PHYSICS

Paper 5054/11
Multiple Choice

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

General Comments

The standards revealed by the candidates varied widely. Whilst some candidates produced very few correct responses, others answered all or nearly all the questions correctly. Similarly, some questions were correctly answered by a high proportion of the candidates whilst others were only answered correctly by the candidates who scored highly on the rest of the paper.

Comments on Specific Questions

Question 1 was well answered with a large majority of candidates choosing the correct option. The question was a fairly straightforward test of knowledge which was widely understood by the candidates.

Questions 9, **10**, **22** and **24** were also well answered by many candidates.

Many candidates struggled with **Question 5**, however, and only a few candidates produced the correct answer. The most popular answer, over all, was D but not for the candidates who scored highly on the rest of the paper. When a car is accelerating forwards, the friction between the tyres on the driving wheels and the road does act in the forwards direction but this is not so when a car is braking.

In **Question 12** there were two possible sources of inaccuracy. The vertical distance moved was given in centimetres but the formula $h\rho g$ requires that the numerical value of h in metres is substituted. Secondly the distance between the water levels is 40 cm (not 20 cm); it is the distance moved by each meniscus that is 20 cm. Only a small minority of candidates gave the correct answer and these were the candidates who scored highly on the rest of the paper

When energy is supplied to matter, the molecules do not expand. Commonly, however, the space between the molecules does increase in size. Consequently, in **Question 18** neither option A nor option B was correct even though option B was chosen more frequently than the correct option C.

In **Question 26**, the correct answer in amperes was only obtained when the time was given as 0.0032 s. Many candidates offered option B which was obtained when the time was left in milliseconds.

In **Question 31**, the two options C and D were almost equally popular. With a small number of the candidates who scored highly on the rest of the paper choosing the incorrect option D. The switch is placed immediately after the live terminal so that when the fuse is replaced, the switch may be open and both terminals of the fuse isolated from the live terminal.

The correct option B, in **Question 34**, was only chosen by a small minority of the candidates. The most commonly selected answer was C where the voltmeter would measure the total potential difference across both the lamp and the variable resistor. Only when the variable resistor had a resistance of zero would the potential difference across it be zero.

In **Question 38**, the most commonly selected answer was the correct one B. A significant number of candidates opted for answer C, however. One possible explanation for this is that the symbol for a relay was either not recognised or perhaps the operation of the relay was misunderstood. A small number of candidates, who scored highly elsewhere on the paper, chose option A even though the left-hand lamp is in parallel with the rest of the circuit and so not affected by what is happening in the rest of the circuit.

The candidates who performed the best on the whole paper were the candidates who performed the best on all of the questions.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

As is regularly the case, there was a considerable variation, from candidate to candidate, in the number of correct answers selected in this paper. A small number of candidates gave forty correct answers whilst at the other extreme there were candidates who chose very few correct answers or who left many answers blank. Likewise, some questions were correctly answered by almost all candidates whilst other questions proved challenging and were only correctly answered by those candidates who performed well on the paper as a whole. There were a few questions where some of the high-scoring candidates gave the same incorrect answer. Even so, in all questions, the candidates who performed best on the paper as a whole were the candidates most likely to select the correct answer.

Comments on Specific Questions

Although more candidates chose the correct answer to **Question 12** than any other answer, almost as many chose the incorrect option D. Either candidates misinterpreted the question and assumed that the piston was being inserted into the cylinder or, perhaps in some cases, there are candidates who believe that the pressure of the trapped gas is directly proportional to its volume.

The most frequently selected option in **Question 17** was the correct option C but the other three options were also commonly chosen. It is possible that some candidates believed that thermometer S had the greatest range because it was able to measure the highest temperature. Since, however, the lowest temperature it can measure is 100 °C, this is not the case.

More than half of all the candidates selected the correct answer A in **Question 21**. A small number of candidates who performed well on the rest of the paper, omitted to convert the frequency in kHz to the corresponding value in kHz. This led to the selection of option D.

Questions 28 and **29** were the most straightforward questions on the paper. The overwhelming majority of candidates gave the correct answers in these two cases. Both questions were direct factual recall of knowledge which most candidates clearly possessed.

In **Question 31**, the correct answer A was the most frequently selected, although a significant number of candidates selected answer B. A number of these candidates were candidates who on the rest of the paper produced an above-average performance.

The most commonly chosen answer to **Question 38** was the incorrect C rather than the correct B. One possible explanation for this is that the symbol for a relay was either not recognised or, perhaps, the operation of the relay was misunderstood. A small number of candidates, who scored highly elsewhere on the paper, chose option A even though the left-hand lamp is in parallel with the rest of the circuit and so not affected by what is happening in the rest of the circuit.

Question 39 tested an understanding of the concept *radioactive half-life*. The number of candidates who chose the correct option C was only slightly greater than the number who selected B and some otherwise very good candidates made this error. This probably reflects the belief that during one half-life, the mass of a radioactive sample decreases. This ignores the mass of the product of the decay which is very commonly only slightly less than that of the original radioactive substance.

The incorrect options in **Question 40** are not just incorrect deductions from the experiment. All of the incorrect options are, more generally, incorrect statements. The correct answer was the most commonly chosen but many candidates chose option B. In fact, alpha-particles are attracted by electrons not repelled.

PHYSICS

Paper 5054/21

Theory

Key Messages

- A small number of candidates write some answers in pencil before writing over the answer in ink. This often leads to the answer being less legible and, when combined with crossings out and uncertain expression, the answer can be extremely difficult to interpret.
- To gain full credit, candidates should always give units when giving the final answer to numerical questions. They should also be encouraged to give answers to an appropriate number of significant figures (usually at least two), and for this reason, fractions are not accepted.
- A carefully drawn diagram can often show what the candidate intends to convey much more accurately than just words. Whenever a diagram is asked for or suggested, it is usually worth drawing it carefully and neatly and then labelling it, so that its intention is clear.
- The number of marks shown and the amount of space provided give a guide to the length of the answer required. Sometimes, the need arises to cross out an answer to part of a question and replace it with a new answer elsewhere. If this is done, candidates should make a simple reference to the location of the new answer. Candidates must not, however, write answers on the front of the cover sheet.

General comments

The questions were accessible to all candidates and there was no section of any of the questions where a correct response was not seen.

Question 2 almost invariably produced very low scores, indicating the confusion that exists amongst candidates when describing the absorption, emission and reflection of radiant heat, and also explaining on a molecular level the variation of the pressure of a gas with temperature.

Question 10 also proved to be very demanding for candidates, with very low scores being achieved by candidates who selected this optional question because the concept of electromagnetic induction was not understood. **Questions 1 (b)** and **11 (c)** also produced only a handful of correct responses.

The standard of written English was high and there was no evidence of a language problem. The quality of expression good, even if the underlying physics was sometimes inaccurate.

Where a question calls for extended prose, candidates should take time to plan their answer, and not list everything that they know about a topic. For example in **Question 9 (c)(ii),** answers lacked structure and the reasons for the fact the aeroplane was accelerating, even though its speed was not changing were not made clear. The more able candidates expressed themselves eloquently and succinctly, confining their answers to the question asked, and were awarded full credit.

Calculations were generally performed well, except in **Question 11 (c)**, which was found difficult. Most candidates were able to quote a relevant formula, either in words or symbols and substitute correctly into it. Occasionally candidates who had performed a correct calculation lost a mark by either omitting to give a unit or by giving an incorrect unit.

A minority of candidates ignored the rubric for **Section B** and answered all three questions.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates knew how to calculate the average acceleration of the arrow, but correct answers were often spoiled by the division of the final answer by 2, because the question had asked for the average acceleration.

(ii) The average force was usually calculated correctly. Candidates who had calculated the acceleration incorrectly in **(i)**, were able to obtain full credit if the correct method was used here.

(b) This part was very poorly done, with only the better candidates being able to complete the sketch graph to show how the speed of the arrow was changing as it was being fired. Most candidates incorrectly thought that because the speed of the arrow was increasing, the acceleration of the arrow was increasing**.** Only a small minority of candidates realised that after 0.011 s, the speed of the arrow would become constant.

Question 2

(a) Only a minority of candidates realised that the outside of the freezer was painted white, so that it would be a poor absorber/good reflector of (infra-red) radiation.

(b) It was surprising to note that about half the candidature thought that the pressure of the air inside the freezer would increase as the air inside it was cooled. Better candidates were able to link the reduction in speed of the molecules with a decrease in the rate of molecular collisions with the wall of the freezer.

(c) Again, only a very small minority of candidates realised that the lid of the freezer would be more difficult to open because the external atmospheric pressure was now greater than the pressure inside the freezer.

Question 3

(a) The kinetic energy of the lorry was calculated correctly by the majority of candidates. Where marks were lost, candidates either forgot to square the velocity term, or omitted to include a unit in their answer.

(b) (i) The formula relating the work done to the braking force was well known.

(ii) Most candidates were able to use the hint given in part **(i)** to enable them to calculate the size of the braking force.

Question 4

(a) A majority of candidates realised that for the screwdriver to be in equilibrium, its centre of mass needed to be directly above the fulcrum, and marked its position on the diagram correctly.

(b) (i) Although almost all candidates were able to select and apply the equation $W = mg$ to calculate the weight of the screwdriver, a large proportion did not convert the mass from grams to kilograms before substitution into the formula.

(ii) The arrow drawn by candidates on the given diagram, to represent the weight of the screwdriver, rarely passed through the centre of mass that they had previously marked on the diagram.

(c) Most candidates were able to state at least one of the two conditions that apply when an object is in equilibrium. In some cases, the term ‘momentum’ was used instead of ‘moment’.

Question 5

(a) Only about half the candidates stated that the boiling point of a liquid is a temperature. Most candidates contented themselves by stating that the boiling point of a liquid is a point at which a liquid becomes a gas. This is not a precise enough definition to earn credit.

(b) (i) Many candidates did not describe the molecular structure of a liquid, as requested, but proceded to compare liquids with solids and gases.

(ii) Only the more able candidates were able to explain why thermal energy needs to be supplied to water as it boils. Very few candidates stated that the thermal energy is needed to increase the separation of the molecules and even fewer stated that thermal energy is needed to beak bonds/increase the potential energy of the molecules.

Question 6

(a) The term *focal length* was not well understood, with only a minority of candidates being able to give an adequate definition of this term.

(b) (i) Less than half the candidates were able to mark the two focal points on the given grid accurately. Many candidates were unable to interpret the scale on the axis and marked the focal points 2.8 cm from the optical centre of the lens, instead of 2.4 cm, as instructed.

(ii) Most candidates correctly drew an undeviated ray from the tip of the image through the optical centre of the lens. Many then had trouble drawing a second ray from the top of the image to enable the top of the object to be located.

(iii) The question was frequently misread, with candidates measuring the distance of the image of the candle to the centre of the lens, instead of the distance from the candle to the lens.

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Question 7

(a) The majority of candidates were unable to describe one difference between a compression and a rarefaction in a sound wave. Most incorrect answers stated that in a compression, the wavelength of the wave was smaller than in a rarefaction. All that was required of candidates was to state that the molecules are closer together in a compression (or that the pressure is higher).

(b) (i)(ii) Most candidates were able to state the equation relating the wavelength of a sound to its frequency, but far fewer were able to explain how the wavelength of an audible sound compared with that of an ultrasound wave. References to the frequencies of these waves were rare, despite the hint given in part **(i)**.

(c) About one half of the candidature was able to describe one use of ultrasound waves. These waves were often confused with X-rays.

Question 8

(a) (i) This part of the question produced the best responses from candidates. Most candidates selected and used the correct equation to use for the calculation, but many answers were out by a factor of 1000, because candidates neglected to convert kΩ to Ω.

(ii) Far fewer candidates were able to calculate the reading on the voltmeter. Answers far greater than the e.m.f. of the power supply were often seen, with no comment from the candidates that this could not possibly be so.

(b) Answers to this part were frequently guesses, with only the more able candidates able to back up their statement with a valid explanation.

(c) Very few candidates were able to make a sensible suggestion for a practical use of the circuit that they had just analysed.

Section B

Question 9

(a) (i) Most candidates knew the difference between a vector and a scalar quantity.

(ii) Nearly all candidates were able to name one other vector quantity and one other scalar quantity. Very occasionally, despite the instruction given, candidates named the quantities already given in the stem of the question.

(b) Completely correct answers to the problem were rare. Most candidates could make some headway and used the given scale to draw vectors representing the two given forces. Many correct parallelograms of forces were drawn, but candidates almost invariably drew in and measured the wrong diagonal to represent the resultant of the forces. Candidates who used the triangle of forces generally met with more success.

(c) (i) Less than half of the candidature gave the correct energy change, namely chemical/fuel energy to kinetic energy. Answers were spoiled by the addition of several intermediate forms of energy between the two correct ones. Many candidates thought the aeroplane's kinetic energy was increasing at the expense of its potential energy, despite being told that the plane was travelling at a constant height.

(ii) 1 Many candidates realised that the plane would reach a constant speed when the resultant force on it became zero, or that the forces were balanced. The explanation of why the forces eventually became balanced was not well known. A popular, incorrect reason frequently given was that the force of the engine would eventually become equal to the weight of the aeroplane. When resistive forces were mentioned, only a minority of candidates realised that the relevant force was air resistance, and that this force increased as the plane accelerated.

2 The concept that a resultant force towards the centre of the circular path/centripetal force is needed for constant speed in a circular path was not well known. Many candidates realised that the velocity of the plane was changing because its direction was changing, and were awarded credit. Far fewer candidates could continue the argument and explain why the plane was therefore accelerating, although its speed was constant.

Question 10

(a) (i) This straightforward question was very poorly done. Totally correct, neat diagrams of the magnetic field in and around the solenoid were very rare. Few candidates appreciated that the field inside the solenoid was uniform, and even fewer realised that outside the solenoid, the magnetic field resembled that of a bar magnet.

(ii) 1 Most candidates did not realise that the deflection of the needle of the ammeter was due to electromagnetic induction. Many were able to state that reducing the resistance of the variable resistor, increased the current in the solenoid X, but did not go on to state that this would cause the magnetic field of the solenoid to change/increase. Only a small number of the more able candidates related this to the production of an induced e.m.f. (or current) in solenoid Y.

2 Even the more able candidates found this difficult and failed to realise that when the switch was opened, the magnetic field decreased to zero and an induced current would now flow in the opposite direction to previously, and that this would produce a larger defection in the opposite direction.

(b) (i) Many candidates correctly stated that the purpose of the iron core in a transformer was to increase the strength of the magnetic field. Far fewer candidates realised that it also served to direct the magnetic flux from the primary coil into the secondary coil.

(ii) 1 Most candidates were able to choose an appropriate equation and calculate the power delivered by the transformer to the factory.

2 Candidates knew how to calculate the electrical energy received by the factory, but in at least half the attempts at this part, the time was not converted from hours into seconds before substitution into the equation $E = VIt$.

Question 11

(a) This question about identification of atoms from a table giving information about the proton and nucleon number was done well by a large proportion of the candidates.

(b) The change in the structure of the nucleus of a radioactive atom which emits a beta-particle was well understood.

(c) (i) Most candidates were able to suggest at least one major source of background radiation.

(ii) 1 The interpretation of the count rate against time graph caused problems for all but the best candidates. Few candidates realised that because the decay curve became steady at a constant value of 22 counts per minute, then this was the value of the background radiation.

2 Again, few candidates realised that the initial count rate due to the source on its own was equal to the initial count rate minus the background count rate.

3 Despite the fact that candidates had been guided through this question by the calculations set in parts **1** and **2**, correct estimations of the half life of the sample were rare.

(d) (i) Most candidates realised that enclosing the detector in lead would reduce the background count recorded. Most candidates incorrectly thought that the count rate would be reduced to zero. Only a small number of the most able candidates stated that there would still be some gamma rays in the background count.

(ii) Most answers appeared to consist of guesswork. A majority of candidates incorrectly thought that encasing the detector with lead was a sensible thing to do.

PHYSICS

Paper 5054/22
Theory

Key Messages

An examination paper such as this is designed to test a candidate's understanding of the topics outlined in the syllabus. There are, of course, various examination techniques and different approaches that may help candidates to reveal as clearly as possible their level of their understanding but the single most important preparation for the examination is the achieving of as thorough an understanding of the subject at this level as is possible.

The wording of the instruction in each question specifies the type of answer that is required and the number of marks allocated to each part is also an indication of the sort of answer that is expected. A one-mark question that is introduced with the word *State* cannot score more than one mark, no matter how detailed the answer is and no matter how much background explanation is included. Likewise, a few words making one point is unlikely to achieve full credit where more marks are indicated on the paper.

Section B consists of three questions of which only two should be answered. Candidates should be strongly advised to choose only two questions.

The answers given need to be both comprehensible and legible. Candidates should be advised to write legibly in ink and if a change or correction needs to be made, a straightforward crossing out will indicate what should be ignored. If the answer space fills up as a result, then the amendment may be written in a blank area somewhere close by. There ought to be an indication in the original answer space that there is more to read and the Examiner should be directed to it. There should be no answers, however, on the front cover.

Many candidates use the correct SI unit with a numerical answer that requires a unit and only a small number of candidates omit to do this. Candidates should show working to ensure they receive credit for demonstrating their knowledge.

General Comments

The level of attainment of different candidates varied quite widely. The answers of the candidates who scored the most highly, tended to address the point being asked for in relatively simple and direct terms.

Comments on Specific Questions

Question 1

(a) The majority of candidates knew what was meant by density and were able to produce a numerical answer with the correct unit. A relatively frequent error was to use a mass of 6500 kg rather than to calculate the actual mass of water which was 2400 kg.

(b) (i) The correct answer here was fairly uncommon, with rather more candidates suggesting gravitational potential energy or occasionally kinetic energy.

(ii) Again, it was only a minority of candidates who obtained full credit. Whilst many candidates gave one or other of the correct answers, giving both was uncommon.

(c) The formula for gravitational potential energy was well known and many candidates were able to use it appropriately and obtain full credit.

Question 2

(a) There were four different effects given by the mark scheme. Whilst a significant number of candidates were able to suggest one effect, rather fewer produced two.

(b) (i) Whilst most candidates drew a straight line from the origin to begin the graph, the second part of the line was commonly drawn with a smaller gradient or even horizontally. It was unfortunate when a candidate drew a correctly shaped graph but then omitted to indicate the location of the point P.

(ii) Some candidates realised that the spring would now be permanently deformed and longer than its original length whilst a similar number of candidates suggested that it would return to its original length when the masses were removed.

Question 3

(a) This was very frequently correct but candidates who attempted to apply the equation $P = F / A$ (which is a possible, alternative approach) rarely obtained the correct answer.

(b) (i) Some candidates realised that the difference was due to atmospheric pressure but many did not.

(ii) Most candidates used the correct formula here but a common error was to use the pressure calculated in part **(a)** rather than the value given for the pressure in the water.

(c) This was almost universally correct.

Question 4

(a) This part was usually correct.

(b) (i) This mechanism was less well known and only occasionally was full credit awarded.

(ii) This part was asking for a description and explanation of the process of convection. This was well answered and full credit was awarded often. Candidates who referred to the expansion of molecules or the reduced density of the molecules (rather than of the water) did not obtain full credit.

Question 5

(a) (i) Very few candidates realised what was being asked for here and full credit was only occasionally awarded.

(ii) This part was also awarded full credit only occasionally. Many candidates listed various features of a liquid-in-glass thermometer.

(b) (i) Many realised what was wanted but the word *temperature* was very commonly omitted.

(ii) Many candidates realised what was required here and produced a decent answer to this question.

Question 6

(a) This was commonly correct and well explained. Candidates should be aware that in this type of question, reference must be made to the frequency of the molecular collisions with the wall. The answer *There are more molecular collisions* is not sufficient for full credit.

(b) This was also well answered and well explained.

Question 7

(a) Although the angle of refraction was marked and referred to in the question, the angle of incidence had to be deduced from the size of the angle marked on the diagram. Many candidates did not notice this and used the angle given on the diagram as the angle of incidence.

(b) Many candidates were able to supply one of the two conditions needed for total internal reflection to occur and obtain full credit.

(c) The reflected ray was often drawn in an acceptable direction although a few candidates drew it at 90° to the ray in the glass.

Question 8

(a) This was a question where some candidates knew the answer straight away and obtained full credit whilst others struggled. A common source of inaccuracy was to divide the voltage by the current.

(b) (i) This part was only occasionally correct; the multiplication of the answer to **(a)** was very commonly by 30 rather than by 1800.

(ii) This part was more commonly correct. There were, however, candidates who did not use the power of the spotlight and who frequently obtained the answer *11.5 cents*.

Question 9

(a) This was often correct although when the answer was given as 12 kg, the wrong unit ensured that no credit was obtained.

(b) (i) 1. Here the correct answer was 0 and so a missing unit was ignored. An inappropriate unit did lead a few candidates astray, however.

2. This was only occasionally correct. The incorrect answer *40 m / s* was quite common.

3. Many candidates realised what was expected here and gave a suitable answer.

(ii) Only a few candidates realised that the ice is travelling at a constant speed by this point. Answers that involved the term *kinetic energy* were very common.

(c) (i) This was well answered by many candidates. A common source of inaccuracy was to omit the square symbol from either the line where the numerical substitution was made or from the calculation. Candidates who wrote down the formula first ($KE = ½mv^2$) almost always included the square term.

(ii) This part proved quite testing and whilst some candidates obtained some credit only a few obtained full credit.

(d) There were many good answers here with many candidates selecting three credit-worthy points.

Question 10

(a) (i) A significant number of candidates were able to supply a correct explanation for this part.

(ii) The two parts here were very commonly correctly answered.

(b) (i) Most candidates had some idea about what was being asked for in this part and full credit was quite frequently awarded.

(ii) The two calculations expected here were commonly understood and the correct answers were often supplied. A common source of inaccuracy was the misinterpretation of the unit (mA) for the current. Where the same misinterpretation was made in both calculations, it was still possible for nearly full credit to be awarded.

(c) (i) A fair number of candidates stated that the second current was the larger although very few indeed stated that it was twice the size of the first current. Some candidates whose statement was correct did not continue and offer an explanation.

(ii) Most candidates struggled with this part and very few answers obtained any credit.

(d) Some candidates struggled to express their answers clearly but even so there was a significant number of candidates who obtained full credit in this part.

Question 11

(a) This part was very commonly well answered with a significant number of candidates being awarded full credit. There was a minority of candidates who only described the composition of the atom and gave no indication as to its structure.

(b) (i) This was correctly answered by some candidates but there were also candidates who did not seem to understand what was expected.

(ii) This part was well-answered and full credit was very commonly awarded.

(iii) The trajectory drawn was quite commonly correct both in direction and shape. An error made by some candidates was to draw an initial section in the magnetic field that was horizontal for several centimetres.

(c) (i) This was usually well answered.

(ii) Nearly all candidates were able to suggest one source of background radiation and many suggested two appropriate sources.

(iii) Some candidates struggled to answer this part and only a minority produced the correct final answer. Candidates are not always clear as to the quantity that halves during a period one half-life. Similarly, some candidates interpreted the question to mean that only one half-life had elapsed.

PHYSICS

Paper 5054/31

Practical Test

Key Messages

As mentioned in previous examination reports the key messages, particularly for the weaker students are:

- Always give the unit of the quantity that is being measured.
- Always take measurements to the precision of the instrument that is being used, e.g. 0.1 V if a 5.0 V voltmeter is being used.
- If a question says “Determine an average value for...”, then the examiner will expect to see repeated measurements correctly averaged.
- If measurements are repeated, note down the repeated values even if they are the same as the initial value. In this way the examiner can see that measurements have been repeated.
- Always ensure that you read the question and in a question such as **Question 4**, ensure that you take measurements with all the resistance values that are quoted in the question.
- If one point lies some distance from the line of best fit, consider if you may have made a mistake either when taking measurements or when processing the results.

General Comments

Overall the standard of the paper was similar to previous years. **Question 3** was poorly answered either because candidates did not repeat readings or did not measure to the precision of the stopwatch provided or did not understand the idea of direct proportion.

Comments on Specific Questions

Section A

Question 1

(a) In the question paper the length l was shown as the unstretched length of the coil of one spring. It was clear from the answers obtained that candidates had taken a variety of measurements including:

- The total length of both springs.
- The total length of the coiled part of both springs.

Where a correct value of l was obtained, there was often only a single measurement. The question asked candidates to determine an average value for l, so examiners expected to see the two values and then an average found. Candidates should always record all measurements, even if values are the same.

(b) As a general rule l_A was correctly found to be greater than l_B but candidates did not always record values to the nearest mm or better and sometimes units were omitted.

(c) Usually the calculations of the extensions were correct as were the calculations of forces. Problems often occurred with the units, in particular, the unit of force was incorrectly given as N/cm, presumably because of confusion with the unit of *k* which was given in the question.

Question 2

In this question the apparatus spent most of the time below room temperature so it was expected that heat would be gained from the surroundings rather than lost to the surroundings. It was therefore expected that the temperature rise of the cold water would be greater than the temperature fall of the water at room temperature. The majority of candidates did not find this, although some argued successfully for a reverse argument.

(a) The majority of candidates recorded a sensible value for room temperature. When 50 cm^3 of the ice/water mixture was transferred to the measuring cylinder and its temperature measured, examiners were surprised to find that the majority of candidates obtained quite a high temperature, in the region of 15 °C. This was allowed but would not have been expected if the mixture contained ice and water and the procedure had been carried out quickly as suggested in the instructions. A reasonable value was usually obtained for the highest temperature recorded but as stated in the opening remarks, it was rare to find that the temperature rise was greater than the temperature fall.

(b) Many candidates repeated the question and simply said that it was particularly important to stir the water to obtain a uniform temperature. This does not explain why the water is stirred. Good candidates pointed out that the hot water would remain above the cold water because it was less dense and so stirring was required to mix the layers together.

(c) The majority of candidates correctly calculated the average temperature. The answer to the last part depended on the relationship between θ_H and θ_{av} as follows:

- If $\theta_H > \theta$av then this implies that the heat gained is greater than the heat lost so that heat must have been gained from the surroundings.
- If $\theta_H < \theta$av then this implies that the heat gained is less than the heat lost so that heat must have been lost to the surroundings.
- If $\theta_H = \theta$av then this implies that the heat gained is equal to the heat lost. It could be that the heat gained from the surrounding air is equal to the heat lost to the cold measuring cylinder.

There were too many answers along the lines of “heat lost to the surroundings” without any reference to the circumstances of this experiment or to the experimental results obtained.

Question 3

(a) The majority of candidates did not repeat the measurement of the time for 20 oscillations.

(b) A large number of candidates only recorded the time for 20 oscillations to the nearest second. With an analogue or digital stopwatch, examiners expect candidates to record time to 0.1 s or better.

(c) T_2 was meant to be slightly smaller than T_1. The majority of candidates pointed out this small difference. However the value of l_2 was half of l_1, this means that the quantities could not be directly proportional. For a direct proportionality T = constant × l, hence if l is reduced by ½ then T would also have to be reduced by ½, which was obviously not the case from the data obtained by the candidates.

Section B

Question 4

(a) Apart from the usual mistakes of omission of units or incorrect precision, e.g. 1 V rather than 1.0 V, the most common error in this section was confusion between the three voltages V_{AB}, V_{BC} and even V_{AC}. Where candidates obtained a voltage in the region of 3.0 V, it was clear that V_{AC} had been measured rather than one of the other two. It was even more obvious later in the question where there was no change in voltage when the values of the resistors were changed. Usually candidates calculated the correct current but sometimes omitted the unit or gave the unit as Ω.

(b) The common errors in the table of results were:

- Omission of units from the table.
- Omission of the results from **(a)** from the table.
- Not including all the resistor combinations that were asked for in the table.
- Incorrect calculation of resistor combination values, in particular the value for the 4.7 Ω and 10 Ω resistors in parallel (3.2 Ω). Many candidates left this answer as 0.31 Ω.
- Incorrect calculation of the current.
- Using another parallel combination rather than another series combination.

(c) If a good set of data had been obtained in **(b)** then graph plotting was generally good and the graph was a clear curve. On the other hand if the resistance of the parallel resistor combination had been miscalculated then there was often points that lay some distance from the best fit curve, which could leave candidates to conclude that the graph was a straight line graph with a considerable amount of scatter. Both answers were allowed in the mark scheme.

(d) The resistance of the filament lamp at V_{AB} = 1.5 V is simply defined as $1.5/I$. To obtain this resistance candidates should have read the current at 1.5 V from the graph and then done the above division. Only the best candidates did this.

PHYSICS

Paper 5054/32

Practical Test

Key Messages

As mentioned in previous examination reports the key messages, particularly for the weaker candidates are:

- Always give the unit of the quantity that is being measured.
- Always take measurements to the precision of the instrument that is being used, e.g. 0.1 V if a 5.0 V voltmeter is being used.
- When explaining precautions, the technique used should always be described, e.g. not just avoid parallax but avoid parallax by placing your eye at the level of the lower meniscus.
- When tracing the paths of rays through optical systems, in order to locate the position of the ray as accurately as possible, points marked on the ray should be as far apart as possible.
- If measurements are repeated, note down the repeated values even if they are the same as the initial value. In this way the Examiner can see that measurements have been repeated.
- If units are given on the paper, ensure that measured quantities are converted to these units before the answer is given on the answer line.

General Comments

The descriptive elements of **Question 1** seemed to cause candidates the most difficulty as well as all the possible resistor combinations in **Question 4**.

Comments on Specific Questions

Section A

Question 1

(a) (i)(ii) The majority of candidates gave the correct mass of 500 g. A slightly smaller number of candidates gave a volume in the range 150 cm^3 to 200 cm^3.

(iii) Techniques used to measure the volume varied. Examiners expected candidates to fill the measuring cylinder twice, record the reading each time and then add the two readings together to obtain the value of *V*. Good candidates described this method and showed the individual readings that they had taken. Some candidates gave a vague answer such as 'I used the measuring cylinder to measure the volume' and others gave a partial answer such as 'I measured 100 cm^3 on the side of the beaker and the remaining water in the measuring cylinder'.

(iv) Candidates have much difficulty with the idea of explaining two precautions. They recognise that parallax error should be avoided but cannot explain how this is achieved. An answer that would gain a mark would be, parallax was avoided by keeping the eye level with the lower meniscus of the water. In the same way, avoid losing water when the masses are removed is not worth a mark, but avoid losing water by shaking the masses gently above the surface of the water when they have been removed would get a mark. Another problem was candidates saying that they had repeated measurements of *V* and averaged the results but with no evidence of this in the answer to the question.

(b) (i)(ii) The majority of candidates obtained a correct value for V_0 and went on to obtain a reasonable value for the density. The mark was lost for the following reasons:

- V was used instead of V_0.
- Either no unit was given for the density or the unit given was incorrect.

Question 2

(a) The majority of candidates drew the line AX and the line L in the correct positions.

(b) Many candidates had the first reflected ray in the correct position but the points P_1 and P_2 were insufficient distance apart. For more accurate ray tracing points on the ray should be as far apart as possible. In this case Examiners expected one point to be between AX and AB and a second point to be beyond B.

(c) Not all candidates had the new position of AX correct. In some cases the new AX was drawn at an angle of 60° to the original AX rather than 60° to AB. Where the new AX was in the correct position, the new position for the reflected ray was frequently correct (parallel to the original reflected ray). The lines representing the reflected rays were not always projected backwards to meet at a point. If this construction had not been done the mark for the angle could not be scrored because the construction was required for the angle to be measured. Some candidates may have been able to work out the angle by theoretical considerations but the question required the construction and the measurement of the angle.

Question 3

(a) (i)(ii) With the apparatus provided, the values of the total mass of the mass hanger and slotted masses (m) and the mass of the half-metre rule (M) should have been approximately the same. Examiners allowed a difference of up to 20 g with the proviso that the mass hanger and slotted masses must be an integral number of 10 g. A large number of candidates had values that satisfied these conditions. However not all gained the mark because when the ratio was calculated units were quoted with the value.

(iii) A surprisingly small number of candidates could explain how it was checked that the string AB was horizontal. The usual technique here is to measure the heights of both A and B above the bench and to check that they are the same. It is also acceptable to align AB with a horizontal surface in the room such as a windowsill. Methods that involved holding a metre rule vertically and the placing a set square between it and the string AB were not allowed because of the instability of the arrangement.

(b) (i) The mark for the measurement of the lengths was often lost because of one of the following:

- Lengths were recorded to the nearest cm rather than the nearest mm.
- Units of measurement were omitted or incorrect, e.g. m rather than cm.
- The height difference $h_2 - h_1$ was not in the range 20.0 cm to 30.0 cm.
- The length l was not in the range 49.0 cm to 55.0 cm.

(ii) Because errors in the distance values were carried forward and because inclusion of units for the ratio was ignored, the calculation of R was often correct as was the measurement of the angle θ.

Section B

Question 4

This question differentiated well between candidates, with a good range of marks being scored.

(a) V_0 should have been in the range 3.0 V to 5.5 V depending on which type of power was used. V should have been 0.5 V_0. Marks were lost because:

- Values were obtained outside these ranges, possibly because voltmeters had not been read correctly.
- Voltages were recorded to insufficient precision, e.g. 5 V rather than 5.0 V.
- Units were omitted from voltage values.

(b) Omission of, or wrong, units for $1/V$ and $1/R$ was ignored in the table of results. However Examiners insisted on units for R and V. Some candidates lost the mark for calculation of $1/R$ and $1/V$ because these quantities were quoted to too few significant figures. Good candidates completed measurements for the 2.7 kΩ resistor, three series combinations of resistors and the parallel combination but weaker candidates could only complete some of these. Most completed measurements for the 2.7 kΩ resistor and one series combination. The parallel combination had often been connected correctly but candidates calculated an incorrect value for the resistance, resulting in a point that was some distance from the best fit line.

(c) Virtually all candidates lost the mark for axes labelled with units because the units of $1/V$ and $1/R$ were either omitted or incorrect, typically Volts and kΩ. Because graphs were allowed to start at the origin, the scale mark was usually awarded. If the parallel resistance had not been determined correctly, this lead to a data point that was far from the best fit line. It was then difficult to choose the position of the line unless the incorrect point was treated as anomalous. Some candidates tried to include the point so that, unfortunately, the line was in totally the wrong position, typically with a negative gradient rather than a positive gradient.

(d) Good candidates obtained a correct value for the gradient from a large triangle and went on to find a value for V_0G that was in the correct range. Weaker candidates:

- Misread the sides of the triangle used to determine the gradient.
- Used points that were not on the line of best fit.
- Used a small triangle in their determination of the gradient.
- Obtained an inaccurate value of V_0G because of poor positioning of the best fit line.

PHYSICS

Paper 5054/41
Alternative to Practical

General comments

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

- graph plotting;
- tabulation of readings;
- manipulation of data to obtain results;
- drawing conclusions;
- dealing with possible sources of error;
- control of variables.

The level of competence shown by the candidates was sound, although, as in previous years, some candidates continue to approach this paper, as they would a theory paper, and not from a practical perspective. Only a very small number of candidates failed to attempt all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Many candidates dealt well with most of the practical skills required but some had difficulty in suggesting suitable practical techniques. The better candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were well known and usually included where needed, writing was legible and ideas were expressed logically. The standard of graph plotting continues to improve.

Comments on specific questions

Question 1

(a) All candidates seemed to know that the magnet had a north and a south pole but only the more able candidates realised that the north pole was a 'north seeking' pole and so this was the one pointing to geographic north. Many candidates thought the south pole of the magnet would be attracted to the geographic north.

(b) (i) The majority of candidates gained at least one mark here by showing a magnet freely suspended in some way. Diagrams were frequently poorly drawn and so these candidates failed to gain the second mark. All that was required for the second mark was to show that the magnet needed to be suspended from its centre. This could be stated in writing or shown in a clear diagram. Some candidates drew excellent diagrams here. The second mark could also have been gained with a good practical detail, e.g. using a string stirrup, but this was rarely seen.

(ii) This question was answered poorly overall. A surprising number of candidates simply placed the magnet in water and did not appear to realise that it would sink and not float. Others suspended it with string in the water. The more able candidates placed the magnet on a material that would float to gain the mark.

(c) Only the most able candidates gained a mark here. The majority of candidates appeared to think that the magnet suspended in air would come to rest first. Those who correctly chose the magnet suspended in water were unable to give a correct explanation for their choice. The difference between air resistance and water resistance was only understood by a small number of candidates.

Question 2

(a) (i) The majority of candidates gained the mark here as they understood that the towel was shaken to remove excess water.

(ii) This was more challenging as candidates found it difficult to express their thoughts as to why a whole towel should not be used. Some realised that all the water would be absorbed at once and this was given credit. However, the desired response of a smaller range of results was rarely seen.

(iii) Again this proved challenging although many candidates did gain the mark for stating that using smaller pieces of towel would increase the time taken for the experiment. Some said that it would 'waste time' and this was not given. A number of candidates stated that smaller pieces of towel would tear apart and this was not given credit.

(b) (i) The standard of graph plotting continues to improve. Most candidates had correct, labelled axes, and had used sensible scales which maximised the use of the given grid. Points were generally accurately plotted but some lost this mark for the lack of clarity in the placing of their points or by using an oversized dot or 'blob'. The majority of candidates did draw a straight line of best fit through the points but some lost the mark by not ensuring that the line went through the majority of the points with other points evenly distributed above and below the line. Marks lost could often be avoided if candidates were to use a sharp pencil to plot their points and draw the line. There was less evidence this year of scales on the axes which were multiples of 3, 7 etc. The use of such scales, makes it difficult for the candidates to plot their points accurately, and difficult for the Examiner to check the accuracy of these plots.

(ii) The majority of candidates answered this well and gained the mark. Some candidates lost the mark for leaving their answer as a fraction or for calculating the inverse of the gradient. The answer should have been given to 2 significant figures but for those candidates where the answer was exactly 0.5(0), this was credited.

(iii) Sadly, very few candidates referred to their graph in answering this question. The point was clearly a long way from the best fit line and so was anomalous or did not fit the pattern. Most candidates talked about accuracy which gained no credit here but many did get the mark for stating that the reading was the same as for the previous volume.

(iv) To gain the mark here, the candidates needed to extrapolate the graph to show the reading for 16 small towels and this needed to be seen clearly on the graph or the mark was not awarded. Those candidates who had errors on their graph could still gain this mark if the point could be clearly seen but the mark was not given for those candidates who only used the table of results to estimate the value.

(c) Those that chose the yellow towel as being the more absorbent were unable to gain a mark here and those choosing the white towel also had to explain their choice to gain the mark. The question was discriminating with only the higher ability candidates gaining the mark.

(d) Only a small minority of candidates gained the mark. Very few candidates seemed to have grasped the idea of keeping variables the same in order to ensure that an experiment is fair or to allow a fair comparison to be made.

Question 3

(a) (i) This question required candidates to follow the instructions given and then to measure the angle between two rays of light on their diagram. The question was done well by the majority of candidates and many gained all three marks. Some marks were lost due to a poor quality diagram and the use of a sharp pencil would have improved this. Some candidates clearly did not use a protractor and estimated the angle, usually incorrectly.

(ii) The question asked how the angle was measured as accurately as possible. The majority of candidates interpreted this as asking how the protractor should be used but the accuracy was not addressed. Very few candidates understood that extending the lines or measuring the angle from both rays (i.e. repeat measurements) improved the accuracy of the measurement.

(iii) Many candidates understood that the intersection or crossing of the two rays meant that ray A formed the bottom of the image and vice versa and so they gained the mark. Some candidates stated correctly that the image was real and thus would be inverted and this was also given credit. Weaker candidates talked about lenses or mirrors which were clearly not used so no credit was given.

(b) This question was intended to discriminate and did so. The candidate first needed to follow the instruction correctly and draw two rays from A going through the pinhole at different points. This meant that there were two (or more) possible images of the same point leading to a blurred image. Only the most able candidates realised this and gained credit here.

Question 4

(a) (i) Candidates have been asked on previous papers to mark and label lengths on a diagram and so this should have been a familiar question. The performance of candidates was much better at this skill than in previous years and there were many excellent responses. However, marks are still lost by careless marking of the arrows, lines not being drawn carefully with a ruler or simply marking the wrong lines. Again, the use of a sharp pencil would be an advantage.

(ii) Candidates were expected to measure the three lengths correctly to the nearest millimetre using a ruler. Answers could be correctly given in centimetres or millimetres but they needed to be accurate and many lost marks here.

(iii) The majority of candidates could correctly substitute their values into the equation to obtain a valid answer but many lost a mark by not giving their answer to two significant figures.

(b) This was answered well with most candidates suggesting suitable measuring instruments.

PHYSICS

Paper 5054/42
Alternative to Practical

Key Messages

- Candidates should be reminded to include units when quoting the values of physical quantities. They should be encouraged to check that the unit they have provided is appropriate for the calculated or measured quantity.
- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule should be given to the nearest millimetre. If a measured length is, say, exactly 5 cm, the value should be quoted as 5.0 cm.
- Candidates often lose credit for lack of care and attention to detail when drawing or annotating diagrams. The accuracy of straight lines on diagrams could be greatly improved by using a sharp pencil and a ruler.
- Candidates should be advised to avoid using rote phrases, such as, 'to make it more accurate' or 'to avoid parallax error'. These comments need to be linked to the practical situation being considered, and candidates should state why the accuracy has improved or how parallax error was avoided.
- Candidates should be reminded that, when plotting a graph using data obtained from practical work, there will almost always be some scatter about the line of best fit. Forcing the line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.

General Comments

The level of competence shown by the candidates was sound, although, as in previous years, some candidates continue to approach this paper, as they would a theory paper, and not from a practical perspective. Only a very small number of candidates failed to attempt all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Many candidates dealt well with the range of practical skills being tested. The stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were well known and usually included where needed, writing was legible and ideas were expressed logically. The standard of graph plotting continues to improve.

Comments on Specific Questions

Question 1

(a) This question was very poorly answered by most candidates. The idea that the object needs to be distant was the main problem. Few candidates mentioned this or drew parallel rays incident on the lens. Even fewer candidates mentioned a screen on which to capture the image, so that the focal length could be measured. Many drew a standard text-book ray diagram without a screen, and some suggested measuring the dimensions of the lens using a ruler.

(b) (i) The majority of candidates marked *u* and *D* correctly, but the arrows were often not drawn accurately (although this was difficult because of the perspective of the diagram). The most common error was to mark *D* between the lens and the screen. Candidates should be reminded to draw arrows using a ruler and to be precise about the start and end of arrows.

(ii) Most candidates performed the calculation to find D_{av} correctly. However, many candidates either omitted units or did not round to three significant figures, as asked for in the question.

(iii) Many candidates suggested repeating the experiment or just wrote 'avoid parallax error'. The most common correct answers were a qualified description of avoiding parallax, or checking for zero error. Few mentioned other options, such as placing the lens or screen close to the ruler or using a darkened room.

(c) (ii) The graph question was done well, with most candidates scoring 3 or 4 marks. The axes were usually labelled and sensible scales were chosen. Most candidates plotted the points accurately and drew a best fit curve with a minimum through them. The most common error in plotting was the point at u = 25, because the value of D was often rounded down to 41. Candidates should be reminded that they need to plot to the nearest half square, so rounding down 41.6 to 41 will mean an error in the plot. Occasionally a best fit line was attempted through the points, despite candidates being asked to draw a smooth curve of best fit.

(iii) Most candidates read the minimum values from the graph within the range specified in the mark scheme.

(iv) This was poorly answered, although perhaps the vague instruction, for candidates to comment on their answers was not easy. In questions of this nature, if a comment on the answer is required, then one must be given to gain the mark. All that was required of candidates was to state that the results were the same allowing for experimental error. Most who gained the mark did so for stating that their results were the same or nearly the same.

Question 2

(a) Almost all candidates who gained this mark did so for explaining that the ball would move or it was difficult to judge the middle of the ball. Far fewer mentioned not squashing the ball, or that the ball was large and therefore difficult to hold.

(b) (i) The more able candidates used the method of holding the ball between two parallel planes, and many gained both marks from a diagram. The most common incorrect answers were to wrap a tape measure round the ball, stand a metre rule next to it, or deflate the ball.

(b) (ii) Many candidates gained at least one mark here. The most commonly gained marks were for repeating the measurements and calculating an average, and for avoiding parallax error in reading the ruler. Again some lost the mark for just saying 'avoid parallax error' and a common non-scoring suggestion was to enlist the help of another student. A less commonly seen correct answer gained was for not squashing the ball whilst measuring the diameter.

Question 3

(a) Candidates did not express the method they would adopt to measure the length of the laboratory well, or explain clearly that the rulers would need to be placed end to end.

(b) Many candidates omitted to say that the end of the tape needed to be fixed in place, thus losing the mark. The most common correct answers were to use a second student to hold the end of the tape, place a block on the tape or use the hook at the end. A small number of students described measuring the height of the laboratory or the distance from corner to corner, instead of the length of the laboratory.

(c) (i) The majority of candidates knew that the speed of laser light would be needed.

(ii) Less than half the candidates realised that the advantage of using visible light was that it could be seen. Common incorrect answers mentioned that infra-red would be absorbed by the wall, or that it was dangerous.

(iii) Candidates found this part very difficult. Only a minority of the most able candidates stated that the device should be placed against the wall.

(iv) The most common correct answers were that the device is expensive or needs batteries. Some candidates also correctly mentioned the laser hazard to eyes or that objects could get in the way of the line of sight.

Question 4

(a) A majority of candidates drew the circuit correctly, although diagrams were often untidy and drawn without the aid of a ruler. Common errors were to include more than one cell, despite being told to use only one cell in the rubric of the question. Many candidates drew an incorrect symbol for the resistor or connected the meters incorrectly. Some candidates included extra components such as lamps.

(b) (i) Candidates found it difficult to explain why the terminals of the ammeter are different colours, with many stating that the colours just differentiated the terminals. The best candidates mentioned that it would enable the ammeter to be connected correctly.

(ii) About half of the candidates labelled B correctly, even if they had not gained the mark in part **(a)**.

(c) (i) A surprisingly large number of candidates did not understand this question and gave various random numbers instead of multiples of 1.5 V.

(ii) Again, only about half of the candidature drew four cells in series. They connected the cells into a variety of circuits but this was ignored on the mark scheme.

(d) Only a very small number of the most able candidates gained this mark because they realised that R would not change. Many candidates thought, incorrectly, that the resistance was directly proportional to the voltage.