

# PHYSICS

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<p><b>Paper 9702/01</b> <b>Multiple Choice</b></p>
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<i>Question Number</i>	<i>Key</i>	<i>Question Number</i>	<i>Key</i>
1	<b>C</b>	21	<b>A</b>
2	<b>D</b>	22	<b>B</b>
3	<b>C</b>	23	<b>A</b>
4	<b>C</b>	24	<b>C</b>
5	<b>D</b>	25	<b>B</b>
6	<b>C</b>	26	<b>D</b>
7	<b>B</b>	27	<b>D</b>
8	<b>C</b>	28	<b>B</b>
9	<b>D</b>	29	<b>A</b>
10	<b>D</b>	30	<b>A</b>
11	<b>A</b>	31	<b>C</b>
12	<b>A</b>	32	<b>B</b>
13	<b>A</b>	33	<b>C</b>
14	<b>A</b>	34	<b>C</b>
15	<b>D</b>	35	<b>C</b>
16	<b>A</b>	36	<b>D</b>
17	<b>C</b>	37	<b>A</b>
18	<b>B</b>	38	<b>B</b>
19	<b>C</b>	39	<b>C</b>
20	<b>B</b>	40	<b>B</b>

## 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. The mean mark out of 40 was 23.8 for the 12 206 candidates, with a standard deviation of 7.29. 25 candidates managed to get all 40 questions correct, which was a considerable achievement.

Since there is considerable time pressure on candidates to complete 40 questions within the time limit of one hour, there is pressure to ignore the checking process. It is all the more important, therefore, to read the question carefully in the first place. In particular, when answering verbal questions, candidates should check all four options, 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; something that may not have been thought about when reading the first, apparently correct, option. Powers of ten are a source of many errors with numerical questions. These arise not just by using a calculator incorrectly, but also with the metric system prefixes.

### **Comments on individual questions**

**Question 12** caused difficulties for those candidates with the misconception that the Archimedean upthrust on a body in air is quite large. The reverse is the case. It will only be approximately a thousandth or less than the weight of a solid. Viscous drag, on the other hand, will be almost as large as the weight when a body is at terminal velocity.

In **Question 16**, many candidates thought that a positive charge moving in the direction of the electric field would be gaining potential energy.

In **Question 22**, a large number of candidates did not appreciate that the limit of proportionality is not the same as the elastic limit.

For **Question 27**, a quick sketch diagram would have reduced the large proportion of candidates who incorrectly marked option **C** as the solution. Candidates must use space on the paper for working: on leaving the examination room their paper should be covered with writing.

**Question 34** required great care. One small slip and a factor of 2 can be lost or the reciprocal of the answer can be given. Here 39% incorrectly gave **A** with only 44% getting the correct answer, **C**.

Finally, **Question 23** showed how carefully candidates need to work. Here all four options were similarly chosen, though 39% did get the correct answer, **A**. Many candidates will have done questions like this in practice, but where the force is causing an extension. It requires clear thinking to cope with compression and to realise that the answer is obtained from the area of the triangle for  $L$  between 70 mm and 100 mm for the answer.

# PHYSICS

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<p><b>Paper 9702/02</b> <b>AS Structured Questions</b></p>
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## General comments

This paper contained many sub-sections involving short, straightforward answers that gave candidates ample opportunity to show familiarity with, and understanding of, the syllabus content. There were some excellent scripts. Nevertheless, there was the usual wide variation of standard, both within and between Centres.

In comparison with recent papers, there was a welcome reduction in the number of candidates quoting answers to eight or ten significant figures. However, the practice of 'rounding off' answers at intermediate stages of a calculation should be discouraged. Such 'rounding off' leads to inaccurate final answers.

## Comments on specific questions

### Question 1

Most candidates did give acceptable estimates for at least two of the four quantities. No single quantity was answered correctly significantly more frequently than any other.

As is usually the case in such questions, there were many highly inaccurate answers, particularly for the density of air.

### Question 2

- (a) (i) A significant minority did assume that the spring constant would be the gradient of the graph. However, the most common error was incorrect units.
- (ii) Most candidates did confirm the given value for the strain energy though, frequently, explanation was either totally lacking or was inadequate. Candidates should be advised that, where they are expected to derive a given quantity, full explanation is vital.
- (b) (i) Answers were, in general, disappointing. Although there were many correct and well-argued answers using the principle of conservation of linear momentum, these were outnumbered by invalid attempts to derive the result using energy considerations. Many candidates noticed that the desired result was, in fact, numerically equal to the ratio of the masses and offered no explanation beyond a statement that 'speed is inversely proportional to mass'. Frequently, equations purporting to express the principle of conservation of momentum contained only symbols that were not defined and which could be associated with one or both of the trolleys.
- (ii) Most candidates did attempt this calculation using energy considerations. There were many clearly expressed solutions equating strain energy to the sum of the kinetic energies of the two trolleys. By far the most common answer, however, was based on the total strain energy being transferred to one trolley only.

**Question 3**

- (a) (i) With few exceptions, candidates selected an appropriate equation and arrived at the correct answer. The most common problem was using too few significant figures.
- (ii) This was answered correctly by most candidates.
- (b) Most answers were correct. However, a minority of candidates assumed accelerated motion rather than a steady speed of  $1.2 \text{ m s}^{-1}$ .
- (c) (i) This part of the question was more demanding. Errors frequently arose either through choice of an incorrect trigonometrical ratio or attempting to include the force opposing the motion.
- (ii) Many candidates used either the component of the weight down the slope or the total resisting force in order to determine the acceleration of the trolley on the slope. Most candidates correctly determined the required time appropriate to their values of acceleration. Some did, however, assume that the acceleration would be the acceleration of free fall.
- (d) Most candidates did have ideas about speed, acceleration or time, although some merely stated that the trolley would be likely to topple. Answers were frequently badly expressed so that it was not possible to decide if candidates were explaining why the increase in speed, acceleration or time was applicable to the situation before or after the slope was made steeper.

**Question 4**

- (a) (i) The majority of answers were acceptable. The most common errors were defining *ultimate* tensile stress rather than tensile stress, using 'extended length' rather than 'extension' and referring to 'length' without distinguishing between 'extended length' and 'original length'.
- (ii) Many answers were limited to a statement such as 'no fixed shape'. Fewer candidates successfully conveyed the idea that the fluidity of liquids and gases means that it is not possible to deform a fluid in one direction only, as is implicit in the definition of the Young modulus.
- (b) Very many answers did not make reference to the given equation. Comments such as 'there is no space between molecules' were common. Of those who did refer to the equation, many thought that an increase in pressure would give rise to an increase in volume. Comparatively few referred to the magnitude of the constant and that its large size means a very large change in pressure would be required to cause a significant change in volume.
- (c) This section was quite well answered. Most candidates calculated either the actual pressure for a change in depth of 10 m or the true change in depth for a one atmosphere change in pressure. The most common error was to express the calculated result, rather than the difference, as a percentage of the relevant assumed value. A minority of candidates attempted to calculate a change in the density of water, or a change in  $g$ .

**Question 5**

- (a) (i) With few exceptions, attempts to explain the term *frequency* were disappointing. Frequently, the definition was given in terms of 'number of waves'. Acceptable expressions such as 'number of oscillations per unit time' were rarely supported by a statement as to what would be oscillating.
- (ii) Many defined *speed* as the product of frequency and wavelength. Very few offered a fundamental definition in terms of, for example, rate of displacement of a point on a wavefront.

- (b) (i) Many explained, with varying degrees of success, the formation of a stationary wave without coming to a conclusion as to why the wave is termed 'stationary'. Acceptable explanations were approximately equally divided between references to zero energy transfer and static nodes.
- (ii) Candidates frequently confused the terms *displacement* and *amplitude* and thus failed to define what is meant by an *antinode*.
- (iii) A small minority gave an incorrect position for an antinode. A significant number of candidates identified only one position, rather than the three that were expected in the question.
- (c) Many candidates completed this calculation successfully. The most common error was to take the internodal distance as being the wavelength. Some candidates ignored the given information as regards  $T$ . Instead, they assumed that  $T$  was the period of oscillation.

### Question 6

- (a) With few exceptions, candidates used an appropriate formula and correctly calculated the resistance of a heating element.
- (b) It was surprising that a significant number of candidates did not seem to realise that when switch  $S_1$  is open, there would be no current in the circuit.

More able candidates usually successfully completed the table. The majority of candidates appeared to have difficulty in deciding which elements would be operating when switch  $S_2$  is open or closed.

### Question 7

- (a) Most candidates attempted to relate  $\alpha$ - and  $\beta$ -particles to helium nuclei and electrons respectively. However, many stated that an  $\alpha$ -particle is a helium atom. Others thought that  $\alpha$ - /  $\beta$ -particles are emitted by helium nuclei / electrons. Many candidates compared properties such as speed, range and ionising power. However, such comparisons frequently either lacked sufficient detail or were inaccurate so that credit could not be given.
- (b) (i) Most candidates correctly gave the required equation. The most common error was the representation of the  $\alpha$ -particle with some symbol other than that of a helium nucleus.
- (ii) Most candidates did show the correct position on the grid for uranium-237. Comparatively few positioned the neptunium nucleus to show that  $\beta$ -decay resulted in an increase by one in the proton number and a corresponding decrease in the neutron number.

# PHYSICS

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Paper 9702/31

Advanced Practical Skills 1

## General comments

The general standard of the work done by the candidates was similar to last year, with a reasonably good range of marks. As in previous years, there was a significant variation in performance between Centres. It would be helpful to all candidates if attention could be drawn to the published mark schemes.

The majority of Centres had no problem in providing the equipment required for use by candidates. Any deviation between the requested equipment and that provided to the candidate should be written down in the Supervisor's Report as well as notifying the board so that the Examiners can take this into consideration during the marking period. Experiments are designed with the view that Centres will have the apparatus as outlined in the syllabus available for use. Some help was given to candidates from Supervisors in setting up the apparatus in **Question 2**. 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. 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.

There were no common misinterpretations of the rubric.

## Comments on specific questions

### Question 1

In this question, candidates were required to investigate how the angles of the strings in a pulley system are affected by the mass suspended from the mid-point of the string.

#### Successful collection of data

- (b) Many candidates were able to set up the equipment without help from the Supervisor. A surprising number of candidates did not read the angle between the strings to be between  $90^\circ$  and  $180^\circ$ . This may be as a result of mis-reading the protractor or measuring the angle of one of the strings to the horizontal. Interestingly, some candidates implied that they were able to measure the angle to the nearest  $0.01^\circ$ , e.g.  $26.00^\circ$ .
- (c) Most candidates were able to tabulate six sets of readings of  $n$  and  $\theta$ . If the protractor was mis-read, the values of  $\theta$  increased with increasing  $n$ , instead of decreasing. A surprising number of candidates failed to repeat their measurement of  $\theta$  and failed to gain credit.

#### Range and distribution of marks

- (c) It was expected that candidates would use the full range of objects supplied given that eleven objects were provided for each candidate. Often candidates used up to six objects, thus failing to gain credit.

**Presentation of data and observations****Table**

- (c) Almost half the candidates failed to gain this mark.  $\cos\left(\frac{\theta}{2}\right)$  has no unit, whilst  $\theta/^\circ$  needed a separating mark between the quantity and unit. The consistency in the values of  $\theta$  given were good. However, the corresponding significant figure given in the calculated quantity  $\cos\left(\frac{\theta}{2}\right)$  was more difficult to gain credit. A candidate who wrote 139.0 (1 d.p., 4 s.f.) for  $\theta$  was often penalised in the significant figure mark for 0.350 (3 s.f.) and would have been credited for 0.3502 (4 s.f.). Calculated quantities can have the same or one more significant figure than that in the raw data. Most candidates calculated  $\cos\left(\frac{\theta}{2}\right)$  correctly.

**Graph**

- (d) Candidates were required to plot a graph of  $\cos\left(\frac{\theta}{2}\right)$  against  $n$ . Many candidates used suitable scales and few compressed their scales. Some candidates used awkward scales (multiples of three). There were fewer errors in the plotting and reading of plots, as the x-axis had integer values. Many candidates plotted dots greater than half a square in diameter, although this was Centre specific. This failed to gain credit. Most candidates were able to draw an acceptable line of best fit from five or six trend points although some candidates forced the line through the origin. The quality mark was awarded if all the plotted points lay close to the best fit line. There was a reasonable allowance for scatter in order to gain credit for the quality mark (given the nature of this experiment) and most candidates gained this mark.

**Analysis, conclusions and evaluation****Interpretation of graph**

- (e) 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 or inverted their gradient ratio and lost the gradient mark, although this tended to be Centre specific. Often, the same candidates who misplotted points went on to misread gradient points. If a candidate had misplotted a point which later was re-plotted by the Examiner onto the line of best fit, there was still a chance that the candidate could score the quality mark.

Many candidates read off the  $y$ -intercept at  $x = 0$  successfully. Some candidates correctly substituted into  $y = mx + c$  in the determination of the  $y$ -intercept (even though often they had access to  $x = 0$  on the graph. There were many odd scales with a false origin, e.g.  $x = 0, 1, 3, 5, 7, 9, 11$  means that the origin will be  $-1$  and not  $0$ ).

**Drawing conclusions**

- (f) Most candidates were able to work out  $T$  correctly, although some candidates used sines and triangles incorrectly.
- (g) In the analysis section many candidates were able to equate the gradient with  $\frac{mg}{2T}$  and the  $y$ -intercept with  $k$ . The mark for the correct value and unit of  $m$  within range was difficult to obtain. Many candidates incorrectly chose substitution of known points into the equation to find  $m$ , instead of using the gradient from (e) as stated in the question. Incorrect measurement of  $\theta$  in (b) and (c) and  $T$  in (f) often led to the answer for  $m$  being out of range.

**Question 2**

In this question, candidates were required to investigate how the voltage across a light dependent resistor (LDR) depends on the thickness of an absorber. Candidates were expected to set up an electrical circuit, construct black cylinders over the LDR and light emitting diode (LED) and place tracing paper between the tubes.

**Successful collection of data**

- (b) Most candidates gave an initial voltage of the LDR, although many omitted a unit. It is worth pointing out that if Centres cannot provide a multimeter that can be read to the nearest 0.01V, as stated in the Confidential Instructions, this should be noted on the Supervisor's Report, as otherwise the candidate is penalised.
- (c) (i) It was obvious that a few candidates had attempted to measure the thickness of  $16t$  with a ruler even though a micrometer screwgauge should have been made available. Few candidates were able to read the micrometer to the nearest 0.01 mm (or 0.001 mm if a digital micrometer screwgauge was used) and also carry out repeat readings of the measurement of  $16t$ . Some candidates incorrectly used a ruler to measure the thickness of  $t$ .

**Quality**

- (b),(d) It was expected that as the number of layers increase, the voltage across the LDR increases. Sometimes candidates' values decreased, suggesting an incorrect setup with the voltmeter (across the resistor), or the voltage remained constant (voltmeter connected across both the LDR and the resistor or across the power supply), or the voltages were negative (voltmeter connected the wrong way round).

**Presentation of data and observations****Display of calculation and reasoning**

- (c) (iii) Most candidates were able to work out  $t$  from  $16t$ . A few attempted to measure the thickness of a single sheet. This was penalised as no further thickness measurements were expected.
- (iv) It was expected that the number of significant figures expressed in  $t$  was related to  $16t$ . Many candidates related the number of decimal places in the micrometer reading incorrectly, e.g. 'read micrometer to 0.01 mm so reading is to two significant figures'.
- (e) A large number of candidates failed to calculate the two values of the ratio  $V-V_0/n$  so did not gain this mark. Many candidates stopped short of  $V-V_0$  or used 16 layers instead of 4.

**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 calculation. 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. The candidate could instead choose their own limit. Many candidates failed to gain credit by writing, 'Yes, because as  $n$  increases  $V-V_0$  increases'.

**Estimating uncertainties**

- (c) (ii) It was expected that candidates could read the micrometer to the nearest 0.01 mm (or 0.001 mm) so the uncertainty in  $16t$  was expected to be 0.01 mm (0.001 mm) and not 0.005 mm (or 0.0005 mm). Most candidates were then able to express the percentage uncertainty calculation correctly.

**Evaluation**

- (f) The evaluation proved to be the hardest section on which to score high marks and accounts for 20% of the overall marks. The key is to identify specific problems for this particular experiment and then come up with practical solutions (not change the experiment itself). Clarity of thought, experience and ability to express their ideas are needed here to produce a *better* experiment, not a

different one. Too few candidates considered that to each limitation there is a solution and all too often candidates cited equipment failure as a limiting factor and proposed that 'using better apparatus' is a solution. Answers that gained credit and those that did not are outlined below.

Credited problem (common): 'Difficult to hold both cylinders and tracing paper' or 'voltmeter fluctuates.'

Credited solution: 'Use clamps to hold cylinders.....'

Credited problem (very common): 'Outside light coming into cylinders and interfering with the LDR.'

Credited solution: 'Do experiment in dark room' or 'do experiment in a room with lights off and blinds down.'

No credit: 'Dim the lights' or 'light escaping' or 'lights in room may affect experiment.'

Credited problem: 'Difficult to align the cylinders.'

Credited solution: 'Align using ruler on table.'

No credit: 'Parallax error' or 'get someone else to hold the cylinders.'

Credited problem (common): 'Two values of  $n$  and  $V$  are not enough.'

Credited solution: 'Record different values of  $n$  and  $V$ , and plot a graph of  $n$  against  $V-V_0$ .'

No credit: 'Repeat the readings in  $n$ .' (very common) or 'Plot graph.'

The 'no credit' points were common and penalised for not providing enough detail or not being supported with a reason. Candidates needed to be much more specific by stating the *method* needed to improve this particular experiment.

# PHYSICS

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Paper 9702/32

Advanced Practical Skills 2

## General comments

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

Most candidates had been well prepared for the practical work and were aware of the requirements for clear presentation and analysis of results, and this led to a generally good standard in the first question. In the second question, where less guidance was given in the question and where nearly half the available marks were for critical evaluation, marks were generally lower.

A few candidates apparently had difficulty reading digital stopwatches – it is important that they are familiar with the use of the equipment provided. They should be made aware that they can ask the Supervisor for help with the setting up and operation of equipment and that this help, when reported to the Examiners, will only incur a small mark penalty.

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 investigate how the time period of a pendulum varied as a mass was moved up the pendulum rod.

#### Successful collection of data

- (b) Most candidates measured the initial length correctly, showing that they had set up the apparatus correctly. A few ignored the unit already provided on the answer line.

In a very few cases the rod had been set up inverted.

- (c) Candidates were expected to take repeated measurements of  $10T$  (or more) and, after averaging, divide by the number of oscillations to get the time for a single oscillation. Many did this well, even if evidence had to be looked for in the table, but a minority only recorded  $T$  as a single measurement.

#### Range and distribution of marks

- (d) Only about half of the candidates chose the full range of lengths available and spaced their intermediate lengths approximately equally.

#### Presentation of data and observations

##### Table

- (d) The standard of results tables was generally high, with the quantities and suitable units usually clearly presented as headings and with consistent decimal places in the raw data. However, the majority of candidates had difficulty in choosing correct significant figures for their values of  $T^2$  – their values of  $10T$  were often to 4 s.f. but their  $T^2$  value to only 3 s.f.

**Graph**

- (e) Most candidates made good use of the graph grid, with points occupying a good part of the area available. In some cases this led to the use of a false origin (acceptable) or to the use of an awkward scale such as 3 units to each large square (unacceptable, since intermediate readings are difficult to determine).

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, though credit was sometimes lost 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  $l$  axis.

**Drawing conclusions**

- (g) It was pleasing to see a large number of candidates using their gradient and  $y$ -intercept values correctly in determining  $M$  and  $z$ . However, some of these lost credit when they gave an incorrect unit (or no unit), or chose unsuitable significant figures for  $z$ .

**Question 2**

Candidates found this question more challenging.

They were asked to roll modelling clay into two different-sized cylinders wrapped in paper, timing each cylinder as it rolled down a ramp. The results were then analysed to see if they fitted a given relationship between cylinder radius and time. Finally, candidates were asked to make a critical evaluation of the experiment.

**Successful collection of data**

- (b) Most candidates recorded a value for the circumference of the first cylinder to the nearest mm, as expected.
- (c) Surprisingly few candidates showed evidence of repeated readings (and averaging) for the time  $t$  – this is essential for such a short time interval.

A few read a digital stopwatch incorrectly.

**Quality**

- (d) It was expected that the time  $t$  would be shorter for the cylinder with the smaller circumference, but a number of candidates apparently found the reverse.

**Presentation of data and observations****Display of calculation and reasoning**

- (b), (d) Most candidates were able to use the circumference measurement to calculate the radius, though a small number did not know the correct formula, and some gave too few significant figures.

**Estimating uncertainties**

- (b) Very few candidates gained credit for this. Although they could calculate a percentage, most assumed an absolute uncertainty of 1 mm (based only on the precision of measurement) whereas the Examiners were expecting between 2 and 5 mm since the measuring technique itself would contribute extra uncertainty.

**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  $t^2$  and  $r$  for each cylinder, and then discussed whether the ratio could be considered constant (given the uncertainties in the measured values). This usually involved calculating the percentage difference between the two ratios.

Weaker candidates just pointed out that  $t^2$  decreased as  $r$  decreased (not worthy of credit since it does not by itself support proportionality).

Candidates with a reversed trend could get some 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 performed 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 difficulties related to:

- basing a judgement on only two sizes of cylinder
- making an accurate cylinder shape
- determining its radius
- judging the moment of finishing the distance
- measuring the short time interval

The improvements, to be credited, had to include sufficient practical detail.

For example 'light gates with timer' was credited but 'electronic timer' was not, and 'use vernier callipers to measure diameter' was only credited if 'repeat and average' was included.

Many candidates were concerned with reducing friction between the cylinder and the ramp, but since friction is necessary for rolling without slipping, this was not credited.

# PHYSICS

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Paper 9702/04

A2 Structured Questions

## General comments

This examination session appeared to follow the general pattern as seen in previous years. There were some excellent scripts with candidates scoring very high marks, thus showing that the paper was accessible to well-prepared candidates. There were, however, many candidates who scored low marks.

The level of explanation associated with calculations, even when such explanation was explicitly requested, was frequently well below standard. Candidates should realise that adequate explanation is not provided by merely writing down an equation. When substituting values into an equation, there is a growing practice of writing down numbers with a prefix rather than giving the power of ten. This practice should be discouraged. For marks to be awarded for intermediate stages of a calculation, particularly where 'error carried forward' is being applied, then full substitution must be seen.

Most candidates appeared to have sufficient time to complete their answers.

## Comments on specific questions

### *Section A*

#### Question 1

- (a) (i) A significant number of candidates attempted to define radian measure, rather than the radian. Frequently, it was not stated that the angle is subtended at the centre of the circle of which the arc is a part.
- (ii) Many answers included statements such as 'angle swept out per unit time' or 'rate of change of angular displacement'. However, comparatively few made it clear that it is the string rotating about P that creates this angle or angular displacement.
- (b) Candidates were asked to explain their working. Many obtained the correct answer but lost credit through not explaining the initial situation or the stages in their calculation. A calculation giving an angular velocity of  $4.49 \text{ rad s}^{-1}$  with the next line stating that the number per minute is 43 cannot be awarded full credit.
- (c) The majority of candidates did think that the mud at the edge of the plate would leave first. However, comparatively few could give a satisfactory explanation. Some assumed a constant centripetal force and a frictional force that becomes smaller as the disc speeds up. Others thought that it is the centripetal force which holds the mud in place. It was common to find an explanation which did not include either friction or the centripetal force. Answers such as 'at the edge, because the force will not hold the mud in place' were seen frequently.

#### Question 2

- (a) Most answers included a statement that gas atoms or molecules collide with the walls of the containing vessel. Some mentioned random motion, but few related the collisions to a momentum change and hence a force acting on the container walls. Very rarely was there a mention of the pressure resulting from the averaging of the forces due to a very large number of collisions per unit time.

- (b)(i)** The calculation was relatively straightforward for those candidates who could recall the relationship between pressure, density and mean-square-speed. However, there were many errors made by candidates who commenced their working with either  $pV = nRT$  or  $pV = \frac{1}{3}Nm\langle c^2 \rangle$ . Some did confuse mean-square-speed with r.m.s. speed.
- (ii)** Rather than relate mean-square-speed to thermodynamic temperature, many assumed constant volume and used the gas laws to calculate the new pressure. They then substituted into the equation in **(i)**.
- (c)** The vast majority of candidates incorrectly used their equation from **(b)(i)**, assuming that density is inversely proportional to mean-square-speed.

### Question 3

- (a)** This was, in general, answered correctly with only a minority giving the amplitude as 1.0 cm or the time period as 1.6 s.
- (b)(i)** Most candidates did calculate the angular speed correctly. However, although many wrote down a correct equation for the speed, most did not substitute correctly. It was common to find that the amplitude was given as 16.5 cm, despite having obtained the correct answer in **(a)(i)**, and the displacement as 16.2 cm. Some candidates successfully completed the calculation by using the gradient of the curve at the appropriate point.
- (ii)** Most answers were correct.
- (c)(i)** Most answers made reference to either a decrease of amplitude or a decrease of total energy. The cause of damping was omitted by some, whilst others merely mentioned an 'external force'. Specific examples of damping forces were accepted, rather than general statements.
- (ii)** There were some very good sketches that clearly showed all the features. The time interval for successive 'loops' varied significantly, and there was no continuous reduction in amplitude.

### Question 4

- (a)** Many omitted either 'unit' or 'positive' from their definitions thus losing marks.
- (b)(i)** The major error here was in reading the scale. An answer of 15.6 cm was not uncommon.
- (ii)** The great majority equated the potentials due to A and to B, despite being told in **(i)** that the potential is zero. Consequently, the sign of the charge was incorrect.
- (c)** There were comparatively few correct answers where the force was related to electric field strength and this field strength was then related to the gradient of the graph. Most candidates considered the two charges as if they were isolated, reaching the conclusion that the force would be greatest when either at the shortest distance from one of the charges, or near the larger charge.

### Question 5

- (a)** There were some very clear and concise derivations. However, many candidates quoted a relevant expression for the energy of a charged capacitor but then substituted an inappropriate value for the potential. They did, however, arrive at the correct answer. Candidates should be advised that, where inappropriate substitution is, quite wrongly, shown as giving the correct answer, then the work is treated as if there is an arithmetical error.
- (b)** Many average and below-average candidates left this section blank. Of those who did attempt it, the great majority realised that some capacitors must be connected in series to avoid too large a voltage across any one capacitor.

**Question 6**

- (a) The majority of candidates thought that the coil would be normal to the field.
- (b)(i) Having seen that this question is about electromagnetism and then reading that a force had to be calculated, many candidates tried to give a solution in terms of the equation  $F = BIL$ . Of those who did use an equation for torque, a common error was to use the side AB, rather than BC.
- (ii) Some candidates went to a great deal of trouble to show that the force is zero. However, there were many brief, correct answers, but a significant number did calculate a force for side BC.
- (c) In many answers, the number of turns was omitted. However, they were able to arrive at the required value for  $B$  when an incorrect force had been substituted or  $N$  had been omitted.
- (d)(i) The majority of definitions were satisfactory. However, many referred to rate of change of flux, rather than rate of change of flux linkage. This may have contributed to a common error in (d)(ii).
- (ii) Many candidates appeared to understand how to approach this calculation. However, having found the change in flux, it was common to find that  $N$  was omitted when finding the rate of change of flux linkage.

**Question 7**

- (a) Most answers did include the term *quantisation*.
- (b)(i) Many answers were limited to a statement that a uniform field is required. Comparatively few candidates showed a clear link between parallel plates and a uniform field, and horizontal plates and the need for a vertical field.
- (ii) Most candidates were able to complete the calculation successfully. However, despite the clear warning in the question to consider the sign of the charge, the majority assumed a positive charge.
- (c) In many answers, it was assumed that the charge was  $1.6 \times 10^{-19}$  C. Candidates found great difficulty in expressing themselves clearly as to why this would be so. Some attempted to take an average. Others summed the charges and then divided by 11.

**Question 8**

- (a) There were very few correct answers based on an understanding that the initial momentum is zero and, consequently, the total momentum of the photons must be zero. Many answers assumed that the photons would be charged. Some candidates even wrote that the photons would be oppositely charged, thus giving rise to repulsion.
- (b) Some candidates attempted to use the equation for the energy of a photon. There were, however, many answers that correctly involved Einstein's mass-energy relation. It was not uncommon to find that the combined energy of the two photons was calculated.

**Section B**

As is often the case, the ability of candidates to answer questions in **Section B** varied considerably between Centres.

**Question 9**

- (a) There were many correct answers. However, it was not uncommon for the first block to be named 'input', rather than identifying the input as being a sensor or transducer.

- (b) (i) Many candidates attempted to include an op-amp in the circuit. This was completed successfully by many but was not necessary. It was surprising to note the large proportion of candidates who were unaware of the electrical symbol for an LED.
- (ii) Some attempted to give a use for the circuit (e.g. traffic lights) rather than explain its action. Explanations were frequently inadequate in that they merely identified which diode would be forward-biased, rather than go on to state that the diode would then conduct and emit light.

#### Question 10

There were some very good answers and many more where the basic facts had been learned. However, in these descriptions, it was common to find that MRI was thought to be associated with atoms, rather than nuclei, and the use of r.f. pulses was not understood. There were numerous attempts where it was clear that the candidate had no real understanding of the application. Frequently, there were elements of MRI, ultrasound diagnosis, X-ray and CAT scanning all included.

#### Question 11

- (a) (i) Many candidates had learned to quote this answer perfectly.
- (ii) In **1**, most gave the correct answer. However, in **2**, very few attempted to give a quantitative description based on the given data. Of those who did attempt a quantitative analysis, many gave an incorrect frequency range.
- (b) A common answer was that FM is more expensive, without giving a reason. Others referred to repeater amplifiers, rather than transmission stations. There were, however, many references to the range of FM broadcasts and also bandwidth.

#### Question 12

- (a) (i) Many answers were limited to statements related to 'the tapping of calls' and 'conversations overheard'. Rarely was it made clear that cross-talk is associated with the picking-up of a signal in one cable from a second nearby cable.
- (ii) Some described acoustic noise. Many realised that noise would interfere with a signal but were unable to describe noise as being random power fluctuation.
- (b) There were some very clear solutions to the problem which clearly demonstrated an understanding of the situation. However, there were some candidates who did not appreciate how to approach the calculation. Many candidates calculated the ratio, in dB, of the input signal to the noise in the amplifier. They then did not use the 30 dB signal-to-noise ratio at the receiver when calculating the length of the fibre.

# PHYSICS

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Paper 9702/05

Planning, Analysis and Evaluation

## General comments

This paper again produced a wide range of marks. A number of candidates scored full marks on **Question 2**, although **Question 1** was not as well answered.

It was evident, in the planning question, that candidates needed to give more detail of experimental techniques that they had acquired in the laboratory, while in **Question 2** candidates appeared to be better this session with the treatment of errors. 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 stated before, it is clear that high scoring candidates have benefited from a wide experience of practical techniques throughout their A Level Physics course. 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.

It is clear from the syllabus that the content of the questions for this paper will not be strictly bound to the syllabus and there may be questions which will require candidates to apply their knowledge of theory and experimental skills to unfamiliar situations. This confirms the need for candidates to have benefited from a practical course, so that they can apply the skills gained to unfamiliar situations.

## Comments on specific questions

### Question 1

Candidates were required to design a laboratory experiment to determine the resistivity of glass, having been given a number of sheets of glass of the same thickness but different area. The question also stated that the resistivity of glass was believed to be of the order of  $10^6 \Omega\text{m}$ . Sadly, this information was rarely used.

The initial marks were awarded for correctly identifying the independent and dependent variables. Some weaker candidates described an experiment to investigate how the resistance of a wire is affected by the length of the wire. Good candidates made it clear that the area was changed and the corresponding resistance in each case was determined. Candidates should have considered the variables that were to be controlled. Good candidates wrote an explicit statement such as "the temperature of the glass will be kept constant".

Marks were available for the methods of data collection, a correct circuit diagram and the method used to determine the resistance. Most candidates opted for the use of a voltmeter and ammeter, although a significant proportion did suggest the use of an ohmmeter. Unfortunately, many candidates who used an ohmmeter also connected a power supply in their circuit. Very few candidates considered the orientation of the glass. It was expected that with a high value of resistivity, the connections to the glass would be across the greatest surface area of the glass sheets. Often candidates either described how the wrong area was determined, or their method was not clear. A detailed description of the dimensions to be measured together with the instrument and an appropriate method was required. Use of vernier callipers or a micrometer screw gauge to measure the thickness of the glass sheets was credited.

It was expected that candidates would suggest the quantities that would be plotted on each axis of a graph and then went on to explain how the resistivity was determined from the gradient of their graph. Some candidates discussed plotting an appropriate logarithmic graph, which could still gain full credit. Calculation

and/or averaging methods did not gain credit. A large number of weaker candidates suggested plotting resistivity against area.

Description of an appropriate safety precaution was credited. Candidates should be encouraged to ensure that the safety precaution(s) are relevant to the experiment and are clearly reasoned, as vague answers do not gain credit. Creditworthy responses included precautions taken when handling the glass, such as the wearing of gloves, or precautions needed when dealing with EHT power supplies.

Candidates should be encouraged to write their plans adding appropriate detail. Vague responses such as 'high voltage' did not score. It was hoped that candidates would use the numerical value given for the resistivity in this part of their plans. Examples of creditworthy points included: calculation of typical resistance of glass using value of resistivity given; range of ammeter or ohmmeter with reasoning; use of EHT or power supply  $>1000$  V or microammeter/galvanometer; taking many readings of thickness and calculating the average; ensuring good contact between circuit and glass, e.g. metal plates, foil, conducting putty; metal plates/foil/conducting putty to cover all of the cross-sectional area in use; method of ensuring good contact between circuit and glass, e.g. G clamps, weights; ensuring that the glass is clean and dry.

Most good candidates who had followed a 'hands on' practical course during their studies, scored the additional detail marks. It was essential that candidates gave appropriate detail in their answers.

## Question 2

In this data analysis question candidates were given data on how the count rate reaching a Geiger-Müller tube from the radioactive source varied with the thicknesses of lead absorbers.

**Part (a)** asked candidates to state the quantities that the gradient and y-intercept would represent if a graph were plotted of  $\ln R$  against thickness were plotted. The most common error was to not realise that the gradient was negative.

In **part (b)** most candidates calculated and recorded values of  $\ln R$ . A number of weaker candidates did not label the column heading and a large number of candidates did not record their values to an appropriate number of significant figures correctly. A number of candidates only gave one decimal place. It is expected that the number of significant figures in calculated quantities should be the same or one more than the number of significant figures in the raw data. However, in logarithmic quantities the number of significant figures is determined by the number of decimal places e.g. for a count rate of 750,  $\ln$  (count rate) would be expected to be given to either 2 or 3 decimal places, e.g. 6.62 or 6.620. Candidates were also expected to include the absolute errors in  $\ln R$ . Good candidates determined  $\ln R$  for the worst value, e.g. using a value of 750, candidates calculated  $\ln R$  for either 730 or 770 and found the difference from their value of either 0.027 or 0.026. It was acceptable to write this as  $\pm 0.03$ .

The graph plotting in **(c)** 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 either be the steepest possible line or the shallowest possible line that passes through the error bars of all the data points. Too often candidates did not distinguish clearly the lines on their graph which should have been clearly labelled.

**Part (c) (iii)** was generally answered well. Candidates who had correctly plotted the points and drawn an appropriate best-fit line were expected to have calculated a gradient within a specified range. Some candidates did not use a sensibly sized triangle for their gradient calculation. A common error was to write the gradient as positive. To determine the absolute error in the gradient candidates were expected to find the difference between the gradient of the best-fit line and the gradient of the worst acceptable line.

In **part (d)** candidates were expected to have used their gradient value to determine the value of the mass absorption coefficient. Good candidates answered this question well, clearly demonstrating that they divided their value of the gradient by the density. There were a number of acceptable methods of determining the error. In a large number of cases, the unit ( $\text{m}^2 \text{kg}^{-1}$ ) was omitted. When the unit was given incorrectly it was often due to 's<sup>-1</sup>' appearing.

The final part asked candidates to determine the thickness of lead required to reduce the count rate to 10% of the original count rate. It was expected that candidates should determine an answer in the range 0.0410 m to 0.0425 m. Some candidates only gave their final answer to one significant figure, while others could not determine the ratio of 10% correctly. Again there were a number of ways of carrying out this stage correctly using errors determined in either **part (c)(iii)** or **part (d)**.