PHYSICS

Paper 0972/11
Multiple Choice (Core)

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

General comments

Candidates answered **Questions 1**, **2**, **18**, **19** and **40** well but found **Questions 21**, **23**, **34**, **34**, **36**, **37** and **39** more challenging.

Comments on specific questions

Question 1

Most candidates answered this question well.

Question 2

The vast majority of candidates showed an understanding of how to calculate speed.

Question 3

Most candidates recognised that the falling ball would have its greatest speed in the lowest section of its flight. However, not all of these candidates could relate this to the fact that this section would also be covered in the shortest time.

Question 17

Only the strongest candidates understood the meaning of the term "thermal capacity".

Question 18

Most candidates were able to interpret the diagram and recognised that the relevant change of state was condensation.

Question 19

This question was answered well and the majority of candidates understood that a material needs to be present for conduction to occur.

Question 21

This question was challenging for many candidates. Only the strongest candidates understood that when a wave undergoes refraction, the frequency remains constant and it is the wavelength that changes. Even when candidates did recognise this, few realised that the wavelength increases when the speed increases.

Question 23

This question needed careful analysis. Many candidates gave option **A**, showing that although they knew that the image in a plane mirror is the same distance from the mirror as the object (30 cm), they had not thought the problem through to realise that this made it 60 cm from the object.

Question 24

Candidates showed little understanding of total internal reflection. Despite being told that the angle of incidence was greater than the critical angle, the majority of candidates thought that the ray would be refracted out into the air.

Question 26

Only the strongest candidates recognised that when the echo sounds, the pulse of sound has to travel down to the fish and then travel back up to the sensor on the boat.

Question 31

This question proved very challenging for many candidates who thought that both the ammeter and voltmeter should be connected in series with the main circuit. This is an area which candidates should be familiar with at this level.

Question 34

Only the strongest candidates answered this question correctly. Many candidates saw a variable resistor and thought that that must be the answer. Amongst the other choices, there appeared to be some guessing.

Question 36

Electromagnetic induction is conceptually difficult, and although most candidates rejected option **A**, there was clearly a lot of guessing when choosing between the other responses, with a small majority incorrectly believing that an e.m.f. is not induced when the magnet is moved away from the coil.

Question 37

Although stronger candidates answered correctly, many candidates seemed to be unfamiliar with the magnetic field of a current carrying solenoid. Most candidates thought that the compass needles above and below the solenoid would point directly towards the centre of the solenoid.

Question 39

Candidates needed to approach this type of problem logically. A thin piece of paper causes a large drop in the count rate, indicating that α-particles are present. The introduction of the aluminium made no further change, ruling out the presence of β-particles. The large drop with the introduction of lead indicates the presence of γ-rays.

Question 40

Most candidates showed an understanding of the term radioactive decay.

PHYSICS

Paper 0972/21
Multiple Choice (Extended)

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

General comments

Candidates answered **Questions 1**, **2**, **4**, **5, 7**, **13**, **14**, **17**, **32** and **38** well. **Questions 9**, **10**, **16**, **20** and **23**, caused varying degrees of difficulty to candidates

Comments on specific questions

Question 1

The vast majority of candidates answered this question correctly.

Question 2

This question was usually answered correctly.

Question 4

Candidates showed a good understanding of the terms “mass” and “weight”.

Question 5

Almost all candidates answered this question correctly.

Question 7

This question was answered well by most candidates.

Question 9

Only the strongest candidates recognised that the change in velocity of the bouncing ball was 18 m / s as shown by (10 – (–8)) not 2 m / s.

Question 10

Only the strongest candidates answered this question correctly. The easiest way to tackle it was to consider the energy transfer from gravitational potential energy to kinetic energy, which gives $mgh = ½mv^2$ hence $v^2 = 2gh$.

Question 13

Most candidates answered this question correctly.

Question 14

Candidates showed a good understanding of the collision process between gas molecules and larger particles, such as smoke particles.

Question 16

This was a challenging calculation, and although the majority of candidates had some idea how to carry it out, a common error was to assume that all the ice had melted, despite being told in the question that 18 g remained.

Question 17

This question was answered well by most candidates.

Question 20

This question was challenging for many candidates. This was possibly because it asked for the least diffraction, whereas candidates tend to think in terms of the most diffraction.

Question 21

This question needed careful analysis. Many candidates gave option **A**, showing that although they knew that the image in a plane mirror is the same distance from the mirror as the object (30 cm), they had not thought the problem through to realise that that made it 60 cm from the object.

Question 23

A number of candidates found this question challenging and of those candidates who did not recognise that all electromagnetic radiation travels at the same speed in a vacuum, many appeared to have guessed.

Question 25

Candidates had little problem in identifying the reason for the experimental technique described in the question.

Question 28

Many candidates showed a good understanding of the meaning of electromotive force, but a considerable number thought that e.m.f. was the rate of energy transfer per unit charge, rather than just the energy per unit charge.

Question 29

The most common error in answering this question was for candidates to think that decreasing the temperature of a metallic conductor increased its resistance.

Question 31

Many candidates saw a variable resistor and thought that this must be the answer without investigating how the p.d. would change or not change.

Question 32

Most candidates correctly identified the logic gate as an and-gate.

Question 37

Although many candidates were able to identify the correct direction of the force on the wire, a significant number did not recognise that the question was testing Lenz's law.

Question 38

Candidates showed they had the ability to balance the nuclear equation in this question.

PHYSICS

Paper 0972/22
Multiple Choice (Extended)

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

General comments

Candidates answered **Questions 1**, **8**, **9**, **10, 13**, **14**, **25** and **39** well and although there were no questions which caused major difficulties, **Questions 20**, **23**, **28**, **30**, **31**, 32 and **38** challenged some candidates.

Comments on specific questions

Question 1

Most candidates answered this question correctly.

Question 8

This question was answered well.

Question 9

Candidates showed they have a good knowledge of the concept of momentum.

Question 10

Candidates usually answered this question correctly.

Question 11

This question was answered well.

Question 13

Most candidates answered this question correctly.

Question 14

Candidates showed a good understanding of the factors effecting compressibility of gases and solids.

Question 20

This question was challenging for some candidates. This was perhaps because it asked for the least diffraction, whereas candidates tend to think in terms of the most diffraction.

Question 23

A number of candidates found this question challenging and of those candidates who did not recognise that all electromagnetic radiation travels at the same speed in a vacuum, many appeared to have guessed.

Question 25

Candidates had little problem in identifying the reason for the experimental technique described in the question.

Question 28

Many candidates showed a good understanding of the meaning of electromotive force, but a considerable number thought that e.m.f. was the rate of energy transfer per unit charge, rather than just the energy per unit charge.

Question 31

Many candidates saw a variable resistor and thought that this must be the answer without investigating how the p.d. would change or not change.

Question 32

Almost all candidates recognised that a thermistor was required in order for the potential difference across Y to change. However, having established this important fact, almost **as many candidates chose the incorrect option** C**, as the correct answer,** D**.**

Question 38

Many candidates recognised that α-particle scattering led to the adoption of the nuclear model of the atom. However, other candidates incorrectly thought it was the emission of γ-rays during radioactive decay was the evidence.

Question 39

Candidates showed their abilities in balancing the nuclear equation and completed the question without difficulty.

PHYSICS

Paper 0972/31
Core Theory

Key messages

- In calculations, candidates must set out and explain their working correctly. If poor or no working is shown, when an incorrect answer is given it is often impossible for credit to be given for those parts that are correct.
- Greater clarity and precision was needed 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

Many candidates were well prepared for this paper. Equations were generally well known by stronger candidates, but a significant number of weaker candidates struggled to even recall the equations.

Often candidates had been taught how to apply their knowledge and understanding to fairly standard situations. On occasions, when asked to apply their knowledge to a new situation, they found this challenging and 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.

Occasionally candidates did not set out their calculations clearly and in some cases it was not possible to follow what they had recorded. Some candidates had problems in transposing equations and often started with a correct formula but could not always translate this into correct use of the data in the question.

The questions on levers, advantages and disadvantages of using natural gas as an energy source and explaining the action of a potentiometer in a circuit were generally more challenging for many candidates. 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.

The English language ability of the 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.

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 would have been better entered for the Extension paper.

Comments on specific questions

Question 1

(a) **(i)** Most candidates answered correctly. Very few candidates gave incorrect weighing instruments such spring balance or Newton-meter.

(ii) This calculation was done well by almost all candidates. The formula was well known and the correct numerator and denominator were used when numbers were substituted. Most candidates evaluated the correct answer. Most candidates knew the unit and only a small minority made a mistake: g/cm^2, kg/cm^2, g/cm or simply cm^2 were the most common errors.

(iii) The majority of candidates calculated the mass in kg correctly, but a significant number incorrectly divided by 100 or multiplied by 1000.

(b) Most candidates gained at least partial credit for calculating the weight of the vase, but only the strongest candidates correctly recognised that the two forces were equal in magnitude.

Question 2

(a) The majority of candidates answered this question correctly. Most knew "moment" as the correct term for a turning force and "torque" was also seen a few times. "Work" or "work done" was probably the most common incorrect answer, although "momentum" was also given by some candidates.

(b) (i) This question proved challenging for many candidates. Candidates should be encouraged to practise working out calculations using the principle of moments. The majority of candidates worked out the moment of the 400 N force and then stopped. Another common error was the addition of the two distances on either side of the pivot in the figure.

A significant number of candidates failed to show any working, and for many this resulted in no credit awarded for the question. Candidates should be encouraged to state the equation they are using, and then to show substitution of values into the equation.

(ii) Most candidates answered this question correctly. However, a significant number were not precise enough in their answer. "Make the distance longer" was the most common answer but had little meaning unless the distance was specified. Some candidates thought that making the distance between the pivot and the log longer would produce the required result and a small number thought that it was necessary to apply the force nearer the pivot.

Question 3

(a) Most candidates gained full credit for this question. A common error was subtracting 8 from 22 and dividing by 2. Many other candidates misjudged the length of one or more of the bars resulting in a total different from 67.

(b) The vast majority of candidates gained full credit. A common error was having the letters in reverse order.

(c) This calculation was done well by the majority of candidates. A small number started with the correct equation of speed = distance ÷ time but somehow managed to rearrange this so that they divided 16 by 11 rather than 11 ÷ 16.

Question 4

(a) (i) This calculation was done well by the majority of candidates. Most evaluated P = F/A to give the correct answer, with only a few candidates using an incorrect re-arrangement of the equation such as 90 (50 × 1.8) and even fewer giving 1.8 divided by 50.

(ii) The majority of candidates divided their answer to **(i)** by 500 instead of multiplying. A significant number gained credit from an incorrect area of 90 in **(i)** and gave 45 000 as their answer to this question.

(b) (i) There were many candidates who correctly identified the mercury barometer. Common errors included manometer and thermometer.

(ii) Only stronger candidates identified the space above the mercury as being a vacuum and very few mentioned mercury vapour. Common errors included air, gas and the atmosphere.

(iii) The vast majority of candidates gained credit with answers lower than 760 mm Hg.

Question 5

(a) (i) The majority of candidates gained credit for answers that stated that the supply is limited/will run out. The most common misconception was that they could not be re-used or used only once.

(ii) This question proved challenging for many candidates, with only stronger candidates identifying nuclear and oil as non-renewable. Fewer candidates realised that nuclear is non-renewable. Presumably these candidates thought that only fossil fuels are non-renewable.

(b) Stronger candidates answered this question well but many candidates gained at least partial credit. There was some lack of precision in answers with vague and sometimes irrelevant suggestions. Common answers which were not accepted included “cheap” or “pollution” without further explanation. “Renewable” as an advantage together with “non-renewable” as a disadvantage was occasionally seen.

Question 6

(a) Only the strongest candidates answered this question correctly by identifying the fixed points as 100 °C and 0 °C and of these candidates, only a small number went on to work out a temperature between 34 °C and 38 °C.

(b) (i) The majority of candidates gained credit for answers that stated that the process was melting, and they usually went on to give a creditworthy description of molecular arrangement/movement.

(ii) The majority of candidates gained at least partial credit for their explanations but many stated that the process involved was evaporation and not boiling.

Question 7

(a) Many candidates answered fully correctly and almost all candidates scored at least partial credit. Some strange choices such as X-rays for binoculars and gamma rays for sun-beds showed that this section of the specification was not well understood by many candidates.

(b) (i) The majority of candidates gave correct answers from either infra-red, microwaves or radio waves. Common errors included gamma rays and ultra-violet.

(ii) Many candidates correctly identified the property as speed, but common errors included amplitude and frequency.

Question 8

(a) (i) Most candidates answered this question correctly. Weaker candidates chose protons instead of electrons.

(ii) The majority of candidates gave a correct answer of ”negative” but a significant number thought there was a positive charge on the rod.

(iii) Most candidates gained credit by explaining that like charges repel (one another), but many incorrectly stated that like poles repel (one another).

(b) (i) (ii) The vast majority of candidates gave a correct answer of copper to **(i)** and this was usually followed up with a sensible reason in **(ii)** for using copper for an earth connection.

Question 9

(a) Most candidates answered this question correctly.

(b) This calculation was done well by most candidates, with almost all arriving at a correct solution of 12 Ω. A small number started with the correct equation of $V = I \times R$ but somehow managed to rearrange this so that they divided 0.5 by 6.0 rather than 6.0 ÷ 0.5 but these were very much in the minority. Almost all candidates gave the correct unit of ohms for their answer.

(c) The vast majority of candidates gained credit for stating that one lamp could fail without the other doing so. However, few candidates gained full credit. Candidates tended to answer in terms of equal voltage/current/brightness rather than considering optimum voltage/brightness. The few who stated that the lamps would be brighter rarely compared this to what they would have been in series.

Question 10

(a) The majority of candidates gave the correct name for the device but a very common error was to give thermostat.

(b) (i) (ii) (iii) Only the strongest candidates answered this question correctly. Few candidates understood how a potentiometer worked and that the connection to **A** represented very low voltage. Many candidates were able to gain partial credit by stating how the brightness of the lamp changed with the different settings of the potentiometer. Weaker candidates attempted to explain these differences in brightness in terms of the distance the current had to travel or how far the slider was from the positive/negative terminal of the battery.

Question 11

(a) Almost all candidates answered correctly.

(b) (i) The majority of candidates gave good descriptions of an acceptable method for generating an e.m.f. Common errors included having electrical connections to the magnet and including a power supply to their circuit.

(ii) Most candidates gave two of the three possible responses and so gained full credit for this question. Common errors included vague responses such as “use a bigger magnet”, or incorrect responses such as “more current” or “bigger battery”.

(c) Only the strongest candidates realised that the generator generated alternating current. Of these, a great number incorrectly described the current as alternative rather than alternating.

Question 12

(a) Most candidates gained at least partial credit for this question. Full credit was often not awarded as candidates stated that the charge on the nucleus of an atom is neutral rather than positive.

(b) (i) (ii) (iii) Almost all candidates gained partial credit for this question. Common errors included 138 for the number of protons and 226 for the number of neutrons.

(c) Many candidates found this question challenging. The topic of half-life was not well understood. Very few candidates attempted to determine the number of half-lives that had passed during the decay of Radium-226 from its original mass of 8.0 mg to its final mass of 1.0 mg.

PHYSICS

Paper 0972/41
Extended Theory

Key messages

- When a question is answered, particular attention must be paid to the exact instruction given on the paper. Where an explanation is asked for, a straightforward statement of what is happening will not be awarded full credit. Similarly, a question that includes a phrase such as “in terms of molecules” should generate an answer that clearly refers to molecules.
- Calculations are best approached by writing the appropriate equation, rearranging it if necessary and then substituting the numbers supplied.
- Numerical answers should be stated to at least two significant figures and where appropriate the correct unit must be used with it. Candidates are reminded to include units in these responses as appropriate.
- Candidates should be aware that they will be required to apply their knowledge of physics to unfamiliar situations in questions.

General comments

There were many strong performances this year but often candidates did not read the questions carefully enough and wrote known standard facts when, in fact, the question required the application of these facts. Candidates generally had a sufficient control of English in answering questions and there was no evidence that candidates were unable to complete the paper due to a lack of time.

Comments on specific questions

Question 1

(a) Many candidates supplied a correct definition of acceleration but less precise comments such as “this is when the velocity is increasing” were not accepted and in some cases contradicted a correct answer already supplied.

(b) Stronger candidates produced convincing answers but others simply copied the graph from **Fig 1.1**. Some good graphs were spoiled by a line which passed through the origin with a gradient that was clearly greater than zero.

(c) (i) Many candidates had some understanding of the principle of conservation of momentum but in some answers, the discussion was only about energy.

(ii) Only the strongest candidates answered this question correctly and gave a simple explanation of the application of the principle in this context.

Question 2

(a) This calculation was very often correct and almost all candidates were awarded full credit. However, occasionally the mass was quoted or the wrong unit used with the answer.

(b) (i) There were many good answers here. Even when full credit was not awarded, many candidates gained some credit for an answer such as 34 000 × 1.8 which revealed some understanding of the term, moment.

(ii) 1 Whilst some answers were clear and direct, some others were too vague. A common misunderstanding was that the centre of mass is at the centre of an object.

2 Candidates who were not awarded full credit for this part often approached the question in one of two ways. Either the moment from **(b)(i)** was divided by 0.70 or some attempt was made to divide a number from the question by 10 (N/kg).

(c) A significant number of candidates gave an answer that explained why the sign and support rotated when the concrete post was removed. However, this was not what was asked and only a small number of answers were awarded full credit.

Question 3

(a) There were many good answers here and although some candidates did not mention momentum, many candidates used the term correctly in this context. Although the force referred to acts on the face of the cube, there were candidates who described how a force was generated elsewhere.

(b) (i) This was well answered and most candidates gave the correct answer with the correct unit. A small number of candidates did not use a value for the gravitational field strength when calculating the answer.

(ii) Although full credit was often awarded, a number of candidates did not use the area of the base of the cube when calculating the force. Areas such as 0.028 × 0.040 (m^2) or even simply 0.040 (m^2) were not unusual in the calculation.

(c) (i) There were many good answers here but a significant number of calculations used a distance of 0.028 (m) rather than 0.034 (m).

(ii) Only the strongest candidates were able to suggest a cause of the inefficiency.

Question 4

(a) (i) This was well answered with many answers awarded full credit.

(ii) 1 This was also well answered. A few candidates used an equation such as $E = P / t$ and obtained an incorrect answer.

2 This question led to some well-presented answers but also to answers that were too general. An answer such as “heat is lost” could be applied to many situations and was too vague. Stronger candidates clearly considered the situation described and stated where the thermal energy ended up.

(b) (i) The strongest answers were clear and straightforward. Other candidates used terms which were harder to interpret. “The piston moves upwards” was not clear enough and was not awarded credit. An explanation was asked for and the clearest answers were the most direct and simple.

(ii) Many candidates used the correct equation but more candidates made incorrect substitutions than made the correct one.

Question 5

(a) (i) There were strong answers here and many candidates were familiar with this part of the course. Candidates should be advised to supply only the number of answers requested. Extra answers can contradict answers already supplied and cannot lead to more credit being awarded.

(ii) Many candidates had a good understanding of what was happening and were awarded at least partial credit but few candidates gave answers that matched the mark allocation and which were sufficiently detailed.

(b) Many candidates referred to the spacing of the molecules in a liquid but fewer referred to the intermolecular forces. The attractive forces are not relevant in impeding the compression of liquids.

Question 6

(a) Candidates who drew on **Fig.6.1** were often awarded partial credit. Those who relied purely on written explanations tended to produce less convincing answers but a few written answers were awarded full credit.

(b) (i) This was often completely correct.

(ii) This question was best approached in two stages and most of the candidates who gained full credit set out their answers clearly and calculated an intermediate answer before moving on to the second part. Some candidates reached the end of the first stage and gave this as the final answer.

Question 7

(a) Component X was correctly identified very commonly but a few candidates gave the answer "variable resistor".

(b) In these two parts, equations were asked for and so answers that were not equations were unlikely to gain any credit. A frequent answer to **(ii)** was the incorrect $E = V_X + V_{30} + V_{20}$.

(c) There were many good answers to these two parts. In **(i)**, almost all candidates used the equation for resistors in parallel correctly and only occasionally was the final reciprocal ignored.

(d) Most candidates knew what was happening but some stated that the resistance of the thermistor increased as the temperature increased. Where full credit was not awarded, usually the effect on the resistance of the thermistor was stated, but how this affected the resistance of the complete circuit and hence the current and the ammeter reading was not.

Question 8

(a) (i) There were many good answers here with full credit often awarded.

(ii) This was less well answered and some answers described the position of the coil in ways that were not clear. Few candidates referred to the rate of cutting magnetic flux and simply stated that more flux was cut where the output voltage is a maximum.

(b) Only the strongest candidates answered this question correctly.

Question 9

(a) (i) Many candidates realised that this was a consequence of the very small volume of the nucleus and gave an appropriate statement of the fact. However, how this led to the observation described was generally less well explained.

(ii) There were some good answers here but some candidates just reworded the answer already given in **(i)**.

(iii) There were again a few good answers but few candidates used the word "nucleus".

(b) A few candidates gave two apposite and separate differences here but a common approach was to describe either the ionisation properties or the penetration properties of these particles.

PHYSICS

Paper 0972/42
Extended Theory

Key messages

- It is essential that candidates show their working and write down the equations.
- Sometimes candidates appeared to have learnt facts by rote without the supporting understanding of the physics. This was particularly noticeable in **Questions 8(a)**, **9(a)** and **9(b)**, which were standard situations.
- All but the very strongest candidates would benefit from more practice in applying their knowledge in unfamiliar situations. This would deepen candidates' understanding and improve their performance in the examination. Many candidates, when asked to apply their knowledge to a new situation were unable to do this. This was most evident in responses to **Questions 7(a)** and **(b)**.

General comments

Most candidates were well prepared for this paper. Equations were generally well known but the use of equations and the quantities represented were not always understood. There were frequent examples where candidates substituted numbers from the question in the wrong place in equations. This applied particularly to **Questions 3(c)** and **5(b)(i)** where candidates needed to remember and apply two equations correctly.

Unless otherwise stated it is expected that candidates should round their final answer to 2 significant figures. However, intermediate values should not be rounded or truncated as this frequently leads to an inaccurate final answer. This is most likely to happen in multi-stage calculations such as **3(c)** and **5(b)(i)** where some candidates rounded more than one intermediate value which led to considerable inaccuracy. Many candidates also did this in **Question 1(b)**, rounding the time calculated in hours sometimes to 1 significant figure.

Generally candidates followed the instructions in the questions. However, candidates must not give more than one answer to a question or choose an answer that might cover two situations. Similarly, candidates in nearly all situations must commit to an answer. Saying, for example, in **Question 10(b)** that the temperature of the lamp might increase was insufficient, as was saying in **Question 4(a)** there might be more collisions with the walls. Similarly as mentioned in **Question 6(a)(i)** words like defraction or reflaction did not gain credit.

Often candidates did not read the questions carefully enough and wrote known standard facts when, in fact, the question required the application of these facts.

The use of units by most candidates was good.

Overall the English language ability of the vast majority was adequate for the demands of this paper. However, on this paper there were specific situations e.g. **Questions 8(a)**, **9(a)** and **9(b)(i)** where some candidates found it challenging to write answers in English.

Comments on specific questions

Question 1

(a) There were mixed responses to the question. Most candidates answered that section BC represented moving forward at constant speed. Fewer candidates realised that the decreasing gradient of section AB represented decreasing acceleration and that the constant gradient of section CD represented constant acceleration.

(b) Most candidates used the distance, speed, time equation but many weaker candidates failed to convert the time into units consistent with the speed in km/h. This question caused quite a few issues with rounding errors. Many candidates rounded 2/60 to 1 significant figure before evaluating the distance, which meant that the final answer was inaccurate. Candidates should leave fractions or other values unrounded until the final answer at the end of a question to avoid this problem.

(c) This was generally well answered, especially the first section requiring a horizontal line from D for 1 minute. Many candidates found it harder to answer the next section correctly failing to draw a line of constant gradient for 30 seconds.

Question 2

(a) (b) This was answered well. Those candidates who had problems usually failed to spot the link in **(b)** to **(a)** using the impulse equation. Instead they often attempted to use F = ma, often unclear about whether it was applied to the model or the water. This is an invalid method as there is no information that leads to determining any acceleration.

(c) Candidates struggled with the explanation for this question, even if the statement was correct. Answers were often too vague and did not refer correctly to force or acceleration.

(d) Of those candidates who made the correct statement, most went on to explain that the mass had become less but credit was not given for stating that the weight was less. Only the very strongest candidates then went on to link the reduction of mass to the increase of acceleration using F = ma, Newton's 2nd Law or the change of momentum. A significant number of candidates thought that there was a change in the reaction force from the jet of water.

Question 3

(a) This question was generally well answered.

(b) (i) This question was usually fairly well answered but a more specific answer than "less pollution" was required to gain credit e.g. "less carbon dioxide produced" or "no greenhouse gases produced".

(ii) While stronger candidates answered this question well, some weaker candidates did not read the question carefully enough.

(c) A significant number of students failed to recognise that they needed to multiply the input power by the area, which led to the incorrect answer of 83%. The layout of working for many candidates was clear and organised. However, there were many others who did not write down the equations they were using, which led to confusion on their part and the loss of possible partial credit for their working out. Many candidates rounded or truncated their intermediate answers which led to an inaccurate final answer.

Question 4

(a) Nearly all candidates correctly stated that the pressure increased. Most candidates gained credit for stating that the molecules hit the walls more often but few gained full credit for completing their explanation e.g. by stating that there was a greater force or rate of change of momentum per unit area of the walls.

(b) This was generally very well answered.

Question 5

(a) Both parts of this question were generally very well answered.

(b) (i) This was another multi-stage calculation which was well answered by stronger and mid-range candidates. Again, those candidates who wrote out the two equations and set out their work systematically were most likely to gain full credit.

(ii) This was generally well answered.

Question 6

(a) (i) The majority of candidates gained credit for stating "refraction". A few gave incorrect answers like "defraction" or "reflaction" which gained no credit.

(ii) This was less well answered with only stronger candidates stating that the waves moved faster in region B. Vague or inadequate reasons such as "a change in density" or "a change in speed" or "a change in refractive index" were common responses.

(b) Most candidates gained credit on this question. Many stronger candidates drew really accurate and careful diagrams of waves with half the amplitude and greater frequency.

(c) (i) Many candidates gained credit for stating that sound travelled faster in a solid than a gas. But a few tried to compare the speeds of sound and light, which was irrelevant and gained no credit.

(ii) This calculation was successfully carried out by most candidates. However, there were a significant number of unit errors including quite a few candidates who wrote λ as the unit.

Question 7

(a) (b) Many candidates read the question and answered it carefully gaining most or all of the credit. However, many candidates drew vaguely converging rays which were often the same for the two different lenses of **(a)** and **(b).** Stronger candidates realised that rays from the lens in **(a)** converge on the screen but the rays of the thinner lens in **(b)** converge less, meeting behind the screen.

(c) (i) (ii) Many stronger candidates gave clear, accurate answers gaining full credit. Other candidates gave vague answers referring to images being to the right or left or in front and behind, which without clarification, were meaningless and gained no credit.

(iii) This was generally well answered with most candidates stating one of the three properties and stronger candidates gaining full credit for stating all three properties.

Question 8

(a) Most candidates gained credit for suggesting bringing the rod close to the sphere and earthing the sphere. However, weaker candidates did not make the order in which the rod and the earth wire were removed clear.

(b) This was generally well answered.

(c) Although most candidates knew the values for the NAND gate truth table, many put no column headings or did not explain what their headings meant. A and B without explanation are not necessarily inputs.

(d) There was a range in quality of answers to this question but most stronger candidates gained full credit.

Question 9

(a) Most candidates realised that the a.c. should be connected to the coil and the magnet inserted in the coil. A significant number of weaker candidates thought that the a.c. should be passed through the magnet. Far fewer candidates gained full credit for also stating that the magnet should be removed from the coil with the a.c. still switched on, or that the current should be reduced to zero.

(b) (i) Stronger candidates answered this question well. Many other candidates thought the commutator stopped wires getting tangled. Some referred to it keeping current in the same direction. Others referred to the gap momentarily stopping the flow of current but did not recognise the significance of it reversing the current through the coil. Some candidates thought the question was about electromagnetic induction and talked about cutting magnetic fields.

(ii) This question was generally well answered.

Question 10

(a) The equation for calculating total resistance in parallel caused candidates some problems. Some were unable to gain credit because they wrote: $1/R_1 + 1/R_2$, which failed to show that the answer required inverting. Sometimes the equation was written down correctly but a significant proportion of candidates failed to carry out the inversion required to obtain the parallel resistance. Others wrote $1/R_p = 1/R_1 + 1/R_2 + 1/R_3$ which does not apply in this particular question. A significant number of candidates also struggled with adding the two fractions together even with the benefit of a calculator.

(b) Only stronger candidates realised that the resistance of the lamp would increase and few of them related that to a temperature increase.

Question 11

(a) This was well answered by stronger candidates who gained full credit. Common errors by weaker candidates were to use neutron numbers in place of nucleon numbers or to get the numbers the wrong way up.

(b) Most candidates realised that there were 2 half-lives and calculated the correct final answer.

PHYSICS

Paper 0972/51
Practical Test

Key messages

- Candidates need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability and control of variables.
- Candidates should be aware that as this paper tests an understanding of experimental work, explanations and justifications need to be based on practical rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.
- Candidates should be ready to apply their practical knowledge to different situations. Questions should be read carefully to ensure that they are answered appropriately.

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 IGCSE 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.

The practical nature of the examination should be considered when explanations, justifications or suggested changes are required, for example in Questions **1(e)**, **2(d)** and **3(e)**.

It is expected that numerical answers will be expressed to a number of significant figures which is appropriate to the data given in the question or a measurement carried out by the candidate.

Comments on specific questions

Question 1

(a) The majority of candidates successfully recorded the *a* and *b* values. A few appeared to have misread the rule.

(b) Most candidates labelled the graph axes correctly and drew them the right way round, choosing a suitable scale. Some candidates ignored the advice that they did not need to begin the axes at the origin and chose a scale that resulted in the plots occupying too little of the graph grid. Plotting was generally accurate. Candidates should use neat crosses for the plots, or neatly circled dots so that the accuracy of the plotting can be read clearly. Many candidates drew a well-judged straight line but some drew a 'dot-to-dot' line whilst others drew a straight line that did not match the plots, usually by forcing the line to go through the origin or false origin.

(c) Here candidates needed to clearly show the triangle method on the graph. Many candidates achieved this.

(d) The value of *W* was generally correctly calculated and given to 2 or 3 significant figures.

(e) Candidates were expected to record an aspect of the experiment that proved difficult in practice. Many sensibly chose to comment on the difficulty of achieving balance or the problem of the loads obscuring the reading on the rule.

(f) Here candidates gained credit for obtaining a value for *W* by experiment that matched the value of mass to within the allowed tolerance.

Question 2

(a) (i) Most candidates recorded the current to at least 2 decimal places.

(ii) Most candidates recorded the potential difference values in the table to at least 1 decimal place and increasing with the length of resistance wire. V/l values were expected to be correct and given to a consistent 2 significant figures or consistent 3 significant figures.

(b) (i) and **(ii)** Here candidates were required to make a judgement based on their own results. The justification needed to be clear and consistent with the results to gain credit.

(c) Many candidates used the correct information from their results, calculated *R* successfully and gave the result to 2 or 3 significant figures with the unit Ω. Credit was available for significant figures and unit if the calculation was incorrect. Some candidates used the wrong information, for example using the 100 (cm) in place of the value of *V* at 100 cm.

(d) Many candidates answered this correctly. However, a variety of impractical suggestions was seen which could not be credited.

Question 3

(a) Most candidates recorded a realistic value for room temperature with the correct unit, °C.

(b) and **(c)** Many well completed tables were seen with the expected pattern of results. Some candidates recorded room temperature at time $t = 0$ in place of the initial hot water temperature. A consistent use of significant figures was expected for the temperature readings.

(d) (i) Here candidates were required to make a judgement based on their own results.

(ii) The justification needed to be clear and consistent with the results to gain credit. Readings, or differences in readings over the full time, needed to be quoted in order to obtain full credit.

(e) Stronger candidates were able to analyse the question well and gave relevant answers concentrating on providing a shiny can and a black-painted beaker. However, some candidates gave answers that were not appropriate for the question as it had been set. This usually resulted in candidates suggesting precautions rather than identifying changes.

Question 4

Many candidates coped well with the challenge of this planning question. Those who followed the guidance in the question were able to write concisely and addressed all the necessary points. Many candidates explained a relevant experiment, but some described an investigation that involved timing rather than simply reading the force required. This arose when candidates did not suggest a forcemeter as the additional apparatus required. A significant number of candidates copied the list of apparatus given in the question without suggesting any additional apparatus.

Candidates were expected to briefly describe pulling the box up the slope using a forcemeter (or a pulley and weights mechanism) recording the distance moved and the force.

Many candidates realised that the angle of the slope should be kept constant. Fewer candidates identified the distance moved as a constant.

The table needed to include columns for mass and force with appropriate units.

Candidates were expected to explain how to reach a conclusion from their readings. The most straightforward response was to suggest a graph of mass against work done. Candidates should be aware that this is not the equivalent of making a prediction about expected results.

PHYSICS

Paper 0972/61
Alternative to Practical

Key messages

- Candidates need to have a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability and control of variables.
- Candidates should be aware that as this paper tests an understanding of experimental work, explanations need to be based on data from the question and practical rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.
- Candidates should be ready to apply their practical knowledge to unusual situations. Questions should be read carefully to ensure that they are answered appropriately.

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 IGCSE 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 doing experiments. However, there are parts of this examination in which 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 experience of similar practical work. Some candidates gave responses that were not appropriate to the questions as they had been set.

The practical nature of the examination should be kept in mind when explanations, justifications or further developments are asked for. For example, see **Questions 1(d)**, **2(e)**, **3(c)** and **3(d)**.

It is expected that numerical answers will be expressed to a number of significant figures which is appropriate to the data given in the question or a measurement carried out by the candidate.

Comments on specific questions

Question 1

(a) Most candidates labelled the graph axes correctly and drew them the right way round, choosing a suitable scale. Some candidates ignored the advice that they did not need to begin the axes at the origin and chose a scale that resulted in the plots occupying too little of the graph grid. Plotting was generally accurate. Candidates should use neat crosses for the plots, or neatly circled dots so that the accuracy of the plotting can be read clearly. Many candidates drew a well-judged straight line but some drew a 'dot-to-dot' line whilst others drew a straight line that did not match the plots, usually by forcing the line to go through the origin or false origin.

(b) Here candidates needed to clearly show the triangle method on the graph, with a large triangle using at least half the distance between the extreme plots. Many candidates achieved this.

(c) The value of W_1 was expected to be correctly calculated and given to 2 or 3 significant figures with the unit N.

(d) Candidates were expected to use their experience of practical work to record an aspect of the experiment that proved difficult in practice. Many sensibly chose to comment on the difficulty of achieving balance or the problem of the loads obscuring the reading on the rule.

(e) Here candidates were expected to record 113 g.

(f) (i) Few candidates successfully converted from kg to g to obtain the answer 1.13 N.

(ii) Here candidates were effectively asked to explain their understanding of "within the limits of experimental accuracy". Credit was awarded for a sensible explanation that matched their own values of W_1 and W_2.

Question 2

(a) Most candidates recorded the current to at least 2 decimal places.

(b) V/I values were expected to be correct and given to a consistent 2 significant figures or consistent 3 significant figures. A significant number of candidates did not complete the column heading.

(c) (i) and **(ii)** Here candidates were required to make a judgement based on their own results. The justification needed to be clear and consistent with the results to gain credit.

(d) Most candidates used the correct information from the table, calculated R successfully and gave the result to 2 or 3 significant figures with the unit Ω. Credit was available for significant figures and unit if the calculation was incorrect. Some candidates used the wrong information, for example using the 100 (cm) in place of the value of V at 100 cm.

(e) Many candidates answered this correctly. However, a variety of impractical suggestions were seen which could not be credited.

(f) Many candidates drew the correct symbol with care. Some candidates drew the symbol for a thermistor.

Question 3

(a) Most candidates correctly recorded 24 (°C).

(b) (i) Most candidates gave the correct units, s and °C.

(ii) Here candidates were required to make a judgement based on the readings in the table.

(iii) The justification needed to be clear. Initial and final readings, or differences in those readings, needed to be quoted and the small difference noted in order to obtain full credit.

(c) (i) Stronger candidates were able to analyse the question well and gave relevant answers concentrating on providing a shiny can and a black-painted beaker. However, some candidates gave answers that were not appropriate for the question as it had been set. This usually resulted in candidates suggesting precautions rather than identifying changes.

(ii) Many candidates made sensible suggestions here.

(d) Candidates were expected to suggest a relevant practical precaution here. Many chose to refer to perpendicular viewing of the thermometer scale.

Question 4

Many candidates coped well with the challenge of this planning question. Those who followed the guidance in the question were able to write concisely and addressed all the necessary points. Many candidates explained a relevant experiment, but some described an investigation that involved timing rather than simply reading the force required. This arose when candidates did not suggest a forcemeter as the additional apparatus required. A significant number of candidates copied the list of apparatus given in the question without suggesting any additional apparatus.

Candidates were expected to briefly describe pulling the box up the slope using a forcemeter (or a pulley and weights mechanism) and recording the distance moved and the force.

Many candidates realised that the angle of the slope should be kept constant. Fewer candidates identified the distance moved as a constant.

The table needed to include columns for mass and force with appropriate units.

Candidates were expected to explain how to reach a conclusion from their readings. The most straightforward response was to suggest a graph of mass against work done. Candidates should be aware that this is not the equivalent of making a prediction about expected results.

PHYSICS

Paper 0972/62
Alternative to Practical

Key messages

To perform well in this examination, candidates need to have a thorough grounding in practical work during the course. Candidates should have as much personal experience of carrying out experiments themselves as possible. The practical work should include reflection upon, and the discussion of the significance of results, precautions taken to improve reliability and control of variables.

Candidates should be advised to read the questions through very carefully to ensure that they are answering the question as written, and not simply recalling the answer to a different question.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques. These include:

- handling practical apparatus and making accurate measurements
- tabulating readings
- graph plotting and interpretation
- manipulating data to obtain results
- drawing conclusions
- understanding the concept of results being equal to within the limits of experimental accuracy
- dealing with possible sources of inaccuracy
- control of variables
- choosing the most effective way to use the equipment provided.

The majority of candidates were well prepared and the range of practical skills being tested proved to be accessible. Most candidates demonstrated that they were able to draw upon their own personal practical experience to answer the questions. No parts of any question proved to be inaccessible to candidates and there was no evidence of candidates running short of time. The majority of candidates were able to follow instructions correctly, record measurements clearly and perform calculations accurately and correctly. Units were well known and were invariably included. Writing was legible and ideas were expressed logically. However, candidates seemed less able to derive conclusions from given experimental data and justify them.

The vast majority of candidates finished the paper and there were few candidates who left a substantial number of questions blank. There were some candidates who showed an exemplary understanding of practical skills but equally, there were those who demonstrated a lack of graph skills, poor understanding of significant figures and a lack of comprehension of good practice in carrying out experiments.

Comments on specific questions

Question 1

(a) Many candidates did not answer the question as it was asked, and wrote about the difficulties involved in achieving an exact balance of the metre rule. Only stronger candidates were able to state that if the rule was non-uniform, and its centre of mass/gravity was not in the centre, then the pivot would not be at the 50.0 cm mark at balance.

(b) Graph plotting was generally good. Candidates nearly always chose sensible horizontal and vertical scales. The instruction to start both axes at the origin was ignored by some candidates. A few candidates used scales that increased in inconvenient increments, such as 3 or 7. Choosing such scales makes the points much harder to plot and more difficult to read.

There were many excellent, carefully drawn, best-fit lines produced. However, there were some graphs where the best-fit line was forced through the origin and so did not produce a suitable line.

(c) To obtain full credit on this question, the gradient triangle needed to be clearly shown on the (straight) line and should have been at least half the length of the line, preferably more. Candidates were told in the question to clearly show on the graph how the necessary information to calculate the gradient was obtained. However, many candidates gave no indication at all on the grid.

(d) The intercept *C* on the *x*-axis of the graph was usually quoted correctly to the accepted tolerance of ± ½ of one small grid square.

(e) The width of the load P was usually measured correctly. However, some candidates did not include the unit in their answer.

(f) Most candidates were able to state whether or not their results supported the statement given. Far fewer candidates were able to give a convincing justification for their statements. The idea of experimental tolerances and whether two measured quantities are close enough to be considered equal was not well understood by the majority of candidates.

(g) Most candidates realised that the reason that the values of *a* and *b* were not accurate, was because of the difficulty in achieving a complete balance of the loaded metre rule. Other sensible, acceptable answers were that the pivot tends to slip during the experiment and that load Q obscures the scale reading of the rule, so that the reading at the centre of Q is difficult to judge.

Question 2

(a) Almost all candidates recorded the reading shown on the thermometer correctly. Where mistakes were made, the most common incorrect answers were 20.2 °C and 38 °C.

(b) The column headings in the table of results were usually completed correctly. Most candidates ticked the correct box to match the conclusion about the rates of cooling of the water in the two beakers to the readings in the tables. However, far fewer candidates were able to justify the conclusion they had chosen. Despite the question asking candidates to refer to their readings in their answers, a significant number of candidates did not do so. Readings from the table were expected in answers along with some reference to calculated temperature drops in the same time.

In questions of this type, candidates should compare the initial and final temperatures to reach a conclusion about the overall pattern of cooling. Often conclusions were made based upon isolated, random 30 s intervals during the cooling, which often did not match up with the overall trend.

(c) Many candidates found it difficult to suggest a change to the procedure carried out that would result in a decrease of the rate of cooling of the water. Acceptable answers seen were the use of insulation around the beakers, a lower starting temperature of the hot water or a higher room temperature.

(d) This was well answered with the majority of candidates providing at least one sensible precaution. Avoiding parallax errors on its own did not receive credit. Where parallax was quoted, candidates needed to state how parallax errors in reading the thermometer are avoided. A common incorrect answer was the use of the term “parallel viewing” instead of “perpendicular viewing”. A significant number of candidates incorrectly focussed on reducing heat losses, which was not appropriate here.

(e) Most candidates gave at least one control variable to make the experiment a fair test. Common correct answers seen were to use of the same volume of water and to maintain a constant room temperature. Vague answers, such as keeping the temperature of the water the same, scored no credit because the water was cooling continuously. Candidates needed to specify that it was the initial temperature of the (hot) water that needed to be kept the same.

(f) The fact that the line of sight needed to be at right angles to the scale of a measuring cylinder when taking a reading was known by the majority of candidates. The most common incorrect answer was that the line of sight should be parallel to the scale.

Question 3

(a) The reading and recording of the readings on the scales of the ammeter and voltmeter were not problematic for the majority of candidates. The voltmeter reading was occasionally incorrectly quoted to be 3.3 V.

(b) The resistance of resistor P was almost always calculated correctly.

(c) The resistance of lamp L was almost always calculated correctly.

(d) Candidates were asked to compare their values for the resistances of resistor P and resistor Q and to state whether their values indicated that both resistors had the same value of resistance. Most candidates were able to state whether or not their results supported the statement given. Far fewer candidates were able to give a convincing justification for their statements. The idea of experimental tolerances and whether two measured quantities are close enough to be considered equal was not well understood by the majority of candidates.

(e) Only stronger candidates could make a sensible suggestion as to how they could tell that the temperature of the lamp filament changed during the experiment. Few candidates made the link between the temperature of the filament and the brightness of the lamp.

(f) Most candidates were able to draw a combination of two resistors and a lamp all connected in parallel with each other. The correct position of a voltmeter to measure the potential difference across both resistors and the lamp was more demanding. Often the voltmeter was drawn connected in series with one of the components. The most common errors were connecting all three components in series or omitting one or more of the components from the circuit they had drawn.

(g) The extra component needed to vary the current in the circuit was identified correctly by most candidates as a rheostat/variable resistor. The most common incorrect answer was a diode.

Question 4

Credit was available for a labelled diagram showing the orientation of the apparatus to be used, and how it would be arranged so that the object distance *u* and the image distance v could be measured. Most candidates drew a diagram with the object, lens and screen positioned in the correct order, but the labelling of the diagram to indicate the object and image distances was not always done well. The distances were not drawn accurately because arrows drawn to indicate the object and image distances were often drawn free-hand and stopped at distances up to one centimetre short of the object, lens or screen.

Credit was also available for a brief explanation of how the investigation would be carried out. Most candidates gained at least partial credit by stating that they would measure/record the values of the object and the image distances and repeat the procedure with a lens of different thickness. Far fewer candidates gained full credit because they did not give any indication of how they would obtain a sharp or focussed image before measuring the required distances.

The measurement of the thickness of the lens was problematic for many candidates. Most ignored the two wooden blocks that were provided and stated that they would use a ruler to do so. They did not consider the practical difficulties involved with measuring the maximum thickness of a lens using a ruler. Stronger candidates realised that the lens could be placed between the blocks and the separation of the blocks could then be measured.

The table drawn by candidates to display the readings they would take frequently did not include a column for the thickness of the lens. Of those candidates who realised correctly that a three-column table with headings for *u*, *v*, and *t* was required, many failed to supply units for these quantities.