PHYSICS

Paper 9702/11
Multiple Choice

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

The mean mark on this paper was 22.9 with a standard deviation of 6.2. Only 56 out of 4600 candidates were completely out of their depth, scoring less than the guessing mark of 10.

Questions 7, 11, 20, 36, 37 and **38** were found to be particularly straightforward, with no subtle twists for the candidate to worry about or to ignore.

Candidates did well to sort out **Question 5**. 78% got the correct answer. They were less successful with the unusual presentation of **Question 6** where only 51% were successful. As might have been expected, **Question 9** proved difficult with only 29% being successful. This does need careful analysis and the temptation is to guess. It is essential here to incorporate the elastic collision situation of velocity of approach being equal to the velocity of separation.

A disappointing 45% gave the correct answer to **Question 12**. Many thought that R_2 would be less than R_1. **Questions 13, 14** and **15** were all poorly answered. This was understandable for **Question 13** where the torque is provided by just the top part of the belt, so radius is required rather than diameter, but **Question 14** should have been answered more reliably. It was probably the resolution aspect that caused the difficulty here. There was no doubt in **Question 15** that too many people concentrated only on the 2 kg trolley. Only 13% correctly applied the conservation of momentum first and then found the kinetic energy to be 12 J.

In **Question 21** almost as many answers were **B** as **C**. Obviously, therefore, candidates knew what to do but half of them did not realise that the shape of the graph implies an answer 10% greater than the straight line graph would give. A great deal of guessing was used for answers to **Questions 23** and **28** where all four responses were popular. For **Question 26** candidates forgot the central beam and the pattern on the opposite side of the central beam. **Questions 31** to **40** were answered well so there was no indication of candidates running out of time.

Now that space is being left for working it is essential that candidates use it. For their own benefit they should use words when working things out and not just a string of letters and figures. It is all too easy to make careless mistakes when answers are worked out in one's head.

PHYSICS

Paper 9702/12
AS Structured Questions

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

The mean mark on this paper was 23.7 with a standard deviation of 6.2. Only 50 out of 5000 candidates were completely out of their depth, scoring less than the guessing mark of 10.

Questions 6, 10, 19, 35, 36 and **37** were found to be particularly straightforward, with no subtle twists for the candidate to worry about or to ignore.

Candidates did well to sort out **Question 4**. 79% got the correct answer A. They were less successful with the unusual presentation of **Question 5** where only 56% were successful. As might have been expected, **Question 8** proved difficult with only 33% being successful. This does need careful analysis and the temptation is to guess. It is essential here to incorporate the elastic collision situation of velocity of approach being equal to the velocity of separation.

A disappointing 47% gave the correct answer to **Question 11**. Many thought that R_2 would be less than R_1. **Questions 12, 13** and **14** were all poorly answered. This was understandable for **Question 12** where the torque is provided by just the top part of the belt, so radius is required rather than diameter, but **Question 13** should have been answered more reliably. It was probably the resolution aspect that caused the difficulty here. There was no doubt in **Question 14** that too many people concentrated only on the 2 kg trolley. Only 17% correctly applied the conservation of momentum first and then found the kinetic energy to be 12 J.

In **Question 20** almost as many answers were **B** as **C**. Obviously, therefore, candidates knew what to do but half of them did not realise that the shape of the graph implies an answer 10% greater than the straight line graph would give. A great deal of guessing was used for answers to **Questions 22** and **27** where all four responses were popular. For **Question 25** candidates forgot the central beam and the pattern on the opposite side of the central beam. **Questions 30** to **40** were answered well so there was no indication of candidates running out of time.

Now that space is being left for working it is essential that candidates use it. For their own benefit they should use words when working things out and not just a string of letters and figures. It is all too easy to make careless mistakes when answers are worked out in one's head.

Part **(a)** was generally well answered although in **(i)** the answer of 3.14 was often seen, the terms multiple and factor were confused leading to common errors of **(iii)** 3 and **(v)** 88, and a small number gave the sum of 10 in error to **(vi)** rather than the product of 24.

PHYSICS

Paper 9702/21
AS Structured Questions

General comments

The general impression of the Examiners who marked the paper was that the level of difficulty of the questions was appropriate for the candidates for whom it was intended. The candidates produced a very wide range of responses and the majority of questions provided good differentiation. There was an almost complete range of marks but very few scored more than 50. The range of marks obtained suggests that the paper contained sufficient material to test the most able candidate. All the questions provided the opportunity for the weaker candidates to score some marks, and each question had at least one part in which the more able candidates were able to show their understanding of the subject. **Questions 2(a), 3(a)(ii)**, **5** and **7** proved to be the most difficult for the majority of candidates. The length of the paper was considered to be about correct, with the vast majority of the candidates finishing the paper in the required time. There were few examples of blank sections and this suggested that candidates had sufficient time to complete the paper.

Comments on specific questions

Question 1

This question was generally well answered.

(a) (i) This part was generally well answered. A significant number of candidates calculated the fuel used as 15 litres and left this as their answer for the fuel remaining in the tank.

(ii) This part was again generally well answered. A few tried to give incorrect fractions, which had been obtained from reading the graph, rather than giving a change in the meter reading.

(b) (i) The correct answer was given by good candidates. However, a number of candidates stated that the feature that showed a systematic error was either the line not going through zero or that the line was non-linear. These were not given any credit.

(ii) The majority of candidates were able to give the required answer for this part. Some answers for which no credit was given suggested the car would never run out of fuel.

Question 2

This question produced good differentiation with a full range of marks being obtained by candidates.

(a) (i) This was generally poorly answered. There were only a very few answers that linked the increase in air resistance with the speed of the sky-diver. Many described the conditions for terminal velocity or suggested that the sky-diver slows down due to air resistance. Only the very good candidates discussed the decrease in resultant force due to the increase in air resistance.

(ii) A significant number of candidates were able to state that air resistance was zero or that the only force acting was the gravitational force. There were many poor answers, with the acceleration value given in the question often related only to the acceleration due to gravity.

(b) A large proportion were able to draw an acceptable tangent to the graph and obtained a value within the required range. A significant number of candidates used the co-ordinates (6.0, 20) to calculate the acceleration, and were awarded no credit in this part, but were able to score in part **(c)** where error carried forward was applied.

(c) (i) The vast majority were able to calculate the weight with very few penalties being applied for the use of $g = 10$. Full marks were generally awarded for this part, often because of an error carried forward.

(ii) The common error in this part was to add the weight to the accelerating force, but in general credit was awarded.

Question 3

This question produced a significant number of low scores and very few candidates were able to score full marks.

(a) (i) This part produced the full range of marks in almost equal numbers. The common errors were either to repeat the word 'conservation' (or 'conserved') that was given in the question, or to fail to include the sum or total (momentum) or to omit the idea of a closed system.

(ii) Very few candidates scored full marks and only a small minority scored any credit for this part. The vast majority did not discuss the conservation of momentum and relate the final momentum with the initial zero momentum.

(b) (i) The vast majority scored some credit for starting with the equation for kinetic energy. Subsequent credit was generally obtained by all but the weaker candidates. The common errors were to use the wrong value for the mass of an alpha particle, the wrong value for u or attempting a conservation of momentum analysis.

(ii) The determination of the velocity of nucleus D by the conservation of momentum was carried out correctly by a large number of candidates. A minority of candidates attempted a solution with an incorrect analysis using conservation of kinetic energy.

(c) The calculation of the deceleration was generally well answered using an appropriate equation of constant acceleration. A small minority forgot to square the initial velocity or attempted to determine the time using time = initial velocity / distance.

Question 4

The majority of candidates scored at least half marks and many were able to score full marks.

(a) (i) The majority scored full marks on this part, with only the weaker candidates using inappropriate descriptions such as 'returns to the initial position or form'. A minority failed to state the required condition of removing the load.

(ii) The equations were generally given correctly. Only the weaker candidates gave answers that did not use the symbols stated in the question or that were incorrect.

(b) The good candidates were able to score full marks. The mathematical analysis required in this question was found to be challenging by the average and weaker candidates. A significant minority resorted to letting one of the unknowns (length or area) equal unity. This resulted in an unrealistic value for the other unknown which was then totally ignored. There was often little or no explanation in this method and hence frequently no credit could be awarded

Question 5

This question was the least well answered on the paper. The good candidates scored well in parts **(a)** and **(b)**. The weaker candidates often gave poor responses to both parts **(b)** and **(c)** or left these sections blank. There were very few candidates who gave answers to part **(c)** that achieved more than half marks.

(a) The majority of candidates knew that a progressive wave transferred energy, but very few described the origin of the wave as being due to vibrations or oscillations. A significant number of candidates failed to gain credit, as a progressive wave was described as a wave that carried energy with no indication that the energy was moved from one place to another.

(b) (i) A large number of candidates gave amplitude for their answer to this part. Some gave both displacement and amplitude and hence failed to gain any credit.

(ii) Very few candidates answered the question and distinguished between the two types of wave and the quantity *y*. The majority of answers were descriptions of the two types of waves. These types of answer were given some credit if the descriptions were clear. However, the answers given were often ambiguous about the direction of motion of the vibrating particles and the direction of transfer of energy of the wave, and hence failed to gain any credit.

(c) A very small proportion of the candidates appreciated what was required for this question. The majority obtained some credit in the diffraction experiment for a slit and a screen. There were very few candidates that gave a light source that was labelled, and even fewer included a slit with this light source. The observation of light spreading into the geometric shadow region was seldom stated. In the interference experiment a mark was generally awarded for a single light source, a double slit and a screen. Credit was often lost as the need for a monochromatic light source to produce bright and dark fringes was often omitted. The need for, or the means of obtaining, coherent light was not appreciated by the majority of candidates. The dimensions of the apparatus were seldom given by candidates. Weaker candidates often failed to read the question and gave answers in terms of water waves on ripple tanks. There was also some confusion between refraction and diffraction with some candidates giving apparatus that showed dispersion due to refraction with a prism.

Question 6

This question produced good differentiation for the average to good candidates. The weaker candidates found the question very demanding and generally managed to obtain no more than half the available marks.

(a) The definition was not generally given in sufficient detail to obtain full marks. The good candidates referred to the correct energy transformation but often failed to add the required phrase ‘per unit charge’. Answers that were not given any credit referred to a force, the work done driving charge around a circuit or the statement ‘when energy is transformed’.

(b) The solution to this question was generally well presented by the good candidates. However, a significant number of candidates tended to lose some credit for failing to give sufficient detail. The usual omission was not to give either $E = I(R + r)$ and / or power produced by the cell = EI. There were many different attempts that reached the required answer by incorrect physics by the weaker candidates.

(c) (i) The vast majority of candidates were able to read the graph correctly and score full marks.

(ii) A significant number of candidates from all abilities were able to derive the correct answer to this question. The candidates that were unable to quote $E = I(R + r)$ struggled to obtain an answer by correct physics. Many confused the power with e.m.f. or the p.d. across the external resistor with the e.m.f. of the cell.

(d) A significant number of candidates failed to gain credit. There were a large number of answers that were too vague or clearly showed misconceptions of the reasons for the variation in power output when using a cell with an internal resistance.

Question 7

The average mark for this question was very low.

(a) Very few candidates showed the angle of deviation by drawing two construction lines. The majority marked an angle between a continuation of the horizontal section and the curved section. The weaker candidates put a *D* on the diagram without any angle being marked.

(b) The good candidates generally scored some credit in this part for showing less deflection. However, a large number of candidates started the deflection far too late and the curve drawn was not symmetrical about the nucleus N. The weaker candidates often showed the same deflection for both particles A and B.

(c) The commonest answer was to state that the atom was mostly empty space. Only a minority of candidates compared the size of the nucleus with that of the atom. A significant number of candidates referred to the atom of the α-particle or its proximity of approach to the nucleus and hence failed to answer the question.

(d) The majority of candidates obtained some credit for realising that the deviation would not change as the number of protons would not change. Very few candidates explained that the deflection depended on the charge present on the nucleus N, and hence few scored full marks. A significant minority suggested that the deflection would differ due to the change in mass of the nucleus.

PHYSICS

Paper 9702/22

AS Structured Questions

General comments

As is usually the situation with this paper, there were some well-prepared candidates but there were many others who did not have the skills necessary to achieve success. There were many instances where most of the candidates from a Centre did not have a satisfactory knowledge of the syllabus content.

Candidates need to be encouraged to improve their recall of standard definitions, laws and equations.

There was no real evidence amongst adequately prepared candidates of a shortage of time to complete the answers to all of the questions.

Comments on specific questions

Question 1

(a) With few exceptions, candidates were able to calculate the percentage uncertainties. However, there were frequent errors as regards 'rounding down' of the number of decimal places.

(b) In general, this was completed successfully. However, a significant minority merely added the percentage uncertainties as calculated in **(a)**.

(c) (i) Many answers included a reference to significant figures or decimal places. Unfortunately, this reference was frequently confined to a statement regarding the number of significant figures in the value of *g*, rather than comparing this number with the number in the raw data. A minority of answers were based on the difference between the measured value of *g* and the accepted value of $9.81\,\text{m}\,\text{s}^{-2}$.

(ii) This part of the question was answered correctly by only a small minority of candidates. In nearly all answers, the uncertainty was calculated correctly. However, candidates did not appreciate that this uncertainty should be quoted to only one significant figure. This significant figure then determines the number of allowable decimal places in the value for *g*.

Question 2

(a) (i) Most answers included a reference to change of state from liquid to gas/vapour. The need to supply thermal energy to maintain constant temperature during both processes was also accepted.

(ii) Answers were, in general, quite comprehensive although a minority found difficulty when expressing the fact that evaporation occurs at any temperature of the liquid.

(b) (i) This was answered correctly by most candidates.

(ii) The calculation in **1** of the volume occupied by each atom presented very few problems. However, in **2**, only a minority realised that, in order to find the separation of the atoms, then it is necessary to take the cube root of the answer in **1**. Candidates should be encouraged to consider the answers they obtain so that ridiculous answers, produced as a result of power-of-ten errors, can be avoided.

Question 3

(a) With very few exceptions, part **(i)** was answered correctly. Most candidates completed part **(ii)** successfully. However, the explanations were not always adequate. Candidates should be advised that, where the command word is either '*show*' or '*derive*', then a full explanation is required because the answer is given.

(b) The instruction was to draw a vector diagram to scale. Although most diagrams were approximately the correct shape, the majority of candidates chose to draw what amounted to a sketch diagram and then to calculate the answers. Credit was lost for this approach.

(c) (i) Most answers were correct although, in a minority, the horizontal component of the velocity ($4.0\,\mathrm{m\,s^{-1}}$) was incorporated into the equation for vertical motion.

(ii) A very common error in **1** was to subtract, rather than add together, the momenta before and after bouncing. In **2**, most candidates could recall the expression for impulse.

Question 4

(a) It was expected that *strain energy* would be explained. This should include the concept that *energy* indicates an ability to do work. Candidates should be advised that all terms shown in italics should be explained. A common error was to state that strain energy is the energy required to deform the material.

(b) Many answers were disappointing in that they amounted to stating and subsequently simplifying two equations. Little or no explanation was evident. Candidates should be advised that the physics of the situation in such derivations is all important.

(c) (i) Apart from a lack of explanation on the part of some candidates, there were very few problems in this part of the question.

(ii)1 Apart from powers-of-ten errors, most candidates were able to calculate the result.

(ii)2 There were very few correct answers. Of those who realised that the energy is found by calculating the difference in the energies for extensions of 3.6 cm and 2.1 cm, many calculated $(0.036 - 0.021)^2$ rather than $(0.036^2 - 0.021^2)$.

(ii)3 Again, there were very few correct answers. Even amongst those candidates who had succeeded in parts **1** and **2**, many did not realise how to determine the work done from their earlier answers.

Question 5

(a) Factors of 8 were very common in the answers, rather than just f and A.

(b) There were very few correct answers and, even where the magnitude was given, the unit was frequently omitted.

(c) (i) Despite incorrect answers in **(a)**, most gave the speed as fL.

(ii) There were some good answers but many were confined to a statement that two waves travelling in opposite directions interfere, and that the speed is the speed of one of these waves. The reflection of the incident wave at P to produce the reflected wave was not included.

Question 6

(a) A surprisingly large number of answers were incorrect with $2/R$ substituted into the denominator of the ratio, rather than $R/2$.

(b) With few exceptions, the correct answer was obtained.

(c) In most scripts, the values for the p.d. were correct. However, it was common to find that either the resistance of a single lamp was thought not to change or that, in both cases, the resistance of the combination would be twice that of a single lamp.

(d) The calculation of the ratio was very straightforward. Although most candidates realised that the resistance would increase as the potential difference increases, very few attributed this change to the non-linear increase of current with potential difference. Frequently, the answer was a statement without any explanation.

Question 7

(a) As is usual with questions on this topic, there was widespread confusion between terms such as *nucleus*, *nuclide*, *neutron*, *element* and *isotope*. For example, a common answer was a statement that isotopes are 'elements with the same proton number......'. Candidates should be encouraged to use the terms *proton number* and *nucleon number* rather than *atomic number* and *mass number*.

(b) Most candidates could explain the meaning of spontaneity. However, explanations of randomness frequently lacked precision. Rather than 'it cannot be determined which atom will decay next', candidates should be encouraged to consider constant probability per unit time of the decay of a nucleus.

(c) A common error was to give the symbol for the daughter nucleus as W. Surprisingly, the representation of the β-particle was frequently incorrect.

PHYSICS

Paper 9702/31
Advanced Practical Skills 1

General comments

The overall performance of candidates was similar to previous years, with a good range of marks. There was a wide variation in the performance of individual Centres.

Most Centres had no difficulty in providing the equipment specified in the *Confidential Instructions* although a few Centres were unable to obtain the exact springs recommended for **Question 1**. Any deviation between the requested equipment and that provided to the candidates should be given in the Supervisor's Report, as well, so that Examiners can adjust the mark scheme appropriately. Any help given to a candidate should be noted on the Supervisor's Report. Supervisors are reminded that under **no circumstances** should help be given with the recording of results, graphical work or analysis.

Candidates appeared to complete both questions in the time allowed. As in previous years, **Question 1** was generally answered more successfully than **Question 2** by most candidates. Some found it difficult to identify sources of error in the experiment performed in **Question 2** and many could not suggest relevant improvements to the procedure. It would be helpful to all candidates if attention could be drawn to the published mark schemes.

There were no significant misinterpretations of the rubric.

Question 1

Successful collection of data

(a) Most candidates were able to record values of h and z to the nearest mm, though some tried to record to 0.1 mm, or to the nearest cm, so were not credited.

(b) Almost all candidates scored full marks for the collection of 6 sets of readings. A few obtained values of h greater than z. There was no penalty for this, although these candidates usually obtained values for k that were out of range in part **(e)**.

(d) (i) Most values for d were within the required range but few candidates repeated their measurement of the diameter and many candidates struggled to use the vernier callipers with the required precision. Units were also sometimes omitted.

Range and distribution of data

(b) Some candidates failed to gain credit for the range, as their largest value of $z - h \leq 6.0$ cm

Presentation of data and observations

Table

(b) All columns in the table require a quantity and the correct unit (where appropriate) separated by either / or (). Almost all candidates were credited for the headings. Most were also awarded the consistency mark, expressing their values of z (and h) to the same number of decimal places, though a significant number of candidates lost this mark because of 'trailing zeros', adding an extra '0' to each of their values to give the impression of greater precision.

Graph

(c) (i) Candidates were required to plot a graph of *z* against *h*. Graph axes were usually correctly labelled and well laid out with sensible choices of scales (though a few candidates chose awkward scales losing credit and making the correct plotting of points more difficult for themselves). Credit is lost if the scales are chosen such that the plotted points occupy less than 6 large squares in the vertical direction or 4 in the horizontal direction. Scale markings should not be more than 3 large squares apart.

Most plotted the points from the table accurately. Examiners penalise any points that are too large – the plotted points should be no more than half a small square in diameter. Sharp pencil points (ringed) or crosses are recommended. Most candidates were able to draw a reasonable line of best fit, though some tended to join the first and last points, regardless of the position of the intermediate points. Some lines could be rotated to give a better fit. A significant number of candidates lost credit for the line of best fit because their lines were not straight – they had almost certainly used a small ruler giving rise to 'kinks' in the line.

Calculated quantities

(d) (ii) Most candidates calculated the cross-sectional area of the wooden rod correctly (though a few candidates failed to square the diameter in their calculation). Some candidates lost credit through a power-of-ten error. Answers were usually expressed to an appropriate number of significant figures.

Analysis, conclusions and evaluation

Interpretation of graph

(c) (ii) Most candidates used a suitably large triangle to calculate the gradient (the hypotenuse should be at least half the length of the line drawn).

There were a few read-off errors in calculating the gradient, particularly where the candidate had chosen to use an awkward scale for the graph. A few candidates also calculated $\Delta x/\Delta y$ for the gradient, so lost credit.

Drawing conclusions

(e) Many candidates appreciated that the gradient of the graph was equal to ($k/\rho Ag + 1$), but scoring the second mark proved more difficult. Apart from *k* being out of range, many failed to give a correct unit. Another common error was to forget the +1 term, and some candidates tried to employ a substitution method rather than using the value obtained for the gradient directly, as the question requires. Where Centres had used springs with a different spring constant, and a sample set of results was provided in the Supervisor's report, Examiners took this into account in deciding a suitable range of values for *k*.

Question 2

Successful collection of data

(a) (i) The majority of candidates scored credit, though units were sometimes omitted and a few candidates had values of l outside the allowed range.

(b) (i) The first value of *d* was outside the range for some candidates.

(ii) Many found this question difficult. A common answer was to suggest repeating the measurements, whereas the question asks how the **apparatus** is used to obtain accurate measurements. A large number of candidates had the idea of using a marker though often not expressed very clearly, but very few made any reference to the notion of **refining** their measurement. A few candidates suggested placing the ruler underneath and viewing the displacement from directly above the swinging ball.

(d) Almost all candidates obtained second values for l and *d* but fewer than half of these repeated their measurements (of the first or the second deflection) to obtain full credit.

Quality

(d) Most candidates obtained a value for the second deflection which was smaller than the first deflection.

Presentation of data and observations

Display of calculation and reasoning

(c) (i) Whilst almost all candidates successfully substituted in values of *l* and *d* to find *k,* the majority lost credit because no unit for *k* was given.

(ii) Some candidates linked the number of significant figures for *k* directly to the number of significant figures used for *l* and *d*, but many made only a vague reference to the 'raw data' or 'the measurements' so lost the mark.

(e) Few candidates scored on this part. A calculation of the percentage (or fractional) difference between the two values of k obtained was expected, but many chose to compare only the absolute difference between the two.

Analysis, conclusions and evaluation

Drawing conclusions

(e) Candidates were awarded credit if they had drawn a conclusion consistent with the values of *k* they had obtained, using the candidate's 'benchmark' tolerance where stated, or a nominal 20% uncertainty in the values of *k*. Candidates are encouraged to state what they think is a reasonable uncertainty.

Estimating uncertainties in *d*

(b) (iii) Many candidates used 1 mm for the absolute uncertainty in *d* so lost the mark (the allowed range for the uncertainty was $2\text{ mm} \leq d \leq 10\text{ mm}$). Candidates need to be shown how to make realistic estimates of absolute uncertainties so that they can calculate percentage uncertainties. It is incorrect to assume that the absolute uncertainty is just the smallest division on an instrument – some account needs to be taken of the nature of the measurement. Correct ratio ideas and percentage calculations were often used correctly. Very few candidates chose to use half the range of repeated readings.

Evaluation

(f)(i)(ii) In the evaluation section candidates are expected to identify specific problems relevant to the particular experiment. Answers such as *parallax error* or *ball moves too quickly* lack sufficient detail, whereas *parallax error in the measurement of d* or *hard to measure d because the ball moves too quickly* would be credited. Candidates' attention is drawn to the mark scheme where a comprehensive list of valid problems and possible limitations is given. Finding solutions to the limitations and problems outlined requires a good deal of practice so that candidates appreciate the need to give full descriptions. Answers such as *take more readings* or *use better apparatus*, do not receive credit whereas *take further sets of readings and plot a graph*, or *use a video camera and record the motion and then play the video back slowly*, will receive credit. There were many invalid suggestions associated with changing the experiment rather than helping to improve it, such as using a larger marble or using a rubber ball instead of a table-tennis ball. A table giving details of potential improvements can be found in the mark scheme.

PHYSICS

Paper 9702/32
Advanced Practical Skills 2

General comments

The performance of candidates was generally similar to last year, with a wide range of marks awarded. There was variation between Centres in some sections of the questions.

Candidates' responses showed that they had been well-prepared for the practical work. Scores were good in the earlier sections of both questions (these included most of the measurements and calculations) but were weaker in the later sections (interpretation and evaluation of results, and review of experimental procedures).

Candidates appeared to have plenty of time to complete the experiments, and there were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

Successful collection of data

(a) This initial measurement for *h* usually gained credit, with just a few candidates recording a value to the nearest cm rather than the nearest mm.

(b) Most candidates' values of *h* gave the expected negative trend on the graph, suggesting that apparatus and procedures were correct.

(d) A number of candidates appeared to have difficulty with the use of a vernier caliper. Some recorded values suggested that the caliper had inch as well as mm scales, and that the wrong one had been used. Some values were recorded to a precision of 0.01 mm instead of 0.1 mm, but since a digital caliper may have been provided this error was given benefit of the doubt.

Surprisingly, hardly any candidates showed evidence of repeated measurements for the rod diameter *d* (important for this type of measurement).

Calculation of *A* was generally well done, but the use of a *d* value to 0.01 mm (e.g. 25.04 mm) often led to loss of credit for significant figures in *A* (three would not be acceptable). A less common error was the failure to convert cm to m (the instruction requested *A* in m^2).

Range and distribution of readings

(b) Very few gained credit for the range of values of *m* used. The problem was usually that the full range of masses available was not used, or that some increments were very large, but sometimes the mass of the hanger was included in the added mass.

The quality of the data (judged by the amount of scatter about a straight line trend on the graph) was good for nearly all of the candidates.

Presentation of data and observations

Table

(b) Results tables were usually clearly presented. Headings generally included suitable units, with only a few giving kg or g as the unit for the weight *W*. In addition to this confusion of weight with mass, a number of candidates calculated *W* using inconsistent units (e.g. with g = 9.81 and *m* in g but *W* given in N).

Graph

(c) Most candidates had been well prepared in this area. They made good use of the graph grid, with points occupying a good part of the area available and with sensible, easy to use axis scales. Plotting was usually accurate, though a few candidates were penalised for using very large dots (bigger than 1 mm diameter).

Analysis, conclusions and evaluation

Interpretation of graph

(d) This was also done well. The gradient was usually accurately determined, with very few losing any credit through using too small a triangle.

Drawing conclusions

(e) The majority of candidates correctly attempted to use the gradient of their graph in their analysis, but many equated it to $(k + \rho A g)$ rather than $-(k + \rho A g)$. Examiners were looking for a correct substitution, including the sign. 'Power of ten' errors in the earlier calculations often led to a value for *k* outside the expected range, as did the use of inconsistent units.

Question 2

There were some good scores for this question, but overall they were slightly lower than for **Question 1**.

Successful collection of data

(a) A small number of candidates recorded the length l to the nearest cm rather than the expected mm.

(b),(e) Candidates' values for *a* and *b* were usually sensible, but most failed to record repeated measurements of the rebound distance *b.* This is an important and fairly obvious feature of this type of experiment and to get credit actual <u>evidence</u> is expected (e.g. the calculation of an average value).

(c) (i) Here the best answers were often accompanied by a diagram. Examiners were expecting a description of a technique to minimise parallax error when measuring the rebound distance *b*, such as positioning the set-square at the extreme position of the ball as a marker. Candidates often mentioned the set-square but did not explain clearly how it was used.

Estimating uncertainties

(ii) Most candidates knew how to calculate percentage uncertainty, but many used an absolute uncertainty of ±1 mm for *b*, and this was unreasonably small due to the movement of the ball.

Presentation of data and observations

Display of calculation and reasoning

(d),(e) The calculation of the two *k* values was generally well done, including a sensible choice of significant figures.

Quality

(e) It was expected that *b* would increase as *a* increased, and this proved to be the case for nearly all candidates.

Analysis and conclusions

(f) There were many very good responses to this part of the question and candidates from some Centres had clearly been prepared well.

Examiners expected candidates to compare their two *k* values by calculating the percentage difference between them. The best candidates carried this out and then went on to consider whether this difference was significant in the light of experimental uncertainties.

Evaluation

(g) (i) The evaluation demands a good level of thoughtful analysis and again proved to be the most difficult section on the paper. Candidates from some Centres did very well. This could be partly from study of the mark schemes for previous exams, although each new experiment requires consideration of some new difficulties.

In this question the Examiners were looking for identification of specific difficulties related to the nature of the experiment and the methods used, including:

- basing a judgement on measurements for only two release distances
- the difficulty in judging the rebound distance (because of the movement)
- parallax error when measuring the rebound distance
- inconsistency of repeated measurements
- effect of air currents

Weaker candidates tended to list ‘standard’ experimental difficulties such as ‘zero error’ and ‘parallax error’. Problems should be linked to one of the measurements, e.g. rebound distance, or procedures, e.g. releasing the ball, to gain credit.

(ii) The best responses in this section often paired improvements with the difficulties already listed. Some were too vague to gain credit, e.g. ‘use a video camera’ without further detail, and some described procedures that should have been used already, e.g. ‘view ball and rule at eye level’.

Candidates should always consider whether their suggested improvement is changing the basic experiment, e.g. ‘use values of *a* greater than 25 cm’. This type of suggestion will not be credited.

PHYSICS

Paper 9702/33
Advanced Practical Skills 1

General comments

The general standard of the work done by the candidates was similar to last year, with a reasonably good range of 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. Any deviation between the requested equipment and that provided to the candidate should be written down in the Supervisor's Report so that the Examiners can take this into consideration during the marking period. Experiments are designed with the view that Centres will have the apparatus as outlined in the syllabus available for use. Any help given to the candidate should be noted on the Supervisor's Report. 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 and both questions were attempted. Once again, most candidates were more confident in the generation and handling of data than they were with the critical evaluation of their own experimental skills. It is worth noting that in this paper eight marks (20%) are given to the evaluation section at the end.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

Successful collection of data

(a) (b) Most candidates were able to record the suspended mass M, measure the length l, of the coiled section of spring A and calculate the extension x of the spring. A minority of candidates measured l to the nearest cm instead of mm, thus failing to gain credit.

(c) Many candidates failed to show their working and hence failed to gain credit in this section. No credit was given for using an alternative method, e.g. Pythagoras or trigonometry, to find v.

(d) Most candidates were able to tabulate six sets of values for M and l gaining credit for this section.

Range and distribution of marks

(d) It was expected that candidates would use a range of M to include 100 or 150 g at the lower end (common) and 400 or 450 g (rare) at the upper end. Many failed to use the whole range and so were not awarded the range mark. In the rare case that Centres used a spring with a different spring constant, and the exam board was notified, then the Examiners took this into account in deciding a suitable range.

Presentation of data and observations

Table

(d) Many candidates failed to gain the mark for column headings. In particular the heading *M/v (kg* m^{-1}*)* caused problems. The raw values of l were generally given correctly to the same number of decimal places, but some candidates were not sure whether to keep the number of significant figures or the number of decimal places the same. The corresponding significant figures given in the calculated quantity *M/v* were often incorrect. The number of significant figures in the calculated quantity should be the same as, or one more than, the least number of significant figures in *M* or *v.* Most candidates calculated *M/v* correctly.

Graph

(e) Candidates were required to plot a graph of *M/v* against *x*. A significant number of candidates plotted the wrong graph, plotting for example *M* against *M/v.* Many candidates used awkward scales, e.g. 3:1, often leading to errors in plotting or in reading off the gradient points. The plots should occupy half the graph grid or more. Plots and read-offs should be accurate to within half a small square in both the *x* and *y* directions. 'Points' that were greater than half a small square in diameter were penalised. Many candidates were able to draw an acceptable line of best fit from five or six trend points. Some lines could be rotated round to give a better fit and some lines were clearly drawn with two short lengths of ruler giving rise to 'kinks'. Some lines were drawn by connecting the first and last points together without thinking whether this was actually the best line. There was a reasonable allowance for scatter in order to gain credit for the quality mark and many candidates gained this mark.

Analysis, conclusions and evaluation

Interpretation of graph

(e) (iii) In order to determine the gradient of the line of best fit, candidates are expected to use triangles with the hypotenuse equal to or greater than half the length of the line drawn. A fair proportion of candidates used triangles that were too small and lost credit. Often, the same candidates who mis-plotted points or who set out awkward scales, went on to mis-read gradient points.

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

Drawing conclusions

(f) Candidates were able to work out *C* using the correct method, i.e. gradient = qk and *y*-intercept = qC with gradient and intercept values taken from **(e)(iii)**. Candidates using the substitution of known plots into the equation failed to gain credit. Good candidates were able to obtain the final mark for the value and range of *C* in range (±1N) using the correct method. The use of cm and grams earlier on in the experiment led to power of ten errors in this last section.

Question 2

Successful collection of data

(a) Many candidates (over 50%) failed to repeat their readings of *d.* Also many failed to read the diameter to the nearest 0.1 mm (or 0.01 mm) using a set of vernier callipers.

(e)(f) Most candidates measured a first and second mass for when the nylon is wrapped one and a half times and two and a half times around the wooden rod respectively. Surprisingly hardly any candidates repeated their readings of either the first or second mass. This reading was the most unreliable reading of the whole of the experiment and repeat readings were expected.

Quality

(f) Many candidates gained credit in this section for value of the second mass being more than twice that of the first mass.

Presentation of data and observations

Display of calculation and reasoning

(d) Many candidates successfully calculated the value of the length of nylon thread l in contact with the rod using $1.5\pi d$.

(d) In quoting l many candidates failed to use the same or one more significant figure than that used in the raw value of *d*.

(g) The calculation of m^2/l^3 to find *k* resulted in many mathematical errors, e.g. squaring instead of cubing l. Often only one value of *k* was found instead of two so that a comparison later could not be made.

Analysis, conclusions and evaluation

(g) It was expected that candidates would compare their values of *k* and link this to a judgement of whether or not their results support the given relationship. On the whole this was very poorly carried out. Candidates would do well to work out the percentage difference between the two *k* values and then make a judgement whether this is above or below what is expected for this particular experiment. Candidates are encouraged to state what they think is a sensible limit. If candidates do not state their own limit then the Examiners will impose their own.

Estimating uncertainties in *d*

(b) Many candidates used 0.05 mm (half a division) for the absolute uncertainty in *d* instead of 0.1 mm. Correct ratio ideas were often used. Very few candidates choose to use half the range of repeated readings.

Evaluation

(e)(i)(ii) The key to this section is to identify specific problems associated with setting up this experiment and in obtaining the required readings, and then come up with practical solutions. Clarity of thought, experience and the ability to express ideas are needed here to produce a better experiment, not a different one. Marks were lost owing to insufficient detail, for example, 'take more readings', 'not enough masses', 'diameter of the rod not constant'. Candidates need also to look at how the solutions actually help this particular experiment, for example 'use a video' will not actually help decide the point at which the masses fall any more than the experimenter's eyes. There were many invalid suggestions associated with changing the experiment as opposed to helping to improve it, for example, changing the thread. Comprehensive problems and solutions can be found in the mark scheme.

PHYSICS

Paper 9702/34
Advanced Practical Skills 2

General comments

The general standard of the work done by the candidates was similar to last year, with a reasonable spread of marks. The candidates from most Centres had been well prepared and could carry out all of the tasks and analysis.

Most candidates were more confident in the collection and handling of data than they were in the critical evaluation of their experimental skills. **Question 1** and the first part of **Question 2** were relatively straightforward and it was pleasing to see that a number of candidates scored full marks on **Question 1**. All candidates attempted the evaluation section in **Question 2** but found the marks difficult to obtain.

As in previous years, there was a significant variation in performance between Centres. It would be helpful to all candidates if teachers could help their candidates to understand how marks are awarded using the published mark schemes.

The majority of Centres were able to provide the equipment required for the experiments. Some help was given to candidates by Supervisors in setting up the electrical circuit in **Question 1**.

Candidates did not seem to be short of time, and there were no common misinterpretations of rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the potential difference in the circuit changed as one of the resistances in the circuit was varied.

Successful collection of data

(b),(c) Most candidates recorded sensible values (suggesting the circuit had been correctly assembled) and realised they should include the unit (V) for V_o. Some candidates had made connections incorrectly giving a voltage outside the expected range.

(d) Many candidates were able to set up the circuit without help from the Supervisor. A small amount of credit was lost for help in setting up the whole circuit or for minor changes to the circuit.

Most candidates were able to neatly tabulate 6 sets of readings for *R* and *V*. Occasionally the voltage reading showed the wrong trend, indicating that candidates may have changed the position of the movable lead.

Range and distribution of readings

(d) Candidates had the opportunity to use resistors from the full range of 100 Ω to 4700 Ω but not many chose to use the full range available.

Presentation of data and observations

Table

(d) Many candidates were awarded credit for the column headings realising that the heading for *R*/(1000+R) should not include a unit and the 1/*V* column should be given as 1/V or V^{-1}. Most candidates were able to record voltage values with consistent precision, but many candidates needed to be more careful with the significant figures for their calculated values of 1/*V*. These often needed to change down the 1/*V* column (e.g. 4 sf is acceptable for 1/*V* if *V* is 1.03 V, but not if *V* is 0.96 V). The number of significant figures given for 1/*V* is expected to be the same as or one more than the significant figures in the corresponding *V* value.

Graph

(e) Many graphs were drawn using good scales occupying most of the graph grid but a common weakness was to use less than half the grid on the 1/*V* axis. The majority of scales were easy to use but some candidates chose awkward scales (e.g. those based on three squares). Another uncommon error was to make the plotted points too large (> 1 mm diameter).

Many candidates recorded values with care and were able to draw an acceptable line of best fit. Most were given credit for quality, based on their points being close to a straight-line trend.

Analysis, conclusions and evaluation

Interpretation of graph

(c) Many candidates showed clearly the points they were using to find the gradient and took accurate read offs. Only a few chose small triangles for their calculation.

Most candidates correctly read off the intercept from the line where $x = 0$, but some did not recognise that their *R*/(1000+*R*) axis did not begin at 0 which led to an invalid read off.

Drawing conclusions

(f) Many candidates used the required method in their analysis (i.e. equating their intercept value to *k* and then using this and their gradient value to find *P*), but a good number of candidates did not give a correct unit for *P*.

Question 2

This question normally involves a simple experiment in which a couple of sets of readings are taken to investigate a relationship. This provides an opportunity for the candidate to decide which factors in the experiment are most influential on the outcome. The candidate should realise that as only two sets of measurements are collected it is important that these measurements are reliable, so they should normally be repeated. The experiment is designed to give the candidate opportunities to look for improvements based on which measurements are difficult to take and which lead to large uncertainties. Improvements generally involve modifying the procedure or the apparatus, but not the experiment itself.

Successful collection of data

(c),(f) Most candidates understood how to raise the mass, and recorded a value for the height h_{final} in the required range.

Repeated readings were important as scatter could be expected in this type of experiment. However, few candidates did repeat with additional threads of the same length to find more values for h_{final}.

Estimating uncertainties

(d) Candidates need to think carefully about the uncertainty in an experiment. The uncertainty is not necessarily equal to the smallest scale division. Here, trying to hold the mass still and hold the ruler whilst taking a reading proved a challenge. The value will not have an uncertainty of 1 mm (as may be the case when measuring a length with a ruler resting on a bench or clamped). It was disappointing that the majority of candidates chose 1 mm as the uncertainty in h_{final}, even though most would have found it difficult to take the reading.

Presentation of data and observations

Display of calculation and reasoning

(e),(f) The majority of candidates were able to use the equation to find the two values of $E_{p,}$ but many failed to change their mass into kg or did not change the height into m, giving rise to 'power of ten' errors. Normally they gave a sensible number of significant figures.

(g) Values of *k* were usually calculated well, with just a few errors where h_{final} was used instead of *l*.

Quality

(f) The majority of candidates were able to complete the experiment using a longer length of thread and discovered that a longer length gave a larger h_{final} value (the expected trend).

Analysis and conclusions

(g) Most candidates looked at the % difference between their *k* values when deciding whether the relationship was supported, and most of these were given credit. The best answers suggested what % difference could be accepted (based on experimental uncertainties) for *k* to still be considered constant.

Evaluation

(h) The evaluation demands a good level of thoughtful analysis and again proved to be the most difficult section on the paper. Candidates from some Centres did very well. This could be partly from study of the mark schemes for previous exams, although each new experiment requires consideration of new difficulties.

Many candidates had thought carefully about the experiment and gained credit for ideas linked to thread deterioration, the large increment size linked to *h*, the difficulties of measuring *h* and *l*, etc.

Common misconceptions (not credited) were:

1. That *l* was measured to the "centre" of the mass: looking closely the measurement was to the top of the indent, so the "centre" of the mass was not relevant.
2. Idea of parallax errors linked to *l* and *h*: as the measurements were both taken when the mass was stationary candidates had the opportunity to move the ruler and their heads to take accurate measurements not involving parallax errors.
3. Just noting "difficult to measure *h*" is not enough to gain credit: candidates needed to add a reason.
4. Since *h* was measured before the mass was dropped, when the mass was stationary, the suggestion of using a video camera did not gain credit. A video camera is only a valid improvement when the measurement is of a moving object.
5. Errors linked to a force applied to the mass when it was dropped. This idea has been relevant to other experiments and if the object being dropped had been very light or made of a material which may have stuck to the fingers it would have been relevant here. However, the mass could easily be held gently in the fingers and released. Ideas linked to fans would not be relevant as the effect of air movement on the mass would be negligible.
6. 'Repeat readings' was not creditworthy as it was expected that the candidates would have done this.

PHYSICS

Paper 9702/41
A2 Structured Questions

General comments

The standard of candidates' answers was, in general, similar to that of previous years. Many scripts indicated a distinct difference in standard between answers to *Section A* and those to *Section B*. It was common to find that candidates produced disappointing answers to *Section B*. On the other hand, it was evident that a number of Centres had placed due emphasis on *Section B*. This had, quite clearly, paid dividends as regards the final marks achieved by candidates.

Candidates should be advised to give explanation of all their working. In calculations where there are errors of working, then adequate explanation allows for marks to be scored for the procedures followed. In other questions where candidates are asked to '*show'* or to '*deduce*', then the credit is awarded for clear explanation of the procedures and not for the final deduction.

There was no evidence that candidates, apart from those scoring very low marks, suffered from a shortage of time to complete their answers to the paper.

Comments on specific questions

Section A

Question 1

(a) With few exceptions, a basic statement of Newton's law was given. However, relatively few answers included the condition that the law applies to point masses.

(b) (i) It was pleasing to note that few answers were based on a statement that 'the satellite appears to be overhead'. The period and direction of rotation of the satellite were expressed adequately in most scripts. Some candidates had problems when attempting to describe the fact that the satellite orbits in the equatorial plane.

(ii) A common problem was to equate centripetal force to gravitational force, giving the impression that there is an equilibrium situation. Candidates should make it clear that the centripetal force is provided by the gravitational force. Most answers scored either full credit or no credit for the algebra leading the given expression.

(iii) The most common problems were all associated with taking the squares of quantities and taking the square root, rather than the cube root, for the final answer.

Question 2

(a) The answer was given to candidates. A clear statement of the relevant equations, together with a correct substitution of the quantities involved, was required. Many lost credit as a result of inappropriate substitutions without a clear statement of the equations.

(b) (i) It was accepted that the volume occupied by a single atom could be assumed to be either a cube or a sphere. The most common error was to find the product of the Avogadro number and the diameter and then to calculate the cube of this product.

(ii) It was expected that a comparison would be made between the volume occupied by the atoms and the volume of the containing vessel. Many answers did not include a comparison.

Question 3

(a) Most answers included only one observation, namely either melting or boiling. Very few discussed temperature difference as indicating the direction of thermal energy transfer or made a reference to either mass or to specific heat capacity. Many answers were a mere statement that temperature measures the 'degree of hotness' of a body.

(b) (i) Answers here were very disappointing. Very few deduced that when the rate of rise is zero, then the power input is equal to the rate of energy loss from the block. Many attributed the constant temperature to the melting of the block.

(ii) There were many correct answers to the calculation, despite a failure to give a sensible explanation in **(b)(i)**.

Question 4

(a) As expected, these relatively easy questions were completed successfully by most candidates.

(b) Higher-scoring candidates gave correct times. However, many others incorrectly stated times for maximum speed as being at maximum displacement.

(c) A small number of answers were based, correctly, on the gradient of the line at 0.60 s in Fig. 4.1. Most candidates used equations of simple harmonic motion. The most common error associated with a correct statement of equations was regarding powers-of-ten.

(d) (i) In general, statements were adequate.

(ii) Most candidates could quote an example. However, many failed to state what would cause the vibrations and that it is vibration which causes the problem. An answer such as 'soldiers must break step when they cross a bridge to avoid it collapsing' does not explain the effect of resonance.

Question 5

(a) The definition presented very few problems for the well-prepared candidate.

(b) (i) Candidates should be advised always to look at the mark allocated to the question. In this instance, there were two marks but the vast majority did little more than state that repulsion would occur. Candidates were expected to state that all of the kinetic energy of the α-particle would be converted to electric potential energy.

(ii)1 Most answers included a correct calculation of the kinetic energy. However, when substituting into the expression for electric potential energy for the product of the two charges, many failed to include either the 2 factor or the 79 factor, or they failed to use e^2 rather than e.

(ii)2 In general, those who completed **(ii)1** successfully were then able to determine the force.

Question 6

(a) As is usually the situation where candidates are asked to draw field lines, insufficient care was taken. Most drew lines that, with some imagination, could be considered to be concentric circles. However, very few showed increasing separation with distance from the wire. Candidates should realise that the spacing of field lines does have significance.

(b) (i) Most drawings showed the position as being to the left of the wire, but precision was frequently lacking.

(ii) Apart from power-of-ten errors, the calculation presented few problems.

(c) There were many correct answers. However, most did actually carry out a full calculation involving the answer in **(b)(ii)**, rather than solve the problem using proportionality.

Question 7

(a) In general, some reference was made to 'more continuous' current or voltage.

(b) (i) Many candidates did not seem to realise that, for an ideal diode that is forward biased, the potential difference across it would be zero. There were many poorly-drawn sketches with peak values shown above those on Fig. 7.2.

(ii) There were very few correct responses here. In many answers, an inverted voltage was indicated.

(c) (i) A significant number of candidates showed the capacitor as being in series with the load resistor.

(ii)1 The majority of answers were correct. However, a significant minority merely stated 'use another capacitor', without indicating where the capacitor should be connected.

(ii)2 Again, many lost marks as a result of poor sketches. It was expected that the capacitor discharge would be shown correctly. In many sketches, the capacitor discharge was shown as a concave shape rather than being exponential.

Question 8

(a) The expected answer was that a neutron is a single particle. Some candidates attempted an explanation by considering a neutron to be a nucleus. This may have arisen from the common problem of distinguishing between the terms *neutron*, *nucleus* and *nuclide*.

(b) Most answers included the equation $E = mc^2$. However, there was much confusion as to the energy, in MeV. It was common to find that candidates used binding energy per nucleon as the total binding energy of the nucleus. This problem was also observed in **(c)(ii)**.

(c) (i) A surprising number of candidates gave the answer as *fussion*. Perhaps they were hoping that this would be taken as a spelling error for both *fusion* and *fission*.

(ii) As already mentioned, there was widespread confusion between binding energy of a nucleus and binding energy per nucleon. Furthermore, many candidates were unsure as to how to include the 17.7 MeV in the energy equation.

Section B

Question 9

(a) In general, answers were very satisfactory although a significant minority failed to mention that the area of cross-section would decrease.

(b) Most answers were simply the percentage change in the resistance. The percentage change in the resistance was not related to the percentage increase in the width of the crack.

Question 10

Answers were very disappointing with very few candidates showing a clear understanding of the situation.

Many candidates calculated the potential difference across the thermistor and assumed that the numerical value obtained would be the potential at the inverting input. Where a clear statement of the output potential was given, then few considered the states of both diodes.

Question 11

There were some very good accounts but equally, some candidates showed very muddled thinking by including elements of ultrasound scanning and X-ray diagnosis.

It was common to find that candidates did not realise this to be a phenomenon associated with hydrogen nuclei. Many thought that the non-uniform field is responsible for the resonance. Comparatively few candidates made reference to r.f. pulses.

Question 12

(a) Although most candidates could give at least one advantage, there was a popular misconception that digital signals do not pick up noise.

(b) In general, candidates either scored full marks or none.

(c) (i) Most answers were correct.

(ii) Very few candidates were able to make reasonable attempts to answer this question. Of those who did make an attempt, many paraphrased the question rather than giving an explanation of the terms '*parallel*' and '*serial*'.

(d) Many candidates were able to make at least one suggestion. However, comparatively few were able to go on to state how the given suggestion would affect the reproduction of the input signal.

PHYSICS

Paper 9702/42

Planning, Analysis and Evaluation

General comments

The overall standard of performance of the candidates this year was slightly above average. There were some very good scripts that scored high marks, thus showing that the paper was fully accessible to well-prepared candidates. However, it was disappointing to see that some candidates were unable to answer parts of questions requiring a straightforward recall of knowledge.

There were few scripts where the performance over the entire paper was consistently good. Although many of the applications tested in *Section B* were better understood than in previous years, there are still significant knowledge gaps.

There was no real evidence that adequately prepared candidates had insufficient time to complete their answers.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates correctly defined gravitational field strength as 'force per unit mass', although a small minority did not appreciate that a ratio is involved and therefore incorrectly defined it as 'force on a unit mass'.

(ii) Not all candidates realised that in order to calculate the mass of the Earth to 3 significant figures, it is necessary to substitute into the equation the value of the gravitational field strength to 3 significant figures.

(b) (i) There were few entirely correct answers. Many candidates confused the radius of the satellite's orbit with either the radius of the Earth or the height of the satellite above the Earth's surface. Another common error was a failure to substitute distance in units of metres.

(ii) There are a number of different ways of showing that the GPS satellite is not in a geostationary orbit. Most candidates showed either that it did not have the same angular speed as the Earth or that its period of orbit was not 24 hours.

(c) Very few candidates appreciated that in order to enable them to provide cover at the Earth's poles, GPS satellites are not in equatorial orbits.

Question 2

(a) Most answers included a statement that the internal energy of a gas is the sum of the kinetic and potential energies associated with the molecules of the gas. However, very few answers mentioned that it is the random distribution of the kinetic and potential energies which is of significance.

(b) Only a minority of candidates gave an entirely correct answer. It was common to see incomplete answers such as $+w$ is the 'work done' rather than the 'work done on the system', $+q$ is the 'heat supplied' rather than the 'heat supplied to the system' and $+\Delta U$ is the 'change in internal energy' rather than the 'increase in internal energy'.

(c) (i) The calculation of work done was successfully attempted by most candidates, although some had difficulty in substituting the volume in m^3 rather than cm^3. Very few went on to explain that the work done by the gas is the change in its internal energy because there is no heat supplied to it.

(ii) Unfortunately, the information provided in the question was insufficient for a correct calculation of the required temperature change. This section of the question was not included in the overall assessment.

Question 3

(a) Many answers described in general terms what is meant by simple harmonic motion, but did not answer the question which was to state *the two features of the graph* that show that the cone is performing simple harmonic motion.

(b) Generally well answered, although a common error was failure to substitute the displacement in units of metres.

(c) Although many scripts showed a straight line through the origin, only a minority of candidates drew the line with the correct acceleration at maximum displacement.

Question 4

(a) Capacitance was usually defined correctly as the ratio of charge to potential, although some candidates considered 'potential difference' whilst others were clearly defining the capacitance of a parallel plate capacitor.

(b) With few exceptions, the expression was derived with adequate explanation.

(c) (i) Generally well answered, with almost all candidates remembering to substitute the radius in units of metres.

(ii) The majority of candidates attempted to use the expression $E = ½CV^2$ in their answers. However, a common error was to use the expression $E = ½QV$ and then assume that Q remains constant during the discharge. Another frequent mistake was to use a 25% loss of energy.

Question 5

(a) (i) The vast majority of responses correctly showed the magnetic field lines as anticlockwise concentric circles. However, the quality of some sketches was poor and in almost all cases the separation of the field lines did not increase with distance from the wire. Candidates should be aware of the significance of the spacing of field lines.

(ii) Candidates who attempted this part of the question usually managed to show the arrow pointing in the correct direction.

(b) (i) Although many candidates tried to use the given expression and $F = BIL$ to calculate the force per unit length, mistakes were frequent. A common error was to substitute a current of 5.0 A where 7.0 A was needed or vice versa. The permittivity of free space was sometimes substituted into the equation instead of the permeability of free space, whilst some candidates mistakenly calculated the force on a 2.5cm length of wire.

(ii) Very few candidates realised that the forces on the two wires are equal in magnitude and rarely was an explanation given in terms of either the force being dependent on the product of the two currents or Newton's third law of motion.

Question 6

(a) (i) With few exceptions, the law was quoted correctly.

(ii) It was generally understood that a direct current produces a constant flux and that an e.m.f. can be induced only when the flux is changing. However, one misconception was that a direct current does not produce any flux.

(b) (i) The recall of Lenz's law was often incomplete. A correct statement is: 'The direction of the induced e.m.f. is such as to produce effects to oppose the change causing it'.

(ii) There were very few correct responses in terms of the magnetic field produced by the current in the secondary coil opposing the changing magnetic field produced in the primary coil.

(c) The majority of answers were correct, although a few failed to make it clear that alternating voltage is used because the voltage is easy to change.

Question 7

(a) Answers were generally poor and a significant minority were based on the absorption spectrum. Each line in the emission spectrum corresponds to a specific photon energy. Since the photon is emitted when an electron changes its energy level, it can be deduced that the energy changes are discrete and therefore the energy levels must also be discrete.

(b) (i) The correct answer was given in the vast majority of cases, although sometimes the calculation was not shown. It is recommended that working is always shown as this may enable partial credit to be awarded even when the final answer is incorrect.

(ii) Most candidates were able to draw four correct magnitude transitions from a higher to a lower energy level.

Question 8

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

(b) There was more than one way of deriving the final expression. Good answers showed the derivation broken down into a series of small clear steps with each step carefully explained.

(c) Many candidates were able to calculate the number of atoms in the cobalt-60 source. However, when calculating its mass, a common error was to omit either the molar mass or the Avogadro constant. Some mistakes led to a very large value which should have led candidates to check their working.

Section B

Question 9

(a) Less-able candidates were often unable to recall two of the effects of negative feedback on an amplifier.

(b) The value of G could be calculated simply from the ratio of the feedback resistance to the input resistance at B. However, some answers showed an incorrect circular calculation which involved initially assigning values of voltage to V_{OUT} and V_B (based on an unexplained assumption that G is 2) and then using these voltages to show that G is 2.

(c) The vast majority of candidates were able to complete the table correctly. There were few correct uses suggested for the circuit, although a few candidates did realise that it could be used as a digital-to-analogue converter.

Question 10

(a) (i) Only a small minority of candidates were able to explain that X-ray radiation is produced when the electrons are decelerated at the metal target. Since the electrons have a distribution of decelerations, there will be a continuous spectrum of wavelengths produced because the wavelength is dependent upon the magnitude of the deceleration. A common misconception was to believe that it is the electron's acceleration between the cathode and anode of the X-ray tube that is responsible for producing the X-ray radiation. Another common error was to describe the process that is responsible for producing the sharp intensity peaks.

(ii) With very few exceptions, it was not understood that the sharp cut-off at short wavelengths corresponds to an electron that is stopped in one collision in the metal target so that all of its kinetic energy is given up as one X-ray photon.

(b) (i) Although some candidates recalled the expression $I = I_0 e^{-\mu x}$, very few went on to explain the symbols or to state that the expression applies to a parallel beam in a medium.

(ii) Some answers correctly explained that the low energy photons are less penetrating and are absorbed so that this could result in tissue damage. However, it was seldom pointed out that the low energy photons do not make any contribution to the X-ray image. One common mistake was to state that these photons affect either the sharpness or contrast of the image. Another was to state that the photons are unable to penetrate the surface of the skin. Candidates should avoid making vague and incomplete statements such as ‘low energy photons are harmful’ or ‘low energy photons do not serve any useful purpose’.

Question 11

(a) With very few exceptions, a correct answer was given.

(b) The majority of answers were correct, although some candidates confused the carrier wave with the information signal.

(c) More able candidates often gained full credit here, although the calculation of the frequency of the sidebands and the bandwidth proved problematic for less able candidates.

Question 12

(a) A straightforward recall of knowledge was needed to answer this part of the question.

(b) There were some very good answers where the basic facts had been learned. However, although the question asked for an explanation of the role of the base stations and the cellular exchange <u>during</u> the call, some candidates made the mistake of describing their role when a mobile phone handset is first switched on <u>before</u> a call is made. Candidates should avoid using vague and incomplete statements such as ‘the base station picks up a frequency’ instead of ‘the base station receives the signal from the handset’.

PHYSICS

Paper 9702/51

Planning, Analysis and Evaluation

General comments

Candidates found both questions challenging. In **Question 1** many candidates did not appear to understand the term *resonant frequency*, and in **Question 2** candidates found the analysis sections difficult. Overall a number of candidates scored full marks, although sadly a number of candidates were not awarded any marks.

In **Question 2** candidates appeared to be better this session when determining the *y*-intercept, with many good, clear methods seen. As has been stated before, candidates are still losing marks because they do not present their calculations clearly. Marks are often awarded when a clear (correct) method is seen, for example, in part **(d)** where candidates were required to determine values of g and h with the appropriate uncertainties. In **Question 1** candidates should have included greater detail in their answers.

As has been mentioned before, this paper is designed 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, which are available from the Teacher Support Website.

Comments on specific questions

Question 1

Candidates were required to design a laboratory experiment to investigate how the volume of air in a bottle affects its resonant frequency.

The initial marks were awarded for correctly identifying the independent and dependent variables, which was generally well answered. Candidates were also expected to state that the temperature would be kept constant for which an explicit statement was required.

Five marks were available for the methods of data collection. In general, candidates did not score highly in this section. There were many incorrect diagrams and experiments including bells ringing in jars which have been evacuated. Common misconceptions included changing the pressure in the bottle would change the volume, and the volume of air in the bottle could be changed by adding or removing air by the use of a syringe. One mark was awarded for a labelled diagram indicating a source of sound adjacent to the opening of the bottle but candidates often did not score this mark. There was also a mark awarded for a method of producing sound at different frequencies, e.g. several tuning forks or a signal generator connected to a loudspeaker. Further marks were available for the method of measuring the volume of air in the bottle and for the method of determining the resonant frequency. This latter point was rarely made. It was hoped that candidates would realise that resonance occurs when the loudest sound was heard or displayed. There was also an additional detail mark available for the method by adding/subtracting small amounts of water or changing the signal generator to create resonance. The final mark in this section was for carrying out the experiment in a quiet room or for a method to avoid other noise.

There were two marks available for the analysis of the data. It was expected that candidates would suggest the quantities that would be plotted on each axis of a graph for the first mark. The majority of the candidates suggested plotting a graph of f^2 against $1/V$ or $\lg f$ against $\lg V$; other valid graphs were credited. The second mark was awarded for explaining how the relationship could be proved to be valid. Where a candidate had suggested plotting a graph of f^2 against $1/V$ it was expected that "the relationship is correct if a straight line passing through the origin is produced" would be stated. Where an appropriate logarithmic graph was plotted it was expected that candidates would state that "the relationship is correct if a straight line is produced". There was also an additional detail mark available for either stating that the gradient was *k* when a graph of f^2 against $1/V$ was plotted or for the correct logarithmic equation. Calculation and/or averaging methods were still evident but did not gain credit.

There was one mark available for describing an appropriate safety precaution. 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 for loud sounds such as using ear defenders. Candidates who wrote "wear goggles in case the glass broke" did not gain credit.

There were four marks available for additional detail. Candidates should be encouraged to write their plans including appropriate detail. Too often the candidates answers lacked sufficient detail. Vague responses did not score.

There was one mark for using a microphone connected to an oscilloscope to measure the frequency of the sound. A further mark was available for a clear indication of how the period would be measured from the trace using the timebase, and hence how the frequency would be determined.

In addition to the points already mentioned above, credit was also given for:

detail on measuring volume – use of measuring cylinder/burette;
discussion of container, e.g. end correction/shape of mouth of bottle;
gradient = k or $\lg f = -0.5 \lg V + 0.5 \lg k$ or $\lg f = 0.5 \lg 1/V + 0.5 \lg k$;
constant amplitude/intensity of source of sound;
method to check fundamental frequency.

Usually good candidates who have followed a 'hands on' practical course during their studies score these additional detail marks. It is essential that candidates give appropriate detail in their answers.

Question 2

In this data analysis question candidates were given data on how the resistance *R* of a thermistor varied with the temperature *T*.

Part **(a)** asked candidates to state the quantities that the gradient and *y*-intercept would represent if a graph of lg *R* against lg *T* were plotted. This was generally well answered although some candidates incorrectly gave the *y*-intercept as ln *g* or lg *g* rather than – lg *g* or lg 1/*g*.

In part **(b)** most candidates calculated and recorded values of lg *R* and lg *T*. A large number of candidates did not record their values to an appropriate number of significant figures, which in this question corresponded to the number of decimal places because of the logarithmic quantities. Rounding errors were also made. 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. For example, in this question since *R* was given to two significant figures, it was expected that lg *R* should have been given to either two or three decimal places. The absolute uncertainties in lg *R* were usually calculated correctly. The Examiners allow a number of different methods and do not penalise significant figures at this stage. Sometimes the maximum difference was calculated without dividing by two.

The graph plotting in **(c)(i)** and **(ii)** was generally good. Common mistakes included not plotting the points correctly. Candidates should check suspect plots, particularly as the scales in this case were more difficult to interpret. It was pleasing to see that most candidates attempted to draw the line of best fit. The worst acceptable straight line should either be the steepest possible line or the shallowest possible line that passes through the error bars of all the data points used for the line of best fit. The majority of candidates clearly labelled the lines on their graph. In future, lines not indicated will be penalised.

Part **(c)(iii)** was generally answered well although candidates could often make their working clearer. Some candidates did not use a sensibly sized triangle for their gradient calculation. To determine the absolute error in the gradient candidates were expected to find the difference between the gradient of the line of best fit and the gradient of the worst acceptable line. A large number of good candidates clearly indicated the points that they used from the line of best fit. Some candidates did not realise that the gradient was negative but this was not penalised until part **(d)**.

In part **(c)(iv)** the majority of candidates attempted to determine the *y*-intercept by substituting a point on the line of best fit into $y = mx + c$. Few candidates incorrectly read the *y*-intercept directly from the *y*-axis. Many candidates clearly used a point from the gradient calculation of their line of best fit. Some candidates were confused with the negative signs. To determine the uncertainty in the *y*-intercept, it was expected that candidates would substitute a point on the worst acceptable line into $y = mx + c$ using the gradient of the worst acceptable line, and then find the difference. A number of candidates did not score this mark due to either using the wrong gradient and/or substituting in the wrong points. Good candidates used a point from the gradient calculation of their worst acceptable line.

The final part asked candidates to determine the values of *g* and *h*. To determine *g* a large number of candidates correctly equated *p* to $10^{-y\text{-intercept}}$; a significant number of candidates incorrectly equated *p* to $10^{y\text{-intercept}}$. Again a number of candidates were confused by the negative signs. Candidates who determined the *y*-intercept incorrectly in **(c)(iv)** were not penalised in this part. The value of *h* needed to be the same as the candidate's gradient value, <u>and</u> negative, <u>and</u> given to two or three significant figures. The final mark was for correctly determining the uncertainty in the values of *g* and *h*. The latter value corresponded to the uncertainty in the gradient while to determine the uncertainty in *g* required the worst value to be calculated and the difference found. Some candidates found the difference between the maximum and minimum values but did not divide by two. This last mark could only be scored if the method was clear. Too often values were written by candidates without demonstrating that they understood the underlying physics.

PHYSICS

Paper 9702/52

Planning, Analysis and Evaluation

General comments

Candidates appeared to have completed the paper within the time allocation and all the questions were attempted. Many candidates gained full marks on **Question 2** and a number of candidates scored full marks on the overall paper.

Candidates must be encouraged to show clearly all the steps when carrying out calculations. Answers where the method is not clear do not always gain credit, for example part **(e)** in **Question 2**. In the planning question candidates should try to include greater detail in their answers to descriptive type questions, giving reasons where necessary. In this question it was very pleasing to see that a large number of candidates gained the 'analysis of the data' marks.

As has been mentioned before, this paper is designed to test candidates' practical experience which 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, which are available from the Teacher Support Website.

Comments on specific questions

Question 1

Candidates were required to design a laboratory experiment to investigate the relationship between the displacement y of a current carrying wire and the diameter of the wire d.

The initial marks were awarded for correctly identifying the independent and dependent variables. Candidates are also expected to state physical quantities that need to be kept constant; in this case the current in the wire and the length of wire between the supports. Candidates must state these quantities explicitly to be credited. There was additional credit available for stating that the room temperature needed to be kept constant.

Five marks were available for the methods of data collection. The first mark was awarded for a diagram showing the arrangement of the equipment with a means of measuring y and the wire connected to a power supply. The second mark was for a correct circuit diagram containing an ammeter so as to monitor the current. These two marks clearly expect candidates to have experienced setting up apparatus in a laboratory. There was also a mark awarded for the use of a micrometer screw gauge to measure the diameter of the wire. Good candidates gained an additional detail mark for stating that d would be measured at several different places along the wire and the average determined.

A further method mark was awarded for allowing the wire to reach equilibrium before measuring y. Examiners did not give credit for answers where the current had been switched off. There was also a method mark awarded for recording y when the wire was not heated, and subtracting it from the value of y when the wire was heated. Many candidates did not appreciate these last two mark details.

There were two marks available for the analysis of the data. It was expected that candidates would suggest the quantities that would be plotted on each axis of a graph for the first mark – in this case lg y and lg d. The second mark was awarded for explaining that q was determined from the gradient of their graph. There was an additional detail mark for indicating the logarithmic equation $\lg y = q \lg d + \lg p$ and indicating how this related to the graph drawn. Some weaker candidates suggested plotting y against d^q which meant that neither of these marks could be scored. Calculation and/or averaging methods were still evident but did not gain credit.

There was one mark available for describing an appropriate safety precaution. Safety precautions were acceptable if they related a method of protection to the very hot wire, e.g. using gloves, not touching the wire until cool.

There were four marks available for additional detail. Candidates should be encouraged to write their plans adding appropriate detail. In addition to the points already mentioned, credit was also given for: use of vernier scale to measure *y* or a well described optical method or the use of set square to ensure that the rule was vertical; method for keeping current constant, e.g. detail on using a rheostat; checking starting position for *y* for same wire; use of protective resistor (either labelled or explained).

Few candidates mentioned the use of a protective resistor or the need to check on the starting position of each wire.

Usually good candidates who have followed a 'hands on' practical course during their studies score these additional detail marks. It is essential that candidates give appropriate detail in their answers.

Question 2

In this data analysis question candidates were given data for the free fall of a steel ball though air.

Part **(a)** was generally well answered ($2/g$) although some candidates incorrectly gave $g/2$.

In part **(b)** most candidates correctly headed the column heading (t^2 / s^2) and calculated and recorded values of t^2. The absolute uncertainties in t^2 were usually calculated correctly. The Examiners allowed a number of different methods and did not penalise significant figures at this stage. One common error was to work out the maximum difference without dividing by two. Some candidates incorrectly rounded the uncertainties to 0.01.

The graph plotting in **(c)(i)** and **(ii)** was generally good, although it is important that both the points and the error bars can be seen. Some Examiners commented that in some cases plotted points were faint and error bars had no distinguishable ends. Candidates should be advised to check suspect plots. 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. Some candidates are still not indicating clearly the lines on their graph. The lines should be clearly labelled and in future lines not clearly indicated will be penalised.

Part **(c)(iii)** was generally answered well although often candidates' working was poorly set out and the methods used were difficult for Examiners to follow. Some candidates did not use a sensibly sized triangle for their gradient calculation. To determine the absolute error in the gradient candidates were expected to find the difference between the gradient of the line of best fit and the gradient of the worst acceptable line. Clear working is very helpful – good candidates clearly indicated the points that they had used from the line of best fit. Marks were often lost for careless rounding of values from the graph.

In part **(d)** most candidates used the gradient correctly to determine a value for *g*. A significant number of candidates omitted the required unit. The method for determining the uncertainty in *g* needed to be clear.

In part **(e)** candidates were required to calculate the height of the building which was generally well done. Determining the percentage uncertainty caused a few more problems. Candidates often did not show their working although there were some very good answers. Common errors included not allowing for the uncertainty in *t* or realising that the percentage uncertainty in t^2 is twice the percentage uncertainty in *t*. This last mark could only be scored if the method was clear. Too often values were written by candidates without demonstrating that they understood the underlying physics.