PHYSICS

Paper 0625/12
Multiple Choice (Core)

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

General comments

There were some strong performances this year, but also some candidates who were unable to demonstrate a good understanding of scientific principles. **Questions 1**, **4**, **11**, **14**, **23**, **24** and **34** were usually answered very well but **Questions 2**, **9**, **19**, **29**, **33**, **35** and **39** were more challenging for many candidates.

Comments on specific questions

Question 2

Many candidates had difficulty in interpreting the graphs and worked as though the vertical axis showed the distance that each rocket had travelled.

Question 3

Some candidates did not recognise that the distance travelled by the train was measured in kilometres and the time in minutes, whereas in the responses the average speeds were given in metres per second.

Question 8

Some candidates believed that hydroelectric power involves the heating of water to produce high pressure steam. This fundamental error showed a lack of understanding of the generation of electricity.

Question 9

Almost equal numbers of candidates chose options **A**, **B** or **C**. Candidates appeared to be unsure of how to calculate the weight of child Y.

Question 18

Candidates did not seem to be familiar with this type of experiment. Many thought that the variable being used to measure the temperature was the length of the pointer.

Question 19

This question was challenging for many candidates and they found it difficult to understand that when a solid melts or a liquid boils, the temperature does not change until all the material has melted or vaporised.

Question 20

This question tested the knowledge that dull black surfaces are the best radiators of thermal energy. Only stronger candidates gave the correct answer, with many weaker candidates thinking that a shiny white surface was the best radiator.

Question 29

Only stronger candidates answered this correctly. The increase in the reading on the balance indicated that the upper rod pushes down on the lower rod, meaning they repel, which in turn means that either they both carry positive charge or they both carry negative charge.

Question 33

The strongest candidates were able to answer this question correctly.

Question 35

The question was answered well by stronger candidates but others found it very difficult to understand that induction of an e.m.f. occurs when a magnetic field is actually changing.

PHYSICS

Paper 0625/22
Multiple Choice (Extended)

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

General comments

Many candidates showed an excellent understanding of scientific knowledge and there were many strong performances. In particular, **Questions 1**, **4**, **5**, **14**, **21**, **22**, **26**, and **38** were usually answered correctly. **Questions 2**, **7**, **34**, and **36** were more challenging for some candidates.

Comments on specific questions

Question 2

In general, candidates did not recognise the vector nature of velocity. The change in velocity of the ball was 30 – (–20) m / s = 50 m / s and an acceleration of 500 m / s^2.

Question 7

Although almost all candidates ruled out the centrifugal direction, the fact that the force on the rotating object is towards the centre of the circle was often not recognised.

Question 10

Many candidates correctly calculated that the total work done by the force was equal to the sum of the kinetic energy gained and the thermal energy dissipated as work is done against friction. Nevertheless, a significant number interpreted the question as asking for the useful work done, i.e. the work done in giving the object kinetic energy.

Question 17

Only stronger candidates answered this correctly. Although many candidates recognised there is no change in temperature when a solid melts or a liquid boils, others did not recognise this basic concept.

Question 20

Although the question was usually answered well with the majority of candidates identifying the correct wavelength, a significant number of candidates did not recognise that the wavelength was being asked for, not the more usual frequency.

Question 34

Whilst some stronger candidates were able to give the correct response, many chose one of the other three options.

Question 36

Electromagnetic induction is a very challenging topic but stronger candidates were able to answer the question correctly. Other candidates found it very difficult to understand that induction of an e.m.f. occurs when a magnetic field is actually changing.

PHYSICS

Paper 0625/32
Core Theory

Key messages

- In calculations, candidates must set out and explain their working correctly. When a candidate gives an incorrect final answer and no working is shown, it is often impossible for partial credit to be awarded for working that is correct.
- Candidates should ensure their answers are clear and precise when answering questions requiring a description or explanation.
- It is important that candidates read the questions carefully in order to understand exactly what is being asked.
- In order to improve their performance candidates should practise applying their knowledge to new situations by attempting questions in support materials or exam papers from previous sessions.

General comments

A very high proportion of candidates were well prepared for this paper. The vast majority of candidates indicated by their knowledge and skills that they were correctly entered for this Core Theory paper. A small minority of candidates found the subject matter and level of some questions very straightforward and may have been better entered for the Extended paper.

Equations were generally well known by stronger candidates, but a significant number struggled to recall standard equations.

Often candidates were able to apply their knowledge and understanding to fairly standard situations. On occasions, when asked to apply their knowledge to a new situation, they displayed a lack of breadth of understanding. More successful candidates were able to think through the possibilities and apply their knowledge when the question asked for suggestions to explain new situations. Less successful candidates had difficulty in applying their knowledge to new situations, did not show the stages in their working and did not think through their answers before writing.

The questions on changes in KE and PE, using the principle of moments, difference between longitudinal and transverse waves, describing an experiment to identify a magnetic field pattern, and half-life calculation were generally more challenging for many candidates. There were a significant number of candidates who either did not read the questions carefully enough, or who gave answers that were related to the topic being tested, but did not answer the question in enough detail to receive credit.

The language ability of the vast majority of the candidates was adequate for the demands of this paper. There were a very small number of candidates, who struggled to express themselves adequately.

Comments on specific questions

Section A

Question 1

(a) Only stronger candidates recognised that the kinetic energy of the box increased as its speed increased.

(b) Candidates found this item more challenging than **(a)**. The majority of candidates thought that the potential energy of the box increased as its speed increased.

(c) (i) Many candidates did not read or interpret the question correctly. The majority of candidates attempted to find the speed by determining the area under some part of the graph.

(ii) Only stronger candidates recognised that the resultant force was zero when the box was falling at constant speed. A common error was to state that the resultant force was balanced with the upward force.

(d) Most candidates recognised that the distance travelled by the box was equal to the area under the graph. However, only stronger candidates calculated this correctly. The most common error was to calculate the area of a rectangle rather than a triangle.

(e) This question was well answered, with most candidates relating the acceleration and deceleration to the gradient of the speed–time graph.

Question 2

(a) Almost all candidates correctly calculated the volume of the stone as $24\,cm^3$. However, weaker candidates attempted to read the volume nearest to the top of the stone and gave the answer of $30\,cm^3$.

(b) The majority of candidates were able to correctly calculate the density of the stone as $2.4\,g/cm^3$.

(c) Most candidates gained at least partial credit for this question. Many candidates gave clear and precise descriptions of differences between mass and weight.

Question 3

(a) The vast majority of candidates were able to calculate the moment of the 5.2 N force as 31.2 N m. A common error was to multiply the force by 30 instead of the correct distance of 6.0 cm.

(b) Only stronger candidates gained full credit for this question. Weaker candidates failed to use the principle of moments and unsuccessfully attempted to balance vertical forces. A common error was to identify the clockwise and anti-clockwise moments incorrectly.

Question 4

(a) Most candidates gained at least partial credit for this question. The most common errors were in identifying the turbine as a fan and/or the generator as a motor.

(b) The vast majority of candidates were able to identify two other sources of renewable energy. Weaker candidates only gave one example or gave examples of fossil fuels.

(c) Most candidates gave answers of environmental advantages as “eco-friendly”, “environmentally friendly”, “non-polluting”, etc. These answers were insufficient as they did not identify advantages of the geothermal power station. Candidates needed to be more precise and stronger candidates gave examples such as “reducing acid rain” or “emitting less carbon dioxide”.

Question 5

(a) (i) The majority of candidates correctly calculated the weight of the block as 16 N. Weaker candidates unsuccessfully tried to use some variation of density = mass / volume, or mgh.

(ii) The majority of candidates correctly calculated the pressure as $0.89\,N/cm^2$. A common error was an incorrect rounding to 0.88 or 0.9. Candidates should be reminded to give answers to at least two significant figures.

(b) This was often answered well and many candidates showed a good knowledge of this area.

Question 6

(a) Most candidates answered this well. The most common error was in identifying the angle of incidence, with a significant number of candidates failing to give any answer.

(b) The vast majority of candidates gained at least partial credit. However, a number of candidates did not identify the angle of reflection as being 62°.

(c) Most candidates were able to draw the path of the ray correctly refracted. Weaker candidates drew the ray refracted towards, or even beyond, the normal.

Question 7

(a) Most candidates answered this well. The most common errors were to give the amplitude of the wave as P and the wavelength as T.

(b) This question was answered well by the vast majority of candidates.

(c) Only the strongest candidates scored full credit for this question. The most common error was not stating that the oscillations of the transverse wave were at right angles to the direction of propagation of the wave. Many candidates gave vague statements such as "the wave is at right angles to the wave".

Question 8

(a) (i) Many candidates gave good descriptions of experiments to identify the pattern and direction of magnetic field lines. A common error was to use iron filings to identify the pattern, but then not to use a compass to identify the direction. Weaker candidates simply described the effect of bringing another magnet close to the one in **Fig. 8.1**.

(ii) Candidates found this question challenging, with the majority stating that iron or even soft iron should be used to make a permanent bar magnet.

(b) (i) There was often a lack of precision in answers to this question. Answers such as "change the poles" or "change the current" could not be credited. Candidates should be encouraged to state that the current direction in the wire is reversed, or the magnetic field is reversed.

(ii) Again, lack of precision often resulted in only partial credit being awarded. This was usually for recognising that the force on the wire would be reduced, but then not stating that the increased separation resulted in a weaker field between the poles.

Question 9

(a) Most candidates calculated the resistance as $140\,\Omega$. A common mistake was to use an incorrect form of the equation, such as $R = I/V$.

(b) The majority of candidates recognised that the current in the thermistor would increase but did not state that this was as a result of the thermistor resistance decreasing.

(c) The majority of candidates gave a suitable suggestion for the circuit, such as a fire or high temperature alarm.

Question 10

(a) Many candidates answered this correctly. However, a common error was to suggest how to repair the damage.

(b) Most candidates gained at least partial credit for this question. A common misconception was that the fuse somehow regulates the current in an appliance.

(c) The vast majority of candidates calculated the output voltage as 12 V. This topic was obviously well understood.

(d) Candidates found this question challenging, with most stating that copper is the material used in the core of a transformer. There may have been some confusion between the terms *core* and *coil*.

Question 11

(a) The majority of candidates understood the nuclide notation and were able to gain full credit. Weaker candidates often failed to calculate the numbers of neutrons correctly.

(b) Only stronger candidates answered this question correctly. Many others made errors in reading the scale on the time axis, giving answers of 5150 rather than 5600. Weaker candidates thought that the half-life was half the time indicated by the end of the line graph.

PHYSICS

Paper 0625/42
Extended Theory

Key messages

- It is essential that candidates show their working, including the equations used in calculations. This ensures that they can gain credit for correct physics even if the final numerical answer to a calculation is incorrect.
- Candidates should take great care when reading numerical data provided in questions. Conversions were often incorrect or missing, leading to errors in final numerical answers, e.g. in **Question 1(a)** the volume of the glass was frequently calculated to be 0.3 m^3; the result of multiplying an area of 0.15 m^2 by a thickness of 2.0 cm^2. Similarly, in **Question 5(b)** the wavelength was often quoted as 750 m by dividing 1500 m / s by 2.0 MHz.
- It is important that candidates read each question carefully and ensure that they answer exactly the question that is being asked. For example, in **Question 4(a)** many candidates wrote answers more appropriate for a question about how the pressure in a container changes when temperature increases. This was not the question asked.

General comments

The overall standard on this paper was high, with candidates demonstrating a good understanding across the syllabus and able to recall and use many equations correctly.

Unless otherwise stated, it is expected that candidates will round their final answer to 2 significant figures. However, intermediate values should not be rounded or truncated as this often leads to an inaccurate final answer. Some candidates made significant figure errors, either incorrectly rounding or giving a final answer to 1 significant figure.

When candidates are asked to construct diagrams, it is expected that they will use neat lines drawn with a sharp pencil and ruler and protractor as appropriate.

Comments on specific questions

Question 1

(a) Many candidates correctly recalled and used d = m / V and then W = mg to get the final answer of 78 N. Common errors included neglecting to convert mass to weight and not converting 2.0 cm into 0.02 m.

(b) Stronger candidates realised that they needed to calculate the change in pressure and then divide by the area to get the force in Newtons and they clearly stated that the direction was outwards. Weaker candidates gave the difference in pressure as the resultant force and gave an incorrect or vague answer for the direction, e.g. outside. Careful reading of the question was required to understand that the glass was oriented vertically in this question and not horizontally as shown in **Fig. 1.1** in the previous question.

(c) Many candidates calculated the correct density, realising the need to use $p = h\rho g$. Some weaker candidates confused the terms p and ρ, leading to incorrect substitution of values. Another common error was the use of the unit g / cm^3 with the numerical value 800 for which the correct unit is kg / m^3.

Question 2

(a)(i) Many candidates were able to clearly explain that the moment of a force is its turning effect. Stating that the moment is a force is incorrect and candidates who chose to define a moment using the equation moment = force × perpendicular distance from pivot only gained credit if "perpendicular" was clearly stated.

(ii) Most candidates knew that moment = force × distance but many then went on to substitute the mass of the block without converting mass to a force using W = mg. Candidates could gain partial credit by writing down the formula in symbols even if they went on to substitute incorrect values into the formula.

(b)(i) This question was well answered and most candidates were able to clearly distinguish between scalars and vectors.

(ii) Speed and velocity were given as examples in the question, so candidates needed to give another scalar and vector in this part. Many alternative correct answers were seen with distance / mass and displacement / weight seen often.

(c) Candidates were more likely to gain full credit here if they chose a scale that supported accurate measurement, such as 1 cm = 4 N or 1 cm = 5 N. The scale had to be one that allowed for a drawing that would fit on the page. Some candidates simply copied the diagram from **Fig. 2.2** and joined the ends of the vectors. This showed a lack of understanding in how to add vectors. Credit was awarded for a clear indication of the direction of the resultant, such as marking the angle between the 20 N vector and the resultant. A reference to a compass point such as "south-east" was insufficient. Weaker candidates often did not give any answer to this question.

Question 3

(a) Some candidates confused renewable (crops can be regrown) with reusable and so suggested that the process is non-renewable because once burnt, waste cannot be burnt again.

(b) Stronger answers were specific in stating that thermal energy is lost during transmission. Many candidates were able to suggest that improving insulation of the pipes would reduce the problem. Weaker candidates gave answers relating to transmission of electricity suggesting that they had not read or understood the precise question asked.

(c) Most candidates were able to give two correct consequences of burning coal. Common answers included air pollution, emission of CO_2 and depletion of non-renewable resources. With questions like this one, candidates should make sure that their answers are specific, for example, a general reference to pollution was too vague to gain credit.

Question 4

(a) Stronger answers included a logical explanation of how the molecules of a gas exert pressure on the walls of the container. Many candidates gave answers explaining why pressure increased with temperature, suggesting they had learnt a standard answer rather than applying their knowledge to the question being asked.

(b)(i) Many candidates correctly recalled and then rearranged the equation $p_1V_1 = p_2V_2$.

(ii) Stronger candidates gave good complete answers to this question. Weaker candidates knew the pressure would be greater and described molecules moving faster but did not go on to relate this to more frequent collisions with the walls. Candidates who tried to answer this question in terms of linking the change in pressure to the temperature increase were less successful if they did not realise that the final volume of gas was the same in each case.

Question 5

(a) There were many correct answers to this question.

(b) There was good recall of the correct equation to use here and many candidates were able to rearrange and substitute values correctly. The most frequent error was an incorrect conversion of MHz to Hz.

(c) Stronger candidates carefully drew a line or double-headed arrow that was perpendicular to and just touching adjacent crests. The reflected waves were circular and centred on a point to the right of the barrier (as far as S is to the left of the barrier). The wavelength of the reflected waves is the same as the wavelength of the incident waves. Weaker answers were characterised by thick lines, reflected waves centred on the barrier and with variable wavelengths.

Question 6

(a) Stronger candidates were able to find the correct image position by extending two correct rays backwards. Most candidates managed to construct the ray through the optical centre of the lens, but many weaker candidates did not construct a second correct ray. A few candidates were careless in drawing a ray not quite parallel to the principal axis from O to the lens. This led them to produce an image length that was either too large or too small.

(b) Most candidates who drew a correct diagram in **(a)** were able to give a completely correct answer here. Many candidates who had not drawn a correct diagram in **(a)** also achieved full credit, possibly realising that the position of the object was that for a magnifying glass. Weaker answers often identified that the image was enlarged and virtual or the same way up and virtual. Some of the weakest candidates selected two contradictory answers.

(c) Many candidates knew that the red rays would refract towards the central line and realised that they would refract less than the green rays. This knowledge did not always lead to credit as the central red ray was frequently shown as deviating from the original line and the rays sometimes did not intersect on the central line. Some candidates mistook the label lines for the glass blocks as rays of light.

Question 7

(a) Candidates needed to explain that the magnetic field or flux was not being cut by the wire or was not changing. However, some candidates omitted the word “magnetic” when referring to the field. Weaker candidates often just repeated information from the question.

(b) Only the strongest candidates gained full credit here. Those who correctly explained that the current, motion and magnetic field were mutually perpendicular (usually by mention of the right-hand rule) were often unable to apply the rule to tick the correct box. In this question the left-hand rule was not relevant. A significant number of candidates gained some credit for stating the direction of the magnetic field.

(c) (i) When the wire is moved in the opposite direction, the ammeter needle deflects in the opposite direction. Many candidates did not understand this and a significant number thought that the current would be zero.

(ii) Candidates found this question much more straightforward than **(i)** with many able to state that the deflection would be greater.

Question 8

(a) A full answer to this question required candidates to refer to the energy needed to move unit charge around a circuit. Common misconceptions included the idea that e.m.f. is a force or that e.m.f. is the open circuit reading of p.d.

(b) (i) This question was generally answered well. A common mistake was to use an incorrect equation, e.g. $P = V / R$.

(ii) In this question candidates needed to realise that the e.m.f. is the sum of the values of p.d. across components in series and that the p.d. across components in parallel is the same. The correct value for the p.d. across X is 15 V.

(iii) This question was well answered with most candidates correctly using V = IR and supplying the correct unit to gain full credit.

Question 9

(a) Many candidates knew the truth table for an OR gate and the strongest candidates labelled the columns clearly and included all four combinations of two inputs with the correct output. The most common mistake was vague labelling of the columns, e.g. A, B, X which did not identify what the inputs and outputs were.

(b) A correct answer here required the correct shape for a NOR gate combined with two inputs and one output. Many candidates gave incomplete symbols, omitting one or more of the inputs, output or the little circle that differentiates NOR from OR.

(c) (i) This question was generally answered well.

(ii) There were many excellent answers here with candidates carefully explaining how an AND gate behaves, justifying their statement that X is an AND gate. Weaker answers were not specific enough in indicating that the output would only be 1 if both inputs were 1, i.e. that in all other cases the output would be 0. An answer of “it behaves in a way consistent with the truth table for an AND gate” was not an explanation.

Question 10

(a) There were many fully correct answers to this question. The most common mistake was to omit the magnitude for the charge on an alpha-particle, recording just the + sign for the charge.

(b) Stronger candidates successfully worked out the nucleon numbers for Sr, Y and the beta-particle. Common mistakes included using the neutron number as the nucleon number, omitting the nucleon number for beta and repetition of the Sr symbol on both sides of the equation. A few weaker candidates wrote an equation for alpha-particle decay.

(c) Stronger candidates identified that two half-lives had elapsed in 112 s and retained the unit of mass given in the question to give a final answer of 37 mg. There was no requirement to convert to g or kg and candidates who did a conversion often ended up with an error in the final answer. Weaker candidates sometimes correctly stated that 112 was twice 56 but did not realise that as two half-lives had passed, the original mass of the sample would have been four times that of the mass after 112 s. A common incorrect answer was 18.4 mg.

PHYSICS

Paper 0625/52
Practical

Key messages

- Candidates need a thorough grounding in practical work during the course, including reflection and discussion of the precautions taken to improve reliability.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit where applicable. These techniques will be tested at some point in the paper.
- Candidates should be ready to apply their practical knowledge to designing an investigation. Planning questions can be answered by developing solutions from standard experimental techniques.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques, including the following:

- plotting graphs
- tabulating readings
- manipulating data to obtain results
- drawing conclusions
- dealing with possible sources of error
- controlling variables
- handling practical apparatus and making accurate measurements
- choosing the most suitable apparatus.

It is assumed that, as far as possible, the course is taught so that candidates undertake regular practical work as an integral part of their study of Physics. Questions on experimental techniques were answered much more effectively by candidates who showed evidence of having regular experience of similar practical work. This was seen in the practical details given by some candidates in **Questions 1(a)**, **1(f)** and **2(e)**.

It is expected that numerical answers are expressed to a number of significant figures which is appropriate to the data given in the question or measurements carried out by the candidate. A set of similar quantities should be expressed to a consistent number of significant figures. This was demonstrated in many good responses to **Questions 1(c)** and **3(b)**.

There will be questions which ask candidates to devise approaches to investigations which may or may not be familiar to them. However, candidates can answer these questions by careful reading of the question and the logical application of good experimental practice. This was particularly the case for **Question 4**, but a number of candidates also showed good practical knowledge when answering **Questions 2(d)(ii)** and **3(d)**.

Comments on specific questions

Question 1

Many candidates were able to obtain satisfactory data to plot the graph.

(a) Many candidates were able to outline a satisfactory method for showing that the metre rule was horizontal but fewer were able to describe the condition that would prove it. For instance, many described the use of a ruler between the metre rule and bench without indicating that equal measurements in at least two places were required to show that the rule was horizontal.

(b) Many candidates obtained a set of five *t* values within the expected range.

(c) The calculation of 1 / T was often carried out correctly, but T was sometimes calculated instead.

(d) There were many well-drawn, accurate graphs with clearly labelled axes.

Scales were usually chosen sensibly. Only a few candidates used impractical scales which made determining more difficult positions for plotted points more challenging.

Plotting was mostly careful and many candidates indicated the plots with fine crosses. Small dots are acceptable but are often obscured when the line is drawn through them, making it more difficult for correctly plotted values to be seen clearly. The large dots used by some candidates are not acceptable as the intended value cannot be determined clearly.

A sharp pencil should be used for the plots and for the line so that accurate drawing may be achieved and errors easily corrected.

Many candidates produced a well-judged straight line as indicated by their accurate plots. However, some joined points together or tried to force the line through the origin when this was not indicated by the plots.

A very small number of candidates equally spaced the 1 / T values from the table on the horizontal axis, producing an inconsistent scale meaning that the scale and also the plots were inaccurate as their positions could not be determined correctly.

(e) A gradient was often determined, with a clear indication on the graph of how this was achieved. The most straightforward method was to use a large, clear triangle drawn on the straight graph line.

(f) This question was about the accuracy and reliability of data. Only a small number of candidates gave the reduction in the effect of uncertainties, such as reaction time, as the reason for measuring five oscillations rather than one. However, more candidates realised that reliability could be improved by repeating each reading and taking an average value.

Question 2

Many candidates were able to carry out this practical satisfactorily, but some of the supplementary questions proved challenging for a number of candidates.

(a) Most candidates obtained a clear, continuous fall in temperature in both cups, almost always showing a difference between them. However, some candidates appeared to mix up the cups or fail to replace the lids, producing an unexpected greater cooling rate in the larger but more well-insulated cup.

Only a few candidates recorded room temperature as θ_0 or did not wait for the temperature to reach a maximum value before starting the timing.

(b) Some candidates did not record the units when completing the table.

(c) Good conclusions were often seen, matching the readings in the table.

Correct justifications were based on reference to the difference in temperature change between the cups over the full 180 s of the experiment. Credit could not be awarded if values were not used to support the argument. Stronger candidates were aware that it is the temperature difference rather than the final temperature of the water which is the indicator of cooling rate. However, credit was given to those candidates who used differences in final temperature values while pointing out that their initial temperatures were equal.

(d) Many correctly calculated cooling rates were seen, with the appropriate unit of °C / s. Occasionally candidates did not give the unit.

The simplest additional experiment was to repeat the cooling of water in cup A but with the lid removed. After calculating the new cooling rate this could be compared with x_A to determine the difference. However, few candidates took this approach and the experimental detail was often vague. A number of candidates talked about carrying out an experiment with cup A but adding a lid, suggesting that they had not followed the instructions for their original experiment carefully.

(e) Many candidates were able to suggest a suitable variable to be controlled, generally one of the dimensions of the cup. The volume and initial temperature of the water were also commonly seen, as was room temperature.

Question 3

Many candidates produced good responses to this question and careful practical work was seen.

(a) Many candidates showed good practical skills and obtained good readings and recording them well. Occasionally candidates recorded the current values to less than 2 decimal places.

(b) Calculations were usually carried out well with good attention paid to correct rounding. However, some sets of *R* values were expressed to an inconsistent number of significant figures.

The accuracy of the practical work was assessed by how close R_R values were to each other. A maximum range of 10 per cent was allowed but was seen in only a few responses.

(c) As R_R was not changed during the experiment, it was expected that candidates should find that the value was constant and justify this by quoting figures from the results to show that they were within the limits of experimental accuracy. However, the statement needed to match the results rather than the theory and if, as was sometimes the case, the values were not within 10 per cent of each other, the opposite conclusion was expected. Some candidates did not give figures from the results to support the explanation. At least two figures showing the range of values were required.

(d) Only a few candidates were able to describe a suitable extension to the experiment in sufficient detail. Credit was awarded for the recognition that at least five pairs of values would be needed to plot a graph. The axis labels also needed to be explicitly stated rather than implied. Description of the use of the graph to obtain the necessary value of R_L was often not clear enough. Further credit was awarded for an indication that the graph line should be extended to the R_L axis, with the intercept providing the required value.

(e) Many candidates were able to draw the correct symbol for a variable resistor, a rectangle with a strike-through arrow, but a number did not draw the symbol in a completed series circuit. A parallel connection was often seen.

Question 4

The strongest responses showed a logical approach, structured as suggested by the bullet points in the question, with concise sentences which communicated ideas well. Weaker candidates did not plan in a sequential way.

While many candidates suggested a valid, measurable factor as the independent variable, others simply stated “size” or “material” from the apparatus list. These were not accepted unless candidates subsequently defined them in terms of a measurable quantity such as diameter, mass, density or volume.

The question did not necessarily require the factor to be a property of the ball and a common acceptable response was the angle of the slope or the height of the raised end of the board.

Most candidates were able to identify the need for a stopwatch and metre rule to measure the variables of time and distance needed to calculate average speed. Equivalent devices were acceptable.

It was important to describe the steps of the experiment, including measuring the time for the motion of the ball down the slope, not merely implying this. However, some candidates did not describe the need to measure or identify the distance travelled by the ball.

If the experiment involved timing between fixed points as an indicator of average speed, actual measurement of distance was not required provided that average speed did not need to be calculated later.

It was necessary to explicitly state that the procedure should be repeated with a different value of independent variable rather than this just being implied.

Most candidates stated at least one key variable which should be kept constant. For many this was a property of the ball other than the factor under test. The angle of the slope was another sensible choice.

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Many candidates gained credit for an additional point, suggesting a means of ensuring a reliable experiment. Some of the most common responses suggested taking at least five sets of data or repeating each measurement of the dependent variable and obtaining an average value. Others mentioned further examples of good practice such as releasing the ball without exerting a force or the use of a fiducial mark to aid time measurement.

PHYSICS

Paper 0625/62
Alternative to Practical

Key messages

- Candidates need a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit where applicable. These techniques will be tested at some point in the paper.
- Candidates should be ready to apply their practical knowledge to designing an investigation. Planning questions can be answered by developing solutions from standard experimental techniques.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques, including the following:

- plotting graphs
- tabulating readings
- manipulating data to obtain results
- drawing conclusions
- dealing with possible sources of error
- controlling variables
- making accurate measurements
- choosing the most suitable apparatus.

It is assumed that, as far as possible, the course is taught so that candidates undertake regular practical work as an integral part of their study of physics. This examination should not be seen as suggesting that the course can be fully and effectively taught without practical work. Some of the skills involved in experimental work, including graph plotting and tabulation of readings, can be practised without doing experiments. However, there are parts of this examination in which the candidates are asked to answer from their own practical experience. Questions on experimental techniques were answered much more effectively by candidates who showed evidence of having regular experience of similar practical work. This was seen in the practical details given by some candidates in **Questions 1(a)**, **1(c), 1(g)** and **2(e)**.

It is expected that numerical answers are expressed to a number of significant figures which is appropriate to the data given in the question or measurements carried out by the candidate. A set of similar quantities should be expressed to a consistent number of significant figures. This was demonstrated in many good responses to **Question 3(b)**.

There will be questions which ask candidates to devise approaches to investigations which may or may not be familiar to them. However, candidates can answer these question by careful reading of the question and the logical application of good experimental practice. This was particularly the case for **Question 4** but a number of candidates also showed good practical knowledge when answering **Questions 2(d)(ii)** and **3(d)**.

Comments on specific questions

Question 1

Many candidates found this question challenging. Although the graph was approached well, other aspects were difficult.

(a) Many candidates were able to outline a satisfactory method for showing that the metre rule was horizontal but fewer were able to describe the condition that would prove it. For instance, many described the use of a ruler between the metre rule and bench without indicating that equal measurements in at least two places were required to show that the rule was horizontal.

(b) Most candidates were able to subtract the readings on the metre rule to obtain the correct answer. A few misinterpreted the question and measured the physical distance between the threads on the paper.

(c) Very few candidates suggested that a preliminary trial reading would indicate if the oscillation time was measurable or that a range of suitable *d* values could (begin to) be established.

(d) A correct value of $1/T$ was most often calculated, using the equation given in the question. Incorrect answers were generally due to the use of the candidates' own equation.

(e) There were many well-drawn, accurate graphs with clearly labelled axes.

Scales were usually chosen sensibly. Only a few candidates used impractical scales making determining more difficult positions for plotted points more challenging.

Plotting was mostly careful and many candidates indicating the plots with fine crosses. Small dots are acceptable but are often obscured when the line is drawn through them, making it more difficult for correctly plotted values to be seen clearly. The large dots used by some candidates are not acceptable as the intended value cannot be determined clearly.

A sharp pencil should be used for the plots and for the line so that accurate drawing may be achieved and errors easily corrected.

Many candidates produced a well-judged straight line as indicated by their accurate plots. However, some joined points together or tried to force the line through the origin when this was not indicated by the plots.

A very small number of candidates equally spaced the $1/T$ values from the table on the horizontal axis, producing an inconsistent scale meaning that the scale and also the plots were inaccurate as their positions could not be determined correctly.

(f) A gradient was often determined, with a clear indication on the graph of how this was achieved. The most straightforward method was to use a large, clear triangle drawn on the straight graph line.

(g) This question was about the accuracy and reliability of data. Only a small number of candidates gave the reduction in the effect of uncertainties, such as reaction time, as the reason for measuring five oscillations rather than one. However, more candidates realised that reliability could be improved by repeating each reading and taking an average value.

Question 2

Many candidates answered this question clearly, dealing well with details of the basic practical. However, some of the supplementary questions proved challenging for a number of candidates.

(a) The room temperature was given correctly in most responses and techniques for ensuring accurate temperature readings were usually described well. Perpendicular viewing of the temperature scale was often correctly mentioned but a number of responses referred to precautions, such as equal volumes of water which were not relevant in this context.

(b) Some candidates did not record the units when completing the table.

(c) Good conclusions were often seen, matching the readings in the table.

Correct justifications were based on reference to the difference in temperature change between the cups over the full 180 s of the experiment. Credit could not be awarded if values were not used to support the argument. Stronger candidates were aware that it is the temperature difference rather than the final temperature of the water which is the indicator of cooling rate.

(d) Many correctly calculated cooling rates were seen, with the appropriate unit of °C/s. Occasionally candidates did not give the unit.

The simplest additional experiment was to repeat the cooling of water in cup A but with the lid removed. After calculating the new cooling rate this could be compared with x_A to determine the difference. However, few candidates took this approach and the experimental detail was often vague. A number of candidates talked about carrying out an experiment with cup A but adding a lid, suggesting that they had not taken careful note of the diagram.

(e) Many candidates were able to suggest suitable variables to be controlled, generally including one of the dimensions of the cup. The volume and initial temperature of the water were also commonly seen, as was room temperature.

Question 3

Many candidates produced reasonable responses to this question but appropriate answers to some parts were achieved by only stronger candidates.

(a) The majority of candidates read the values of I and V_R correctly with only a few misinterpreting the graduations on the ammeter.

(b) Calculations were usually carried out well with good attention paid to correct rounding. However, many sets of R values were expressed to an inconsistent number of significant figures.

(c) Most candidates recognised that R_L decreased as V_L decreased. Any suggestion that the two variables were proportional, although incorrect, was ignored.

It was expected that candidates should find that correctly calculated values of R_R could be considered as constant and justify this by quoting figures from the results to show that they were within the limits of experimental accuracy. However, the statement needed to match the results rather than the theory and if, as found in a minority of incorrectly calculated cases, the values were not close to each other, the opposite conclusion was expected. Some candidates did not give figures from the results to support the explanation. At least two figures showing the range of values were required.

(d) Only a few candidates were able to describe a suitable extension to the experiment in sufficient detail. Credit was awarded for the recognition that at least five pairs of values would be needed to plot a graph. The axis labels also needed to be explicitly stated rather than implied. Description of the use of the graph to obtain the necessary value of R_L was often not clear enough. Further credit was awarded for an indication that the graph line should be extended to the R_L axis, with the intercept providing the required value.

(e) Many candidates were able to draw the correct symbol for a variable resistor, a rectangle with a strike-through arrow. Fewer were able to give the variable resistor in a series circuit and a voltmeter in parallel with the fixed resistor.

Question 4

The strongest responses showed a logical approach, structured as suggested by the bullet points in the question, with concise sentences which communicated ideas well. Candidates can often miss straightforward points if planning is not approached in a sequential way.

While many candidates suggested a valid, measurable factor as the independent variable, others simply stated “size” or “material” from the apparatus list. These were not accepted unless candidates subsequently defined them in terms of a measurable quantity such as diameter, mass, density or volume.

The question did not necessarily require the factor to be a property of the ball and a common acceptable response was the angle of the slope or the height of the raised end of the board.

Most candidates were able to identify the need for a stopwatch and metre rule to measure the variables of time and distance needed to calculate average speed. Equivalent devices were acceptable.

It was important to describe the steps of the experiment, including measuring the time for the motion of the ball down the slope, not merely implying this. However, some candidates did not describe the need to measure or identify the distance travelled by the ball.

If the experiment involved timing between fixed points as an indicator of average speed, actual measurement of distance was not required provided that average speed did not need to be calculated later.

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