PHYSICS

Paper 9702/11

Multiple Choice 11

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

General comments

With all multiple choice papers, there is considerable time pressure on candidates to complete the questions within the time limit of an hour. This makes it necessary for candidates to have all the basic facts of the subject at instant recall. It also means that there is little time available for double checking. Checking of answers needs to be built in as part of the initial process. As the question is read, key facts should be written. Space is available on the paper for working and it helps to avoid careless mistakes if, for example, the power of a lamp given as 24 W is written "power = 24 J s^{-1}". Powers of ten are a source of many errors with numerical questions. These arise not just by putting numbers into a calculator wrongly but also with the metric system prefixes, mega, kilo, milli etc.

The mean mark was a rather poor 18.6 and the standard deviation was 7.0. Four questions showed low discrimination. These were **Questions 17, 21, 27** and **33** and most of these were questions where a good deal of guessing must have taken place amongst the good candidates as well as the poor ones. Overall the test proved rather difficult for the candidates but did discriminate well.

Too many candidates seem to work on the principle of finding an equation and putting the numbers into a calculator. This was particularly apparent with **Question 27** where understanding was necessary but an equation was what candidates hoped to find.

Comments on individual questions

Only **Question 40** had facility over the designed maximum of 80%. Eight questions resulted in candidates giving an incorrect option more frequently than the correct one. In **Question 8** 43% of candidates gave answer A by evaluating the average acceleration during the first three seconds rather than using the gradient of the graph at three seconds. 36% gave answer A to **Question 16** and 36% also gave D as the answer to **Question 17** by forgetting to take into account atmospheric pressure as part of the total pressure. Surprisingly, **Question 18** caused problems. Roughly a third of candidates gave each of B, C and D as their answer, with C just the most popular, despite being told that ice contracts on melting. In **Question 21** B was the choice of about half the total number of candidates. These candidates appear not to have felt the situation when an elastic band is stretched, of the long chain molecules being fully aligned so making further stretching almost impossible. It was disappointing to note that only 28% of candidates were able to see A as the correct answer for **Question 24**. As referred to above, in **Question 27** only 14% of candidates realised that the force on the charge moved from P to Q in **Question 27** does not change if it is moved along the circle and that the force is always at right angles to the motion, so no work is done. Another way of considering the problem is in terms of electrical potential. P and Q are at the same potential and so zero is the correct answer. 51% of candidates just used $W = Ex$ and gave C as the answer. Too much guessing was apparent in answers to **Question 33** because the three incorrect answers were equally popular. Electricity questions generally show a lack of understanding among candidates. Here, the p.d. across R is one-third of the total and R carries one-half of the current. Probably many of the candidates did not get as far as dealing with p.d. and current separately, as by this time they may have been running out of time.

The remaining 32 questions fell roughly into two groups. There were those questions where the facility was in the range of 60% to 80%, with the three incorrect options gaining a scattering of choice. These were usually questions on standard material and all candidates who had studied the subject sensibly had a good chance of getting most of these questions correct. The other, larger, group had facilities of 35% to 60%. These were generally more difficult questions for the candidates and there was either one option that was a plausible distractor or weaker candidates were just guessing.

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Paper 9702/12
Multiple Choice 12

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

General comments

With all these multiple choice papers, there is considerable time pressure on candidates to complete the questions within the time limit of an hour. This makes it necessary for candidates to have all the basic facts of the subject at instant recall. It also means that there is little time available for double checking. Checking of answers needs to be built in as part of the initial process. As the question is read, key facts should be written. Space is available on the paper for working and it helps to avoid careless mistakes if, for example, the power of a lamp given as 24 W is written "power = 24 J s^{-1}". Powers of ten are a source of many errors with numerical questions. These arise not just by putting numbers into a calculator wrongly but also with the metric system prefixes, mega, kilo, milli etc.

The mean mark was 23.4 and the standard deviation was 7.4. 13 candidates scored full marks, a remarkable achievement for those candidates. Only a few of the questions showed low discrimination and most of these were the easy questions, deliberately included to lessen the time pressure. Overall there was good discrimination for the test.

Comments on individual questions

Only **Questions 2, 38** and **39** had facility over the designed maximum of 80%. Five questions only resulted in candidates giving an incorrect option more frequently than the correct one. In **Question 9** 42% of candidates gave answer A by evaluating the average acceleration during the first three seconds rather than using the gradient of the graph at three seconds. Surprisingly, **Question 17** caused problems. Roughly a third of candidates gave each of B, C and D as their answer, with C just the most popular, despite being told that ice contracts on melting. In **Question 20** B was the choice of about half the total number of candidates. These candidates appear not to have felt the situation when an elastic band is stretched of the long chain molecules being fully aligned so making further stretching almost impossible. Only 22% of candidates realised that the force on the charge moved from P to Q in **Question 28** does not change if it is moved along the circle and that the force is always at right angles to the motion, so no work is done. Another way of considering the problem is in terms of electrical potential. P and Q are at the same potential and so zero is the correct answer. 51% of candidates just used $W = Ex$ and gave C as the answer. Too much guessing was apparent in answers to **Question 34** because all four options were popular. Electricity questions generally show a lack of understanding among candidates. Here, the p.d. across R is one-third of the total and R carries one-half of the current. Probably many of the candidates did not get as far as dealing with p.d. and current separately, as by this time they may have been running out of time.

The remaining 32 questions fell roughly into two equal groups. There were those questions where the facility was in the range of 60% to 80%, with the three incorrect options gaining a scattering of choice. These were usually questions on standard material and all candidates who had studied the subject sensibly had a good chance of getting most of these questions correct. The other group had facilities of 35% to 60%. These were generally more difficult questions and there was either one option that was a plausible distractor or weaker candidates were just guessing.

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Paper 9702/13
Multiple Choice 13

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

General comments

With all multiple choice papers, there is considerable time pressure on candidates to complete the questions within the time limit of an hour. This makes it necessary for candidates to have all the basic facts of the subject at instant recall. It also means that there is little time available for double checking. Checking of answers needs to be built in as part of the initial process. As the question is read, key facts should be written. Space is available on the paper for working and it helps to avoid careless mistakes if, for example, the power of a lamp given as 24 W is written "power = 24 J s^{-1}". Powers of ten are a source of many errors with numerical questions. These arise not just by putting numbers into a calculator wrongly but also with the metric system prefixes, mega, kilo, milli etc.

The mean mark was a creditable 25.1 and the standard deviation was 5.7. Four questions showed low discrimination. These were **Questions 11, 21, 23, 38** and **39** and some of these were easier questions where most candidates gained the mark. **Questions 2, 5, 6, 22, 38** and **39** had facilities over 80%. Overall the test did discriminate well and showed the ability of many of the candidates.

Comments on individual questions

Four questions resulted in candidates giving an incorrect option more frequently than the correct one. In **Question 14** 41% of candidates gave answer A by evaluating the average acceleration during the first three seconds rather than using the gradient of the graph at three seconds. 43% gave answer B to **Question 19**. These candidates appear not to have felt the situation when an elastic band is stretched, of the long chain molecules being fully aligned so making further stretching almost impossible. In **Question 29** only 20% of candidates realised that the force on the charge moved from P to Q does not change if it is moved along the circle and that the force is always at right angles to the motion, so no work is done. Another way of considering the problem is in terms of electrical potential. P and Q are at the same potential and so zero is the correct answer. 57% of candidates just used $W = Ex$ and gave C as the answer. Too much guessing was apparent in answers to **Question 35** because all four options were popular. Electricity questions often show a lack of understanding among candidates. Here, the p.d. across R is one-third of the total and R carries one-half of the current. Probably many of the candidates did not get as far as dealing with p.d. and current separately, as by this time they may have been running out of time. Answers to **Question 17** showed that 31% of candidates were correct but 31% did choose answer C.

The remaining 35 questions fell roughly into two groups. There were those questions where the facility was in the range of 60% to 80%, with the three incorrect options gaining a scattering of choice. These were usually questions on standard material and all candidates who had studied the subject sensibly had a good chance of getting most of these questions correct. The other, smaller, group had facilities of 35% to 60%. These were generally more difficult questions for the candidates and there was either one option that was a plausible distractor or weaker candidates were just guessing.

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Paper 9702/21

AS Structured Questions 21

General comments

The Paper gave rise to the award of marks over a wide mark range. There were some high-scoring scripts that showed a good understanding of topics across the full range of the syllabus. However, there were also many candidates with gaps in their knowledge of the syllabus content.

A significant number of candidates left several of their answer spaces blank. This represents a severe disadvantage to those candidates, who should be encouraged to attempt all parts of all questions.

Poor quality of writing continues to be a problem. In some instances, it was not possible to distinguish between the numbers 1, 4, 7 and 9.

Comments on specific questions

Question 1

The majority of candidates scored full marks in this question. However, a significant minority gave the prefix for T as 'tetra', rather than 'tera'. Another common error was to state the symbol for 'centi' as cm, rather than c.

Question 2

(a) The correct answers were given by most candidates.

(b) (i)1 Candidates who stated clearly that the gradient of the graph represents the speed and that, at the origin, the gradient is zero were in a minority. Many wrongly assumed that the speed is zero simply because the graph line started at the origin where distance $d = 0$ at time $t = 0$.

2 Only a minority of candidates realised that the straight line towards the end of the motion represented terminal speed. A common mistake was to explain that the air resistance is not negligible because the graph line is not straight throughout its length.

(ii) Candidates who did calculate the gradient of the tangent at $t = 0.40$ s usually gave a value that was within acceptable limits. However, far too many wrong answers were based on calculating the ratio of 0.55 m / 0.40 s which represents the average speed over the first 0.40 s, rather than the instantaneous speed at $t = 0.40$ s.

(iii) A curve with increasing gradient was usually drawn by the more-able candidates. However, the most common answer was a straight line from the origin. A small minority of candidates ignored the instruction to sketch the graph on Fig. 2.2 and instead sketched their graph on a blank area of the page. Such attempts were usually unsuccessful.

Question 3

(a) Despite the wording of the question, many answers did not include any explanation. A significant minority of candidates also made a power-of-ten error or failed to include the factor of ½ in the formula for the energy stored in the spring.

(b) (i) There was more than one way of correctly answering this part of the question. The most-able candidates tended to explain that the total initial momentum was zero and therefore, due to conservation of momentum, the sum of the momenta of the two trolleys must always be zero. However, the majority of candidates gave explanations that lacked key details and many answers merely reworded the information already stated in the question.

(ii)1 Most answers were correct, although in a minority of cases there was confusion as regards signs.

2 Surprisingly, there were numerous incorrect answers. Some failed to realise that the equation is based on the sum of the kinetic energies of the trolleys and many failed to equate the sum of the kinetic energies to *E*.

(iii)1 Good answers showed the derivation broken down into a series of small clear steps, so that each step was carefully explained.

2 There were very few correct answers. All that was required was a realisation that *p* is constant in the relation in **(iii)1** so that a smaller *m* results in a larger kinetic energy.

Question 4

(a) Most definitions were adequate, although some candidates did not make it sufficiently clear as to whether they were considering refraction or diffraction.

(b) Many answers were wrongly based on a formula for double-slit diffraction. Candidates who did recall the correct formula often went on to use the wrong value of *θ* or wrongly identified *n* as the number of lines per metre.

(c) There were some comprehensive answers but many were lacking in key details. The more-able candidates realised that P remains in the same position and that both X and Y rotate through 90º.

(d) Very few candidates realised that the reason for the difference was either that the screen was no longer parallel to the diffraction grating or that the diffraction grating was no longer normal to the incident light.

Question 5

(a) Although many of the answers were satisfactory, there was some confusion between '*electric field*' and '*electric field strength*'. Many inadequate answers included a reference to 'electric force', without explaining that the force was on an electric charge.

(b) (i) With very few exceptions, the spheres were correctly labelled to show their charge.

(ii) The majority of candidates could identify the two regions. However, a significant number of answers failed to be given credit as a result of careless drawing.

(c) (i) Most answers were correct, although a small minority showed both of the forces in the same direction or showed them at right-angles to the electric field.

(ii) Frequently, the answer lacked any detailed explanation. Calculations often made no allowance for the angle of 30˚.

Question 6

(a) With few exceptions, the correct answers and explanations were given for both **(i)** and **(ii)**.

(b) Although there were many correct answers, a significant number of candidates were unable to recall the expression for the area of cross-section of the wire.

(c) Candidates need to be advised on how to answer questions where a quantitative explanation is required. All too often, candidates gave qualitative explanations by merely referring to the 'decrease' or 'increase' of a quantity, without any numerical information being given. A common error, made by those candidates that did attempt a quantitative explanation, was to think that the potential difference across the wire would halve in order to give a constant current.

Question 7

(a) Candidates often made reference, quite wrongly, to 'elements with the same number of protons, but different numbers of neutrons'. The correct statement should be 'nuclei of the same element having the same number of protons, but different numbers of neutrons'

(b) The vast majority of answers were correct.

(c) (i) Weaker candidates did not seem to realise that the mass would be 238*u*. Other candidates used the rest mass of a proton, rather than *u*, in their calculation.

(ii) Many candidates were unable to recall the correct formula for the volume of a sphere. Frequently, a formula was used that was not even dimensionally sound.

(d) This part of the question was often not attempted. Of those who did give some correct reasoning, most referred to the nuclear volume being much less than that of the atom. Few candidates referred to the majority of the mass being in the nucleus.

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Paper 9702/22

AS Structured Questions 22

General comments

The majority of candidates attempted all the questions and there was no indication that there was a shortage of time to complete the paper. There was a wide range of marks but very few gained more than 45. High marks were scored on **Questions 1**, **2**, **3(c)**, **4** and **5(a)**. Most scored low marks on **Questions 3(a)**, **(b)**, **5(b)**, **6** and **7(b)**. There was poor differentiation in **Questions 4(c)**, **5(b)**, **6(d)** and **7(b)**.

Comments on specific questions

Question 1

The majority of candidates scored at least two marks on this question.

(a) The majority of candidates gave the micrometer screw gauge. The use of vernier callipers was seen on a few occasions. This was not given any credit.

(b) (i) The idea of a zero error was introduced by most candidates. However, a significant number did not describe what would be done with this error. Many just stated that the reading should be zero.

(ii) The majority of candidates knew that random errors could be reduced by repeated readings but the second mark was lost as there was no reference to taking readings along the length of the wire or at different angles. The second mark was not given to candidates that merely stated that readings would be repeated without some further explanation. A significant minority suggested avoidance of parallax errors with a micrometer or the plotting of a graph. Neither of these answers was considered relevant to the use of a micrometer to measure the diameter of a wire.

Very few candidates confused random and systematic errors and gave **(i)** and **(ii)** the wrong way round.

Question 2

This question produced some high marks for the better candidates. Many of the average to weaker candidates seemed not to have read the question carefully.

(a) The majority of candidates could give at least one condition. The weaker candidates considered negligible air resistance as a condition or discussed the variables that needed to be known to solve the given equation. Some candidates referred to constant acceleration but then stated that no external forces must act.

(b) (i) The majority were able to calculate the required time. There was a significant minority that took the distance that the ball fell to the centre or the bottom of the ball and had clearly not read the question. Few candidates lost marks by failing to convert the unit of length to metres or by using g = 10. The number of significant figures was generally given correctly. Very few gave only one significant figure.

(ii) A considerable number of candidates did not use the correct equation for this part. Many used the same equation that they had used in **(i)** but used a distance of 0.11 m. They had failed to realise that the initial velocity for this section was then not zero. The good candidates produced excellent answers to both parts of this question with many alternative methods being successfully adopted.

(c) The majority of candidates were able to score at least one mark for stating that the air resistance would cause the acceleration or the velocity to be less than before. Poor answers suggested that the ball would be made to slow down, decelerate or reach terminal velocity. Many did not refer to the changes in the photograph except to comment on the clarity of the pictures. A significant minority referred to the effect on the time to fall the full distance rather than the section for the photograph and then considered that the position of the ball when the photograph was taken had changed. Many of these candidates had apparently failed to read the question carefully.

Question 3

The question was a good discriminator. There were very few full marks but there was a good range otherwise.

(a) (i) The majority of candidates did not give the correct definition with many stating $F = ma$.

(ii) There were many poor definitions given with 'action and reaction being equal and opposite' the most common not to score any marks. A minority referred to two objects interacting and the forces acting on each other being equal and opposite. The required comment that these forces were of the same kind was rarely seen.

(b) (i) Only a minority included the minus sign in their relationship for **1** and hence the majority lost the mark. The majority gave a correct relationship in **2.** There was a significant minority that did not give an equation for their answer in either part.

(ii) The mark was lost by all but the very good candidates because the change in momentum was not related clearly with the force and time from **(i)**. Often momentum rather than change in momentum was equated to force multiplied by time.

(c) This part was a good discriminator. The graph was generally well answered with the majority of candidates scoring at least two marks. The weaker candidates lost marks for not realising that the times for the changes to sphere B would occur at the same time as those for sphere A and miscalculating the new velocity of sphere B.

Question 4

Part **(c)** was often poorly answered or left blank.

(a) The majority of candidates only scored one mark for this part. Generally this was for reference to the non-transfer of energy. There was confusion between amplitude and displacement; nodes and antinodes were given the wrong way round. A considerable number explained how stationary waves could be produced rather than giving two features.

(b) (i) A significant majority obtained this mark. However, the change from metres to centimetres was often inserted as what appeared to be an afterthought.

(ii) The good candidates gained full marks for this part. The average candidates lost marks due to a lack of labelling or poor quality diagrams. The vast majority of marks were lost due to a lack of labelling at the piston and open end of the tube. The weaker candidates scored zero for this part.

(c) The correct answer was only obtained by the very good candidates. Many of the candidates obtained a frequency that was greater than that used in **(b)** without any comment. The number of candidates realising that the length of the tube for the lowest frequency was equal to one quarter of the wavelength was surprisingly low.

Question 5

(a) (i) The majority of candidates obtained full marks for this part. The majority read the scales on the graph correctly. The weaker candidates either went beyond the linear part of the graph or made errors with the powers of ten.

(ii) This mark was removed from the assessment, owing to a power-of-ten inconsistency in the printed question paper.

(b) Very few candidates answered the question fully as no reference was made to the graph in their explanations. The failure to read the question meant that a large number of good candidates were unable to gain any credit.

Question 6

A significant number of candidates left **(c)(iii)** and **(d)** blank.

(a) The majority of candidates considered the power to be proportional to the potential difference and hence failed to gain any credit. Only the very good candidates scored marks.

(b) (i) The majority gave the correct answer but in many cases this was after considerable working. A significant number of candidates gave 0.3 A for both **(i)** and **(ii)**.

(ii) The answers given here were often changed to fit a straight line graph in **(c)**.

(c) (i) The points were generally plotted correctly. However, a significant number failed to plot (0,0) or adjusted the value for **(b)(ii)** to enable a straight line to be obtained.

(ii) The line was poorly drawn by the majority of candidates. Many seem to think that a best fit line implies a straight line.

(iii) The majority of candidates obtained full marks as error carried forward was applied from **(ii).**

(d) Very few candidates were able to score any marks for this part. The effect of the resistance of the ammeter on the total resistance for that section of the wire was not spotted by all but a small number of candidates. Few realised that these resistances were in parallel for that section of the wire. The majority of the answers referred to resistance of the wires, heating effects or internal resistance.

Question 7

The majority of candidates were able to score almost full marks for **(a)** and **(b)(i).** Very few candidates scored full marks for the remaining parts of the question.

(a) (i) The majority of candidates gave the correct response. Only a small minority referred to a helium atom or particle and lost the mark.

(ii) The majority of candidates gave two properties. Vague answers that did not score the marks were the ‘least penetrating’ or the ‘most ionising’.

(b) (i) The equation was generally completed correctly. The lack of knowledge of a symbol for the proton caused the weaker candidates to lose the second mark.

(ii) 1. The majority of candidates were unable to give a satisfactory answer.

2. The conversion of MeV into J was ignored by all but the very good candidates. The use of eV in examination papers is referred to in the ‘Additional Information’ ***section 3.4*** of the syllabus. The mass of the α-particle was also incorrectly given by most candidates. Very few candidates obtained a correct value for the speed of the α-particle.

PHYSICS

Paper 9702/23
AS Structured Questions 23

General comments

The paper gave rise to the award of marks over a wide range. However, there were no marks above 50. The vast majority of marks were within the range 20 to 40.

A significant number of candidates left several of the answer spaces blank. Candidates should be encouraged to make an attempt in all parts of the questions. **Questions 1, 2, 6** and **7** were found to be difficult by many of the candidates.

Poor writing often made it difficult to read numerical answers. Diagrams were often drawn without a ruler. This did cost candidates marks particularly in **Question 2** and **Question 5**.

Comments on specific questions

Question 1

The majority of candidates did not score high marks on this question. Often this seemed to be due to the candidates not reading carefully the information given in the question.

(a) (i) The majority of candidates were able to calculate 1% of the reading. However, a significant number gave the voltmeter reading and the change in the reading as their answer. The weaker candidates gave the change in reading to 4 decimal places and not to the nearest digit.

(ii) A significant number of candidates did not include the uncertainty of ±1 digit in their answer.

(b) The majority of candidates gave a correct answer of systematic or zero error but only the good candidates went on to explain how this might affect the accuracy of the reading. The question asked for a statement and an explanation.

Question 2

Candidates found many parts of this question difficult.

(a) The statements required for equilibrium were generally given correctly. Common errors were to state that all the forces must be equal, or to fail to state that it is the sum of the anticlockwise moments and the sum of the clockwise moments about the same point that have to be equal.

(b) (i) The majority of candidates were able to draw a triangle of lines and arrows to represent three forces. Very few were able to explain that the sides of the triangle represented the force in magnitude and direction. A significant number of candidates suggested that the triangle had to be an equilateral triangle for equilibrium.

(ii) The majority of good candidates were able to describe how the triangle confirmed the condition of *equilibrium* for the three forces.

(c) This part was poorly answered by the majority of candidates. Very few followed the instruction to draw a vector triangle on Fig. 2.1. The vast majority considered the triangle had to have a right angle between T_1 and T_2. A significant number of candidates tried to draw triangles for the tension forces that apparently resolved these forces into components vertically and horizontally using the length of the lines representing the strings that were given on the diagram.

(d) Only the good candidates realised that with the strings horizontal there would not be any component in the vertical direction to support the weight.

Question 3

The majority of candidates scored good marks on this question. The weaker candidates left **(c)** and **(d)** blank.

(a) A significant number of candidates attempted to use an equation for constant acceleration in order to determine the total distance travelled. Those that did attempt to determine the distance from the area under the line often used an inaccurate method and were only able to score one mark. This was usually dividing the area into one rectangle and one triangle.

(b) (i) The majority of candidates were able to calculate the change in potential energy and the change in kinetic energy. A number of candidates then tried to show that these changes were approximately equal.

(ii) The majority of candidates calculated the work done by the cyclist correctly.

(c) (i) The candidates found a number of different ways to show that the values they had calculated for the energy changes and work done resulted in the frictional forces being responsible for an energy conversion of about 600 J. Only the good candidates were able to show this correctly.

(ii) Only the very good candidates were able to calculate the frictional force correctly. Many of the average candidates who made an attempt at this part used the vertical height moved by the cyclist as the distance travelled.

(d) The majority of candidates did not suggest that air resistance was the most significant resistive force and that this force decreased as the speed of the cyclist decreased.

Question 4

(a) (i) This part was generally answered correctly by the majority of candidates.

(ii) Generally poorly answered by all but the better candidates. The answers were not specific to gases or merely repeated the opposite of the answer to **(a)(i)**.

(b) The vast majority of candidates failed to answer this question in the detail required. The most common answer merely referred to collisions by the molecules of the gas producing a pressure. The number of marks for this section should have indicated to the candidates that four steps were required. The better candidates referred to the change in momentum of the molecules being produced by a force. Very few mentioned the large number of molecules and their random motion producing an average force or pressure.

(c) The majority of candidates gained one mark for the straight forward statement about the difference in spacing of molecules for gas compared to a liquid. Very few were able to use the data given to determine the ratio of the spacing.

Question 5

This question differentiated well between the candidates.

(a) (i)1 A number of answers did not refer to the frequency of the source. The number of waves passing a point was not relevant to the question and did not score. Candidates who mixed quantities with units were not given credit.

2 The majority of candidates gave the correct answer to this part.

(ii) Only the good candidates were able to demonstrate a valid method of deducing the correct expression $v = f\lambda$ from the information given in the question.

(b) (i) The weaker candidates had difficulty using the time-base setting and converting the ms into seconds. The average candidate and above completed this part of the question without difficulty.

(ii) There were some very poor diagrams. The candidates would be able to correct their work if they had used a pencil rather than having to cross out work that needed correction but had been done in ink. The good candidates drew correctly constructed waveforms across the diagram. However, these were seldom seen.

Question 6

This question was poorly completed by the majority of candidates.

(a) (i) The majority of candidates were able to describe an electric current as a movement of charge.

(ii) Only the very good candidates were able to give an acceptable definition of electric potential difference.

(b) The majority of candidates stated incorrectly that the resistance was related to the gradient of the current against potential difference graph. The resistance was constant because the straight line went through the origin. Many answers suggested that the resistance was calculated using $\Delta V / \Delta I$.

(c) (i) The candidates did not appear to interpret the circuit diagram and use data from Fig. 6.1 correctly. There were many misconceptions of this circuit showing resistors in parallel.

(ii) Many of the candidates continued with their answer to **(c)(i)** apparently unaware of the different battery producing a different current and hence resistance for the thermistor.

(d) (i) The majority of candidates were not able to interpret this circuit showing resistors in series. The answers were often the potential difference for just one of the resistors.

(ii) The majority of candidates gained marks in this section by error carried forward.

The good candidates scored highly on **(c)** and **(d)**.

Question 7

A significant minority left some or all parts of **(b)** blank.

(a) (i) The majority of candidates answered this part correctly. A minority referred to a helium atom and did not score this mark.

(ii) A minority of candidates gave distances smaller than the size of an atom. However, the majority gave answers within the accepted range.

(b) (i) The MeV unit for energy appeared to confuse a number of candidates. This unit is specifically mentioned in ***section 3.4*** of the syllabus ‘Additional Information’ and should be familiar to candidates at this level. However, the value in SI units was also given and better candidates were able to see the link.

(ii) Candidates did not have to complete **(b)(i)** to be able to complete the next two parts. The good candidates continued to complete the calculation and very few failed to read the need to give the answer to two significant figures.

(iii) Those candidates who completed this part often failed to give an appropriate unit in their answer and lost a mark. Only very good candidates were able to score highly on this part.

PHYSICS

Paper 9702/31

Advanced Practical Skills 1

General comments

The standard of the work carried out by the candidates was comparable to previous years, with a 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 difficulties in providing the equipment required by candidates. Any deviation between the requested equipment and that provided to the candidate should be written down in the Supervisor's Report as well as notifying the board 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. As in previous years, 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 are a number of Centres where the candidates are simply quoting a number on the answer line without showing any working. In such cases the Examiner cannot, for example, check the read-offs for the gradient or check for correct substitution for the *y*-intercept where there is a false origin and so cannot credit the candidate's work. At all times the working should be shown.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the current through a series of resistors changed with the total resistance in the circuit.

Successful collection of data

(c) Most candidates were able to set up the circuit correctly and collected values of current and voltage for six different values of *N* showing the correct trend (I decreasing as *N* increases). Some candidates had difficulty using their ammeter correctly, recording the current values in A rather than mA. Others recorded their values for current to the nearest 0.01A, possibly because they were using the wrong range on a digital multimeter. This meant the quality of their results was poor, losing marks later on in the paper. Centres are advised to pre-set multimeters to the recommended range and then tape over the range dial.

Range and distribution of marks

(c) The majority of candidates used a range of values for *N* including *N* = 1 or 2, and *N* = 11 or 12 though a significant number failed to make use of the full range of resistors, choosing a range for *N* of 2-7.

Presentation of data and observations

Table

(c) Nearly all candidates gained the mark for the correct column headings though a few were caught out by the 1/*R* column either giving units in Ω rather than Ω^{-1}, or omitting the units completely. The raw values of *V* and *I* were usually given to the same number of decimal places. The values for 1/*R* were generally calculated to an appropriate number of significant figures but a few candidates lost the mark by expressing their values to just one significant figure. Almost all carried out the calculation to find 1/*R* correctly.

Graph

(d) Candidates were required to plot a graph of *I* against *1/R*. Graph axes were usually correctly labelled but many candidates chose compressed scales, particularly on the y-axis. Candidates lose the axes mark if they choose scales 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. Others chose extremely awkward scales (most commonly 1:3), making the plotting of points more difficult for themselves. There were many points plotted that were greater than half a small square in diameter ('blobs') - sharp pencil points (ringed) or crosses are recommended. Several candidates plotted points more than half a small square out.

Many candidates were able to draw a reasonable 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 leading to a kink at the join. There was a reasonable allowance for scatter in order to gain credit for the quality mark and many candidates gained this mark though some lost the mark by plotting a point off the grid area.

Analysis, conclusions and evaluation

Interpretation of graph

(d) (iii) 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 many examples of read-off errors in calculating the gradient or the intercept, 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 the mark.

Many candidates read off the y-intercept at x = 0 successfully. Many candidates also correctly substituted into $y=mx+c$ to determine the y-intercept, though some substituted values from the table that were clearly off the line of best fit, or used an incorrect read-off, and so failed to gain credit. A number of candidates lost the intercept mark by attempting to read off the intercept from a graph with a false zero.

Drawing conclusions

(e) Many candidates were able to equate the value of *M* with the gradient and the value of *L* with the intercept for the first mark; a few attempted to substitute values from the table into the equation given in the question and then solve simultaneous equations to find *M* and *L*. This method does not receive credit – the question specifically asks candidates to use their answers from **(d)(iii)**. Fewer candidates were able to obtain the final mark for the value and range of *M* and *L* with consistent units. Many obtained a value for *M* of around 4.5V (the emf of the supply voltage) though some lost the mark because of a power of ten error stemming from the recording of current in A rather than mA, but few candidates obtained a value for *L* of 1 mA or less..

Question 2

In this question candidates were required to investigate how the period of oscillation of a tube suspended by a string depends on its length.

Successful collection of data

(b) The majority of candidates successfully measured the time for several swings (usually 10 or 20), recording an overall time of greater than 10 seconds. Some only measured the time for five, or fewer, complete swings, recording times less than 10 seconds so lost this mark. A few candidates mis-read the stopwatch, recording times for several swings as less than a second.

(c) (i) Most candidates were able to measure l correctly but few candidates showed evidence of repeating their measurements and calculating an average value, even when they stated that this should be done in **(c)(ii)**.

(ii) Many candidates suggested taking repeat readings but only a minority suggested measuring the length of the tube in different places; a small number of candidates recommended checking the vernier callipers for zero error.

(d) (ii) Almost all candidates obtained a value for T for the two tubes combined.

(iii) Most candidates were able to measure the length of the longer tube successfully, though some candidates recorded their (raw) values to the nearest cm, or in some cases to 0.1 mm.

Quality

(d) (ii) Most candidates correctly found that the time T for the two tubes combined was shorter.

Presentation of data and observations

Display of calculation and reasoning

(b) Most candidates calculated T correctly from their data. Some only measured the times for single oscillations but still received credit here if they had calculated an average of their values.

(d) (iv) Most candidates were able to calculate the combined length of the two tubes correctly, though a few added a figure in mm from **(c)(i)** to their answer from **(d)(iii)** in cm.

(e) Many candidates were able to calculate k correctly for the two sets of data, though some substituted the value for the length of the longer tube, rather than the combined length of the two tubes, in their calculation of the second value of k.

Analysis, conclusions and evaluation

(e) This question was carried out better than previous years although it was still poorly answered. Many candidates compared their values of k and linked this to a judgement of whether or not their results supported the given relationship. Candidates are encouraged 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 for the percentage uncertainty.

Estimating uncertainties in l

(c) (iii) Most candidates quoted the equation for calculating percentage uncertainty correctly but many lost the mark by estimating the absolute uncertainty in the measurement with vernier callipers as 0.1 cm i.e. 1 mm.

Evaluation

(f) (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 suggest practical solutions. Marks were lost if there was insufficient detail; for example, answers such as ‘human error’ or ‘wind affects oscillation’ receive no credit. Good answers included identifying that there was a gap between the two tubes, that their ends were uneven or that the tubes were kinked; that the tubes were not aligned with the string; that the time was uncertain because of the difficulty of judging exactly when the tubes had completed an oscillation.

Candidates need also to look at how the solutions they suggest actually help this particular experiment; for example, 'use a video with playback' will not actually help unless there is a timer in view or the timer on the video is used. Answers involving light gates or motion sensors also require clarification about exactly how they would be used.

Marks can often be obtained by making quite simple suggestions: e.g. use one longer tube instead of two tubes combined, or tape them together; use a marker at the centre to help time the beginning and end of complete numbers of oscillations; use a thicker-walled tube.

Some candidates included answers which were procedures that are expected anyway, so were not credited, such as take repeat readings. Candidates would be well-advised to record the problems they encounter when doing the experiment and then try to suggest suitable improvements.

A comprehensive list of problems and solutions 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. There was variation between Centres in some areas, particularly in the analysis and discussion section of **Question 2**.

Candidates' responses showed that they had been well prepared for the practical work. Scores were usually higher for **Question 1** but it was pleasing to see more with good scores in **Question 2** as well.

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

Comments on specific questions

Question 1

In this question candidates investigated the variation of current through a set of resistors in series as the number of resistors was changed.

Successful collection of data

(a) Only a few candidates needed help to set up the apparatus and nearly all measured the current flowing through the resistors correctly. Centres need to ensure candidates look carefully at the scale markings/dial setting on their meter; many candidates recorded currents of 60 A rather than 60 mA.

(b) Nearly all candidates recorded current readings for six circuits each containing a different number of resistors.

A small number of candidates were unable to connect the circuit correctly or take readings and consequently they lost marks. Candidates should understand that it is better to ask for help with connecting the circuit and lose one or two marks for this, rather than the alternative of not obtaining any readings and therefore losing many marks.

Range and distribution of readings

(b) In most cases credit was gained for using a wide enough range of resistors as *N* included both ends of the range available, and the quality of the data (judged by the amount of scatter about a straight-line trend on the graph) was good for the majority of candidates.

Presentation of data and observations

Table

(b) Results tables were usually clearly presented. Headings generally included suitable units, with only a few omitting the unit for $1/I$ or giving the unit as A rather than A^{-1}.

The current readings were normally recorded to the same number of decimal places and candidates were successfully able to calculate values of $1/I$. However, often the values given for I or $1/I$ did not match the unit in the column heading (not penalised here), and a number of candidates gave their calculated values of $1/I$ to an inappropriate number of significant figures.

Graph

(c) The standard of graphs was usually good. As the value of each resistor in the chain was 22 Ω many candidates used one large square on the *y*-axis as 22 Ω. This was considered to be an awkward scale and lost credit. Candidates should be encouraged to use scales based on, for example 2,4,5 or 10 but not awkward values such as 3,6 or as here 22, which lose credit. The majority of candidates correctly chose their scales so that the plotted points filled the graph grid. Although Examiners expect at least half the grid to be used in both directions, scales should enable intermediate points on the line to be read directly (without having to use a calculator).

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

(c) This was usually done well.

Common errors in finding the gradient were to use a triangle whose hypotenuse was less than half the length of the drawn line. Some candidates chose to use table values, which did not lie on the line of best fit. A few candidates incorrectly found $\Delta x/\Delta y$. In finding the *y*-intercept many correctly substituted a point lying on the line of best fit into the equation. However, a significant number of candidates chose to extend their line below the grid trying to take a read off. This method is inaccurate and did not gain credit. Some candidates tried to read off the intercept but did not notice they had used a false origin.

Drawing conclusions

(d) Many candidates struggled to identify the gradient as *G* and the intercept as *H*. Too many candidates recalculated a fresh value for *G* and *H* at this point, not using their previous values of gradient and intercept; recalculation does not gain credit. For those who did make the identification correctly, few gave the correct units and many had power of ten errors due to misreading their scale at the start of the experiment.

Question 2

In this question candidates were asked to investigate the force required to separate attracting magnets as the distance between the poles was increased. The experiment required care and patience on the part of the candidate, but also provided the opportunity for discussion of difficulties and improvements.

Successful collection and presentation of data

(b) The majority of candidates were successfully able to measure the force of separation when the magnets were touching but many either gave the answer as a whole number of newtons or to 0.01N both of which were unreasonable given the apparatus available. A value to 0.1 N was expected. Surprisingly few repeated their readings to find an average force.

The majority of candidates were able to correctly identify a difficulty with measuring the force accurately.

(c) (i) Many candidates were able to measure the thickness of the three slides accurately using the micrometer. However, it was obvious that some candidates struggled to take correct readings from the micrometer and further practice with this instrument is needed. Several candidates gave their readings to the wrong precision.

(ii) Many candidates lost credit here – although they took the average of several readings they failed to specify that the readings were taken in different places. Weak candidates tended to describe how to use a micrometer screw gauge,

(iii) The majority of candidates were able to measure the separation force with three slides between the poles and gave the unit correctly as newtons.

(d) The majority of candidates went on successfully to record the separation force with one slide and gained the correct pattern for the reduction in force in the three situations.

Estimating uncertainties

(b) (iii) Most candidates knew how to calculate percentage uncertainty and many used correctly an absolute uncertainty of between 0.1 N and 0.4 N. With the difficulty in noting the maximum value of force, less than 0.1 N was unacceptable.

Display of calculation and reasoning

(e) The calculation of the two *k* values was generally done well. Only a few candidates got the pairs of values of *F* and *t* mixed up.

Analysis and conclusions

(e) There were surprisingly few very good responses to this part of the question – however, candidates from some Centres had been prepared well with better candidates comparing the percentage difference between their *k* values and the percentage uncertainty in **(b)(iii)**.

Examiners expected candidates to calculate the percentage difference between their two *k* values and then decide whether this difference was too big to be accounted for by experimental uncertainty. In making this decision candidates were expected to state a value of the percentage difference, which would be acceptable. Too many candidates made a vague statement such as "the *k* values are close" which did not gain credit.

Evaluation

(f) Candidates from some Centres gained high marks in this section.

The Examiners were looking for identification of specific difficulties relevant to the nature of the experiment with these two magnets and the method used to measure the maximum force of separation. Suggesting the use of other magnets did not gain credit.

Since measurement of slide thickness was reasonably straightforward, most candidates considered force measurement as the source of error.

Once again, few candidates stated that using two separations, i.e. one and three slides is insufficient to draw a conclusion. Then only a few suggested using a larger variety of separations and plotting a graph. The idea of repeats does not gain credit, as the candidates were able to take repeated readings during the experiment. Many candidates recognised that irregularity in the thickness of the slides would lead to inaccuracy but a common misconception was to suggest "slides of uniform thickness should be obtained". A large number of candidates did well to suggest using a video camera to record the event, but failed to score as they did not then include the detailed suggestion to "playback frame by frame" to note the maximum value. Many candidates suggested inaccuracies due to parallax but here candidates have the opportunity to position their heads above the scale minimising parallax. It was good that many recognised that friction with the bench would impact on the reading. However, vaguely suggesting a "frictionless" surface was not credited. It would be better to state a method for "reducing" friction.

Weaker candidates discussed the accuracy or precision of the measuring instruments and often confused these two ideas.

The published mark scheme lists creditworthy responses.

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 as well as notifying the board 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 are a number of Centres where the candidates are simply quoting a number on the answer line without showing any working. In such cases the Examiner cannot, for example, check the read-offs for the gradient or check for correct substitution for the *y*-intercept where there is a false origin and so cannot credit the candidate's work. At all times the working should be shown.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the current through a semiconductor diode depends on the voltage across it.

Successful collection of data

(c) Many candidates were able to set up the circuit and tabulate six sets of values for V and I gaining credit for this section. A significant number of candidates found setting up the circuit difficult or connected the voltmeter across the diode incorrectly (either the voltmeter was placed across the resistor or across both the diode and resistor). Some candidates had difficulty using their ammeter correctly, recording the current values in A rather than mA. Others recorded their values for current to the nearest 0.01A, possibly because they were using the wrong range on a digital multimeter. This meant the quality of their results was poor, losing marks later on in the paper. Centres are advised to pre-set multimeters to the recommended range and then tape over the range dial. Weak candidates found calculating V^{10} difficult.

Range and distribution of marks

(c) Many candidates used a range of I to include a value equal to or below 10 mA and a value equal to or greater than 35 mA. In the rare case that Centres used a different diode and the exam board was notified then the Examiners took this into account in deciding a suitable range.

Presentation of data and observations

Table

(c) Most candidates gained the mark for correct column headings. The raw values of *V* and *I* were generally given to the same number of decimal places. The corresponding significant figures given in the calculated quantity V^{10} were often correct however a few candidates lost the mark by expressing their values to just one significant figure. Many candidates calculated V^{10} incorrectly (10*V* or *V x* 10^{10}) leading to curved trends on the graph. Some candidates did not show all the appropriate columns (including only V^{10} and *I*) and so lost out on the consistency, significant figure and checking the calculation mark.

Graph

(d) Candidates were required to plot a graph of *I* against V^{10}. A significant number of candidates plotted the wrong graph, for example a logarithmic scale along the *x*-axis for V^{10} or just plotting *V.* Many candidates used awkward scales (e.g. 3:1) often leading to errors in plotting or in reading off the gradient points. There were still too many 'points' plotted that were greater than half a small square in diameter. Several candidates plotted points more than half a small square out.

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 leading to a kink at the join. There was a reasonable allowance for scatter in order to gain credit for the quality mark and many candidates gained this mark though some lost the mark by plotting a point off the grid area.

Analysis, conclusions and evaluation

Interpretation of graph

(d) (iii) 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 many examples of read-off errors in calculating the gradient or the intercept, 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 the mark.

Many candidates read off the y-intercept at x = 0 successfully. Many candidates also correctly substituted into $y=mx+c$ to determine the y-intercept, though some substituted values from the table that were clearly off the line of best fit, or used an incorrect read-off, and so failed to gain credit. A number of candidates lost the intercept mark by attempting to read off the intercept from a graph with a false zero.

Drawing conclusions

(e) Candidates were able to give the values of *a* and *b* using the correct method i.e. gradient = *a* and *y*-intercept = *b* with gradient and intercept values taken from **(d)(iii)**. Candidates using the substitution of known plots into the equation failed to gain credit. Very few candidates were able to obtain the final mark for the value and range of *a* and *b* in the range expected and given with the correct units having used the correct method. There were many power of ten errors in this last section caused either from the use of A instead of mA or from using values of voltage which were too high and hence very high values of V^{10}. (This problem arose when the voltmeter was incorrectly connected.)

Question 2

In this question candidates were required to investigate how the speed of a glass ball falling through oil depends on its size.

Successful collection of data

(a) Surprisingly few candidates could measure distance *x* to the nearest mm, measuring to the nearest cm instead.

(b) (i) Many candidates were able to measure *d* to the nearest 0.1 mm using a set of vernier callipers however many candidates failed to repeat their readings of *d*. A surprising number of candidates quoted *d* = 0.3 mm instead of 3.0 mm. A few candidates measured the diameter with a ruler *d* = 3 mm and suggesting in the evaluation section to use vernier callipers.

(ii) Many candidates recorded the time to be between 1-10s gaining credit. However there were many readings quoted to a fraction of a second suggesting incorrect reading of the stopwatch.

(e) The majority of candidates were able to obtain second readings of *d* and *t* for the larger ball.

Quality

(e) Most candidates found that the time for the larger glass balls to travel distance *x* was shorter.

Presentation of data and observations

Display of calculation and reasoning

(d) Many candidates successfully calculated the value of the speed with consistent units. Some candidates did not look to see if their answer was realistic (e.g. 222 m/s).

(f) (i) Many candidates were able to calculate *k* for the two sets of data.

(iii) Very few related the significant figures for *k* to all the raw values used in calculating *k* i.e. *x, d* and *t*.

Analysis, conclusions and evaluation

(f) (ii) This question was carried out better than previous years although it was still poorly answered. Many candidates compared their values of *k* and linked this to a judgement of whether or not their results supported the given relationship. Candidates are encouraged 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 for the percentage uncertainty.

Estimating uncertainties in *t*

(c) Many candidates stated 0.01 s as the absolute uncertainty in time instead of taking into account difficulty in judging when the ball moves past the markers and suggesting a realistic uncertainty in the range 0.1 – 0.6 s. Many more candidates chose to use half the range of repeated readings. The correct ratio idea was generally used for the percentage uncertainty.

Evaluation

(g) (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. Marks were lost if there was insufficient detail. For example, just stating ‘parallax error’ is not enough. In this question, it was difficult to see the ball pass the markers and so there was a parallax error in moving the head from above one marker to the next. In fact the majority of answers involving parallax referred to the distance measurement and not to the difficulty in taking the time.

Candidates need also to look at how the solutions actually help this particular experiment for example ‘use a video with playback’ will not actually help to see the balls move past the markers unless there is a timer in view or the timer on the video is used. Also the suggestion to ‘switch off the fans in the room’ will surely not affect the motion of the ball through the oil! There were many invalid suggestions associated with changing the experiment as opposed to helping to improve it, for example, changing the glass ball to a steel ball.

Included were procedures that are expected anyway so were not credited such as repeat readings for each ball size, checking the diameter in two different places and having eyes level with the marker. Candidates would do well to record the problems they encounter when doing the experiment and then try to suggest a suitable improvement. For example – the ball moved too fast so timing was difficult. This would be improved by timing over a longer distance.

A comprehensive list of problems and solutions can be found in the mark scheme.

PHYSICS

Paper 9702/34
Advanced Practical Skills 2

General comments

The performance of candidates was generally similar to last year, with a wide range of marks. 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 usually higher for **Question 1** but it was pleasing to see more with very good scores in **Question 2** as well.

There appeared to be plenty of time to complete the experiments and there were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates investigated the extension of a spring supporting one end of a pivoted metal rod.

Successful collection of data

(a) Most candidates set up the apparatus without help and measured the length of the rod, with just a few recording a value to the nearest cm rather than the nearest mm.

(d) Nearly all candidates recorded readings for six different pivot positions.
Surprisingly, several chose pivot positions such that *d* was less than half the length of the rod, which meant that the spring was completely unloaded. This led to a very non-linear graph and the loss of the quality mark.

Range and distribution of readings

(d) In most cases credit was gained for using a wide enough range of pivot positions, and the quality of the data (judged by the amount of scatter about a straight-line trend on the graph) was good for nearly all candidates.

Presentation of data and observations

Table

(d) Results tables were usually clearly presented. Headings generally included suitable units, with only a few omitting the unit for $1/d$ or giving it as m rather than m^{-1}.

Graph

(e) The standard of graphs was usually good although candidates from some Centres chose very awkward scales in an attempt to fill the graph grid completely. Although Examiners expect at least half the grid to be used in both directions, scales should enable intermediate points on the line to be read directly (without having to use a calculator).

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

(e) This was usually done well. The only common error was in reading the *y*-intercept directly from the *h* axis when the grid had a false origin.

Drawing conclusions

(f) Many candidates correctly equated the gradient of their graph to the expression Wz/k and went on to substitute the values provided for *W* and *k* to find *z*. Giving a suitable unit for *z* proved more difficult, with many giving m^{-1} rather than m or cm.

Question 2

In this question candidates were asked to investigate the deflection of a compass (in the form of a suspended magnet) when a current passed through a nearby wire. The experiment called for good dexterity and patience on the part of the candidate, but also provided the opportunity for discussion of many difficulties and improvements.

Successful collection and presentation of data

(a) A small number of candidates either failed to adjust the initial current to a value within the acceptable range, or mis-read their ammeter.

(c) Quite a few gave their value for the distance *x* to the nearest cm (even though they were using a ruler with a mm scale).

(d), (f)(i) The expected deflection θ was around 20° but several candidates gave values much greater, suggesting that they had recorded the final protractor reading rather than the deflection. Surprisingly few recorded clear evidence of repeated measurements of the deflection – important for this experiment.

Estimating uncertainties

(e) Most candidates knew how to calculate percentage uncertainty but many used an absolute uncertainty of ±1° for θ and this was unreasonably small due to parallax problems (caused by the distance between the magnet and the protractor) and to the movement of the magnet.

Display of calculation and reasoning

(h) The calculation of the two *k* values was generally well done. Only a few candidates got the pairs of values of *I* and *x* mixed up, but less than half justified their choice of significant figures by referring to the s.f. in both *I* and *x* instead of just 'raw data'.

Analysis and conclusions

(h) (ii) Once again there were many very good responses to this part of the question – candidates from some Centres had clearly been prepared well.

Examiners expected candidates to calculate the percentage difference between their two *k* values and then decide whether this difference was too big to be accounted for by experimental uncertainty. In making this decision candidates were expected to state what percentage difference would be acceptable.

Evaluation

(i) Candidates from some Centres gained high marks in this section.

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

Apart from the measurements themselves, the main practical problems were the difficulty in holding the thread in a constant position while readings were taken and the constant swinging of the magnet. Clearly it would be better to fix the thread, but to gain credit the candidate had to give some detail of a method (i.e. how it could be fixed or what it could be fixed to).

Of the three quantities measured, I was straightforward but measuring x would have been easier with a clamped ruler, and θ would have been much more easily measured if the protractor had been raised up to reduce parallax problems.

The published mark scheme lists creditworthy responses.

PHYSICS

Paper 9702/35
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 as well as notifying the board 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

In this question candidates were required to investigate the relationship between the power dissipated in a filament lamp and the resistance of the lamp.

Successful collection of data

(c) Most candidates were able to set up the circuit and tabulate six sets of values for V and I gaining credit for this section. Some candidates had difficulty using their ammeter correctly, recording the current values in A rather than mA. Others recorded their values for current to the nearest 0.01A, possibly because they were using the wrong range on a digital multimeter. This meant the quality of their results was poor, losing marks later on in the paper. Centres are advised to pre-set multimeters to the recommended range and then tape over the range dial. Most candidates were able to calculate P, R and R^4.

Range and distribution of marks

(c) Many candidates used a range of V to include a value equal to or below 2 V and a value equal to or greater than 10 V. In the rare case that Centres used a different bulb and the exam board was notified then the Examiners took this into account in deciding a suitable range for the voltage.

Presentation of data and observations

Table

(c) Most candidates gained the mark for correct column headings. The raw values of V and I were generally given to the same number of decimal places. The corresponding significant figures given in the calculated quantity *P* were often correct however a few candidates lost the mark by expressing their values to just one significant figure. Many candidates calculated R^4 correctly.

Graph

(d) Candidates were required to plot a graph of *P* against R^4. A number of candidates plotted the wrong graph, for example just plotting *R* along the *x*- axis. Many candidates used awkward scales (e.g. 3:1) often leading to errors in plotting or in reading off the gradient points. There were still too many 'points' plotted that were greater than half a small square in diameter. Several candidates plotted points more than half a small square out.

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' or were drawn by a thick pencil. There was a reasonable allowance for scatter in order to gain credit for the quality mark and many candidates gained this mark though some lost the mark by plotting a point off the grid area.

Analysis, conclusions and evaluation

Interpretation of graph

(d) (iii) 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 many examples of read-off errors in calculating the gradient or the intercept, 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 the mark.

Many candidates read off the y-intercept at x = 0 successfully. Many candidates also correctly substituted into $y=mx+c$ to determine the y-intercept, though some substituted values from the table that were clearly off the line of best fit, or used an incorrect read-off, and so failed to gain credit. A number of candidates lost the intercept mark by attempting to read off the intercept from a graph with a false zero.

Drawing conclusions

(e) Candidates were able to work out *a* and *b* using the correct method i.e. gradient = *a* and *y*-intercept = *b* with gradient and intercept values taken from **(d)(iii)**. Candidates using the substitution of known plots into the equation failed to gain credit. Very few candidates were able to obtain the final mark for the value and range of *a* and *b* in range with the correct units using the correct method.

Question 2

In this question candidates were required to investigate how the movement of a tube is affected by fluid friction.

Successful collection of data

(a) (ii) Most candidates were able to measure *d* in range to the nearest mm.

(c) (ii) Most candidates were able to repeat their measurement of *t* in a range of 5 – 30 s. However there were many readings quoted to a fraction of a second suggesting incorrect reading of the stopwatch.

(e) (ii) The majority of candidates were able to obtain values for *d* and *t* for the tube set at a greater depth.

Quality

(e) (ii) Most candidates found that the time for the tube set at a larger depth was shorter.

Presentation of data and observations

Display of calculation and reasoning

(d) Many candidates successfully calculated the percentage uncertainty using correct ratio ideas.

(f) (i) Many candidates were able to calculate *k* for the two sets of data.

(f) (iii) Many candidates were able to relate the significant figures for *k* to the raw values used earlier on (i.e. *d* and *t*).

Analysis, conclusions and evaluation

(f) (ii) This was carried out better than previous years although it was still poorly answered. Many candidates compared their values of *k* and linked this to a judgement of whether or not their results support the given relationship. Candidates are encouraged 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.

Estimating uncertainties in *t*

(c) Many candidates stated 0.01 s as the absolute uncertainty in time. They should have taken into account the difficulty in judging the ever-changing position of the mass hanger and the timing of this (so absolute uncertainty in range 0.5 – 1.0 s). Some candidates chose to use half the range of repeated readings and were credited.

Evaluation

(g) (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. Marks were lost owing to insufficient detail, for example candidates readily stated ‘parallax error’ without actually linking this to the question; that it was difficult to see if the bottom of the weights ever reach their maximum displacement on a marker as the oscillation either overshoots or undershoots during the course of one oscillation.

Candidates need also to look at how the solutions actually help this particular experiment for example ‘use a video with playback’ will not actually help to see the bottom of the weight move past the markers unless there is a timer in view (or use the timer on the video). There were many invalid suggestions associated with changing the experiment as opposed to helping to improve it, for example, changing the type of oil to be less viscous.

Included were procedures that are expected anyway so were not credited such as repeat readings for time, having eyes level with the marker. Candidates would do well to write what they notice about the experiment: tube moves too fast or distances covered very small so difficult to time. Comprehensive problems and solutions can be found in the mark scheme.

PHYSICS

Paper 9702/41

A2 Structured Questions 41

General comments

There were some very good scripts that scored high marks, thus showing that the paper was fully accessible to well-prepared candidates. On the other hand, there were numerous candidates who scored low marks due to a poor knowledge of the syllabus content.

A significant number of candidates did not attempt all of the questions. This was sometimes Centre-based and gave the impression that some topics in the syllabus had not been studied in sufficient depth. This was particularly the case for some of the applications tested in ***Section B.***

There was no evidence that adequately prepared candidates suffered from a shortage of time to complete their answers to the paper.

Comments on specific questions

Section A

Question 1

(a) Some candidates attempted to define '*angular displacement*' rather than the '*radian*'. One radian is that angle subtended at the centre of a circle by an arc equal in length to the radius.

(b) (i) Only a minority of candidates realised that the glue snaps when the stone is vertically below point C.

(ii) Fully correct answers were rare. The most common error was to equate the centripetal force to the tension, without making any allowance for the weight of the stone.

Question 2

(a) (i) Many candidates failed to realise that 273.15, rather than 273, should be added to 27.2 °C so that the final answer expressed to 1 decimal place is 300.4 K.

(ii) The vast majority of answers were correct.

(b) (i) Only a minority of candidates understood that the symbol represented mean square speed and a significant number thought that it meant either root mean square speed or mean speed squared.

(ii) Most answers were only partially correct. Despite the wording in the question, many did not explain the symbols used or missed out crucial steps in the derivation. Another common mistake was to confuse the mass of the gas with the mass of an atom.

(c) (i) Generally well answered, although some of the less-able candidates made a power-of-ten error with the volume of the gas.

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

(iii) Only a minority of candidates multiplied the answers in **(i)** and **(ii)** by the Avogadro constant to calculate the total internal energy. Many did not appreciate that the total internal energy of the gas is the total kinetic energy of the atoms, because the atoms of an ideal gas have zero potential energy.

Question 3

(a) (i) It was generally understood that *oscillations* represent to-and-fro motion between two limits.

(ii) Most candidates knew that *free oscillations* have no external force acting and so there is no energy loss or gain.

(iii) The majority of candidates gave an adequate explanation. Some did, however, refer to 'distance' rather than 'displacement'. Candidates should be advised that if a defining equation is quoted, then all of the symbols in the equation must be clearly identified.

(b) Most candidates assumed, quite wrongly, that it was simple harmonic motion because the acceleration always acts towards a fixed point. However, the motion was not simple harmonic because the acceleration of the ball had a constant magnitude.

Question 4

(a) Very few candidates realised that *potential energy* is the ability of a body to do work as a result of its position or shape.

(b) (i)1 A significant number of candidates used the expression for *gravitational potential*, rather than *gravitational potential energy.* Some of those that did use the correct expression then used the wrong value of mass or the wrong value of separation distance.

2 Some candidates used an expression for *electric potential*, rather than *electric potential energy*.

(ii) Despite the wording in the question, many answers did not use the gravitational potential energy from **(i)1** as part of their calculation to find the kinetic energy of each nucleus. Of those that did use it, many failed to express it with the correct sign.

(iii) Fusion was often identified correctly. Vague suggestions, such as 'the nuclei stick together', did not get any credit.

Question 5

(a) (i) The Hall effect was not understood by many candidates. The Hall voltage depends on the angle between the plane of the probe and the magnetic field, so that it is a maximum when they are normal to each other and a minimum when they are parallel to each other. A common misconception was that the Hall voltage was caused by the rate of change of magnetic flux linkage of the probe.

(ii)1 It was expected that ($V_H \times r$) would be calculated a minimum of 3 times. These calculated values could then be used as the basis for suggesting whether the expression was valid or not.

2 Frequently, a straight line feature was identified. However, very few candidates went on to correctly state that the straight line would pass through the origin.

(b) (i) Faraday's law of electromagnetic induction was usually quoted correctly.

(ii) Many answers lacked precision. For example, it was commonly suggested that an e.m.f. could be induced in the coil by moving it, without indicating the necessary direction of movement. Many candidates also decided to introduce into their answers extra pieces of apparatus such as magnets and solenoids. Such answers were outside the context of the question.

Question 6

(a) The diodes were usually drawn in the correct configuration. However, it was disappointing to see that a small minority of candidates were unable to recall the correct diode symbol.

(b) There were very few fully correct calculations. The most common mistake was a failure to undertake the necessary conversion between the peak and the root-mean-square values of voltage.

Question 7

(a) The direction of the electric field was usually identified correctly.

(b) (i) The correct calculation involved equating the force on a charged particle due to the magnetic field with the force on it due to the electric field. However, a significant minority of candidates attempted calculations that required the values of both the charge and the mass of the particles to be known. Since those values were not known, no credit was given for such calculations.

(ii) The correct calculation was based on an understanding that the centripetal force is provided by the force on the charged particles due to the magnetic field. However, a minority of candidates attempted a different calculation that assumed that the particles had the charge and mass of an electron. Since this assumption could not be justified, no credit was given for that type of calculation.

Question 8

(a) (i) Very few candidates understood that, as a consequence of the conservation of momentum, the momenta of the photons must be equal and opposite. Since the photons have the same momenta, they must then have the same energy.

(b) (i) There were many answers that correctly involved Einstein's mass-energy relation. However, it was not uncommon to find that the combined energy of the two photons had been calculated, rather than the energy of a single photon.

(ii) This part of the question was generally well answered.

(iii) Only a small minority of candidates were able to correctly calculate the momentum of a photon, usually by substituting their answer from **(ii)** into the expression $p = h / \lambda$.

Section B

Question 9

(a) (i) A significant minority of candidates confused the position of the *virtual earth* with the position of the real earth.

(ii) When explaining the concept of the *virtual earth*, very few answers mentioned that the open-loop gain of the operational amplifier is very large or infinite.

(b) (i) A surprising number of candidates were unable to recall the expression for the voltage gain of an inverting amplifier. Most of those who did were then unable to show how the negative value of input voltage combines with the negative value of voltage gain to give a positive output voltage.

(ii) It was not uncommon to see answers that lacked precision. For example, vague references to resistance and voltage are inadequate and it should be made explicitly clear which particular resistance or voltage is being referred to.

Question 10

(a) Many explanations were confused and inaccurate, indicating that most candidates did not appreciate how the image in a CT scan is built up. Many thought that taking X-ray images from many angles built up a 3-dimensional image of the whole object, rather than an image of one thin section through the object. In order to build up an image for the whole object, the procedure is repeated for further sections. The 2-dimensional images of the different sections are then used to build up the final 3-dimensional image.

(b) (i) Generally well answered.

(ii) In some cases candidates deducted the background reading, but then failed to divide by 3.

Question 11

(a) Many candidates have learned to quote this answer accurately.

(b) There were many answers that correctly listed two advantages of FM transmissions. However, some candidates stated that FM transmissions pick up no noise, rather than less noise. Others confused bandwidth with waveband. There were also many answers that correctly listed two disadvantages of FM transmissions. However, some candidates incorrectly referred to the need for more repeater amplifiers, rather than transmitters.

Question 12

(a) The majority of candidates stated the correct general expression that relates the ratio of two powers to the number of decibels. However, errors were often made when substituting numerical values into the expression, usually due to confusion between the power received at the satellite and the power transmitted by the ground station.

(b) (i) Candidates were rarely able to recall the frequency of the downlink signal.

(ii) Answers often lacked precision. The reason for having two different carrier frequencies is to prevent the very low power input signal to the satellite from being swamped by the satellite's own high power transmitted signal.

PHYSICS

Paper 9702/42
A2 Structured Questions 42

General comments

There was a good range of marks and candidates were generally able to demonstrate their knowledge and understanding of the learning outcomes for this syllabus. There were some Centres where candidates left blank certain sections, particularly in ***Section B*** but most candidates attempted all the questions. There was no evidence of candidates being short of time to complete the paper. The more demanding questions allowed differentiation for the more able candidates. These were **Questions 2(c)**, **3**, **4 (b)** and **(c)**, **9(c)** and **12(b)**. **Questions 10 (b)** and **4(c)** were found to be difficult by all candidates and many failed to answer the question in **Question 11**.

Comments on specific questions

Section A

Question 1

This question produced a wide range of marks and good differentiation.

(a) The majority of candidates answered the definition of gravitational potential correctly. A minority referred to a body or a mass rather than unit mass and some used charge.

(b) (i) The majority of candidates answered this part well. A minority of candidates chose a different value for *R*, missed the power of 10^7 or misread the vertical scale on the graph. A few candidates ignored the instructions in the question and used a value for *g* of 9.81 to calculate the mass of the Earth. This method received no credit.

(ii) A significant number of candidates did not give the explanation asked for in the question and lost a mark for not stating that the loss of potential energy was equal to the gain in kinetic energy. The majority of candidates used 2*R* rather than 3*R*. The weaker candidates attempted to answer the question assuming circular motion and using an expression for velocity in terms of a centripetal force.

(iii) The majority of candidates realised that the path of the meteorite would bend but a surprising number thought that the speed would reduce. A significant number lost marks due to vague responses that suggested merely a change in speed would take place.

Question 2

The question produced a good range of marks but the majority of candidates were unable to give a satisfactory explanation for **(c)**.

(a) (i) The majority of candidates knew the effect on the oscillations due to damping. However, a significant number were unable to explain the cause of the damping as due to forces opposing the motion. The weaker candidates neglected the allocation of two marks for this section and only gave a brief statement.

(ii) The majority knew that the damping was light but a significant number were unable to give a clear explanation. There was a use of the term displacement instead of amplitude. There were many vague explanations that merely stated that the amplitude decreases.

(b) (i) The vast majority of candidates calculated the frequency correctly.

(ii) This section was completed correctly by the stronger candidates. There were a significant number of candidates who did not show their working in the detail required for such questions. The weaker candidates did not show their working clearly or were unable to link the required equations.

(c) A minority of candidates were able to explain that the amplitude decreased by a smaller amount each oscillation. Some of the better candidates were able to describe the reduction as following an exponential decay but these were very few in number. There was a majority who thought there was a linear decrease in the amplitude.

Question 3

This question was not answered well by the majority of candidates.

(a) (i) The majority of candidates were unable to use the data given to determine the temperature. A significant number of the good candidates calculated a change of resistance of 36.5 Ω $°C^{-1}$ and gained one mark. Very few went on to determine the correct temperature. A large number assumed proportionality and failed to score any marks.

(ii) The majority of candidates failed to give a suitable description of the thermodynamic scale of temperature. There were some statements on the relationship between the Kelvin and Celsius temperatures and some went on to give the actual values determined for this question. Only the very good candidates mentioned the non-linearity of the resistance change.

(b) This calculation gave a good range of marks. Candidates gained one mark for the energy required for the ice to melt. Many candidates then failed to include the energy required for this melted ice to reach the final temperature. The weaker candidates had trouble with the signs for the temperature change or confused the units of mass in g or kg or temperature in °C or K.

Question 4

The majority of candidates did not score any marks in **(b)** or **(c)**.

(a) The majority of candidates scored full marks. The weaker candidates tended to make arithmetic errors or use the wrong distance. In some cases Boltzmann's constant was used for k in the relationship for the force. The failure to square r was an error made by the weaker candidates even though the correct relationship for force had been given.

(b) A small number of candidates stated that P and Q were at the same potential but very few then went on to explain why the work done would be zero using $W = q\Delta V$. The common error was to consider the forces acting and then use $W = Fd$.

(c) Very few candidates were able to cope with the two charges and determine the potential change between the two points. A large number did not realise that the potential at each point was the sum of the potentials for each charge. A number of candidates assumed the midpoint was at zero potential or that there was only one charge. A significant number tried to determine the work done using $W = Fd$ or Vq. Very few were able to determine the change in potential between the two points for both charges and then determine the work done on an electron.

Question 5

This question was found to be accessible by the majority of candidates.

(a) Generally well answered with the majority of candidates obtaining at least one mark. A surprising number of candidates stated the use as for smoothing alternating currents or in rectification.

(b) (i) The majority of candidates correctly calculated the total capacitance. Only the weaker candidates used the equations applicable to resistances or made arithmetical errors.

(ii) The majority of candidates were unable to give the correct answer for this part. Many simply appeared to guess a value without further explanation.

(c) The majority of candidates were able to apply the correct equation and scored full marks. There were a number of answers that suffered from arithmetic errors. These involved the wrong power of ten for μ or the use of energy = ½ $C\Delta V^2$.

Question 6

This question was found to be accessible by the majority of candidates.

(a) (i) The majority of candidates scored both marks. However, some lines were poorly drawn without a ruler.

(ii) The majority of candidates knew the correct shape and scored at least two marks. The marks were generally lost owing to carelessness. A mark was lost if the curve did not reach a clear maximum at 90° or if the curve was of a poor shape and was clearly not about half the maximum at 30°.

(b) (i) The average and above-average candidates explained the deflection of the electron as due to the magnetic force but very few went on to say that the deflection was at right angles to this force. The weaker candidates did not mention a force and referred to a magnetic or electric field.

(ii) The majority of candidates gave the correct side and explanation. Weaker candidates failed to give an explanation and it was therefore difficult to judge whether this was just a guess; hence no marks were awarded. A significant minority stated the right hand rule and then gave the wrong side.

Question 7

The majority of marks lost on this question were in **(a)**, and **(b)(iii)**.

(a) There were very few correct explanations. Many answers referred to a current or failed to state that it is the rate of heating that is the same for both the values. The idea of a constant voltage value was also not clearly stated.

(b) (i) The majority of candidates gave the correct answer.

(ii) The majority of candidates gave the correct answer.

(iii) A significant number of candidates gave the wrong answer.

(c) The good candidates had no problems with this part. However, an incorrect voltage such as the peak value was often used by the weaker candidates.

Question 8

The majority of candidates scored high marks on this question.

(a) (i) The majority of candidates gave the correct answer. There was a tendency to round off calculations a little too early in the process. The weaker candidates had problems with the units and the powers of ten.

(ii) The majority of candidates gave the correct answer.

(iii) The majority of candidates gave the correct answer. The most common error was to fail to convert seconds into years correctly or at all.

(b) The majority of answers stated that the half life was too short to measure and hence did not score the mark. There were very few answers that referred to the difficulty produced by the decay while measurements were being taken.

Section B

Question 9

There were a significant number of good answers to this question

(a) (i) Candidates lost marks here by using the term 'feedback' and not explaining its meaning. Only a small number stated that it was only part of the output that was added to the input. Very few mentioned that this was added 'out of phase by π' although some retrieved the mark by stating it was added to the inverting input.

(ii) The majority of candidates were able to give at least one effect of negative feedback.

(b) (i) The gain was correctly calculated by the majority of candidates. The mark was lost by incorrect rounding of the value.

(ii) The wrong expression for the gain was used by a significant number of candidates and a number made a power of ten error in the calculation of the resistance.

(c) This part differentiated well with the full range of marks being awarded. The good candidates often scored all three marks. There were some candidates who suggested that saturation was a desirable feature.

Question 10

There were very poor answers from the majority of candidates to this question. The circuit diagram caused the majority of the candidates a great problem.

(a) (i) The majority of candidates gave an appropriate answer. A significant number of candidates left both parts of **(a)** blank.

(ii) The majority of candidates gave no answer or an inappropriate answer.

(b) The majority of circuits did not contain the proper symbol for a relay or a symbol labelled relay at all. Many circuits were completed directly from the sensing circuit to the external circuit and hence did not score any marks. A minority of candidates were able to draw the correct connections for the relay and switch. A diode correctly positioned often followed. Very few candidates were able to obtain the last mark for the second diode.

Question 11

The most common error was from candidates who described the use of ultrasound in diagnostics.

The candidates who described the generation of ultrasound generally scored at least three marks. The common errors were to apply a voltage rather than an alternating voltage across the crystal to produce the vibrations and not to make clear the proper provision of electrodes. Many stated the crystal was covered in a metal to act as the electrodes.

The candidates who described the use of ultrasound in diagnostics sometimes gained one mark for the use of a piezo-electric crystal.

Question 12

The candidates generally scored more marks on this question than **Questions 10** and **11**.

(a) A significant number of candidates did not discuss the changes to the signal transmitted in an optical fibre. The advantages seemed to be answered instead. The good candidates usually scored both marks.

(b) (i) The candidates did not appear to know what was wanted and often failed to answer the reason for using a logarithmic unit.

(ii) There were many different ways of answering this part. A significant number of candidates obtained full marks. There were many average candidates that tried to use the relevant equation but had the powers the wrong way round or used logs to base e. There were many answers that gained some credit but were difficult to mark as the working was devoid of any subject for the ‘equations’ used. The weaker candidates did not get much further than a calculation of the attenuation. However, there appeared to be a good distribution of the marks available across the ability range.

PHYSICS

Paper 9702/43
A2 Structured Questions 43

General comments

There was a good range of marks and candidates were generally able to demonstrate their knowledge and understanding of the learning outcomes for this syllabus. There were some Centres where candidates left blank certain sections, particularly in ***Section B*** but most candidates attempted all the questions. There was no evidence of candidates being short of time to complete the paper. The more demanding questions allowed differentiation for the more able candidates. These were **Questions 2(c)**, **3**, **4 (b)** and **(c)**, **9(c)** and **12(b)**. **Questions 10 (b)** and **4(c)** were found to be difficult by all candidates and many failed to answer the question in **Question 11**.

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(ii) The majority knew that the damping was light but a significant number were unable to give a clear explanation. There was a use of the term displacement instead of amplitude. There were many vague explanations that merely stated that the amplitude decreases.

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This question was found to be accessible by the majority of candidates.

(a) (i) The majority of candidates scored both marks. However, some lines were poorly drawn without a ruler.

(ii) The majority of candidates knew the correct shape and scored at least two marks. The marks were generally lost owing to carelessness. A mark was lost if the curve did not reach a clear maximum at 90° or if the curve was of a poor shape and was clearly not about half the maximum at 30°.

(b) (i) The average and above-average candidates explained the deflection of the electron as due to the magnetic force but very few went on to say that the deflection was at right angles to this force. The weaker candidates did not mention a force and referred to a magnetic or electric field.

(ii) The majority of candidates gave the correct side and explanation. Weaker candidates failed to give an explanation and it was therefore difficult to judge whether this was just a guess; hence no marks were awarded. A significant minority stated the right hand rule and then gave the wrong side.

Question 7

The majority of marks lost on this question were in **(a)**, and **(b)(iii)**.

(a) There were very few correct explanations. Many answers referred to a current or failed to state that it is the rate of heating that is the same for both the values. The idea of a constant voltage value was also not clearly stated.

(b) (i) The majority of candidates gave the correct answer.

(ii) The majority of candidates gave the correct answer.

(iii) A significant number of candidates gave the wrong answer.

(c) The good candidates had no problems with this part. However, an incorrect voltage such as the peak value was often used by the weaker candidates.

Question 8

The majority of candidates scored high marks on this question.

(a) (i) The majority of candidates gave the correct answer. There was a tendency to round off calculations a little too early in the process. The weaker candidates had problems with the units and the powers of ten.

(ii) The majority of candidates gave the correct answer.

(iii) The majority of candidates gave the correct answer. The most common error was to fail to convert seconds into years correctly or at all.

(b) The majority of answers stated that the half life was too short to measure and hence did not score the mark. There were very few answers that referred to the difficulty produced by the decay while measurements were being taken.

Section B

Question 9

There were a significant number of good answers to this question

(a) (i) Candidates lost marks here by using the term 'feedback' and not explaining its meaning. Only a small number stated that it was only part of the output that was added to the input. Very few mentioned that this was added 'out of phase by π' although some retrieved the mark by stating it was added to the inverting input.

(ii) The majority of candidates were able to give at least one effect of negative feedback.

(b) (i) The gain was correctly calculated by the majority of candidates. The mark was lost by incorrect rounding of the value.

(ii) The wrong expression for the gain was used by a significant number of candidates and a number made a power of ten error in the calculation of the resistance.

(c) This part differentiated well with the full range of marks being awarded. The good candidates often scored all three marks. There were some candidates who suggested that saturation was a desirable feature.

Question 10

There were very poor answers from the majority of candidates to this question. The circuit diagram caused the majority of the candidates a great problem.

(a) (i) The majority of candidates gave an appropriate answer. A significant number of candidates left both parts of **(a)** blank.

(ii) The majority of candidates gave no answer or an inappropriate answer.

(b) The majority of circuits did not contain the proper symbol for a relay or a symbol labelled relay at all. Many circuits were completed directly from the sensing circuit to the external circuit and hence did not score any marks. A minority of candidates were able to draw the correct connections for the relay and switch. A diode correctly positioned often followed. Very few candidates were able to obtain the last mark for the second diode.

Question 11

The most common error was from candidates who described the use of ultrasound in diagnostics.

The candidates who described the generation of ultrasound generally scored at least three marks. The common errors were to apply a voltage rather than an alternating voltage across the crystal to produce the vibrations and not to make clear the proper provision of electrodes. Many stated the crystal was covered in a metal to act as the electrodes.

The candidates who described the use of ultrasound in diagnostics sometimes gained one mark for the use of a piezo-electric crystal.

Question 12

The candidates generally scored more marks on this question than **Questions 10** and **11**.

(a) A significant number of candidates did not discuss the changes to the signal transmitted in an optical fibre. The advantages seemed to be answered instead. The good candidates usually scored both marks.

(b) (i) The candidates did not appear to know what was wanted and often failed to answer the reason for using a logarithmic unit.

(ii) There were many different ways of answering this part. A significant number of candidates obtained full marks. There were many average candidates that tried to use the relevant equation but had the powers the wrong way round or used logs to base e. There were many answers that gained some credit but were difficult to mark as the working was devoid of any subject for the 'equations' used. The weaker candidates did not get much further than a calculation of the attenuation. However, there appeared to be a good distribution of the marks available across the ability range.

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Paper 9702/51

Planning, Analysis and Evaluation 51

General comments

Overall a number of candidates scored full marks; sadly a number of candidates were not awarded any marks.

Question 2 was generally answered better than **Question 1**. For **Question 2**, it was pleasing to see that some Centres have spent time on the analysis section enabling their candidates to score 15 out of the 15 marks available. For **Question 1** candidates should include greater detail in their answers, while for **Question 2** careless mistakes were often made in the plotting of points on the graph and there were a number of power of ten errors. **Question 1** had a number of boxes at the end of the question for the Examiner's use; they do also give a useful hint to candidates about the criteria used for awarding marks.

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 the relationship between the velocity *v* of a falling mass and the depth *d* of a nail driven into a block of wood when hit by the mass.

The initial mark was awarded for correctly identifying the independent and dependent variables, which was generally well answered. Two marks were then available for stating that the falling mass, the type of nail and the nature of the wood should be constant; the word 'controlled' is not acceptable.

Five marks are available for the methods of data collection. Candidates are expected to draw a diagram; the minimum features of a diagram would include the block of wood, a suitably placed nail and a mass held vertically above the head of the nail. Candidates who had a block of wood falling onto an upturned nail did not gain the mark for the diagram. Diagrams showing falling hammers were accepted provided that it was clear that the nail would be struck vertically. Generally, only a minority of diagrams were conveying worthwhile information.

Further marks were available for the method of changing the velocity. It was disappointing to find that many candidates stated that a greater mass causes greater velocity and a number thought that throwing the mass downwards was a scientific approach. Many used a stopwatch to time the descent of a mass in the laboratory and then went on to talk of error caused by human reaction time! Two marks were available for the measurements needed to measure *v* and an appropriate equation to determine *v*. This was an ideal opportunity to discuss methods of timing which would have the required precision such as light gates which need additional items to time/record; video camera which needs playback at known frame speed or the inclusion of a shot of a digital clock; motion sensor connected to data-logger which needs to be aligned with the direction of displacement. To determine *v* very few used the simple solution involving the conservation of energy equation. Often the equation quoted to determine *v* was $v = s/t$, i.e. average velocity not final velocity at impact. The final mark was to find the depth *d* of the nail after impact. Answers included subtraction of readings, the tail end of the vernier calliper being inserted and inserting a small rod and marking it.

There are two marks available for the analysis of the data which were both generally scored. It is 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 log d against log v; other valid graphs were credited. The second mark was awarded for explaining how the n could be determined from the gradient. There was also an additional detail mark available for stating the correct logarithmic equation. Calculation and/or averaging methods were still evident but did not gain credit. Some candidates suggested plotting graphs of d against v and even d against v^n.

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. Many candidates were obsessed with splinters of wood jumping off the wooden block and flying into the eye of the experimenter; goggles, gloves, ear defenders etc. were not accepted. Words like 'carefully', 'release it properly', 'do not hammer your fingers', 'take accurate readings', do not address the basic problem of this experiment. Expected safety precautions should be related to a falling mass. Only a few candidates saw that an elegant solution would be a plastic tube for guiding the mass vertically down which would also cover their safety consideration.

There are 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.

Candidates should be encouraged to discuss possible preliminary work to get the right type of wood and nails to get a wide range of results with different masses. It is noticeable that most candidates are very much theoretical experimenters and therefore have to rely on their imagination as much as their basic theoretical knowledge. This was borne out by the theoretical marks in this question being scored much more frequently than those which need practical experience in a laboratory. Examples noted by Examiners were:-

D3 Vernier scale is to find depth not diameter of nail

D6 "Ensure nail is vertical" needed a method of achieving this to score a mark.

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 reactance X_c of a capacitor varied with the frequency f of an a.c. supply.

Part **(a)** asked candidates to state the quantity that the gradient would represent if a graph of X_c against $1/f$ were plotted. This was generally well answered.

In **(b)** most candidates calculated and recorded values of $1/f$ and X_c. A large number of candidates did not record their values to an appropriate number of significant figures. It is expected that the number of significant figures in calculated quantities should be the same or one more than the number of significant figures in the raw data. The absolute uncertainties in X_c 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. Another common error was to use the maximum value of V_0 and the maximum value of I_0.

The graph plotting in **(c)(i)** and **(ii)** was generally good. Common mistakes included not plotting the first data point correctly - candidates should check suspect plots. It was pleasing to see that most candidates attempted to draw the line of best fit. 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 used for the line of best fit. The majority of the candidates labelled clearly 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 indicate the points that they have used from the line of best fit.

In **(d)** most candidates scored a mark for determining *C* correctly and determining the uncertainty in *C.* The third mark in this section for a consistent unit was often lost because of power of ten errors from the graph. It was pleasing to see that the majority of candidates used their gradient values correctly. Substitution methods did not score.

For **(e)** candidates needed to find the time constant. This part was used as a 'quality mark' for the whole question and it was pleasing to see many answers were within the permitted range. For **(e)(ii)** candidates were required to determine the percentage uncertainty in the time constant. Again, it was pleasing to see that many candidates often gained the percentage uncertainty mark by adding 10% to the percentage uncertainty of their gradient or their value for C. Some candidates correctly determined the worst value of the time constant – for this method to be correct either the largest *C* and largest *R* values needed to be used or the smallest *C* and smallest *R* values needed to be used; candidates who gave a value of less than 10% did not score this mark.

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Paper 9702/52
Planning, Analysis and Evaluation 52

General comments

It was pleasing to see that a number of candidates scored full marks; sadly a number of candidates were not awarded any marks.

Question 2 was generally answered better than **Question 1** and a large number of candidates scored very highly. It was evident that Centres had spent time on the analysis section enabling their candidates to score 15 out of the 15 marks available. For **Question 1** candidates should include greater detail in their answers, while for **Question 2** careless mistakes were often made in the plotting of points on the graph and there were some power of ten errors. **Question 1** had a number of boxes at the end of the question for the Examiner's use; they do also give a useful hint to candidates about the criteria used for awarding marks.

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 strength of the magnetic field is related to the distance from the centre of a coil.

The initial marks are awarded for correctly identifying the independent and dependent variables, which was generally well answered. Two marks were then available for stating that the number of turns on the coil or radius of the coil and the current in the coil should be constant. The question is referring to variables and thus 'same coil' and 'size of coil' did not gain credit. The word 'controlled' is not acceptable.

Five marks are available for the methods of data collection. Candidates are expected to draw a diagram; the minimum features of a diagram would include the coil and the Hall probe with some evidence of a suitable read-out positioned along the axis of the coil. There was then a mark for showing how the coil was connected to a power supply. Weaker candidates often connected the coil to the Hall probe. Good candidates added a rheostat and ammeter to their coil circuit and explained how the current would be kept constant – this was awarded an additional detail mark.

A mark was awarded for either explaining that the Hall probe needed to be positioned at right angles to the direction of the magnetic field or for explaining that the maximum output was recorded for each measurement of x. Good candidates gained additional detail marks for giving a reasoned method either to keep the Hall probe in the correct orientation or to keep the Hall probe along the axis. Further marks were awarded for measuring x with a ruler and explaining how the axis of the coil was found.

There are two marks available for the analysis of the data. It is 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 $\ln B$ against x; 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 $\ln B$ against x it was expected that candidates would state "the relationship is correct if a straight line is produced". There was also an additional detail mark available for stating 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. Creditworthy responses included precautions linked to large currents in coils or the heating effect of the coil. A mark was not awarded for heating in wires.

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

- the method to produce a large magnetic field,
- to calibrate the Hall probe or stating that the Hall voltage was directly proportional to *B*,
- repeating the experiment with the Hall probe reversed,
- avoid external magnetic fields.

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 time *t* for 10 oscillations of a pendulum varied with the length l.

Part **(a)** asked candidates to state the quantity that the gradient would represent if a graph of T^2 against l were plotted. This was generally well answered although weaker candidates did not always 'square' 2π or ignored the '2π'.

In **(b)** most candidates correctly added appropriate headings to the table of results and calculated and recorded values of T and T^2. A large number of candidates either did not record their values to an appropriate number of significant figures or made rounding errors. 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. The absolute uncertainties in T^2 were usually calculated correctly although there were a number of power of ten errors; 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 when the scales in this case were more difficult to interpret. On this particular question a number of candidates plotted the error bars in reverse. 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 the candidates labelled clearly the lines on their graph; in future lines not indicated will be penalised.

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In **(d)** most candidates scored a mark for determining *g* correctly and determining the uncertainty in *g.* The third mark in this section for a consistent unit was often lost either because of power of ten errors from the graph or the unit was omitted. It was pleasing to see that the majority of candidates used their gradient values correctly. Substitution methods did not score.

For **(e)** candidates needed to find a value for l that is required to give a period of 1.0 s. This part was used as a 'quality mark' for the whole question and it was pleasing to see many answers were within the permitted range; answers also had to be given to an appropriate number of significant figures. For **(e)(ii)** candidates were required to determine the percentage uncertainty in l. It was pleasing to see that many candidates gained this mark. Some candidates correctly determined the worst value of l. Good candidates used either the uncertainty in their gradient value or the uncertainty in their value of *g*.

PHYSICS

Paper 9702/53

Planning, Analysis and Evaluation 53

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