PHYSICS

Paper 9702/01
Multiple Choice

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

General comments

In this question paper, each section of work was introduced with a relatively straightforward question, and then subsequent questions within that section became increasingly difficult. The mean mark on the paper was 24.5 and the standard deviation was 6.6. The results showed that 23% of candidates scored fewer than half marks and that 20% scored 30 or more. There was a particularly marked improvement in the answering of electricity questions in this examination.

In order to encourage more careful working of answers, space for working was deliberately left on each page of the question paper. It is impossible to know exactly how much this space was used but, if the other papers for the award can be used as a guide, it is apparent that too many candidates still do not check their work with sufficient care. Candidates frequently give answers that are implausible: speeds higher than the speed of light, and the density of water at 1 kg per cubic metre, for example. Candidates should check their answers to multiple choice questions immediately and not after finishing the paper. Answers should be checked particularly for power of ten errors and also for positively being able to reject the other three answers to a question. These can often introduce to the candidate another point that they had not previously considered and which might be important.

Comments on individual questions

Question 7 produced some interesting statistics. Only 14% of candidates found the correct answer, but correct responses were from those candidates achieving the highest overall marks on the paper. Newton's first law does follow from the second law in that, by using the second law for a body on which the resultant force is zero, the acceleration will also be zero, and so the first law is thus proved from the second law.

Question 15 was another question with low facility of 15%. Careful working is required to show that the total mass remains the same but that its centre of gravity will only be ¼*h* above the base after the tap is opened.

Only three other questions had a facility under 40%. The first of these was **Question 10**, where 56% of candidates thought that the mass of 2*m* had twice the energy of the mass of *m* and only 31% realised that it is opposite to this. **Question 11** also caused problems for many. 24% thought C was correct, not realising that this would imply no upthrust. 23% thought that B was correct. This would result in a net downthrust. Only 38% gave the correct answer, A. **Question 18** caused difficulties for many candidates, and 64% gave C as the answer rather than the solution, D.

Location Entry Codes

UNIVERSITY of CAMBRIDGE
International Examinations

As part of CIE's continual commitment to maintaining best practice in assessment, CIE has begun to use different variants of some question papers for our most popular assessments with extremely large and widespread candidature, The question papers are closely related and the relationships between them have been thoroughly established using our assessment expertise. All versions of the paper give assessment of equal standard.

The content assessed by the examination papers and the type of questions are unchanged.

This change means that for this component there are now two variant Question Papers, Mark Schemes and Principal Examiner's Reports where previously there was only one. For any individual country, it is intended that only one variant is used. This document contains both variants which will give all Centres access to even more past examination material than is usually the case.

The diagram shows the relationship between the Question Papers, Mark Schemes and Principal Examiner's Reports.

Question Paper	Mark Scheme	Principal Examiner's Report
Introduction	Introduction	Introduction
First variant Question Paper	First variant Mark Scheme	First variant Principal Examiner's Report
Second variant Question Paper	Second variant Mark Scheme	Second variant Principal Examiner's Report

Who can I contact for further information on these changes?
Please direct any questions about this to CIE's Customer Services team at: international@cie.org.uk

PHYSICS

Paper 9702/21
AS Structured Questions

General comments

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

There were some excellent scripts where candidates showed a sound understanding of the concepts across the whole of the syllabus. These were, however, in a minority. It was saddening to see other Centres where no candidate scored more than 30% of the total marks and, indeed, some candidates could be given no credit.

It was pleasing to note that fewer candidates left some of the answer spaces blank. Candidates should be encouraged to attempt all parts of all questions. Writing down relevant formulae may assist to rally thoughts.

Apart from the weaker candidates, most did complete the Paper and consequently, there was no real evidence for a shortage of time.

Comments on specific questions

Question 1

(a) (i) In the great majority of scripts, a micrometer (screw gauge) was correctly suggested.

(ii) Surprisingly, comparatively few answers included both an ammeter and a voltmeter or an ohm-meter. Many answers made reference only to a voltmeter.

(iii) A c.r.o. would have been appropriate. Very few realised that an a.c. voltmeter would not give the peak reading and thus the r.m.s. value would have to be multiplied by $\sqrt{2}$. Many candidates merely suggested ‘a voltmeter’.

(b) Most candidates were able to calculate the density to various numbers of significant figures. The vast majority could proceed with the determination of the uncertainty no further than a calculation of the fractional uncertainty in the mass.

Question 2

(a) In the great majority of answers, some reference was made to ‘bouncing back’ or ‘changing direction’.

(b) (i) Despite the hint provided in **(a)**, a common error was to subtract, rather than to add, the initial and the final momenta.

(ii) Candidates realised that they had to divide the answer in **(i)** by the time for which the change occurs. Unfortunately, there were many incorrect values for this time.

(c) Generally, this part of the question was completed successfully, when based on the candidates’ previous answers.

(d) The question asked for a quantitative response. Such answers were in a minority. A small number of candidates very successfully compared the initial and final kinetic energies. This involved a considerable effort. Candidates should be encouraged to consider, in such circumstances, the relative velocities of approach and separation.

Question 3

(a) There was some confusion between the moment of a force and the torque of a couple. Of those who did define torque, most referred to 'distance between the forces' without any reference to 'perpendicular distance'.

(b) (i) In a significant number of scripts, the answer was incorrectly given as 45˚.

(ii) Those candidates who gave the answer in **(i)** as 90˚ were, in general, successful with this calculation. Where the answer in **(i)** was 45˚, then it was expected that the angle would be included in the calculation of *F*. Some ignored the angle of 45˚ (assuming it to be 90˚) or used cos 45, rather than sin 45.

Question 4

(a) (i) There was widespread confusion as to the meaning of elastic deformation. Many thought that it represented a limit beyond which removal of the deforming force would cause permanent deformation. Others referred to 'deformation' without any explanation as to the meaning of this term.

(ii) Generally, the correct expression was quoted.

(b) The overall standard of answers was disappointing. Many were unable to visualise what the extension would be in the three situations. Furthermore, many candidates thought that the spring constant would be proportional to the maximum extension. Candidates do need to be aware as to the meaning of 'in terms of'. Many gave answers that did not include either *e* or *k*.

Question 5

(a) Answers were disappointing in that references to path difference and to amplitude were rarely seen.

(b) The majority of candidates did not appear to understand how to approach this problem, perhaps as a result of a failure to answer **part (a)**. Very few even calculated the path difference.

Question 6

With the exception of **(c)**, this question was answered well.

(a) Both parts were completed successfully by most candidates.

(b) (i) With few exceptions, the calculation was completed successfully.

(ii) Most candidates wrote down a correct expression and arrived at the correct answer. A minority made a power-of-ten error.

(c) Answers were usually vague. Many stated that the vertical gravitational acceleration would not affect the motion of the electron, rather than not affecting the horizontal component of its motion. Others either made a reference to the weight of the electron being 'negligible', without comparing the weight to the electric force, or did not include any directions. A significant number of responses suggested a belief that gravitational fields do not exist in a vacuum.

Question 7

(a) Answers to **(i)** and **(ii)** were, in general, correct. Incorrect answers to **(iii)** were common, in that candidates did not realise that the parallel combination is in series with the resistors.

(b) Answers to all three parts in the scripts of more-able candidates were correct. The usual errors were associated with the directions of current and e.m.f.

Question 8

(a) The majority of answers included a reference to external factors. Some candidates either confused spontaneity and randomness or described both without making clear which answer was relevant to spontaneity.

(b) In general, **parts (i)**, **(ii)** and **(iii)** were answered correctly. Very few identified the range of energies with β-particles. The most common incorrect answer was γ-rays.

PHYSICS

Paper 9702/22

AS Structured Questions

General comments

The Paper gave rise to the award of marks over the complete mark range. Some parts of questions required recall, but elsewhere candidates were expected to apply their knowledge and understanding to unfamiliar situations. Thus, the Paper provided ample opportunity for candidates to demonstrate their various skills.

There were some excellent scripts where candidates showed a sound understanding of the concepts across the whole of the syllabus. It was saddening to see other Centres where no candidate scored more than 30% of the total marks and, indeed, some candidates could be given no credit.

It was pleasing to note that fewer candidates left some of the answer spaces blank. Candidates should be encouraged to attempt all parts of all questions. Writing down relevant formulae may assist to rally thoughts.

Most candidates did complete the Paper and consequently, there was no real evidence for a shortage of time.

Comments on specific questions

Question 1

(a) In the great majority of scripts, time, electric current and temperature were identified correctly. Some did include either amount of substance or luminous intensity. Both were acceptable.

(b) There were many well-presented determinations of the derived units. Very few misunderstood what they had to do and consequently considered dimensions. The greatest problem was that of explanation. In many scripts, a logical progression through the answer was lacking.

Question 2

(a) With few exceptions, the graph was read correctly.

(b) Many candidates did not realise that, for the graphical analysis, the problem involved calculating the difference between two areas. Most were content to calculate one area only. Some solutions were attempted using the equations of motion. Generally, such attempts included an incorrect substitution of a sign.

(c) (i) This question part was generally completed successfully. However, candidates should be warned that, when reading values from a graph, they should not read to the nearest grid line. In this case, many quoted the final speed as $4\,m\,s^{-1}$ when, quite clearly, the speed could be read to more than one significant figure.

(ii) There were many correct answers to this problem when due allowance was made for 'error-carried-forward' from the candidate's answer in **(i)**.

(d) (i) A significant minority did not realise that the force acting on the sphere is its weight.

(ii) Although most answers did involve dividing weight by mass, there were some attempts to involve *g,* the acceleration of free fall on the Earth's surface.

Question 3

(a) There was some confusion between the moment of a force and the torque of a couple. Of those who did define torque, most referred to 'distance between the forces' without any reference to 'perpendicular distance'.

(b) (i) In a significant number of scripts, the answer was incorrectly given as 45˚.

(ii) Those candidates who gave the answer in **(i)** as 90˚ were, in general, successful with this calculation. Where the answer in **(i)** was 45˚, then it was expected that the angle would be included in the calculation of *F*. Some ignored the angle of 45˚ (assuming it to be 90˚) or used cos 45, rather than sin 45.

Question 4

(a) (i) There was widespread confusion as to the meaning of elastic deformation. Many thought that it represented a limit beyond which removal of the deforming force would cause permanent deformation. Others referred to 'deformation' without any explanation as to the meaning of this term.

(ii) Generally, the correct expression was quoted.

(b) The overall standard of answers was disappointing. Many were unable to visualise what the extension would be in the three situations. Furthermore, many candidates thought that the spring constant would be proportional to the maximum extension. Candidates do need to be aware as to the meaning of 'in terms of'. Many gave answers that did not include either *e* or *k*.

Question 5

(a) Answers frequently included a reference to 'constant phase difference'. However, rarely was 'constant phase difference' put into context.

(b) Most answers did include a statement of the correct expression but, frequently, unconventional symbols were left unexplained. The most common correct estimate for the wavelength was 700 nm but often, estimates gave rise to ridiculous values for the separation.

(c) There were very few correct answers. The most common responses were that 'the dark fringes will get darker' or that 'the light fringes will become darker but the dark fringes will be unaffected'.

Question 6

With the exception of **(c)**, this question was answered well.

(a) Both parts were completed successfully by most candidates.

(b) (i) With few exceptions, the calculation was completed successfully.

(ii) Most candidates wrote down a correct expression and arrived at the correct answer. A minority made a power-of-ten error.

(c) Answers were usually vague. Many stated that the vertical gravitational acceleration would not affect the motion of the electron, rather than not affecting the horizontal component of its motion. Others either made a reference to the weight of the electron being 'negligible', without comparing the weight to the electric force, or did not include any directions.

Question 7

(a) With few exceptions, the answer for both switches 'open' was, surprisingly, given as zero.

(b) Answers to all three parts in the scripts of more-able candidates were correct. The usual errors were associated with the directions of current and e.m.f.

Question 8

(a) The majority of answers included a reference to external factors. Some candidates either confused spontaneity and randomness or described both without making clear which answer was relevant to spontaneity.

(b) In general, **parts (i)**, **(ii)** and **(iii)** were answered correctly. Very few identified the range of energies with β-particles. The most common incorrect answer was γ-rays.

PHYSICS

Paper 9702/31

Advanced Practical Skills 1

General comments

The general performance of 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 understanding that Centres will be able to provide the apparatus that is outlined in the syllabus. Some help was given to candidates from Supervisors in setting up the apparatus in **Question 1**. Any help given to the candidate must 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 how different arrangements of resistors affected the current in a circuit.

Successful collection of data

(a) Most candidates were able to set up six arrangements of resistors in the circuit without the help of a Supervisor. Candidates were often confused by current in mA instead of A.

(b) Most candidates were able to tabulate six sets of readings of R and $1/I$. A few candidates failed to record their current values so marks for consistency in current, significant figures in $1/I$ and the value of $1/I$ could not be awarded.

Range and distribution of marks

(b) It was expected that candidates would use the table of resistance values for the different arrangements in selecting a suitably large range. Many candidates failed to gain this mark, by excluding either the 12/16 Ω resistor or the 141/188 Ω resistor. Choosing only the first six arrangements was not satisfactory.

Presentation of data and observations

Table

(b) Most candidates gained the mark for column headings. The main misconception was that the *1/I* column heading did not need a separating mark between the quantity and unit. The consistency in the values of *I* was generally correct but the corresponding significant figures given in the calculated quantity *1/I* were often wrong. A candidate who wrote 22.3 (1 dp, 3sf) for *I* was often penalised in the significant figure mark in 1/*I* for 45 (2 sf) but would have been credited for 44.8 (3 sf) or 44.84 (4 sf). Calculated quantities (*1/I)* should have the same or one more significant figure than that in the raw data (*I*). Those candidates who wrote the calculated quantity to one or two significant figures often produced a graph with a large scatter and consequently lost out on the quality mark. Most candidates calculated *1/I* correctly.

Graph

(c) (i) Candidates were required to plot a graph of *1/I* against *R*. Many candidates used awkward scales (multiples of 24 on the *x*-axis were common). There were errors in plotting and reading off coordinates on the x-axis as a result. There are still candidates who plotted points greater than half a small square in diameter and so failed to gain credit. 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'. If the line of best fit is a straight line then this line should be drawn using a 30 cm long ruler. Also some of the lines drawn were too thick to gain credit (lines thicker than half a small square); lines should be drawn with a sharpened pencil. There was a reasonable allowance for scatter in order to gain credit for the quality mark and many candidates gained this mark.

Analysis, conclusions and evaluation

Interpretation of graph

(c) (ii) In order to determine the gradient of the line of best fit, candidates are expected to use triangles with the hypotenuse equal to or greater than half the length of the line drawn. Some candidates used smaller triangles or inverted their gradient ratio and lost the gradient mark. Often, the same candidates who mis-plotted points or who set out awkward scales went on to mis-read gradient points. It is worth noting that if a candidate had mis-plotted a point that later was re-plotted by the Examiner onto the line of best fit, there was still a chance that the candidate could score the quality mark.

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

Drawing conclusions

(d) Many candidates were able to work out *P* and *Q* using the correct method i.e. gradient = 1/*P* and *y*-intercept = *Q/P* with gradient and intercept values taken from **(c)(ii)**. Some candidates used the substitution of known plots incorrectly failing to gain credit.

(d) Good candidates were able to obtain the final mark for the value and range of P (1-5V) and Q ($100 \pm 50\,\Omega$). Many candidates left out the units or calculated *P* to be in the thousands (as a result of not taking into account current measured in mA instead of A).

Question 2

In this question, candidates were required to investigate how the angle of tilt of a bottle varies with different amounts of water.

Successful collection of data

(b)(i), (c) Most candidates noted their height measurement to the nearest millimetre, gaining credit, and went on to measure the greater second height. However some candidates only measured the height to the nearest centimetre, whilst others implied that they could measure to a tenth of a millimetre.

(b) (i) Most candidates measured an initial tilting angle to be less than 90°, gaining credit. However some measured their angle to be greater than 90°, indicating that they mis-read the protractor. Most candidates correctly measured their angle to the nearest degree or 0.5 of a degree. Candidates giving their angle to the nearest tenth of a degree failed to gain credit. The majority of candidates failed to repeat the angle measurement, although this was considered to be the most unreliable measurement.

Quality

(c) It was expected that as the height of the water in the bottle decreases, the angle of tilting decreases. Many candidates gained credit here.

Presentation of data and observations

Display of calculation and reasoning

(a) (ii) Justifying the number of significant figures for the volume was poorly answered on the whole. Reference to the measuring cylinder measuring to the same number of significant figures or to the nearest 1 ml was needed here. Many candidates gave a plausible answer only to quote their volume to the nearest 1 decimal place, which was inconsistent with their comments and therefore not credited.

(c) The question asked the candidate to empty and refill the bottle until it is about a quarter full. It was surprising therefore to find that many candidates filled up their bottle to three quarters full. Candidates were penalised for their second volume measurement in this case.

(d) A large number of candidates failed to work out the values of k from their two sets of values of $\sqrt{h}$ and $\cos\theta$. Many candidates failed to recognise that if $x \propto 1/y$ then $xy = k$ and so candidates failed to gain credit for working out $k = \sqrt{h} / \cos\theta$.

Analysis, conclusions and evaluation

(e) It was expected that candidates would give their judgement on whether the relationship holds or not based on their ratio calculations. This was poorly answered. If the candidate stated that they felt the ratio for each experiment was the same and therefore the relationship holds then credit was given provided the ratios were within a certain percentage of one another. It was deemed for this experiment that 20% was feasible. This is not a hard and fast rule. The candidate could choose their own limit. No credit was given for comments like 'Yes, because as $\sqrt{h}$ increases $\cos\theta$ decreases'.

Estimating uncertainties

(b) (iii) As a result of the difficulty of measuring θ, it was expected that the uncertainty of the angle measurement was 2 – 5° and not 1° as many candidates quoted. Instead some candidates used half the range if they had repeated readings. A minority of good candidates then went on to gain this mark for the correct ratio idea: e.g. 2/42 x 100% for the percentage uncertainty.

Evaluation

(e)(i)(ii) The evaluation proved to be the hardest section on which to score high marks and accounts for 20% of the overall marks. That said, marks in this section were generally higher than in previous years. As usual this was Centre specific. The key is to identify specific problems for this particular experiment and then come up with practical solutions (and not by changing the experiment itself, e.g. by changing the bottle). Clarity of thought, experience and ability to express ideas are needed here to produce a better experiment, not a different one. Many problems and solutions made reference to measuring the volume, which was not credited as it was thought the measuring cylinder provided was an accurate way of measuring the volume. However there were large uncertainties associated with measurement of the height and the angle.

Answers that gained credit and those that did not are outlined below.

Credited problem: 'Difficult to hold both bottle and protractor and measure the angle at the same time.'
Credited solution: 'Use clamp to hold protractor.'
No credit: 'Use clamp to hold bottle.' 'Get someone to help.'

Credited problem: 'Difficult to decide when the bottle was about to topple.'
Credited solution: 'Trial and error, bring bottle closer to point of tipping.'
No credit: 'Use bigger protractor.', 'Use a video recorder.'

Credited problem (very common): 'Parallax error in the reading of height' or 'angle.'
Credited solution: 'Align eye level with top of meniscus for a more accurate height measurement.'
No credit: 'Parallax error in reading the measuring cylinder.'

Credited problem (very common): 'Two values of h and θ are not enough.'
Credited solution: 'Record different values of h and θ, and plot a graph of $\sqrt{h}$ against $1/\cos\theta$'
No credit: 'Repeat readings in h.' (Very common)

Credited problem: 'Difficult to measure the height because of the irregular shape of the bottle.' Or 'because meniscus was difficult to see.'
Credited solution: 'Attach scale onto bottle to help measure height.' Or 'Add dye to the solution.'
No credit: 'Use a bottle with straight sides.'

The 'no credit' points were penalised for not providing enough detail or not supported with a reason. Candidates lost most marks by stating valid problems but not assigning those problems to the measurement undertaken. There was no credit for an idea where the candidates should have already undertaken this action, e.g. 'water moving so difficult to measure the height': candidates should already, as part of their experiment, have waited until the water had stopped moving before taking a reading. Candidates need to think about the experiment they have just done, e.g. although movement was involved, filming would not help with the accuracy of the experiment. Further examples 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. There was a wide range of marks and some variation between Centres.

Once again most candidates had been well prepared for the practical work and this lead to a generally good standard in the more structured first question. In the second question there was less guidance about the procedures to follow and marks were generally lower than for the first question. This question also included marks for critical evaluation of the experiment and candidates from several Centres produced very good responses in this section.

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

Comments on specific questions

Question 1

In this question, candidates were required to measure the time for a suspended weight to untwist a twisted length of wool.

Successful collection of data

(b) Most candidates recorded sensible values for time, with only a few getting the very small values that suggested either timing a single revolution or mis-reading the stopwatch

Range and distribution of readings

(b) Many candidates did not vary the length of the wool over a good part of the range available, and some failed to carry out the expected repeated timings for each length.
The correct trend (t increasing as the length of the wool increased) was usually evident.
The quality of the data (judged by the amount of scatter about a straight line trend on the graph) was good for most of the candidates.

Presentation of data and observations

Table

(b) The majority of results tables were clearly presented with quantities and suitable units for each column heading, although some candidates had difficulty with the unit for $\sqrt{l}$ (cm$^{1/2}$). Few candidates recorded the length readings to a suitable precision (i.e. to the nearest mm).
The choice of significant figures for the calculated value of $\sqrt{l}$ was usually suitable but slips were fairly common (e.g. $\sqrt{25.0}$ was often given as 5 rather than 5.00).

Graph

(c) Most candidates made good use of the graph grid, with points occupying a good part of the area available and with sensible, easy to use axis scales. In most cases this led to the use of a false origin.
Plotting was usually accurate, though some candidates were penalised for using very large dots (bigger than 1 mm diameter).

Analysis, conclusions and evaluation

Interpretation of graph

(c) The gradient was usually accurately determined, with very few losing credit through using too small a triangle.

A number of candidates made the mistake of reading the *y*-intercept directly from the graph when they had used a false origin on the $1/\sqrt{l}$ axis.

Drawing conclusions

(d) A large number of candidates successfully equated their gradient and y-intercept values to the constants *p* and *k.* However, few gave correct units, particularly for *p* ($s\,cm^{-½}$ or $s\,m^{-½}$, depending on the unit for *l*).

Question 2

Candidates were asked to complete an electrical circuit and then measure the sag of a length of wire when a current heated it.

Successful collection of data

(c),(d) Candidates' values of current *I* were usually sensible, with only a few mis-reading the ammeter. Some circuits were unable to supply the requested 1.2A but this did not cause the loss of any marks.

(c),(d) Candidates were expected to record measurements of height to the nearest mm and most did, but a few were inconsistent (e.g. recording 26 cm instead of 26.0 cm).

Estimating uncertainties

(c) This task was usually well done.

Presentation of data and observations

Display of calculation and reasoning

(c),(d) There were several instances of the height of the mass hanger apparently increasing when the wire was heated – presumably because the rule was upside down.

(e) When considering the possible proportionality of *I* and *x* it was expected that ratios would be calculated. Where this was done the calculation was correct in nearly all cases.

Quality

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

Analysis and conclusions

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

Weaker candidates just pointed out that *x* increased as *I* increased (not worthy of credit since it does not by itself support proportionality).

Candidates with a reversed trend could get credit by saying that it disproved proportionality (but not if they said that it proved inverse proportionality).

Evaluation

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

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

- basing a judgement on measurements for only two different currents;
- the very large uncertainty in the deflection x (typically 50% or even more) because x is so small;
- parallax error when measuring the height of the mass hanger position;
- rule not vertical when measuring height;
- judging the positions for the contacts;
- fluctuating current.

References to 'inaccurate' meters, zero errors and unspecified parallax errors were not credited.

Improvements related to these difficulties were credited if they were practical and included sufficient detail (e.g. '<u>a setsquare on the bench</u> was used to ensure that the rule was vertical').
The published mark scheme includes the most common examples.

PHYSICS

Paper 9702/04

A2 Structured Questions

General comments

The overall standard of the performance of candidates was similar to last year. There were some excellent scripts from the more-able candidates, who showed a thorough knowledge of the work and were able to apply that knowledge to solve problems. On the other hand, there were numerous candidates who had very scant knowledge of the syllabus content and scored very low marks.

In general, the performance of candidates was disappointing. Many were unable to apply their limited knowledge and appeared to be inadequately prepared for the examination.

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.

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

Comments on specific questions

Section A

Question 1

(a) Definitions frequently lacked precision in that field strength was defined as 'force on a unit mass'. Candidates should realise that a ratio is involved and, consequently, give the definition as 'force per unit mass'.

(b) Most candidates gave a correct mathematical expression for *g*. A failure either to use the radius, rather than the diameter, or to substitute distance in metres was common.

(c) (i) In most scripts, the answer was given correctly as 'point Y'. However, explanation was sometimes less than adequate. Satisfactory answers involved stating that potential becomes more negative as the planet is approached.

(ii) A minority of candidates appreciated that the *change* in potential should be equated with $\frac{1}{2}v^2$. Others attempted answers that involved only one value of the potential.

Question 2

(a) Answers were very disappointing with very few making reference to either a very long half-life or a very small decay constant. The most common incorrect answer was that the half-life must remain constant.

(b) There were some very well-explained correct answers but these were in a minority. Most candidates did quote either $pV = nRT$ or $pV = NkT$. The most common error was to substitute either $n = 1$ or $N = 1$. Surprisingly, in many answers, the total number of helium atoms produced in 40 days was not calculated.

Question 3

(a) Many answers did include a reference to the bonds between molecules. Fewer considered the effect of increase in volume. Candidates should be encouraged to use scientific language. It is far more appropriate to refer to 'work done in expanding against atmospheric pressure' than to 'push back the atmosphere'.

(b) (i) 1. Most candidates could explain how to check for a constant rate. Candidates should, however, be warned against paraphrasing the question.

2. Correct answers were in a minority. Some thought that the procedure would prevent energy losses but many thought that it was a check on the power input.

(ii) There were relatively few correct answers. Many candidates either used only one set of data or used both sets and took an average.

Question 4

(a) (i) Answered correctly by most candidates.

(ii) A significant number of candidates gave the answer as $r\omega t$, rather than $r \sin\omega t$.

(b) It was expected that candidates would recognise the answer in **(a)(ii)** as being the solution to the equation $a = -\omega^2 x$ and that this equation is the defining equation for simple harmonic motion. Instead, many merely attempted to define what is meant by s.h.m.

(c) Both parts of this determination were completed successfully by most candidates.

Question 5

(a) (i) Although most answers included a reference to charge and potential, many considered 'potential difference' whilst others were clearly defining capacitance of a parallel plate capacitor.

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

(b) The calculations in both **(i)** and **(ii)** presented few problems, apart from power-of-ten errors.

(c) There were some very good answers where the conclusion reached was either that there would not be a unique value of potential or that the charge could not be considered to be a point charge at the centre. Many answers were restricted to a statement that the plastic is an insulator. A significant minority thought that this would mean that charge could not be stored on the sphere.

(d) The majority of answers did involve the expression $E = ½CV^2$ although many thought that $(V^2 - v^2)$ would be equal to ΔV^2. A common error was to use the expression $E = ½QV$, with Q remaining constant.

Question 6

(a) Candidates should be encouraged to distinguish clearly between the definition of a quantity and that of a unit. The tesla is the unit of magnetic flux density and should be defined in terms of the units metre, newton and amp. Furthermore, many started their answers by stating that 'the tesla is the force acting.....'. Clearly, this is incorrect.

(b) (i) Fully correct answers were in a minority. Many failed to appreciate that the force is downwards on the magnet, not on the wire, and thus there is an upward force on the wire.

(ii) In general, the calculation was completed successfully although power-of-ten errors were seen quite frequently.

(c) Many answers were long and involved, in that the peak current was calculated and then the force was determined using the equation $F = BIL$. Very few answers were seen where allowance was made for $\pm I_0$. Instead, candidates did, quite wrongly, deduct 2.3 from their answers.

Question 7

Most answers did show a coil connected in series with the meter and the magnet, with known pole, being pushed into the coil. However, many did not concentrate on the direction of the current but, rather, on its magnitude. They did, however, refer to 'current in the opposite direction' when the direction of motion of the magnet is reversed. The rule by which the field in the coil is determined was frequently omitted. Statements of Lenz's law frequently lacked clarity in that it was not stated that the induced current gives rise to effects that oppose the change that produces it.

Question 8

(a) Many candidates mis-read the question. Consequently, they described what is meant by the threshold frequency and the short emission time. Very few stated that wave theory would predict that any frequency would give rise to photo-emission, given a sufficiently long exposure time. Equally, the particle theory was not described.

(b) Most answers included the expression $E = hf$, but frequently the symbols were not explained. There was much confusion as regards the de Broglie relation. Many thought that this applied to photons and not to the wave nature of particles.

Question 9

(a) There were very few correct answers, even in **(i)**.

(b) In many scripts, it was not appreciated that the radioactive decay equation should be used. Of those who did use the equation, very few realised that the source would have to decay by 8%.

Section B

Question 10

(a) Many candidates paraphrased the question, using the term 'fed back'. It was common to find that there was no direct reference to the inverting input. Terms such as 'negative pin' were quite usual.

(b) There were many correct answers although a significant minority used the equation for the gain of an inverting amplifier.

(c) A surprisingly large proportion of candidates did not score marks in this section. In particular, they did not appreciate that, in **(ii)**, the amplifier would saturate.

Question 11

(a) In general, this was answered well although, in a significant number of answers, it was not stated that either the ultrasound has to be pulsed or that the received pulses must be processed and displayed.

(b) (i) Many answers were disappointing, with a significant number of candidates not realising that the equation for the coefficient was given to them. Many others substituted absorption coefficient, rather than acoustic impedance.

(ii) Many candidates did not attempt this part of the question.

(iii) Again, there were many scripts where this question was not attempted. In general, candidates who had completed **parts (i)** and **(ii)** were able to complete the calculation successfully.

Question 12

(a) Most answers were acceptable. However, a minority referred to 'loss of signal', without explaining what they meant by 'signal'.

(b) (i) Generally correct.

(ii) There was considerable confusion here, with many candidates assuming that 21 amplifiers would be used, thus giving a gain of 903 dB.

(c) It was pleasing to note that there were many correct answers, when based on the candidates' answers in **(b)(i)** and **(b)(ii)**. There were, however, some ridiculous answers, for example 9×10^{92} mW, that were left without comment.

Question 13

(a) Answers fell into two categories. There were those answers that were correct or had only minor faults and there were the others where, quite clearly, the candidates had no real appreciation of the problem.

(b) It was pleasing to note that the general standard of answers to questions based on the operation of a mobile phone has improved. However, there are still many candidates, particularly from small Centres, where the level of understanding is very limited.

PHYSICS

Paper 9702/05

Planning, Analysis and Evaluation

General comments

Both questions on this paper were accessible to candidates and it was pleasing to see that the quality of the answers to both **Question 1** and **Question 2** have improved. A significant number of candidates scored full marks on **Question 2** and a smaller number of candidates scored full marks on **Question 1**. Overall a number of candidates scored full marks; sadly a number of candidates were not awarded any marks.

In the planning question, candidates were better at devising experimental techniques, although there were some 'sloppy' answers seen. In **Question 2** candidates appeared to be better this session with the treatment of errors; the most common mistake was made when determining the *y*-intercept, which could not have been read directly from the *y*-axis. As has been stated before, candidates are still losing marks because they do not present their calculations clearly; marks are often awarded when a clear (correct) method is seen.

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 determine the Young modulus of wood by using an equation relating the period of oscillation to the overhanging length of a loaded wooden rule.

The initial marks are awarded for correctly identifying the independent and dependent variables. Candidates generally suggested varying the length. Some weaker candidates described an experiment to measure the extension of the wood. Candidates are also expected to state physical quantities that need to be kept constant; in this case the mass of the load was the obvious quantity. Candidates who suggested varying the mass of the load were not penalised and the latter mark could be gained by keeping the length of the rule constant. There was an additional detail mark for stating that the width and/or depth of the rule needed to be kept constant.

Five marks are available for the methods of data collection. One mark was awarded for a method to fix the wooden rule to the bench; most candidates used a G-clamp. This mark clearly expects candidates to have experienced setting up apparatus in a laboratory. The second mark was for the method of determining the period of oscillation. It was expected that candidates would time a specific number of oscillations and then repeat each time measurement. Candidates who measure the number of oscillations within a certain time period did not gain credit. A surprising number of candidates did not specify a large number of oscillations or suggest repeating each measurement. To determine the Young modulus, the constant *k* needed to be calculated. There was a mark for measuring the mass of the load on an appropriate balance and a further mark for measuring *l*, *w* and *d*. Some candidates confused mass and weight. There was also a mark awarded for the use of vernier calipers or a micrometer screw gauge to measure the width or thickness of the rule. Good candidates gained an additional detail mark for stating that *w* and *d* would be measured at several different places along the rule and the average determined.

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 second mark was awarded for explaining how the Young modulus of wood was determined from the gradient of their graph. A simple statement that the gradient would give the Young modulus did not score. It was expected that candidates would suggest that the Young modulus was equal to *k*/gradient or an appropriate relationship for the graph that they suggested plotting. Candidates had obviously thought about this question more since there were some sensible graphs plotted e.g. l^3 against T^2, kl^3 against T^2, etc. These gained credit and the second mark could also be scored. Some candidates discussed plotting an appropriate logarithmic graph - this could still gain full credit. 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 taken in case the load fell off the rule. The use of goggles in case the rule broke was not allowed.

There are four marks available for additional detail. Candidates should be encouraged to write their plans adding appropriate detail. Vague responses such as 'light gates' did not score. In addition to the points already mentioned credit was also given for:

a discussion of the use of a motion sensor or light gates;
the use of small amplitude oscillations for the relationship to be valid;
a method of securing the load to the rule;
the use of a fiducial marker to assist in the timing; and
to start timing after the oscillations have settled.

Good candidates who have followed a 'hands on' practical course during their studies usually 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 current required to melt a wire depended on the diameter of the wire.

Part (a) asked candidates to state the quantities that the gradient and *y*-intercept would represent if a graph of lg I against lg d were plotted. This was generally well answered although some candidates incorrectly gave the *y*-intercept as ln *p*.

In **part (b)**, most candidates calculated and recorded values of lg I and lg d. A large number of candidates did not record their values to an appropriate number of significant figures, which in this question corresponded to the number of decimal places because of the logarithmic quantities. Rounding errors were also made. A number of candidates only used one decimal place for lg d. It is expected that the number of significant figures in calculated quantities should be the same or one more that the number of significant figures in the raw data; however, in logarithmic quantities the number of significant figures is determined by the number of decimal places. In this question, since d was given to two significant figures, it was expected that lg d should have been given to either 2 or 3 decimal places. The absolute errors (uncertainties) in lg I were usually calculated correctly; the Examiners allow a number of different methods and do not penalise significant figures at this stage. One common error is to work out the maximum difference without dividing by two.

The graph plotting in **(c)(i)** and **(ii)** was generally good, although it is important that both the points and the error bars can be seen. Candidates should be advised to check suspect plots. The worst acceptable straight line should be either the steepest possible line or the shallowest possible line that passes through the error bars of all the data points. Too often, candidates do not distinguish clearly the lines on their graph; the lines should be clearly labelled – in future, lines not clearly indicated will be penalised.

Part (c)(iii) was generally answered well. Some candidates did not use a sensibly-sized triangle for their gradient calculation. To determine the absolute error in the gradient, candidates were expected to find the difference between the gradient of the line of best fit and the gradient of the worst acceptable line. Clear working is very helpful – good candidates clearly indicate the points that they have used from the line of best fit. Some candidates were confused about the *x*-axis and gave answers "x 10^5" – this was not penalised in this part, but was penalised in **part (d)**.

In **part (c)(iv)**, too many candidates incorrectly directly read the *y*-intercept from the graph and thus determined the value of y when x had the value of 1.15 and thus scored zero for this part. Candidates were expected to determine the *y*-intercept by substituting a point on the line of best fit into $y = mx + c$. To determine the error (uncertainty) in the *y*-intercept, it was expected that candidates would substitute a point on the worst acceptable line into $y = mx + c$ using the gradient of the worst acceptable line and then find the difference. Errors in this last part were either due to using the wrong gradient or substituting in the wrong points.

The final part asked candidates to determine the values of *p* and *q*. To determine *p*, a large number of candidates correctly equated *p* to $10^{y\text{-intercept}}$; a significant minority incorrectly equated *p* to $e^{y\text{-intercept}}$. Candidates who determined the *y*-intercept incorrectly in **(c)(iv)** were not penalised in this part. The value of *q* needed to be the same as the candidate's gradient value and in the range 1.20 to 1.30 and given to two or three significant figures. A common error was to include a 10^5. The final mark was for correctly determining the error (uncertainty) in the values of *p* and *q*. The latter value corresponded to the uncertainty in the gradient while to determine the error (uncertainty) in *p* required the worst value to be calculated and the difference found. This last mark could only be scored if the method was clear; too often values were written by candidates without demonstrating that they understood the underlying Physics.