and d_2/d_1. Only a minority of candidates did this.

Drawing conclusions

(g) A few candidates successfully compared their *vd* values and decided that they were close enough to support the inverse proportion, or were too dissimilar. In the absence of a limit set by the candidate, or a reference to the percentage uncertainty calculated in **(d)**, Examiners used a difference of 20% between the two values as the borderline between supporting the suggested relationship or not (this being based on the likely percentage uncertainty in *t*).

The majority of candidates just pointed out that as diameter decreased the terminal velocity increased, but this was not considered acceptable.

Estimating uncertainties

(d) Many candidates used an absolute uncertainty of 0.01s, which was too small. As human reaction time was involved, the Examiners considered an uncertainty of 0.1s to 0.5s to be reasonable. Candidates who used half the range from repeated values were also credited.

Limitations and improvements

(h) The evaluation proved to be the hardest section in which to score marks, probably due to candidates being unfamiliar with this style of question.

Examiners expected candidates to identify specific problems in this particular experiment, and then suggest ways of reducing the difficulties without changing the experiment itself.

For many of the limitations and improvements listed in the mark scheme the Examiners were looking for sufficient detail to make the limitation unambiguous or the improvement practical and specific.

For example:

- 'Cone falls at an angle' was credited as a limitation but 'Draughts affect the speed' was not.
- 'Switch off fans' was credited as a solution but 'Use a draught-free room' was not.

- 'Parallax error' was credited but 'Difficult to take readings' was not.
- 'Use light gates to trigger a timer' was credited but 'use lasers' was not.

- 'Difficult to measure diameter because cone was flexible' was credited but 'Difficult to measure diameter' was not.
- 'Measure diameter in different directions and average' was credited but 'Repeat diameter measurement and average' was not.

Suggestions involving using cones made from different materials were not credited.

PHYSICS

Paper 9702/04

A2 Structured Questions

General comments

The general standard of candidates' work was rather disappointing. There were many answers where it appeared that the candidate had no real appreciation of the underlying concepts.

All parts of all questions were accessible to some candidates. However, there were very few scripts where the performance over the whole paper was good.

In many scripts, candidates who had produced an average or above-average performance in ***Section A*** then scored few marks in ***Section B***. Weak candidates frequently did not answer all the questions in ***Section B***.

Apart from weaker candidates, the time allowance to complete the paper appeared to be adequate. The poor marks awarded in ***Section B*** to average and above-average candidates were usually due to inappropriate and incorrect answers rather than being a penalty for incomplete work.

Comments on specific questions

Section A

Question 1

(a) (i) Very few candidates were able to define the *radian*. In many scripts there was no reference to the radius of a circle or an arc. Many defined the radian by stating that 2π rad is equivalent to 360°.

(ii) There were very few answers that included the ratio of the circumference of a circle to its radius. Many candidates repeated what they had written in **(i)** – in particular, that 2π rad is equivalent to 360°.

(b) (i) Candidates do need to be aware of the fact that, where the command word in a question is *show*, full explanation is required. In many answers, the starting point was the substitution into an equation, rather than a statement such as 'the weight provides the centripetal force'. Consequently, marks were lost.

(ii) In most scripts, credit was given for calculating the force constant of the cord. However, weaker candidates could make no further progress. Most candidates who did realise that the force in the cord would equal the weight plus the centripetal force then made the mistake of assuming that the centripetal force would be constant for all positions of the string.

Question 2

(a) (i) The great majority of answers were correct, with only a few forgetting to use the kelvin scale of temperature.

(ii) The more-able candidates were successful here but weaker candidates frequently made no attempt.

(b) (i) With few exceptions, a correct formula was quoted. It was disappointing to note the large number of answers where the mass of a helium-4 atom was thought to be 4 kg or 0.004 kg.

(ii) In many scripts, marks were awarded only because 'error-carried-forward' from **(i)** was permitted. Although the question specifies the weight of an atom, many candidates failed to include *g*. Candidates should realise that it is meaningless to calculate the ratio of two different quantities. In this case, a weight was compared with a force – i.e. a comparison of two forces and not a comparison of a mass with a force.

(c) Answers tended to lack clarity so that it was not possible to determine whether a statement written by a candidate was meant to be a comment on the answer calculated in **(b)(ii)** or a reference to one of the assumptions of the kinetic theory of gases.

Question 3

(a) (i) With very few exceptions, the correct value of *d* was quoted.

(ii) Most candidates knew how to approach this calculation and there was a pleasing number of correct answers. Common errors were associated with reading the graph for the maximum kinetic energy and with powers-of-ten.

(b) (i) Nearly all candidates gave the impression that they knew where to draw the line but accuracy left much to be desired in many scripts. A ruler should be used when attempting to draw a straight line.

(ii) Many candidates who attempted this part of the question did state a frequency of 4 Hz. However, a fractional reduction in frequency equal to the fractional reduction in total energy was a common misconception.

Candidates did not appear to realise that the graph would have the same basic shape, regardless of total energy. Thus, reading the value of *x* at (2.56 – 1.00) mJ would give the amplitude for a total energy of 1.00 mJ.

Question 4

(a) (i) The majority of answers were given full credit although, in many, terminology could have been improved. Many candidates wrote about field lines (or charge) moving away from the sphere.

(ii) A minority of answers included the idea either that the field lines are normal to the surface or that the lines appear to radiate from the centre of the sphere. Many made reference to 'the nucleus (or protons) being concentrated at the centre'.

(b) The quality of the drawing was frequently so poor that it was impossible to ascertain whether the direction would represent a tangent to the line at A. Many candidates merely drew an arrowhead on the field line. Ideally the arrow should start at A and have sufficient length so that it is clearly tangential to the line of force.

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

(ii) Most candidates realised that the charge would have the opposite sign to that stated in **(a)(i)**. Generally, it was stated that the magnitude of the potential would be less. However, very few could give any justification for their statements. Indeed, comments that were made frequently indicated a lack of understanding of basic concepts.

(d) A minority did state that gravitational forces are always attractive. However, many thought that the gravitational field either 'always acts down' or 'is always parallel lines' or 'always acts towards the Earth'.

Question 5

(a) Most candidates referred to storage of either energy or charge.

(b) (i) The most efficient means of answering this question was to give a word equation. A surprising number of candidates stated that ‘current is proportional to charge’.

(ii) Successful candidates either counted squares or used a series of vertical strips. The conversion of the area to a charge presented few problems apart from a power-of-ten error. A significant number of candidates found the area of a single strip near to the origin on the *x*-axis. Presumably they thought that this initial strip would represent the initial charge stored in the capacitor.

(iii) Most answers to this part of the question were correct, when allowance was made for the candidates’ answers in **(ii)**.

(c) Most candidates quoted a correct expression for the stored energy. However, a majority assumed that the energy would be proportional to the potential difference, ignoring the fact that the charge on the capacitor would change.

Question 6

(a) (i) Most answers involved the correct sine function. However, many gave an expression for force, rather than force per unit length.

(ii) Surprisingly for this level of examination, only approximately half of the answers were correct.

(b) (i) Some candidates thought that this question related to the induction of an e.m.f. More able candidates frequently realised that the current in the two loops is in the same direction. However, rather than explain how this leads to a decrease in separation, most merely stated that ‘the currents will attract’. Such a statement does not constitute an explanation, as required in the question.

(ii) There were some clearly laid-out correct answers. Other candidates appeared to know how to approach the problem but made careless mistakes through untidy work. Common errors were either to assume that the separation of the loops is equal to the length of wire in a loop or to substitute mass, rather than weight, for the force.

Question 7

(a) It is expected that the majority of candidates would be awarded full credit for knowledge such as this. However, many candidates referred to removing either protons or neutrons from the nucleus, rather than separating nucleons to infinity.

(b) (i) Less able candidates labelled the peaks. Many showed the krypton at the maximum of the graph.

(ii) Very few candidates had any real understanding of the situation. Some did refer to *stability* but at no time did they discuss the meaning of this term. Many did not make a comparison between the parent nucleus and the products. Instead, they merely referred to the stability of the uranium nucleus.

For a comprehensive answer, candidates should state what is meant by binding energy and then compare the binding energy of the uranium nucleus to that of the products.

(c) A small number of candidates stated that, in 9 s, the amount of krypton would be reduced to 1/8. However, they did not go on to say that in this same period of 9 s, there would be negligible decay of the barium.

There were some excellent answers based on a full mathematical treatment. This was not necessary. On the other hand, many candidates could do no more than calculate the decay constant for each nuclide.

Section B

Question 8

(a) Most candidates who had any understanding of the situation gave the correct answer. From the responses of some candidates, it was clear that they had not studied this topic.

(b) Most candidates scored either full marks or no marks.

(c) (i) A thermistor connected in series with a resistor was shown in approximately 50% of scripts. In those scripts with a series circuit, it was common to find only one output terminal.

(ii) Most candidates who drew a thermistor in **(i)** did state that the resistance of the thermistor would decrease with increasing temperature (or *vice versa*). However, very few could discuss how this potential divider circuit would give rise to a change in the output potential difference.

Question 9

There was clear evidence that some candidates had not studied this topic.

(a) Of those candidates who defined acoustic impedance as the product ρc, most could state what is meant by ρ but many referred to c as 'the speed of light' or merely 'speed'.

(b) Most candidates did not seem to appreciate that it is the change in acoustic impedance at a boundary that governs the fraction of the incident wave intensity that is reflected. Most candidates who attempted this part of the question were content to write about individual media.

(c) There were some very good accounts here but equally, it was clear that some candidates had little knowledge or understanding of the situation. Indeed, some candidates included aspects of MRI and CT scanning in their accounts.

Even amongst better accounts, the role of the transducer as not only a transmitter but also a receiver was not made clear.

Question 10

(a) The section was answered well by many candidates but it was clear that some others had not studied this topic.

(b) There were very few incorrect answers. Either candidates could give the correct answer or the answer space was left blank.

(c) Sketches were, in general, poor. Many drew an unmodulated carrier wave whilst others drew only the envelope.

Question 11

(a) Very few answers indicated that the candidate understood why an area is divided into cells. Many realised that the base stations have different frequencies but thought that this was merely to prevent interference, rather than allowing the carrier frequencies to be re-used.

(b) In the majority of answers, it was not made clear that the identifying signal is received by more than one base station. In others, any selection appeared to be made at the base stations, rather than by a computer at the cellular exchange.

Some candidates explained the role of the computer at the cellular exchange during a call, rather than before the call is made. Candidates should always read the questions carefully.

PHYSICS

Paper 9702/05

Planning, Analysis and Evaluation

General comments

This was the second Paper 5 for the revised syllabus. The paper was similar to the specimen paper and produced a wide range of marks with some candidates scoring 30. It was also pleasing to see that a number of candidates scored full marks on **Question 1** and likewise on **Question 2**. Conversely there were also a number of candidates who scored poorly on either **Question 1** or **Question 2**.

It was evident in the planning question that candidates were willing to give more detail of experimental techniques that they had acquired in the laboratory. There was also evidence candidates were better at coping with the treatment of errors in **Question 2**, although there were still a significant number of candidates who 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. It is clear that high scoring candidates have benefited from a wide experience of practical techniques throughout their Physics course. This paper is designed so as to test candidates' practical experience; this is best achieved through the teaching of a 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.

It is essential that candidates present their answers clearly, particularly when calculations are involved. Marks are often awarded when a clear (correct) method is seen; conversely marks are often lost because it is not clear how an answer has been determined. Plans should contain all the necessary detail; there are four additional detail marks on **Question 1**.

Comments on specific questions

Question 1

Candidates were required to design a laboratory experiment to investigate whether the amplitude of sound transmitted through a double glazed window is related to the air pressure in the space between the panes.

The majority of the candidates understood the problem and most were able to explain that the pressure between the two panes of glass needed to be varied and the amplitude of the sound recorded. Sometimes these points were stated in terms of independent and dependent variables. Candidates should also be considering the variables that are to be controlled. Good candidates wrote an explicit statement such as "the incident amplitude of the sound will be kept constant". Further evidence of keeping additional variables constant was credited in the additional detail section.

Five marks are available for the methods of data collection. One mark was awarded for a labelled diagram of a workable arrangement. It was expected that the there would be a loudspeaker connected to an audio frequency generator, the glass window and a microphone connected to an oscilloscope. Data loggers or computers on their own did not score this mark. Some weak candidates carried out the whole experiment inside a bell jar. Marks were available for a suitable device such as a Bourdon gauge or manometer for measuring the pressure and using a vacuum pump to reduce the pressure between the two panes of glass. It was expected that the amplitude of the received sound would be displayed on a cathode ray oscilloscope. Finally candidates were expected to specify that the experiment would be carried out in a quiet room. Again clear diagrams indicating shielding were very helpful.

There are two marks available for the analysis of the data. It is expected that candidates would explain the quantities that would be plotted on each axis for the first mark and then for the second mark explain how the given equation is valid. A very large number of candidates suggested plotting a graph of A against $\sqrt{p}$ or A^2 against p for one mark. For the second mark candidates were expected to state that if the relationship given is valid there 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 a half – this gained full credit. Calculation/averaging methods did not gain credit.

There was one mark available for the describing an appropriate safety precaution for this particular experiment. Candidates should be encouraged to ensure that the safety precaution(s) are relevant to the experiment and are clearly reasoned; vague answers did not gain credit. Credit worthy responses included precautions taken due to the danger of the glass breaking or the intensity of the sound.

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

- method of ensuring that the output from the speaker is constant;
- method of reducing sound reflections from bench/walls – e.g. foam / speaker and microphone close to glass;
- window perpendicular to sound source;
- detail explaining use of oscilloscope to measure amplitude;
- difficulty in measuring amplitude at small pressures / use a loud incident source;
- control (or monitoring) of one additional variable – e.g. temperature, frequency, distances;
- allow time for the temperature/pressure between the glass to stabilise;
- discussion of attenuation in air/frame/glass.

Usually good candidates who have followed a 'hands on' practical course during their studies score these additional detail marks. Indeed there were some very detailed answers particularly with regard to measuring the amplitude from the cathode ray oscilloscope in terms of *y*-gain and switching off the time-base.

Question 2

In this data analysis question candidates were given data on how the current in a filament lamp varied with the potential difference across it.

Part **(a)** asked candidates to explain why plotting a graph of lg (*I*/A) against lg (*V*/V) 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 did not rearrange the formula. Some disappointing answers stated that lg (*I*/A) was directly proportional to lg (*V*/V).

In part **(b)** most candidates calculated and recorded values of lg (*V*/V) and lg (*I*/A) correctly, although marks were lost where the correct number of significant figures was not used. 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; however, in logarithmic quantities the number of significant figures is determined by the number of decimal places e.g. for a current of 2.7 A, lg (*I*/A) would be expected to be given to either 2 or 3 decimal places, e.g. 0.43 or 0.431. Candidates were also expected to include the absolute errors in lg (*I*/A). Good candidates determined lg (*I*/A) for the worst value – e.g. using a value of 2.7, candidates calculated lg (*I*/A) for either 2.8 or 2.6 and found the difference from their value of either 0.43 or 0.431.

The graph plotting in **(c)** was generally good. Candidates should be advised to check suspect plots. Some candidates 'forced' their best-fit line through the origin. The worst acceptable straight line 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 clearly distinguish the lines on their graph.

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.

Part **(c)(iv)** caused greater problems and was not very well answered. Candidates who had correctly plotted the points and drawn an appropriate best-fit line were expected to take a point on their line and substitute it into $y = mx + c$. Candidates who extended the graph paper did not gain credit. To determine the absolute error in the *y*-intercept candidates were expected to find the difference between the *y*-intercept of the best-fit line and the *y*-intercept of the worst acceptable line. To determine the *y*-intercept of the worst acceptable line candidates needed to use both a point on the worst acceptable line and the gradient of the worst acceptable line.

In part **(d)**, candidates were expected to have used their gradient and y-intercept values to determine the values of *k* and *n*. Good candidates answered this question well, clearly demonstrating that they realised that the *y*-intercept was equal to lg *k* and that the gradient was equal to *n*. To determine the error, the worst acceptable value of *k* needed to be determined.