# PHYSICS

**Paper 9702/01**
**Multiple Choice**

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

**General comments**

This paper had a few easy questions on it to introduce each section of work and generally the questions within a section increased in difficulty within that section of work. The mean mark out of 40 was 25.7 for the 8743 candidates with a standard deviation of 7.09. This mean was about 2 marks higher than the corresponding paper taken last June. 13 candidates managed to get all 40 questions correct; a considerable achievement. Only 78 candidates scored below the 10 mark guessing score.

As 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 results in there being little time for double checking. Checking needs to be built is as part of the initial answering process. As the question is read, key facts should be written. It helps to avoid careless mistakes if, for example, the power of a lamp given as 24 W is noted down by the candidate as "power = 24 J / s". Words produce fewer careless errors than symbols. It is amazing how many times density is given as mass/velocity, as a result of using *v* for both volume and velocity. With verbal questions all four answers should be read rather than looking at just one or two of them. This is because one option may look correct but a further option may trigger a different thought for the candidate. 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.

Careless mistakes can so easily result in 4 or 5 lost marks. A candidate on this test, who might have scored 32 but actually scored 27 because of carelessness, would have found that about 2500 other candidates overtook them as a result. 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**

The questions having high facility were 3, 5, 15, 22, 39 and 40. These were usually at a point in the test where a new topic was introduced with a straightforward question. Five questions only resulted in candidates giving an incorrect option more frequently than the correct one. In **Question 4** most candidates failed to recognise that the 1% systematic uncertainty needed to be added to the 1% random uncertainty to get a 2% overall uncertainty and the answer D. A mere 14% gave this answer. In answering **Question 10**, 45% of candidates took the velocity of approach to be $u_1 - u_2$ but the better candidates realised this was not so and gave the correct answer as D. As has come to be expected, 48% of candidates did not realise that the 2.0 kg mass also needs to be accelerated in **Question 11** and answers to **Question 32** resulted in a surprising 59% who put all the cables in series to give C as the correct answer. It was clear that it was the able candidates who did not fall into making this mistake. The rather specialised **Question 37** was the last question in this category. 32% thought that D was the correct answer rather than knowing that the e.m.f. of cell $E_2$ must be known.

The remaining 29 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.

 

# PHYSICS

**Paper 9702/02**
**AS Structured Questions**

## General comments

There were some candidates who were very well prepared for the examination and who scored very high marks. On the other hand, there were others who found difficulty in answering most of the questions. The answers that they did give were indicative of little, if any, understanding of the basic concepts.

Questions requiring descriptive answers (e.g. **Question 6**) proved to be the most difficult. The standard of such answers appeared to be very Centre-dependent. Many candidates who scored well on numerical questions found difficulty with descriptive work. It appeared as if little emphasis had been given as regards practice in answering such questions.

Many candidates wasted time or lost marks needlessly. There is a marked tendency for many candidates to begin answering a question by copying out large sections of the question. This should be discouraged. Any answer should not need to repeat the question and, indeed, the answer space is designed such that the question should not be copied. In other scripts, answers were given with no working. The answers to even simple questions should be given with a clear indication as to how the answer was derived. When unexplained answers are incorrect, then no credit can be given even though the error may be purely arithmetical.

Candidates do need to ensure that answers are sufficiently detailed and unambiguous. For example, in **Question 7(b)(i)**, a statement such as 'resistance changes' does not indicate whether the candidate is referring to a particular resistor or the resistance of the whole circuit. Furthermore, the direction of any change has not been stated.

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

## Comments on specific questions

### Question 1

**(a) (i)** With very few exceptions, a correct expression was given.

**(ii)** Although most answers did include current and time, a significant minority quoted charge as being a base quantity.

**(b) (i)** There were many correct responses. Surprisingly, some candidates who had given current as a base quantity in **(a)(ii)**, now quoted the base units of current as C $s^{-1}$.

**(ii)** This part of the question did produce a number of difficulties. Principally, candidates attempted an answer without writing out the equation in terms of base units. Of those who did write down an equation, many included m $s^{-1}$, rather than (m $s^{-1})^{k}$.

### Question 2

**(a) (i)** Correctly answered by the majority of candidates. However, many substituted an incorrect distance into an appropriate equation of motion.

**(ii)** This simple calculation should have caused very few problems. However, it was quite common to find that it was assumed there would be a change of speed during this time interval.

**(b)** In most answers, a conversion was shown between km $h^{-1}$ and m $s^{-1}$, leading to a sensible comment based on the candidate's answer in **(a)(i)**. Unfortunately, despite being instructed in the question to use both of the answers in **(a)**, many did not comment on the time interval. Of those who did comment, the great majority considered a reaction time of about 2 seconds to be quite appropriate.

**Question 3**

**(a)** The great majority of answers were given, quite appropriately, by reference to definitions of the two terms. However, frequently, the perpendicular distances in each case were not clearly specified. Some descriptions of a torque did not indicate clearly that two forces are involved.

**(b) (i)** The calculation was completed successfully by most candidates. The most common error was to quote in metres the distances for the sliding weights, but to leave in centimetres the distance of the load from the pivot.

**(ii)** Comparatively few correct answers were given. The usual answers were that the steelyard would be too short or that the weight would bend the arm.

**Question 4**

**(a) (i)** The calculation was completed successfully in the majority of scripts. The most common error was to fail to convert to metres the separation of the plates.

**(ii)** This problem could be approached from more than one direction. Some candidates did use the simple expression *energy* = *charge* × *potential difference.* Others used equations of motion and the formula for kinetic energy. Both were acceptable.

**(iii)** A common error was to calculate $v^2$ and to then quote this as the magnitude of the speed. Candidates should be encouraged to consider whether their answers are realistic. In this case, $v^2$ has a magnitude greater than $3 \times 10^8$, alerting candidates to some error in the working.

**(b)** Answers were, in the main, disappointing. Most were based on the field strength changing, giving rise to different forces on the electron and thus different speeds. Very few, including those who used the expression *energy* = *charge* × *potential difference* in **(a)(ii)**, considered that energy, and hence final speed, is dependent on potential difference, not field strength.

**Question 5**

**(a)** Most candidates made a reference to random or haphazard motion. However, it was not always clear that the motion referred to the smoke particles. Some actually mentioned gas atoms/molecules whilst others made vague references to 'particles'.

**(b)** Unfortunately, very few answers included any evidence for random motion of gas atoms. Most answers merely included a statement referring to random motion without any comment as to how such motion can be inferred from Brownian motion.

**(c)** This was answered very poorly by most candidates, perhaps as a result of not being able to answer **(b)** satisfactorily. The basic concept that randomness of collision would not be apparent for particles with 'large' surfaces was not appreciated.

**Question 6**

**(a)** With few exceptions, a satisfactory explanation was given. However, in some answers, it was not made clear whether the change in direction of wavefronts was due to diffraction or to refraction.

**(b) (i)** Most candidates attempted to describe single slit diffraction of light or the use of a ripple tank. Explanations were frequently vague in that, for example, the source of the waves was not made clear. Furthermore, many did not describe what would be observed to lead to the conclusion that diffraction had taken place. When using a ripple tank, very few gave a clear indication as to how the waves would be made visible.

**(ii)** Surprisingly, some candidates described an experiment involving transverse waves. Where experiments involving sound waves were described, the most likely explanation for the observations was reflection rather than diffraction.

**Question 7**

**(a)** This was, in general, poorly answered or not attempted. Many answers merely involved a re-arrangement of the symbols in the given equation. Very few candidates considered the current in the circuit, setting up equations for the p.d. *V* and the e.m.f. *E*.

**(b) (i)** There were many acceptable explanations. However, weaker candidates tended to use vague terms such as ‘change’. Others failed to realise that the thermistor and the 5 kΩ resistor act as a parallel combination.

**(ii)** Some candidates showed a good understanding of the underlying concepts and gave concise answers. A common error was to find the resistance of the parallel combination and then to assume that this is the resistance of the thermistor.

**Question 8**

**(a)** Many answers involved a statement that it is not possible to predict when a nucleus will decay. Such a statement is inadequate at AS Level. Others made reference to constant probability of decay without stating that this constant probability is per unit time.

**(b)** With few exceptions, both parts were answered satisfactorily.

**(c)** Most answers included a statement that the curves would be ‘the same’. Usually, some explanation was given although this was not necessary. A minority of candidates thought that the curve would be steeper.

# PHYSICS

**Paper 9702/04**
**A2 Structured Questions**

## General comments

There were very few scripts where the performance over the whole paper was good. In many instances, candidates who had produced an above-average performance in ***Section A*** then failed to score many marks in ***Section B***. As in previous examinations, candidates have insufficient knowledge to be able to describe adequately the various applications included in the syllabus.

Apart from weaker candidates where answers were missing throughout the script, the time allowance to complete the paper appeared to be adequate. Low marks awarded in **Question 11** (the final question) were usually due to inappropriate and incorrect answers rather than being a penalty for incomplete work.

Candidates should always be encouraged to consider the answers to numerical questions. All too frequently, an inappropriate answer involving powers-of-ten could be avoided if the candidate spent a short time considering whether the answer is reasonable. For example, in **Question 10(b)(i)**, an answer of the order of kilovolts should be quickly recognised as incorrect.

## Comments on specific questions

***Section A***

**Question 1**

**(a) (i)** With few exceptions, a correct expression was given.

**(ii)** Although the majority of answers were correct, some were given in terms of linear speed. An added problem for some candidates was the standard of their writing. In some scripts, it was not possible to decide whether the candidate had written *M* or *m*.

**(iii)** There were comparatively few correct responses. Many did not involve the answers to **(i)** and **(ii)**. Instead, they attempted to include the acceleration of free fall *g*.

**(b) (i)** Candidates who understood the question frequently did not give a clear, unambiguous answer. Many merely stated that *R* would vary. They did not distinguish between *R* in the expression $GMm/R^2$ and *R* in the expression $mR\omega^2$. Others did not read the question carefully and stated that the radius of the spherical planet would vary.

**(ii)** The calculation in **1.** was completed successfully by the majority of candidates. However, in **2.**, many thought that $\omega$ would be zero, rather than the radius. Although the question makes a clear reference to centripetal acceleration, a significant minority thought that the acceleration of free fall should be included.

**(c)** The most frequently quoted answers included references to the planet not being spherical and to variations in the density of the material of the planet. Some did refer to nearby moons and planets.

**Question 2**

**(a)** Weaker candidates should be encouraged to learn carefully definitions such as this. Questions involving knowledge should provide candidates with some easily earned marks. Frequently, weaker candidates failed to make a reference to either unit mass or to constant temperature. Candidates should appreciate that fusion is the change of state from solid to liquid.

**(b) (i)** Very few answers included a statement that allowance can be made for thermal energy gains from the surroundings. All too often, comments were vague or implied that the thermal energy gains from the surroundings could either be calculated or be eliminated.

**(ii)** All too frequently, the suggestion did not include how it would be known that the rate is constant. Common answers included statements such as ‘weigh the beaker at regular intervals’ or ‘count the number of drops per minute’.

**(iii)** It was pleasing to note that in the great majority of answers, an attempt was made to allow for energy gains from the surroundings. However, very few noted the difference in time for the collection of water in the two situations. Others did not make it clear as to how they obtained the final answer in kJ $kg^{-1}$ when the data was given in terms of joules and grams.

**Question 3**

**(a)** The majority of candidates could give 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) (i)** Incorrect answers were partly due to insufficient detail being given. For example, specifying a distance from the cloth does not indicate whether the point is above or below the cloth.

**(ii)** Surprisingly, many could not quote the amplitude. A common incorrect answer was 22 mm. The calculation of $\omega$ was completed successfully in most scripts.

**(c) (i)** This calculation was completed successfully by most candidates, using the candidates’ values for the amplitude as stated in **(b)(ii)**.

**(ii)** Although most answers did include a quote of the correct expression for the calculation of the speed, there was much confusion as to what to substitute for the values of the amplitude and the displacement.

**Question 4**

**(a)** The great majority of answers were acceptable.

**(b)** Answers were, in general, disappointing. A significant number of candidates came to the conclusion that the temperature would change. Most concluded that the internal energy would change because the pressure changes. Very few made separate statements as regards the kinetic energy and the potential energy of the gas atoms.

**Question 5**

**(a)** Candidates were instructed to explain their working. However, many failed to do so. Instead, they quoted a formula and launched themselves into the calculation. Consequently, they lost credit. A common error was to consider the kinetic energy of only one deuterium nucleus. However, in many of these scripts, the answer given in the question was quoted by the candidate.

**(b)** Many candidates could not state the expression for mean kinetic energy in terms of kelvin temperature. Of those who did give a correct quote, a significant number thought that the speed in **(a)** would be equal to $\langle c^2 \rangle$.

**(c)** The answer obtained in **(b)** and the subsequent comment revealed that many candidates did not appreciate the conditions necessary for fusion to occur. However, there were some pleasing comments from a minority who made reference to the fact that the temperature is 'very high' or stated that the temperature would be associated with the interior of stars.

**Question 6**

**(a) (i)** Only a small minority of candidates appreciated why the core is a continuous loop. A common misconception was that the loop would enable currents to move through the core.

**(ii)** This was answered correctly by more candidates than could answer **(a)(i)**. However, many thought that the laminations would prevent eddy currents and prevent power losses, rather than reduce them.

**(b) (i)** This law was quoted correctly by the majority of candidates.

**(ii)** There were some well constructed explanations. Other candidates appeared to know how to approach the task but did not make it clear that it is the changing current in the primary giving rise to changing flux in the core and in the secondary coil that gives rise to the induced e.m.f.

**(c)** As would be expected, there were many correct responses. However, weaker candidates tended to express themselves rather poorly. A common statement was that high voltages reduce power losses, without any reference as to when the losses would be reduced.

**Question 7**

**(a)** Most candidates could give two pieces of evidence but answers were not always clearly stated. Frequently, reference was made to 'energy' but whether the energy was associated with a photon or a photoelectron was not made clear. Furthermore, weaker candidates made reference to the existence of a threshold frequency. Whether photoemission occurs at frequencies above or below this threshold was not indicated.

**(b) (i)** Nearly all answers made reference, in one way or another, to a discrete amount of energy. However, in a significant number, it was not stated that the energy is associated with an electromagnetic wave.

**(ii)** Answers were very poor, with many based on an absorption spectrum. The basic concept that discrete wavelengths mean photons of particular energy and that this energy is associated with particular energy changes between discrete levels was not made clear.

**(c) (i)** It was surprising that many average and below-average candidates could not identify the three energy changes. Furthermore, many associated the smallest energy change with the shortest wavelength.

**(ii)** Most candidates could quote a correct expression for photon energy. However, only a minority calculated correctly the energy. Many determined the difference between two wavelengths before substituting into the equation for photon energy. The impression gained was that candidates associated each energy level, rather than a change in energy level, with a particular wavelength.

**Question 8**

**(a)** There were some very good answers. The most common error was to make reference to force on a charge, without making it clear that the force is experienced only when the charge is moving.

**(b)** More-able candidates usually gave all four correct answers. However, the answers given by weaker candidates gave the impression that their attempts were not based on scientific thinking.

*Section B*

**Question 9**

**(a)** Many candidates had no real understanding as to the reason. Many thought that infra-red is monochromatic whereas visible light has a spectrum of wavelengths. Others thought that infra-red has a shorter wavelength than visible. Very few had any understanding of the relative attenuations per unit length in an optic fibre.

**(b)** A minority scored full marks for discussing either the short range or the short wavelength of UHF. However, many others demonstrated a complete lack of understanding of the topic.

**(c)** As in **(b)**, there were many scripts where the candidate appeared to have no understanding of the topic. Of those who did mention swamping, it was not always clear as to which signal would be swamped.

**Question 10**

**(a) (i)** Most candidates did recognise the circuit as being that of an inverting amplifier although many quoted 'inverting op-amp'. When explaining the concept of the 'virtual earth' very few mentioned that the open-loop gain of the op-amp is very large.

**(ii)** There were some clear, well presented derivations. However, the majority merely quoted the current in terms of the input and the output signals. Credit was lost because it was not stated that the input impedance is very large, leading to the conclusion that the currents in $R_1$ and $R_2$ are the same.

**(b) (i)** Many gave answers where the reading was greater than the supply potential difference. Although there were some very clear answers, many candidates did not appear to realise that $R_2$ in parallel with the thermistor provides the total feedback resistance.

**(ii)** Most candidates realised that the thermistor resistance would increase but a significant number did not mention decreasing light intensity. The outcome for the voltmeter reading was frequently confused, contradicting the answers obtained in **(b)**.

**Question 11**

**(a)** Most answers were restricted to a comment based on two-dimensional and three-dimensional images. In some scripts, there were references to the colours of the images.

**(b)** Suggestions were very confused and inaccurate, indicating that the great majority of candidates did not appreciate how the image in a CT scan is built up. Many candidates thought that taking X-ray images from many angles built up a 3-dimensional image of the whole object, rather than one thin section through the object. The role of the computer to store and to process huge quantities of data was seldom clearly expressed.

# PHYSICS

**Paper 9702/05**

**Planning, Analysis and Evaluation**

## General comments

This paper produced a wide range of marks with a number of candidates gaining full marks both on **Question 1** and **Question 2**. Conversely there were also a number of candidates who scored poorly on either **Question 1** or **Question 2**. In general, candidates scored higher on **Question 2** than **Question 1**.

It was evident in the planning question that candidates were willing to give more detail of experimental techniques that they had acquired in the laboratory. Again, there was evidence that candidates were better at coping with the treatment of errors in **Question 2** and a significant number of candidates scored well on **part (e)** which was particularly difficult mathematically. It is clear that high scoring candidates have benefited from a wide experience of practical techniques throughout their Physics course. This paper is designed so as to test candidates' practical experience; thus preparation is best achieved through the teaching of a practical course where the skills required for this paper are developed and practised over a period of time with a 'hands-on' approach. To assist Centres, CIE have produced two booklets – Teaching AS Physics Practical Skills and Teaching A2 Physics Practical Skills.

It is essential that candidates present their answers clearly particularly when calculations are involved. Marks are often awarded when a clear (correct) method is seen; conversely marks are often lost because it is not clear as to how an answer has been determined. Candidates should also ensure that they take care over the detail in their work.

## Comments on specific questions

### Question 1

Candidates were required to design a laboratory experiment to investigate how the resistance of a light dependent resistor varies with the distance from an intense light source and thus test a power law relationship.

The majority of the candidates understood the problem and most were able to explain that the distance needed to be varied and the resistance measured. Candidates should also be considering the variables that are to be controlled. Good candidates wrote an explicit statement such as "the intensity of the intense light source will be kept constant". Further evidence of keeping additional variables constant, such as temperature was credited in the additional detail section.

Five marks are available for the methods of data collection. A mark was awarded for the use of an independent light source that was not affected by the resistance of the LDR. The second mark was awarded for the clear indication of the measurement of distance; a number of candidates were vague as to exactly what distance was being measured. A circuit diagram showing how the resistance would be measured gained a mark; too many diagrams contained poorly drawn symbols which were often incorrect. There was also evidence of voltmeters being put in series with ammeters or power supplies being connected to ohmmeters – candidates who are experienced in practical work benefit in this particular section of the question. Candidates also scored a mark for explaining how their circuit could be used to determine the resistance. A number of candidates successfully described potential divider methods. Finally, candidates were expected to specify that the experiment would be carried out in a dark room or indicate how they would ensure that only light from the intense light source would reach the light dependent resistor.

There are two marks available for the analysis of the data. It is expected that candidates would explain the quantities that would be plotted on each axis for the first mark, and then for the second mark explain how the given equation is valid. A very large number of candidates suggested plotting a graph of lg $R$ against lg $d$ or ln $R$ against ln $d$ for one mark. For the second mark candidates were expected to state that if the relationship given is valid there should be a straight line. This latter point was often omitted; candidates should be making this point explicitly. Some candidates did mention the straight line passing through the origin – this was treated neutrally on this occasion since it would depend on the value of the constant *k*. Calculation/averaging methods did not gain credit. A large number of candidates scored an additional detail mark for showing that for a graph of lg *R* against lg *d* the gradient was equal to *n* and the *y*-intercept was equal to lg *k*.

There was one mark available for describing an appropriate safety precaution for this particular experiment. Candidates should be encouraged to ensure that the safety precaution(s) are relevant to the experiment and are clearly reasoned; vague answers did not gain credit. Credit-worthy responses included precautions taken due to either the bright or hot light source.

There are four marks available for additional detail – candidates who have experienced a comprehensive practical course score highly in this section. Examples of credit worthy points not already mentioned above included:

Detail on measuring the distance.

Keep orientation of LDR with respect to the light source constant.

Reasoned method for keeping light and LDR in correct orientation. (e.g. use of set square, fix to rule, optical bench or equivalent).

Determination of a typical current.

Range of ammeter/ohmmeter.

Reason for performing experiment in a dark room related to the LDR.

Method for checking the output of the light source is constant.

**Question 2**

In this data analysis question candidates were given data on how the diameter of the path of a beam of electrons varied with the accelerating voltage when a magnetic field was applied at right angles to the beam.

**Part (a)** asked candidates to write down an expression for the gradient in terms of *e*, *m* and *B* having been given an equation. This was reasonably well answered; some candidates omitted the '8' or inverted the relationship.

In **(b)** most candidates calculated and recorded values of $d^2$ correctly although marks were lost where the correct number of significant figures were not used. It is expected that the number of significant figures in calculated quantities should be the same or one more than the number of significant figures in the raw data; in this case *d* was given to 2 s.f. so it was expected that $d^2$ would be given to 2 s.f. or 3 s.f. Candidates were also expected to include the absolute errors in $d^2$, which was usually proficiently determined.

The graph plotting in **(c)** was again good. Sadly some candidates 'forced' their best fit line through the origin. The worst acceptable straight line should be either the steepest possible line or the shallowest possible line that passes through the error bars of all the data points. It is important that candidates do distinguish clearly the lines on their graph – in future lines not clearly indicated will be penalised.

**Part (c)(iii)** was answered well. Some candidates did not use a sensibly sized triangle for their gradient calculation. Other errors included using plotted points that did not lie on the best-fit line. A common error was to omit $10^{-4}$ for their $d^2$ values although this was not penalised at this stage. To determine the absolute uncertainty in the gradient candidates were expected to find the difference between the gradient of the best-fit line and the gradient of the worst acceptable line. Weaker candidates just stated their earlier calculated error bars.

**Part (d)** caused greater problems because of the possibility of a power of ten error from the values for $d^2$. To determine *e*/*m* candidates needed to use their value for the gradient. To determine the uncertainty in *e*/*m* candidates could use the gradient for the worst acceptable line and then find the difference between the two values. Alternatively a large number of candidates successfully used fractional errors in terms of the uncertainty in the gradient. The final mark was awarded for the correct unit. Surprisingly a large number of candidates omitted this part. Marks were awarded for $C\,kg^{-1}$, $A\,s\,kg^{-1}$ and $V\,m^{-2}\,T^{-2}$.

In **(e)** candidates were expected to use their values for *e*/*m*. Good candidates answered this question well, clearly showing their working and gaining an answer within the range (3.80 – 4.00) $\times 10^{-3}$ T. The final mark was awarded for correctly determining the uncertainty in *B*. Many good candidates worked this out by working out the worst possible case. A common error was not to use the worst acceptable value for *d*. Many other good candidates correctly worked out the fractional uncertainty allowing for the square root of *B*.

# PHYSICS

**Paper 9702/31**
**Advanced Practical Skills 1**

## General comments

The performance of candidates was similar to last year, with a wide range of marks and significant variation between Centres.

Once again most candidates had been well prepared for the practical work and this led to a generally good standard in the more structured **Question 1**. In **Question 2** less guidance was given about procedures and nearly half the available marks were for critical evaluation. Here marks were generally lower than for **Question 1** although the difference was less marked than last year.

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 time the interval between successive occasions on which two different length pendulums swung in phase.

**Successful collection of data**

**(c)** Most candidates recorded a sensible value for a preliminary time, showing that they had set up the apparatus as required.

**Range and distribution of readings**

**(d)** Most of the candidates varied the length of one pendulum over a good part of the range available, and carried out the expected repeated timings for each length.

The correct trend (*t* increasing as the lengths of the two pendulums became closer) 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 about half of the candidates.

**Presentation of data and observations**

**Table**

**(d)** 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 $1/\sqrt{l}$ ($m^{-1/2}$). The raw data was usually given to a consistent number of decimal places.

In this question most candidates recorded times to the nearest 0.01 s (e.g. 29.84 s) even though for manual timing a precision of 0.1 s (e.g. 29.8 s) is more appropriate. Once again, however, the majority of candidates made mistakes in choosing correct significant figures for derived values – the s.f. for each value of $1/t$ should have been the same as or one more than the s.f. in the corresponding raw values of *t* (even if this means that the number of decimal places for $1/t$ has to vary down the table). For instance, if $t$ = 29.84 s the corresponding calculated value of $1/t$ should be given as 0.03351 $s^{-1}$ or 0.033512 $s^{-1}$.

**Graph**

**(e)** 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**

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

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

**Drawing conclusions**

**(g) and (h)**
A large number of candidates successfully used their gradient and *y*-intercept values to determine values for *p* and *q*, the only common error being to equate their intercept to $p/q$ rather than $-p/q$.

**Question 2**

Candidates found this question more challenging.

They were asked to construct an electrical circuit and then use voltage and current measurements, together with a diameter measurement, to find the resistance per unit length of wire provided in the form of a cylindrical coil.

**Successful collection of data**

**(a) (i)** Most candidates recorded a value for the diameter of the first cylinder to the nearest mm, as expected, but few took repeated measurements to allow for any ovality.

**(c) (i)** All candidates recorded values for voltage and current, but a small number lost credit because their values were unreasonable (probably through misreading the meters) or because units were omitted.

**Estimating uncertainties**

**(a) (ii)** This task was well done.

**Presentation of data and observations**

**Display of calculation and reasoning**

**(a) (iii)** Most candidates were able to use the diameter measurement to calculate the circumference as an approximation of the length of wire in a single turn of the coil.

**(c) (iii)** Again, most calculated $\mu$ correctly.

**Quality**

**(d)** It was expected that the two values of $\mu$ would be similar, and this proved to be the case for more than half the candidates.

 

**Analysis and conclusions**

**(e)** There were many good responses to this part of the question – candidates from some Centres had clearly been prepared well. These candidates calculated the ratio between *R* and *n* for each resistance, and then discussed whether the ratio could be considered constant. Weaker candidates just pointed out that *R* decreased as *n* decreased (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.

**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 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 methods used in the experiment:

**a.** Basing a judgement on measurements for only two values of *n* (number of turns).

**b.** Non-circular tube, leading to an inaccurate value for *d.*

**c.** The length of wire in one turn being different to the tube circumference.

**d.** Judging the positions for the moveable contacts.

**e.** Unwanted resistance being included in the measured value.

References to ‘inaccurate’ meters, zero errors and parallax errors were not credited.

Improvements related to these difficulties were credited if they were practical and included sufficient detail. The published mark scheme includes the most common examples.

# PHYSICS

**Paper 9702/32**
**Advanced Practical Skills 2**

## 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 difference 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 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 were not short of time. Most candidates were more confident in the generation and handling of data than they were with the critical evaluation of their experimental skills. It is worth noting that in this paper eight marks (20%) are given to the evaluation section at the end of **Question 2**.

There were no common misinterpretations of the rubric.

## Comments on specific questions

### Question 1

In this question candidates were required to investigate the equilibrium position of a pivoted wooden strip as the turning load was varied.

**(a) (ii)** Most candidates were able to set up the equipment without help from the Supervisor with an initial angle between 5º and 10º.

**(b)** Most candidates were able to tabulate six sets of readings of $n$ and $\theta$. It was expected that candidates would use the full range of $\theta$ i.e. $5^\circ \le \theta \le 60^\circ$. Many candidates did not add enough paper clips in order to extend the angle above 45° and failed to gain credit.

**(b)** Many candidates failed to gain the mark for labelling the column headings appropriately. Cos$\theta$ and $1 / \cos\theta$ have no unit, whilst $\theta / ^\circ$ needed a separating mark between the quantity and unit. The consistency in the values of $\theta$ given by candidates was given appropriate in many cases, but there were a significant number of candidates who added trailing zeros to their value of $\theta$ and lost a mark. The number of significant figures in the calculated quantity 1 / cos $\theta$ should be the same or one more than in the corresponding value of $\theta$. Few candidates were awarded this mark. Most candidates calculated 1 / $\cos\theta$ correctly although some calculated cos(1 / $\theta$).

**(c)** Candidates were required to plot a graph of $1 / \cos\theta$ against $n$. Surprisingly, many candidates used awkward scales making read-off's for the gradient difficult and often inaccurate. Axes were sometimes compressed with plots occupying less than half the graph grid failing to gain credit. Although there were few errors in the plotting as the x-axis had integer values, many candidates plotted dots greater than half a square in diameter failing to gain credit. There was a reasonable allowance for the drawing of the best fit line and many candidates were awarded this mark. The quality mark awarded for the spread of results about the line of best fit was not often awarded. Many candidates whose choice of range of $\theta$ was small often produced curved trends and the corresponding lines of best fit were treated leniently.

 

**(d)** Candidates are expected to use triangles with the hypotenuse greater than half the length of the line drawn to determine the gradient. Many candidates used smaller triangles failing to gain credit. Many candidates read off the y-intercept at x = 0 successfully. Some candidates correctly substituted into y=mx+c in the determination of the y-intercept (even though often they had access to *x = 0* on the graph).

**(e)** In the analysis section many candidates were able to use the correct method to find *k* using gradient = *2km* and then use the *y*-intercept = *kM* to find *M.* Some candidates used substitution methods to find *k* and *M* failing to gain credit. Many candidates failed to obtain a value of *M* within 50% of the Supervisor's value. A few Centres failed to give their value of *M* and thus it was impossible to compare the candidates results and award due credit.

**Question 2**

In this question candidates were required to investigate how the period of oscillation of a metal strip varies with its length.

**(b) (i)** Most candidates gave an initial length in range.

**(ii)** Most candidates stated the error in reading the length to the nearest 1 mm or 2 mm and were then able to perform the percentage uncertainty calculation correctly.

**(iii)** The majority of candidates calculated $l^3$ correctly.

**(iv)** It was expected that the number of significant figures given in $l^3$ was related to those in $l$. Some candidates referred to decimal places and lost the mark. Some candidates related the significant figures correctly but failed to apply this to their answers.

**(c)** Most candidates timed the motion over ten or more oscillations and quoted their times to the nearest 0.1 or 0.01 seconds. A few candidates failed to repeat their readings or gave values of frequency instead of period and lost marks.

**(d)** A surprisingly high number of candidates were unable to give values of length to the nearest millimeter.

**(e)** A large number of candidates failed to calculate the two values of the ratio $T^2/l^3$ so did not gain this mark. It was expected that candidates would give their judgement on whether the relationship holds or not based on their ratio calculation. 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 10% for this particular experiment. Many candidates stated 'as $l$ increases, *T* increases, so the relationship holds'. This was not credited.

**(f)(i)(ii)** The evaluation again proved to be a hard section on which to score high marks although this is slowly improving. Clarity of thought, experience and ability to express the candidate's ideas are needed here to produce a <u>better</u> experiment. Many problems were identified but candidates were unable to suggest effective improvements. Many answers lacked precision, for example the suggested use of light gates, motion sensors and computers were not supported with detail. A few credited and not credited problems and solutions are given below.

Credited Problem (common): 'Difficult to put the clamps in place to hold the blade'
Credited Solution: 'Use another person to help assemble the equipment.'

Credited Problem (common): 'Parallax error in reading the length.'
Not credited: 'Parallax error' or 'Difficult to read length'.
Credited Solution: 'Place a scale on the blade.'

Credited Problem: 'Oscillations are too quick so time is very small.'
Not credited: 'Difficult to time oscillations'.
Credited Solution: 'Video the oscillations and play back frame by frame or have a timer in view.'

Credited Problem (common): 'Two values of $l$ and *T* are not enough.'
Credited Solution: 'Record different values of $l$ and *T*, and plot a graph of $l^3$ against $T^2$.'
Not credited: 'Repeat the readings of T' (Very common) or 'Plot a graph.'

The 'no credit' points were common and penalised for not providing enough detail or not supported with a reason. Candidates needed to be more specific and consciously state the method needed to improve this particular experiment. Further examples can be found in the mark scheme.