PHYSICS

Paper 0625/12
Multiple Choice (Core)

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

General comments

There were some strong performances this year, but also many candidates who were unable to demonstrate a good understanding of the principles being tested. **Questions 2**, **10**, **11**, **21**, **32**, and **37** were generally answered well but **Questions 1**, **3**, **9**, **19**, **20**, **24**, **25**, **35** and **36** were more challenging for many candidates.

Comments on specific questions

Question 1

This question about finding the average period of a pendulum was rarely answered well. The majority of candidates chose option **D**. They averaged the times for 20 oscillations but then did not divide their answer by 20 to find the average period of one oscillation.

Question 3

A significant number of candidates incorrectly thought that the acceleration of a ball falling freely in air increased as the ball fell.

Question 9

This question was about a toy slowing down as it moved along a horizontal surface and the energy transfer taking place. Many candidates thought the energy transfer was from kinetic to gravitational (potential) and did not see that this was not possible as there was no change in height of the car.

Question 19

Many candidates thought that all three conditions in the table needed to be satisfied to have a valid test. The temperature of the water would not have altered the validity of the test and the correct option was **C**. Only the strongest candidates answered correctly.

Question 20

This question tested the knowledge that darker colours are the best radiators of thermal energy and so the darker coloured container would cool more rapidly. More candidates chose option **B**, a shinier surface, than the correct option **C**.

Question 24

Most candidates correctly rejected options **B** and **D** as they understood that diagram 1 was correct. However, many did not recognise that diagram 3 was also correct and so they chose **A** rather than **C**.

Question 25

Most candidates understood that the frequency of infrared waves is greater than the frequency of microwaves, but many went on to choose the incorrect use of infrared waves.

Question 35

Few candidates answered this correctly. Candidates needed to be able to work out the polarity of each end of the coil. In this case, the left-hand side is an S pole, and the right-hand side is an N pole and so both X and Y are repelled by the coil. Most candidates thought both X and Y would be attracted.

Question 36

This question was challenging for many candidates and all four options were attractive, but many stronger candidates answered well. Many candidates did not recall that transformers can only be used with a.c. inputs.

PHYSICS

Paper 0625/22
Multiple Choice (Extended)

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

General comments

Many candidates showed an excellent understanding of scientific knowledge and there were many strong performances. In particular, **Questions 3**, **4**, **5**, **9**, **15**, **19**, **26** and **32** were answered correctly by the majority of candidates. **Questions 12**, **18**, **22** and **35** were the most challenging.

Comments on specific questions

Question 2

A significant number of candidates incorrectly thought that the acceleration of a ball falling freely in air increased as the ball fell.

Question 12

Many candidates incorrectly believed that neither the total kinetic energy nor the total momentum were conserved when a cannonball is fired from a cannon.

Question 18

Only stronger candidates answered this correctly. Many candidates did not understand the difference between the specific heat capacity of a material and the thermal capacity of an object. Most candidates chose either option **A**, **B** or **C**.

Question 22

Many candidates did not understand that reducing the depth of the water would decrease the diffraction of a wave as it passes through a gap. A significant number thought that increasing the amplitude of the wave would increase the diffraction.

Question 28

Only stronger candidates answered this correctly. Candidates needed to understand how doubling the voltage in a circuit would affect the charge and the energy in the circuit. A good knowledge of the relevant equations was needed.

Question 35

Only stronger candidates answered this correctly. Many candidates chose option **A** and thought that both magnets would be attracted by the coil rather than repelled. They needed to know how to determine whether the ends of the coil were N poles or S poles. In this case, the left side of the coil is an S pole and the right side is an N pole.

Question 36

Most candidates correctly rejected options **B** and **D**, but many candidates incorrectly chose option **A**. Candidates needed to determine the polarity of each coil at X. Both were N poles in this case so the coils repelled.

Question 38

Most candidates chose either option **A** or **B**. Option **B** is a correct statement, but is not the answer to the question, as the presence of neutrons cannot be inferred from these observations. Stronger candidates chose the correct option **A**.

PHYSICS

Paper 0625/32
Theory (Core)

Key messages

- In calculations, candidates must set out and explain their working correctly. If no working is shown, partial credit cannot be awarded where the final answer is incorrect.
- Candidates should ensure they 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.
- Candidates should practise applying their knowledge to new situations by attempting questions in support materials or exam papers from previous sessions.

General comments

Many candidates were well prepared for this paper. Equations were generally well known by stronger candidates.

Often candidates were able to apply their knowledge and understanding to familiar situations. Some candidates found it more challenging to apply their knowledge to a new situation and showed a lack of breadth of understanding. Stronger candidates were able to think through the possibilities and applied their knowledge when the question asked for suggestions to explain new situations.

The questions on weight, timing, moments, determining resistance and explaining the effect of increased resistance on size of current in a circuit were generally well answered. There were a significant number of candidates who either did not read the questions carefully enough, or gave answers that were related to the topic being tested, but did not answer the question in enough detail to receive credit.

Comments on specific questions

Question 1

(a) Most candidates correctly calculated the total weight as 3 N. The most common error was failing to convert the mass in grams to a mass in kilograms, giving an answer of 3000 N.

(b) (i) Most candidates correctly gave the reading as 66.4 s. Weaker candidates simply wrote down the reading on the stop-watch.

(ii) Most candidates correctly divided their time from **(i)** by 20. The most common error was to divide 20 by the time in **(i)**.

(c) Most candidates gave a correct energy transfer. A common error was a partial repeat of the question by stating that elastic potential energy is released.

Question 2

(a) Most candidates correctly calculated the moment as 45 N m. The most common error was to divide the force by the distance.

(b) (i) Most candidates stated that section AB indicated acceleration, and in DE that the athlete was stationary. A common error was to state that the motion in DE was constant, or the athlete was moving at a constant speed.

(ii) Most candidates realised that the distance travelled was the area under the speed–time graph, but a significant number failed to calculate this correctly. The most common error was $5 \times 8 = 40$ m.

Question 3

(a) Almost all candidates correctly calculated the volume of the block as 48 cm^3. A common error was to use $2 \times l \times b \times h$.

(b) (i) (ii) Most candidates correctly calculated the density of the metal in **(i)**, and then gave a suitable density for the liquid.

(c) Many candidates gave very precise descriptions on how to use the equipment to determine density. Weaker candidates failed to state that the mass was measured using the balance and the measuring cylinder was used to measure volume.

Question 4

(a) Most candidates gained partial credit for this question. The most common error was failing to state that the turbine turned a generator to generate electricity. Weaker candidates thought that the water in the reservoir was turned to steam to be used in generating electricity.

(b) Many responses were not precise enough. Candidates should be made aware that general statements such as “eco-friendly” or “no pollution produced” are not detailed enough for credit.

(c) Once again, a lack of precision meant the many answers were incomplete.

Question 5

(a) Most candidates gained at least partial credit. The most common error was to add the two forces instead of subtracting.

(b) Many candidates gained partial credit here. A number of candidates gave the unit as pascals rather than N / cm^2. Weaker candidates either did not take the four wheels into account or used an incorrect rearrangement of the equation.

Question 6

(a) The majority of candidates answered this correctly. The most common error was only giving one valid point in the description.

(b) The vast majority of candidates answered this correctly with a statement such as “the speed of the gas particles decreases”.

(c) The majority of candidates only scored partial credit. Very few stated that, as a result of collisions with the wall of the container, a force was imparted on the wall.

Question 7

(a) The vast majority of candidates answered this correctly.

(b) Many candidates gained partial credit, but only the strongest answered fully correctly. The most common error was to state that the water molecules expanded, rather than that the water molecules moved further apart, so decreasing the density of water when it is heated.

(c) The majority of candidates gained full credit. The most common error was failing to state that the black surface is a better absorber of thermal radiation compared to the white surface.

Question 8

(a) (i) The majority of candidates answered this correctly. The most common error was to draw an arrow twice the length of the amplitude.

(ii) Lack of precision and accuracy resulted in many candidates not gaining credit here.

(b) (i) Many candidates gained credit for showing three reflected wavefronts, but only stronger candidates drew the wavefronts travelling down the page correctly.

(ii) The majority of candidates answered this correctly. The most common error was to show the diffracted waves with either much smaller or much greater wavelengths.

Question 9

(a) (i) Most candidates answered this well.

(ii) Only stronger candidates recognised that the waves were increasing in frequency. The most common error was to state "wavelength".

(b) Most candidates gained full credit, but once again lack of precision resulted in many candidates only being awarded partial credit.

(c) Many candidates answered this correctly, but others did not give sufficient detail in answers.

Question 10

(a) (i) Most candidates correctly added a voltmeter symbol to the diagram, but weaker candidates drew the voltmeter in series with the LDR.

(ii) The majority of candidates answered this correctly. The most common error was to use an incorrect rearrangement of the equation.

(b) This question was usually answered well. The most common error was to subtract instead of adding the two resistances.

Question 11

(a) Most candidates gained at least partial credit. Weaker candidates used an incorrect form of the equation.

(b) Most candidates scored at least partial credit. Weaker candidates thought that the fuse controlled the supply of current in the circuit.

Question 12

(a) (i) Most candidates gained credit for knowing alpha-radiation has a high ionising ability. However, few candidates knew that a beta-particle is an electron, or that the relative charge on an alpha-particle is plus two.

(ii) The vast majority of candidates answered this correctly.

(b) The vast majority of candidates correctly identified the particles in the nucleus. The most common error was to have the answers interchanged.

PHYSICS

Paper 0625/42
Theory (Extended)

Key messages

- When candidates are asked to explain physics ideas in a specific context, e.g., **Questions 3(c)** and **10(b)(ii)** they need to apply their physics knowledge to the specific situation described in the question.
- Candidates should be encouraged to read questions carefully to ensure that they answer exactly the question that is being asked.
- The number of marks available for a question gives candidates a guide as to the number of points they should include in their answer.
- In questions where candidates are required to show how an answer has been calculated, it is important that they explain their method and not simply write down a string of numerical values that lead to the final answer without any explanation.

General comments

Many candidates demonstrated a good understanding across the syllabus and were able to recall and use many equations correctly and apply their physics knowledge to explanations in different contexts.

Most numerical answers were given to two significant figures and included the correct unit. It is also important for candidates to avoid simply repeating phrases from the question when an explanation is asked for. When candidates are asked to draw diagrams, it is expected that they will use neat lines drawn carefully with a sharp pencil and rulers and protractors as appropriate.

Comments on specific questions

Question 1

(a) Many candidates answered this correctly. A common error was a misreading of the scale giving an answer of 2.4 s or 2.25 s. Another common incorrect answer was 1.5 s, i.e., a misunderstanding of the section of the graph relating to the start of the rough horizontal surface. A few candidates omitted the unit of time.

(b) Stronger answers stated that the graph was a horizontal line and hence speed was constant or acceleration was zero or stated that the acceleration was zero and that if there was a resultant force it would cause an acceleration. For a question with two marks, candidates should be encouraged to make two distinct points. Many answers referred only to speed being constant. Weaker candidates referred to constant acceleration which may have been due to them analysing the wrong section of the graph. A few candidates simply stated that speed was constant "so there is no resultant force" which was insufficient to explain why there is no acceleration.

(c) Many candidates answered this question well with the correct units and most candidates recalled and used the formula $a = \Delta v / t$. Weaker candidates chose inappropriate values to calculate the gradient.

(d) When asked to "show that" it is important that candidates explain what formula or process they are using. While the numerical answer $0.5 \times 12.8 \times 1.5$ was accepted for use of either the area under the graph or use of average velocity $\times$ time, candidates who used other methods to arrive at the given length of 9.6 m were only given credit with a clear explanation of their approach. A few candidates tried to work back from the final answer but generally did not use the correct physics. Some candidates made no attempt at this question.

Question 2

(a) (i) Most candidates correctly stated Hooke's law. It is important that candidates use correct terms; length and mass were not acceptable for extension and force respectively.

(ii) The force exerted on the spring due to the baby is its weight and so the relationship here is that mass is directly proportional to force on the spring. Candidates should always express a relationship in the most precise terms possible. Mass increases as the force on the spring increases was not precise enough.

(iii) This question was answered well by most candidates. A few weaker candidates tried to use $F = kx$ and used the value of 175 N given in the question. It should be noted that from 2023 this syllabus will require candidates to use $g = 9.8\,\text{m}/\text{s}^2$.

(b) Most candidates gained credit for a straight line with positive gradient from the origin to the dashed line at 175 N. After the limit of proportionality is reached, candidates needed to show a curve with increasing gradient since a small increase in force beyond 175 N produces a larger extension. Candidates should be encouraged to look at the labels on both axes carefully since some textbooks show force on the *y*-axis. A few candidates incorrectly drew curves that flattened immediately after 175 N before becoming steeper.

(c) Many candidates gained full credit here with most using the formula $\Delta\text{GPE} = mgh$. Weaker candidates sometimes tried to include 175 N in their calculation, often as a mass.

Question 3

(a) Almost all candidates correctly identified the process of evaporation, and many fully described the process in terms of more energetic molecules leaving from the surface of the water. References to breaking bonds or overcoming forces of attraction were insufficient to explain the decrease in volume of the puddle.

(b) Partial credit was available for identifying an appropriate change in the weather. "A cold day" or "a day with less wind" were acceptable answers. Some candidates stated "a humid day". On its own this was insufficient. Nothing had been said about humidity in the question and so such a statement needed to be clearly about the weather being more humid.

It is important that the change in weather was linked to the rate of evaporation. A simple statement that there is less evaporation without reference to time was insufficient.

Candidates should be advised against giving multiple changes when only one is asked for as a contradictory statement, e.g., "colder and more windy", did not gain credit.

(c) Stronger answers linked knowledge of evaporation to the specific situation given in the question, sweating. Full answers covered molecules of sweat gaining energy from the body, more energetic molecules escaping and leaving behind less energetic molecules thus lowering the temperature of the skin or body. Candidates should avoid repetition of phrases from the question when giving an explanation.

Question 4

(a) (i) Candidates who correctly recalled and used $m = \rho V$ were usually awarded full credit. There were a few powers of ten errors. Weaker candidates did not identify the correct equation and tried to use all three numerical values given in the question.

(ii) Many correct calculations were seen but a lot of candidates added an incorrect unit, often J or J / kg. A few weaker candidates tried to use latent heat or specific heat capacity equations, or just combined some of the numerical values given in the question.

(iii) Many candidates correctly answered this part of the question even if they had been unable to calculate the thermal capacity in **(ii)** correctly. They did this by combining the equations $E = mc\Delta T$

and $P = E / t$. Weaker candidates often confused temperature (T) with time (t), or failed to calculate energy before trying to use $P = E / t$.

(b)(i) Many candidates stated that energy was transferred by conduction. A few said that sand molecules gained KE. When thinking about thermal energy being stored in molecules, candidates should take care to be specific about the type of energy store, and not just say that energy is gained by molecules.

(ii) This question was answered well by only the strongest candidates. Many other candidates recognised the idea that energy is lost from the sand but did not make the connection with the rate of energy being supplied to the sand. There were a few misconceptions evident in the answers. A lot of weaker candidates thought that the temperature was constant due to latent heat and suggested the sand was melting. Others suggested that the sand had a certain capacity for heat and after that was full no more could be taken in, so the temperature stayed constant.

Question 5

(a) (i) Most candidates drew rays with the angle of reflection equal to the angle of incidence. Some common errors included the omission of, or wrong direction of, arrows on the rays, or the rays not reaching the eye. Credit for the straight line from clock to mirror and mirror to eye was not awarded unless rays were drawn with a ruler.

(ii) Stronger candidates carefully marked with an X the position of the image as far behind the mirror as the clock was in front of the mirror along a line from the clock perpendicular to the mirror. Due to the dimensions of the clock, a range of positions was given credit. Some candidates used two rays coming from the clock at angles other than 90° to the mirror. This would also have found the correct position for the image if it had been done carefully but often these rays came from different points on the clock, rather than from the same point. Weaker candidates did not understand how to locate the image and the letter X was frequently located on the surface of the mirror.

(iii) Stronger candidates stated clearly that either the virtual image could not be formed on a screen or that the light rays do not intersect at the image. While only the weakest candidates thought the image was real, there were many who could not explain why the image was virtual. Some listed properties of the image as upright or laterally inverted.

(iv) This question was answered well by most candidates. Common errors included showing no change in appearance or a vertical inversion.

(b) (i) The syllabus defines monochromatic light as being light of a single frequency. Most answers referred to colour, which on its own was not sufficient since each colour of light covers a range of frequencies. Referencing light of a single wavelength was also credited.

(ii) To gain full credit, candidates needed to recall the formula $f = v / \lambda$ and recall speed of light = 3×10^8 (m / s) and then recall that the unit of frequency is Hz. Many candidates omitted the unit here. Some weaker candidates had powers of 10 errors in the final answer that may have been due to poor handling of standard form with calculators and the very weakest candidates either copied the wavelength on to the answer line or calculated $1 / \lambda$.

Question 6

(a) Stronger candidates produced a careful drawing of several lines between the poles, equally spaced, perpendicular to the magnets and with arrows pointing from N to S. Candidates who drew the lines carelessly often only gained partial credit for the correct direction.

(b) (i) While stronger candidates gained credit here, some other candidates contradicted themselves when they added the word “commutator” after slip rings and many weaker candidates referred to split rings instead of slip rings.

(ii) A number of candidates drew a clockwise arrow on or next to the coil, but only stronger candidates also identified the right-hand rule or explained that the field, force and motion were mutually perpendicular. A few candidates got muddled with the right-hand grip or thumb rule. Candidates needed to take care where they put their arrows. Those drawn in the centre of the coil were often ambiguous. Some confused the direction of the current with the direction of the field.

(iii) Few candidates gained full credit for this question. Many candidates answered in the context of a motor rather than a generator. A common misconception was that the current changed direction because the coil rotated in the opposite direction. There was a lack of clarity in describing when the direction of the current changed, i.e., every 180 degrees or as it passed the vertical position. It was important to state that current is induced in the coil, not just produced. Candidates needed to describe the (induced) current either being transferred to the galvanometer or causing the needle to deflect and not just repeat the wording from the question, i.e., that the galvanometer shows an alternating current.

Question 7

(a) There were many correct answers. A common mistake was to state 2 cells, probably arrived at by inspection of the diagram and misunderstanding the circuit symbol for a battery.

(b) (i) This question was answered well by most candidates. Almost all candidates gained credit for recall of $V = IR$ and it was only the weakest candidates who were unable to rearrange the formula correctly to arrive at the final answer.

(ii) Stronger candidates correctly applied the formula for two resistors in parallel and then subtracted their answer from the total resistance calculated in **(i)**. Some weaker candidates did not attempt to use the equation for resistors in parallel and often just added resistances. Some candidates forgot to invert their answer for $1 / R$ and others did not attempt to subtract their answer from the answer to **(i)**.

(c) (i) Most candidates used the correct symbol and placed the voltmeter appropriately across both lamps. A few weaker candidates put the voltmeter in series or showed a horizontal wire inside the voltmeter symbol.

(ii) Most candidates correctly quoted $P = IV$. However, only stronger candidates were able to substitute a correct value for the current I and very few candidates identified that $V = 3.6\,V$.

Question 8

(a) Many correct answers were seen with an iron core, primary and secondary coils labelled and with clearly fewer coils on the secondary coil. Candidates needed to know that a circuit symbol does not show the structure of a transformer. Weaker candidates often omitted the soft-iron core, did not label it, or drew two cores.

(b) Only the very strongest candidates gained full credit. Many others misunderstood the question and gave an answer about the function of a transformer instead of its operation, describing the relationship between the number of turns and the output voltage and how that determined whether it was a step-up or step-down transformer. There was often a lack of clarity in explaining the operation and in identifying the current as alternating or saying which coil was relevant for each part of the answer. A few candidates described e.m.f. passing through the core or used the phrase “mutual induction” without further detail.

(c) Many candidates knew the correct equation to use but then substituted numerical values incorrectly. A few candidates gave an answer to one significant figure. Candidates should be advised to always give the equation they are using in symbols first before substituting numerical values.

Question 9

(a) (i) Stronger candidates explained that digital refers to the signal having one of only two possible states. Common incorrect answers included references to electronic devices being digital or a digital device being “not analogue”.

(ii) The majority of candidates gave completely correct answers. Those who made a mistake in column C were often awarded partial credit for realising that column D is the output of C through a NOT gate.

(b) Very many correct answers were seen here even when candidates did not gain full credit in **(a)(ii)**. A few candidates who made a mistake in **(a)(ii)** gained credit here for describing the correct single gate to produce their output at D.

Question 10

(a) This question was answered well by most candidates. Full marks were obtained by almost all who knew the proton and nucleon number for an alpha-particle. Some weaker candidates made mistakes in balancing the equation when they had given the correct values for an alpha-particle and a few candidates were unable to recall any appropriate physics in this question.

(b) (i) The strongest candidates gave clear descriptions of alpha-particles being emitted from the americium and the resulting collisions between alpha-particles and molecules in air knocking out electrons to leave ions. Common errors included thinking that americium collided with air particles, or that the alpha-particles were attracted to the metal plates, or that alpha-particles gained electrons to become atoms. Very weak candidates simply restated the question that the alpha-particles ionise air without any explanation of the mechanism by which this happens.

(ii) This question asked candidates to “suggest and explain”. Stronger candidates clearly stated properties of alpha and gamma-radiation and then applied those properties to the smoke detector described in the question. Most candidates gave statements about properties of alpha and gamma without linking the property to the smoke detector. Statements such as “alpha is stopped by thin paper” needed to be made relevant to the question, e.g., “so the alpha-particles are stopped by the smoke particles”.

PHYSICS

Paper 0625/52
Practical Test

Key messages

- Candidates need to have had a thorough grounding in practical work during the course, including an understanding of the procedures and precautions necessary to produce reliable and accurate results.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. These aspects will be tested at some point in the paper.
- Candidates should be familiar with applying their knowledge of practical work to plan investigations and to suggest modifications/improvements to given methods.

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 will be 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 good practical details given by some candidates in **Questions 1(e)**, **2(e)** and **3(e)**.

This paper contains questions in which candidates are asked to devise approaches to investigations which may or may not be familiar to them or to suggest improvements to methods given. However, candidates will always be able to answer these questions with careful reading of the brief 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 1(e)** and **2(d)**.

Comments on specific questions

Question 1

Many candidates were able to obtain satisfactory data to plot the graph but the extension questions were more difficult for some candidates.

(a) Most candidates obtained sensible values for spring length.

(b) Many candidates obtained a set of 5 increasing values but not all expressed them to the nearest mm.

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

Scales were usually chosen sensibly with very few impractical intervals. Most candidates recognised that the axes started at the origin but quite a number produced a discontinuity on the *x*-axis by showing the first interval as 20.0 cm rather than 10.0 cm.

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 plotting points to be seen clearly. The large dots or thick crosses 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 diverted the line through the origin from the plot at 20.0 cm.

(d) The intercept shown at the *y*-axis was generally accurately read and an appropriate value for the weight of the rule was obtained by many candidates. Some candidates omitted the unit of N or gave an inappropriate unit.

(e) Very few candidates recognised that hanging the load from a loop of thread would allow accurate placement. Marking the centre of the load and the scale position on the side of the rule was an acceptable alternative but most candidates suggested one or other of these procedures, which did not overcome the difficulty by themselves.

There were very few correct suggestions of possible sources of inaccuracy. It was expected that these would refer to sources which the experimenter would have no control over, such as an inaccurate value of the test load or a non-uniform metre rule or spring. Most responses referred to poor experimental practice despite the question stating that the experiment was carried out carefully.

Question 2

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

(a) Most candidates obtained a clear, continuous fall in temperature. 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) Most candidates obtained a second continuous fall in temperature at a lower rate than in the first experiment. However, a few candidates did not include units in their tables.

(c) Good conclusions were often seen, matching the readings in the table. It was expected that responses should indicate that the cooling rate was not just affected but reduced by the air gap and any comment suggesting that was accepted. However, if values in the table showed the opposite result, or no significant difference, a matching conclusion was given credit.

Correct justifications were based on reference to the difference in temperature change between the beakers over the full 180 s of the experiment, with no credit awarded if values were not used to support the argument. Candidates should be 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) Only stronger candidates recognised that the use of a thermally conducting material for beaker B (such as copper or aluminium) would remove the insulating effect of the glass in the second experiment. The glass of beaker A was common to both experiments.

(e) Many candidates were able to suggest two suitable variables to be controlled, generally including the volume and initial temperature of the water or the room temperature. Reference to the apparatus was not accepted as the question specifically excluded this.

Some candidates negated a correct response by including an additional incorrect variable and this practice should be avoided.

(f) Many correctly calculated cooling rates were seen, with the appropriate unit of °C / s. Some candidates did not include a unit. The value was expected to be expressed to 2 or 3 significant figures.

Question 3

Many candidates produced good responses to this question and some careful practical work was seen. It was clear that the quality of response depended on whether this type of experiment had been carried out previously by candidates and a few drawings showing that the expected techniques were unfamiliar.

(a) Most candidates drew the normal well and drew the line **NE** accurately at the required angle.

(b) Some responses had pins which were sufficiently far apart for accurate ray tracing but many did not. The separation should be as large as possible and at least 5.0 cm.

(c) The first refracted ray was often well drawn in an appropriate position. Candidates should avoid using dotted lines for rays, although this is acceptable for the normal line.

(d) The second ray was also well drawn by many candidates and the angle β measured as expected. However, some candidates did not include a unit for β.

Many candidates were able to compare β and θ_S correctly and recognised that they were or were not equal within the range of experimental accuracy. The justification required values to be given as well as a statement referring to the range of experimental accuracy.

(e) Many candidates gained credit here, indicating that they had carried out this type of practical previously. Use of thin lines and viewing pins at their bases were the most common correct responses.

(f) Very few correct answers were seen here. The expected reason was that aligning the pins accurately is a very difficult technique. Candidates who carried out this practical carefully realised this. The issue of the thickness of the pins preventing accurate alignment or refraction problems with a thick mirror were also acceptable responses. Mention of poor experimental practice, such as using thick lines, was not accepted.

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 who had not approached this question in a sequential way sometimes missed points. While many candidates suggested a valid, measurable factor as the independent variable, many others missed this out until later in the method or the table. If the bullet points of the question were being followed, this should have been the first thing mentioned, particularly as some subsequent points relied on it.

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A thermometer was required in most of the investigations but was missing from quite a few apparatus lists.

Many candidates answered well when describing the method but there was a clear need in some responses for these to be reviewed to ensure that they matched other aspects of the plan.

Credit for method was obtained for the measurement of the independent variable, the measurement of the temperature change and time and an explicit statement that the procedure should be repeated with a different value of independent variable. Some responses did not cover all three aspects. Most candidates stated at least one key variable which should be kept constant. Often, this was the initial temperature of water or the current in the circuit.

Many well-thought-out tables were seen, containing clear columns for readings of independent and dependent variables, with appropriate units. Some candidates omitted units or important columns.

Candidates should be advised to check that the table matches the data they require to record. Some candidates incorrectly used a table similar to that in **Question 2** but with an additional column for an independent variable.

A comment on the analysis of results was expected. The most straightforward responses suggested that if a change in the independent variable produced a change in the measured dependent variable, this showed that the factor affected the rate at which the temperature of the water rises. Many candidates incorrectly predicted a conclusion instead, often quoting theory to support this.

Mention of a line graph, with suitable axes clearly stated, was sufficient to gain credit for analysis. Candidates should recognise that the use of a bar chart is not appropriate for a continuous variable such as current or volume of water.

Some candidates gained further credit for an additional point of good practice, with many giving a second control variable.

Some of the other more common responses stipulated taking at least five sets of data in order to draw a graph or repeating each measurement of the dependent variable and obtaining an average value. “Repeat the experiment” was not a suitable response here.

PHYSICS

Paper 0625/62
Alternative to Practical

Key messages

- Candidates need to have had a thorough grounding in practical work during the course, including an understanding of the procedures and precautions necessary to produce reliable and accurate results.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. These aspects will be tested at some point in the paper.
- Candidates should be familiar with applying their knowledge of practical work to plan investigations and suggest modifications/improvements to given methods.

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 will be 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 actually doing the experiments but 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 good practical details given by some candidates in **Questions 1(b)**, **2(b)**, **2(e)** and **3(e)**.

This paper contains questions in which candidates are asked to devise approaches to investigations which may or may not be familiar to them or to suggest improvements to methods given. However, candidates will always be able to answer these questions with careful reading of the brief 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 1(d)** and **2(d)**.

In general, many candidates were able to answer all parts of the paper, with very few responses left blank.

Comments on specific questions

Question 1

The graph was tackled well but the extension questions were more challenging for many candidates.

(a) Most candidates took the readings accurately but many did not record both answers to the nearest mm.

(b) Most 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. Use of a set square or protractor which clearly showed that the rule was at right angles to the stand was also accepted.

(c) There were many well-drawn, accurate graphs with clearly labelled axes. Scales were usually chosen sensibly with very few impractical intervals. Most candidates recognised that the axes started at the origin but quite a number produced a discontinuity on the *x*-axis by showing the first interval as 20.0 cm rather than 10.0 cm.

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 plotting points to be seen clearly. The large dots or thick crosses 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 diverted the line through the origin from the plot at 20.0 cm.

The intercept shown at the *y*-axis was generally accurately read and the expected value for the weight of the rule was obtained by a number of candidates. Some omitted the unit of N for the weight of the metre rule or gave an inappropriate unit.

(d) Very few candidates recognised that hanging the load from a loop of thread would allow accurate placement. Marking the centre of the load and the scale position on the side of the rule was an acceptable alternative but most candidates suggested one or other of these procedures, which did not overcome the difficulty by themselves.

There were very few correct suggestions of possible sources of inaccuracy. It was expected that these would refer to sources which the experimenter would have no control over, such as an inaccurate value of the test load or a non-uniform metre rule or spring. Most responses referred to poor experimental practice despite the question stating that the experiment was carried out carefully.

Question 2

Many candidates were able to answer this question well, particularly the more straightforward aspects of the basic practical. However, some of the supplementary questions proved difficult for a number of candidates.

(a) The room temperature was given correctly in most responses with only a few candidates recording the value as 20.3 °C.

(b) 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 room temperature or water volume, which were not relevant in this context. Some candidates did not record units.

(c) Good conclusions were often seen, matching the readings in the table. It was expected that responses should indicate that the cooling rate was not just affected but reduced by the air gap and any comment suggesting that was accepted.

Correct justifications were based on reference to the difference in temperature change between the beakers over the full 180 s of the experiment, with no credit awarded if values were not used to support the argument. Candidates should be aware that it is the temperature difference rather than the final temperature of the water which was the indicator of cooling rate.

(d) Only stronger candidates recognised that the use of a thermally conducting material for beaker B (such as copper or aluminium) would remove the insulating effect of the glass in the second experiment. The glass of beaker A was common to both experiments.

(e) Many candidates were able to suggest two suitable variables to be controlled, generally including the volume and initial temperature of the water or the room temperature. Reference to the apparatus was not accepted as the question specifically excluded this.

Some candidates negated a correct response by including an additional incorrect variable and this practice should be avoided.

(f) Many correctly calculated cooling rates were seen, with the appropriate unit of °C / s. Some candidates did not include a unit. The value was expected to be expressed to 2 or 3 significant figures. Some answers were rounded to 0.1 and a small number gave the incorrect value of 0.972 rather than 0.0972.

Question 3

This question was answered well by most candidates.

(a) Most candidates drew the normal well and correctly measured the required angle.

(b) Most candidates measured the pin separation correctly and many realised that they were too close together for accurate ray tracing. Most candidates indicated that the minimum separation should be 5.0 cm and many suggested that the pins should be as far apart as possible.

(c) Most candidates correctly drew the lines as requested with only a small number not being straight.

(d) Most candidates had constructed the ray diagram accurately and obtained a value for angle β in the required range. However, some candidates did not include a unit.

Many candidates were able to compare β and θ_S correctly and recognised that they were equal within the range of experimental accuracy. Where the values obtained by the candidate were clearly not in that range, the opposite response was expected. The justification required values to be given as well as a statement referring to the range of experimental accuracy.

(e) Many candidates gained credit here, indicating that they had carried out this type of practical previously. Use of thin lines and viewing pins at their bases were the most common correct responses.

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