PHYSICS

Paper 5054/11
Multiple Choice

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

General Comments

It is clear from the results that the overwhelming majority of candidates had studied and were familiar with large sections of the syllabus. Inevitably, some candidates showed a greater understanding of the topics than others and, whilst some questions were very commonly answered correctly, there were others where only the most highly scoring candidates gave the correct answer.

The questions which proved the most accessible were **1**, **7**, **11**, **15**, **16**, **27**, **38** and **40**. It is encouraging to observe that these are questions on a wide variety of topics from several different sections of the syllabus.

In both **Questions 18** and **29**, a significant minority of candidates chose an answer that was consistent with their ignoring the SI unit suffixes (in kHz and ms respectively) that were given in the question. Such candidates need to be more familiar with meaning of SI nomenclature.

Comments on Specific Questions

Question 9

There were clearly candidates who found the Boyle Law calculation required here problematic. Ma candidates opted for **D** rather than the correct answer **A**. Perhaps this was because the numerical value o the pressure was less than the numerical value of the volume in **D**.

Question 14

This question required some thought. Most candidates realised that the matt, black surface would absorb more energy in the given time. Only a minority of these candidates, however, deduced that the black surface would also emit more energy.

Question 20

The calculation in this question was relatively straightforward. A very large number of candidates, however, calculated the angle *r* assuming that the angle marked 30° was the angle of incidence. The size of the angle of incidence was, of course, 60°.

Question 24

Although more candidates opted for the correct answer here than any other answer, there was a significant number of candidates who chose **A** which is the exact reverse of the correct order. Such candidates should be advised to read the question carefully.

Question 26

For candidates, this question proved to be the most problematic on the paper even though it tested the recall of a specific fact. The topic of magnetic screening is a small, somewhat isolated one and very few candidates chose the correct answer. Rather more candidates chose **C** or **D** where sheet X was made of iron.

Question 34

The correct answer **A** was chosen by more candidates than any other option, but fewer than half did so. The other three answers were also popular. Many of these candidates need to be more familiar with the application of the left-hand rule (or a similar rule) for the motor effect.

Question 37

The majority of candidates were aware that an electric field was required to deflect the trace vertically. There were, however, many candidates whose answer still suggested a certain confusion with the magnetic effect; as many candidates chose the incorrect option **A** as the correct **C**.

Question 39

The correct option here was the most popular. There were candidates, however, who chose **A** and who need to be aware that background radiation is always present everywhere even in the absence of laboratory radioactive sources.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

It is clear from the results that the overwhelming majority of the candidates had studied hard and were thoroughly familiar with all sections of the syllabus. There were, of course, a certain number of candidates who revealed a very much greater insight into the subject than others and, whilst a very encouragingly high proportion of the questions were frequently answered correctly, there were a few questions where the correct choice was only offered by the most highly scoring candidates.

The questions that very many of the candidates were able to answer correctly were **2**, **5**, **8**, **9**, **18**, **19**, **22** and **29**.

Comments on Specific Questions

Question 11

Whilst the majority of candidates correctly selected **C**, both **A** and **D** were chosen by a significant minority. It is possible that those candidates who chose answer **A** had not read the question carefully.

Question 12

There were clearly candidates who found the Boyle Law calculation required here problematic. Many candidates opted for **D** rather than the correct answer **A**. Perhaps this was because the numerical value of the pressure was less than the numerical value of the volume in **D**.

Question 13

This question deals with a diver who is slowing down as he moves downwards through water. The correct answer **C** was chosen by a small number of candidates. Rather more candidates chose **A** and **B** which suggest that at some point, the kinetic energy of the diver is increasing.

Question 14

This question, though fairly standard in its format, was asking for something which many candidates had not anticipated. Answer **C** was offered by only a small number of candidates. Candidates need to be advised to read all questions carefully.

Question 23

Many candidates did not take into account the fact that the unit of the frequency, given in the question, was the kilohertz. These candidates need to be more familiar with the significance of the SI unit prefixes.

Question 25

This was a relatively straightforward question which required the recall of a fairly standard fact. Few candidates suggested answers **C** or **D** but, although most candidates did give the correct answer, a significant minority opted for answer **A**. The image in a vertical mirror, of course, is neither inverted nor real.

Question 32

In this question, as in **Question 23**, the significance of the SI unit prefix in 5.0 ms was ignored by a noticeable minority of the candidates.

Question 34

This question proved to be, for many candidates, the most problematic; it is a difficult question. Many candidates realised that, when the filament of lamp L_1 breaks, the current in the circuit decreases to zero. Only a small minority, however, realised that this causes a decrease in the voltage across lamp L_2. With less voltage across L_2, the voltage across L_1 increases. Many candidates should be advised to distinguish between current and voltage more carefully.

Question 38

This potential divider is poorly understood by some candidates and a noticeable minority chose answer **B**. The resistance of the LDR decreases when light falls on it, and this must decrease the voltage across the LDR, making **A** correct.

PHYSICS

Paper 5054/21
Theory

Key Messages

- Candidates should read each question carefully and think about their answer before they start to write. They should link their answer to the specific key command words in the question, such as "explain", "state" and "define". The general meaning of such words is found in the glossary of the syllabus.

- Candidates should consider carefully the unit that they give to their final answer, looking at the calculation involved and at the data provided.

- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided. 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.

General Comments

When performing a calculation using a calculator, candidates should be advised to be particularly careful. Sometimes candidates simply press the buttons on their calculator in the order that the final line in the working out seems to suggest. There are several arithmetic operations for which this will not give the correct answer. A candidate who has produced the correct working out but does not obtain the correct answer because the wrong button has been pressed will not gain credit for the answer. Candidates should be advised to check that the calculator is in the degrees mode when calculating trigonometric functions such as the sine of an angle.

It is not uncommon for candidates to use some of the time available to write their answers first using a pencil and then to write over it in ink. This should be very strongly discouraged. It is a waste of the candidate's time which should be used more appropriately for other tasks. Furthermore, it can cause an answer to be significantly less readable by the Examiner, who cannot award credit if the response cannot be read.

Comments on Specific Questions

Section A

Question 1

(a) This very straightforward start to the paper simply involved reading a value from the graph in Fig. 1.1. This was very commonly answered correctly.

(b) Many candidates were able to explain in one way or another that the graph was straight or had a constant gradient. Some candidates used terms which were less clear and did not always gain credit. The meaning of "the graph is constant", for example, is not obviously the same as the more acceptable answers.

(c) (i) Although many candidates gave answers that showed they understood what this expression means, some referred to constant speed or velocity. Others gave the definition of acceleration and did not refer to what the word *uniform* implied. An unfortunately confusing answer which occurred from time to time used expressions such as "the increase of velocity at a constant speed". The word *rate* would have been very much clearer than *speed*.

(ii) This final part proved to be difficult. Many candidates read the force correspondin extension without any trouble and then used it in the calculation. Some candidates, h not obtain the correct force and others used an incorrect formula in order to obtain a valu acceleration. Some candidates obtained the correct numerical answer but were not clear ab unit for acceleration giving, for example, m / s or m / s^{-2}.

Question 2

(a) This was generally answered correctly.

(b) Many candidates were able to calculate the reading correctly and received full credit. Some other candidates, however, used a distance different from the 40 cm given in the question when calculating the moment caused by the 4.0 N weight.

(c) A large number of candidates found this calculation extremely problematic. Only the most highly scoring candidates on the paper as a whole were able to gain both marks here. Candidates might be advised to consider the equilibrium of the rule in terms of the forces acting in addition to the effect of the moments acting.

Question 3

(a) The better candidates who thought carefully about the different pressures within the mercury scored this mark quite frequently, but many candidates suggested the more obvious but erroneous Q and R.

(b) This was very frequently well answered. Many candidates obtained the right answer. The most common error, however, was to divide by 0.76 m in order to find the value.

(c) Most candidates were able to state, in one way or another, what would happen and many attributed this effect to the lower density of water.

Question 4

(a) (i) Although this was very frequently answered correctly, there were also candidates who gave the reading of the thermometer or attempted to define the meaning of *range* in words. It was unfortunate that some candidates who wrote the correct numerical value here omitted the unit. Such candidates may be advised that a unit is likely to be required for nearly all numerical answers.

(ii) It was clear that there were many candidates who quite possibly understood what was being asked for, but who did not score the mark. An expression such as "the numbers are uniformly separated" might just mean that they increase by a constant amount each time. Candidates needed to be making a very clear reference to the constant distance between these numbers.

(iii) This part was well answered with very many candidates scoring the mark.

(b) Many correct answers were given here, but it is probable that candidates who offered suggestions such as mass were not really certain of what was being asked for.

Question 5

(a) Many candidates were aware that the critical angle was being asked for here but there were a few who were not and these gave answers from a wide variety of named angles.

(b) (i) The correct ray was very commonly drawn, sometimes in addition to a reflected ray of some sort.

(ii) In this part, only the reflected ray was acceptable and some correct answers were spoiled by the addition of rays emerging rays from or grazing the surface. Some reflected rays seemed to have been constructed at right angles to the incident ray. In this case, this position is too far from the correct position to be credited.

(c) There were several candidates who correctly gave an equation such as $x = vt$ but who then rearranged it to give $t = v / x$ or something similar. They then obtained an incorrect answer. Such candidates should be aware that a certain level of proficiency in mathematics is essential in this subject. A common error was to use the distance 0.10 m rather than 0.05 m which is the distance from A to B.

Question 6

(a) It was very encouraging to see how many candidates were able to score both marks here. This law has been well learnt.

(b) Although there was a wide range of acceptable values from which the resistance could be calculated, many candidates quite sensibly chose the values 4.0 V and 0.20 A. Consequently the correct answer was very commonly given.

(c) (i) Most candidates attempted this part by using proportions in one way or another. This led to errors, however, and the answer 10 Ω was seen more often than the correct 40 Ω.

(ii) A line that was consistent with the value obtained in **(c)(i)** was frequently drawn by candidates. This very commonly scored both marks.

Question 7

(a) Many candidates drew a circuit diagram that included a power supply and a fixed resistor. Rather fewer included the correct symbol for a thermistor.

(b) (i) There were many candidates who gave the e.m.f. of the power supply as 4.0 V or 8.0 V and even more who halved the current given to obtain an answer of 0.009 A. There are many candidates who need to be clearer as to the distinction between current and potential difference.

(ii) This part was often well answered with many candidates writing down the correct answer with the correct unit.

(iii) This part was generally not well answered; few candidates related their answer to the maximum power rating of the thermistor. It is not clear what answers such as "the resistance increases" suggest.

Question 8

(a) This was frequently correct. Some candidates suggested copper, aluminium or some other non-magnetic material.

(b) The concept of electromagnetic induction is not widely understood and the majority of answers to this part of the question did not either mention magnetism or use the term induction. Many candidates stated erroneously that current passes through the core from the primary coil to the secondary coil. Some candidates used the term induction when describing the production of the magnetic field in the core. Whilst this is not necessarily wrong, it is unusual and probably suggests a certain confusion concerning what is happening in a transformer.

(c) The majority of candidates correctly identified the principal advantage of transmitting power at high voltage.

Section B

Question 9

(a) (i) Most candidates accurately explained what is meant by these two terms. Only the most poorly scoring candidates did not do so.

(ii) The majority of candidates scored both marks here. Of those who did not, many obtained credit for the formula but used a height of 9.0 m rather than the correct value.

(iii) Many candidates were able to work their way through to the correct numerical answer here. It is a two-stage calculation and inevitably some candidates who had written $\frac{1}{2}mv^2$ did not then square the value 0.75 in the next line of the calculation.

(iv) The correct answer was frequently given here.

(v) There were many good answers to **1.** with many candidates scoring two marks. In **2.**, h very few candidates made any reference to the electrical energy input and so this mark was s only rarely.

(b) (i) Whilst there were many good answers here, a very few candidates gave an answer which was essentially a re-statement of the question. An example is “it is an energy source that can be renewed”.

(ii) There were many good answers here with a significant number of candidates scoring two marks. Some of the less highly scoring candidates gave the erroneous fossil fuels as an example. The word “water” on its own was considered too vague to be credited.

Question 10

(a) (i) The answers given here revealed a rather widespread confusion. Very few candidates stated that the kilowatt-hour was a unit of energy. Candidates who write definitions such as “the power consumed per hour by a one kilowatt device” need to make a clearer distinction between power and energy.

(ii) This answer was very commonly correctly calculated.

(b) (i) There were also many correct answers to this part; a frequent error, however, was the use 1.5 kg rather than 1500 g; here the specific heat capacity is given in the unit J / (g °C).

(ii) This was less commonly well answered and, very frequently, candidates tried to use a temperature value here where it is not appropriate.

(iii) Although there were many correct answers here, candidates did not always describe both the arrangement and the movement of molecules as asked for by the question. Many candidates scored both marks in **2.**

(iv) This part is quite testing. A very large number of candidates stated that the kinetic energy of the molecules increases and did not score the mark.

Question 11

(a) (i) Many candidates scored all three marks here. Some candidates merely described the composition of the atom and did not make any reference to its structure.

(ii) A very large number of candidates scored both marks here.

(b) (i) Most candidates scored the first two marks in this part; this is a comparatively straightforward half-life calculation. Rather fewer gained the final mark which, though also straightforward, is not so frequently asked for. The most highly scoring candidates on the paper as a whole did tend to receive full credit.

(ii) Many candidates realised exactly what was being demanded and produced a good answer that scored the mark directly. Others were less certain and offered explanations that were not so explicit and tended to be somewhat vague.

(c) (i) Only the highest scoring candidates on the paper as a whole scored well on this question. There were many candidates who made no reference to the background count and, of those who did, only some mentioned the absence of the source when determining its value. Very few candidates described recording the count over a specific time or alternatively using a ratemeter. Most candidates did mention the positioning of aluminium in the gap, and hence many candidates scored at least this mark.

(ii) The overwhelming majority of candidates realised that the lead would absorb all the beta-particles and many of these continued and explained that this would result in protection for the teacher.

(iii) Although the penetration property of gamma-rays was very commonly referred to, [illegible] always used to answer the specific question asked.

PHYSICS

Paper 5054/22
Theory

Key Messages

- Candidates should read each question carefully and think about their answer before they start to write. They should link their answer to the specific key command words in the question, such as "explain", "state" and "define". The general meaning of such words is found in the glossary of the syllabus.

- Candidates should consider carefully the unit that they give to their final answer, looking at the calculation involved and at the data provided.

- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided. 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.

General Comments

Formulae were generally well known and it was encouraging to find candidates tackling calculations in a sensible way, giving the formula first. However, sometimes the final unit given in the answer was incorrect, for example in **Question 3(a)** where a force in N was multiplied by a distance in cm and the unit of the answer was given incorrectly as J, or in **Question 9(c)** where the mass was sometimes incorrectly given in grams rather than kilograms, even though the density used in the calculation was given in kg/m^3.

Most candidates expressed themselves in good English, but the writing of some candidates was difficult to read, making those answers difficult to follow. This was particularly so when answers were crossed out or amended with additional information. Fewer candidates wrote outside the spaces provided for them than in previous years.

A small number of candidates appeared to have some difficulty understanding what was asked of them, for example in **Question 1(a)** where the question asks candidates to explain how the Figure shows that the ball is accelerating; this was sometimes taken as just an invitation to define acceleration. In **Question 5(c)**, where candidates are asked to explain how the charges move, this was sometimes taken as an invitation just to describe the movement and not explain the cause of the movement.

All the questions were accessible, though **Question 8 OR** was less popular than **Question 8 EITHER**. The minority who answered this question were generally reasonably successful, showing some knowledge of the action and the truth table of a NOT gate. **Question 11** was the most popular of the optional questions in ***Section B***, but the other questions produced some good answers, particularly when chosen by the more able candidates.

Comments on Specific Questions

Section A

Question 1

(a) There were many correct answers where candidates suggested that the distance travelled in each second increases. Weaker candidates did not relate their answer to the diagram and gave vague answers about the velocity increasing, or did not make clear that the distance increases between each position of the ball.

(b) Comparatively few candidates scored full marks by using the correct distance and tim[e] ... candidates calculated the average speed between t = 0 and 3 s rather than between 1 s a[nd] ... gave the answer as 40 m / s rather than 40 cm / s, having misread the units on the metre rule.

(c) Many candidates recognised that air resistance increases with speed, and weight remains constant. A small number of strong candidates suggested that the weight increases slightly as the Earth is closer, and this was accepted.

(d) Many candidates were able to explain that, at constant speed, the forces are balanced. It is not true that the weight actually equals the air resistance but this was not penalised and many candidates were able to explain that there is no resultant force. Some candidates did not answer the question and gave answers that described what happens to the acceleration or speed. A comparatively common incorrect statement was that "air resistance becomes equal to speed".

Question 2

(a) The best answers explained that moment was a turning effect equal to the force multiplied by the perpendicular distance. A number of answers were confused with the concept of multiplication and stated, for example, that moment is "force into distance" without making clear that this was a multiplication rather than a division. A number of answers referred to the moment arm rather than specifying a distance. Some answers effectively defined moment as force times distance moved in the direction of the force, which is actually a definition of work done.

(b) (i) Many correct answers demonstrated application of the law of moments to an unusual situation. A number of candidates, however, merely calculated the moment rather than the force T, or incorrectly gave the unit of the force as N m.

(ii) Many answers correctly quoted Newton's third law in the form "action and reaction are equal and opposite", but they did not always apply the law to the specific situation by stating that the two forces quoted were indeed an action-reaction pair and are themselves equal and opposite.

Question 3

(a) The formula for work and power were well known, but many candidates failed to convert the distance in centimetres into metres and obtained 2700 J as a consequence. They were then able to obtain full marks in **(ii)** provided that they converted the time into seconds and included twenty extensions of the spring.

(b) (i) This calculation, involving the proportionality between force and extension, was very well done and it was unusual to find a wrong answer. Some candidates used a spring constant formula and others merely increased force and extension until they obtained the final answer. The idea of proportionality was firmly understood by the majority of candidates.

(ii) Correct answers to this question were less common. The idea of a permanent extension was not often clearly described, and the spring breaking was not accepted. Better answers suggested that the extension is greater than 10 cm or the total extension was more than 143 cm. A number of candidates incorrectly stated that there was no further extension after the limit of proportionality.

Question 4

(a) There seemed to be no fixed pattern in the responses, although the most common wrong answer was to suggest that light has the longest wavelength.

(b) (i) Although the syllabus clearly states that microwaves are used for communication with satellites, "radio waves" was the most common response.

(ii) The understanding of the action of a satellite required is quite basic, merely that the satellite transmits a signal, rather than reflecting it. Much of the information was given in the question. It is generally the case that the satellite boosts and broadcasts the signal from the station to the consumer. However it was also accepted that the signal may be sent the other way, from an outside broadcast, for example, to the TV station.

(iii) Fewer answers were correct in this section, where the idea of a greater coverage from the or the lack of obstructions was all that was required. Some candidates suggested that the were transmitted faster, even though the signal has further to go to and from the satellite, or the quality was better.

Question 5

(a) Most candidates gained both marks for this question, many simply stating that the cloth loses electrons to the rod. Other answers provided further detail about the consequences e.g. the cloth loses electrons and so has a net positive charge, but this was not necessary for full credit. A few candidates wrote about negative charges moving, rather than referring to electrons as required by the question. References to moving protons, moving positive charge or positive electrons showed a misunderstanding.

(b) Few candidates correctly defined an electric field as a region where a charge experiences a force. Many answers suggested that it was a region around a charge where effects were felt, without suggesting what those effects are, in particular that there is a force on another charge.

(c) (i) This section asks candidates to explain how the charge on the rod causes the particles to move. The majority of candidates correctly described the forces on both positive and negative particles but a number only described the force on one type of particle, usually the negative particles.

(ii) The majority of candidates drew positive charges on the water near the rod. However some candidates, often those who had only suggested that the negative particles in the water were repelled, drew only negative charges on the water near the rod. When candidates used the printed diagram to draw plus signs, they usually gained the mark available. However, several tried to draw their own diagram in the space below the question and often did not show the rod or water.

Question 6

(a) (i) Only about half of the candidates gave the correct range. There were wide-ranging responses seen to this question, showing that many had not understood how resistance can be deduced from a current-voltage graph. The correct range was 2 V – 12 V, with values close to these extreme values being acceptable.

(ii) Comparatively few candidates suggested that resistance rises because of an increase in temperature. Common answers were that "the lamp is not an ohmic conductor" or "resistance is proportional to voltage so as resistance increases the voltage increases too". These were not accepted.

(b) (i) The majority of candidates were able to explain that electric current is a flow of charge, and the best candidates gave good definitions in terms of the flow of charge per unit time.

(ii) The question was very explicit in asking candidates to use the graph in Fig. 6.1 to determine the current in the lamp. Most candidates, however, tried to calculate the current, usually finding the current in the 20 Ω resistor instead.

(iii) Most candidates earned at least one mark for a correct approach, calculating the current in the resistor and then adding it to the current in the lamp. Another successful approach was to calculate the combined resistance of the lamp and resistor. It was encouraging that many candidates were able to handle such a two stage calculation.

Question 7

(a) The circular field line was drawn by most candidates, with a large number giving the correct direction to the field. A number of candidates drew the complete field for the whole area, which was not necessary, and sometimes there was no field line that passed through or near A.

(b) Although many candidates suggested that the fields at B due to the two currents were in opposite directions, comparatively few suggested that the fields cancel at B. A common answer was that B was too far from either current. This will reduce the size of the field but not eliminate it.

(c) (i) A large number of answers correctly gave the direction of the force.

(ii) Although many candidates recognised that "wires carrying current in the same direction which gives the correct direction of the forces, this is not a good explanation as to why the occurs; the explanation required was based on the left-hand rule, for example that the curren wire Y is in a magnetic field.

Question 8

EITHER

(a) The majority of answers correctly suggested that steel was the material used in permanent magnets, although some other materials were accepted.

(b) (i) Most answers recognised that the induced e.m.f. was caused by a change in magnetic flux or that the coil cuts through magnetic lines of force or flux. However, only the best candidates successfully introduced the rate of change or speed of cutting into their arguments.

(ii) The majority of answers correctly suggested that the coil should be vertical.

OR

(a) Although only answered by a minority of candidates it was common for the NOT gate to be correctly identified. Some very weak candidates suggested that the component was a diode.

(b) The truth table was very well known.

(c) (i) It was apparent that many candidates did not recognise that the voltage across R_1 is decreasing.

(ii) There were few correct answers to this section.

Section B

Question 9

(a) The general performance on this section was encouraging, with most candidates stating that the molecules move faster or have more kinetic energy. A surprising number of candidates missed out the fact that molecules collide with the walls or liquid, although the idea of "more frequent collisions" was better expressed than sometimes in the past.

(b) (i) There were many good answers, but some just stated the values of the lower and upper fixed points and did not describe how these could be obtained. A significant number of candidates referred to boiling and freezing the liquid in the flask, which was not given as water in the question. Other answers were not specific enough when they just suggested using ice rather than melting ice or steam, rather than steam above boiling water or boiling water itself.

(ii) A large proportion of the answers successfully suggested using a tube with a finer bore to increase sensitivity. However there continues to be confusion between the sensitivity of a thermometer and the speed of action of a thermometer, as many answers incorrectly suggested using thinner glass for the walls of the flask. This does not increase sensitivity, which is the ability of the level of the liquid in the thermometer to move a large distance for a given temperature rise and not necessarily to rise quickly to the final level.

(iii) Few candidates gained both marks, as their answers were not specific enough to suggest that different distances are produced by the same temperature rise. However it was encouraging to find candidates using correct ideas about non-uniform expansion. Weak candidates referred to circular scales and other examples of non-linearity in general.

(c) (i) Most candidates correctly stated the formula involving density, mass and volume and it was encouraging to find a large number of answers where the volume was found correctly in a separate calculation. Weaker candidates did not realise that they needed to multiply the cross-sectional area by the height to find the volume. There were some unit errors and errors in the position of the decimal point. A number of candidates thought through this two-stage problem in a by using the pressure obtained in **(iii)** to work backwards to find the weight and mass.

(ii) Most candidates correctly realised that they needed to multiply their answer from **(i)** by sometimes omitted the unit or lost credit because they used a mass in grams instead of kg.

(iii) The majority of answers were correct, showing a good knowledge of the formula and the unit for pressure. Some candidates attempted complicated calculations adding atmospheric pressure, perhaps not realising that the question asks for the pressure caused by the liquid column and not the pressure at the base of the column.

(d) Only a small number of candidates successfully realised that the expansion of a liquid is smaller than the expansion of a gas. Many answers suggested, effectively, that it takes more heat to warm a liquid.

Question 10

(a) Strong candidates answered this section well, with the normal drawn at right angles to the surface. Weaker candidates drew the normal as either horizontal or vertical on the page and sometimes incorrectly marked the required angles between the rays and the surface rather than between the rays and the normal.

(b) The statement that speed or wavelength decreases is all that was required, but some candidates neglected to include wave properties and merely stated that the ray was refracted towards the normal.

(c) The formula for refractive index was well known and the calculation was well done. Some candidates were unable to rearrange the formula to make sin *r* the subject of the formula and even a few able candidates failed to give the unit for their answer.

(d) Some candidates unfortunately drew the ray of red light parallel to AB and not along it, but many answers did show the red ray correctly refracted less than the blue ray on entering the glass. Weaker candidates sometimes drew the ray freehand and obviously curving and not straight in the glass.

(e) (i) This was generally answered well, with “travelling along the normal” or “perpendicular to the surface” the most common answers. Weaker answers merely stated that “the ray is at 90°” without explaining that this was with reference to the surface of the glass.

(ii) Good candidates used technical language effectively, such as “critical angle” and “total internal reflection”, in their explanations.

(iii) The question stated that the ray of light does not leave the glass block at Q, yet many candidates drew the ray as emerging along the surface and clearly not being reflected. The majority of candidates correctly drew a reflection at Q but sometimes this ray did not continue through and finally leave the glass block.

(iv) Most answers correctly stated that the light leaves the block at Q. Very few candidates also recognised that there is still a reflected ray which moves closer to the normal, or that the refracted light shows dispersion, or that a spectrum forms.

Question 11

(a) The circuit was drawn correctly by most candidates, although some voltmeters were drawn in series with the heater. A few candidates incorrectly drew a battery containing more than one cell, which was acceptable but not when, for example, the battery had a positive plate at both ends. Many diagrams had a short circuit across the heater itself.

(b) (i) The formula for electrical power and the unit for power were amongst the best known on the paper.

(ii) Many candidates were able to convert the time into hours and the power into kW when finding the energy in kW h.

(c) (i) The simple idea that molecules escape during evaporation was well known, and bett[…] correctly described the escape of the more energetic molecules from the surfac[…] candidates failed to mention molecules, or any alternative, in their answers.

(ii) Possible changes that increase evaporation were well known, such as an increase in area, […] increase in wind speed or a decrease in humidity. Explanations of this increase in evaporatio[…] were often lacking and merely repeated, for example, that an increase in area increases evaporation, rather than describing that there are more molecules at the surface able to escape.

(iii) The differences between evaporation and boiling were very well known. A few ideas were not accepted, such as boiling is faster than evaporation or boiling requires heat and evaporation does not. Occasionally candidates only gave only half of the answer, such as “evaporation occurs at the surface”, without describing the difference between evaporation and boiling.

(d) Although there was general understanding that a hot fluid rises in convection, many of the answers described convection in the water rather than in the air. Good answers explained carefully that heat is lost by the water to the air.

PHYSICS

Paper 5054/31
Practical Test

Key Messages

- Candidates should be aware that it is important to record measurements to the correct precision. In particular, measurements from a metre rule should be given to the nearest millimetre to gain full credit. Measurements of time from a digital stopwatch should be given to 0.01 s.

- A common cause of lost credit on this paper is the omission of units, or use of inappropriate units (e.g. kg when g was intended). Candidates should be encouraged to ensure that all answers are provided with units where needed, and to check that the unit is appropriate for the measured or calculated quantity.

- If asked to determine an accurate value for a particular measurement, then the measurement should be repeated and an average should be taken. The repeat measurements should always be shown, even if they are identical to the original measurement. Time measurements are generally less accurate so at least 3 measurements should be taken.

General Comments

The main sources of difficulty on the paper seemed to be in **Question 1** and **Question 2**. Despite the fact that **Question 4** this year was about the equilibrium of a hanging mass and last year it was about the resistance of a length of wire, the skills required to process the data were very similar and hence there was little change in the spread of marks for this question compared with last year. **Question 1** was possibly a little more unfamiliar than the determination of mass last year and, despite the fact that Examiners thought that **Question 2** would be quite straightforward, it seemed to pose candidates quite a number of difficulties, which are described below.

Comments on Specific Questions

Section A

Question 1

(a) A large number of candidates did not repeat their measurements on the stack of slides and so only scored one of the two available marks. In other cases the dimensions were not recorded in mm, and in particular the height of the stack was given as 1 cm rather than 1.0 cm.

(b) Usually the mass of the stack of slides was consistent with the height of the stack and candidates obtained an acceptable value for the density. In the majority of cases both the density value and the mass value were given the correct units. Significant figures were not penalised on this question but candidates should be aware that an answer to more than 2 significant figures is not appropriate because the thickness of the stack is taken to the nearest mm.

(c) This part was possibly unfamiliar but did seem to pose candidates many problems. The question was misinterpreted by a number of candidates, who thought that they had to describe how to estimate the number of slides in the stack rather than actually find it, so a number of candidates provided no numerical answers. Those that did obtain two answers were often confused by the fact that their answers were different. It is quite reasonable for the answers to differ by a small amount because of measurement errors, particularly in the thickness of the stack. Unfortunately at this stage some candidates tried to amend their measurements to make the number of slides the same by both methods. This often resulted in the loss of a mark for the measurements. The intention of the question was to suggest to candidates that their answers might be di[illegible]t they could offer some reason for the difference when answering **(iii)**.

Question 2

(a) A significant number of candidates thought that the angle of incidence is the angle between the plane mirror and the ray of light. Approximately half the candidates lost credit for this misunderstanding.

(b) To mark the most accurate position of the ray, candidates need to choose points on the ray as far apart as possible, and this has been emphasised in previous Principal Examiner Reports for Teachers. Only a small number of candidates scored the mark for doing this. There is no reason why the reflected ray cannot be marked at a point just in front of the mirror and at the edge of the page in order to locate the position of the reflected ray as accurately as possible.

(c) The 20° rotation of the mirror was drawn correctly in most cases. It was expected that the new position of the reflected ray would be within about 10° of the line XY, and good candidates obtained a ray at this angle. For this mark angles up to about 20° from the line XY were allowed. In other cases the new position of the reflected ray did not make sense. Those candidates who effectively used an angle of incidence of 50° should have obtained a new reflected ray along XY and in many cases did. The final answer had to be in the range 36° to 44°, but also the angle had to be consistent with a correct diagram. In a number of cases, candidates knew that the answer should be 40° but this value was not obtained from a correct diagram.

Question 3

(a) Good candidates had no difficulty obtaining full credit on this question. Problems that arose with the circuit diagram included:

- Some candidates did not know the circuit symbol for a capacitor.
- The switch was sometimes drawn connected in series with the capacitor rather than in parallel with it.
- The resistor and capacitor were sometimes shown connected in parallel.

(b) Nearly all candidates obtained correct values for the potential differences. The only error that occasionally occurred here was the omission of units.

(c) The vast majority of candidates obtained a time in the correct range of 20 s to 45 s. The mistakes that occurred here included the use of 0.25 s from misreading the stopwatch and the lack of repeat readings. In some cases the times obtained by the candidates did not make sense, and possibly the capacitor had not been discharged at the start of the experiment.

Section B

Question 4

(a) There were some excellent responses to this question. The measurement of the length was usually correct with most candidates obtaining a value in the appropriate range, to mm precision and with an appropriate unit.

(b) Again length measurements were usually correct and the lengths followed the correct trend, with $p > y$ and $L < p$. Occasionally candidates gave values to the nearest cm or omitted units.

(c) Both the extension and force were usually determined correctly with the force being in the range 0.39 N to 0.59 N. Some candidates did obtain values outside the range and sometimes the incorrect unit was given for F (typically N / cm rather than N).

(d) Examiners had a table of expected values for F since it was expected that F would be ½Mg, where M was the total mass suspended from the spring. Good candidates obtained values for F that were within an acceptable range of the expected values. Weaker candidates obtained values that were outside the range but could still gain credit for a table of results with units in the headings and for a correct trend in the values of the distances.

(e) Graph plotting skills were good with many candidates getting full marks for the grap... common error was the use of a graph scale that was based on 3 cm. This loses two ma... an inappropriate choice of scale but also a mark for the plotting of the points; the Examiner... attempt to check the plotting of points on such a scale.

(f) Good candidates used a large triangle when determining the gradient of the graph, but there was a significant number who used a very small triangle. The base of the triangle chosen by such candidates can be as small as 1 cm or 2 cm in some cases. Those candidates who had good results in **(d)** often obtained a correct value for the gradient of the graph (in the range 0.0044 to 0.0054 (N / g)). Such good answers were sometimes spoilt by the use of an inappropriate number of significant figures, in particular 0.005 (N / g).

PHYSICS

Paper 5054/32
Practical Test

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(e) Graph plotting skills were good with many candidates getting full marks for the grap[illegible]t common error was the use of a graph scale that was based on 3 cm. This loses two ma[illegible] an inappropriate choice of scale but also a mark for the plotting of the points; the Examiner[illegible] attempt to check the plotting of points on such a scale.

(f) Good candidates used a large triangle when determining the gradient of the graph, but there was a significant number who used a very small triangle. The base of the triangle chosen by such candidates can be as small as 1 cm or 2 cm in some cases. Those candidates who had good results in **(d)** often obtained a correct value for the gradient of the graph (in the range 0.0044 to 0.0054 (N / g)). Such good answers were sometimes spoilt by the use of an inappropriate number of significant figures, in particular 0.005 (N / g).

PHYSICS

Paper 5054/41
Alternative to Practical

Key Messages

- In practical work, units and significant figures are tested. Many candidates could improve their performance by ensuring that all numerical answers have units and are given to an appropriate number of significant figures.
- Candidates often lose credit for lack of care and attention to detail when drawing or annotating diagrams. Many would benefit from further practice at drawing diagrams. The accuracy of straight lines on diagrams could be improved by using a sharp pencil and a ruler.
- The command words used in questions are important and candidates should take note of exactly what the question requires. There is a clear difference between "measure" and "calculate", for example.

General Comments

The range of results shows the considerable variation in the ability of the candidates. Some produced excellent papers showing a very good appreciation of the practical situations in the questions and these candidates had obviously participated in a range of practical activities. Others struggled to express themselves clearly and their responses lacked the detail required.

Describing an experiment is a challenge for many, and often important practical detail was missing, such as freely suspending the lamina in **Question 4**.

Comments on Specific Questions

Question 1

This question concerned a simple timing experiment for an object falling under gravity. The candidates were required to appreciate the practical difficulties involved, plot a graph of the results and draw conclusions from the data.

(a) (i) Most candidates were able to calculate the average of the five values for the time given and gain the first mark here. For the second mark, the candidates had to round the value to two decimal places and include the correct unit on their answer. Many omitted to give the unit.

(ii) Few candidates gave the response that the large variation (0.26 s) in the raw data meant that three decimal places in the answer was meaningless. The response that the raw data was to two decimal places was accepted.

(iii) Most candidates explained that one candidate drops the cup whilst the second candidate times the fall. This was sufficient for the first mark. For the second mark, practical detail of how they achieved this was required. Some excellent responses were seen with a count-down explained.

(b) (i) Many candidates gained full marks for the graph. Smooth lines of best fit are now seen more often with candidates appreciating that the line does not have to pass through all the points.

Common causes of lost credit were:

- omitting to label the axes,
- using irregular scales,

- incorrect plotting (especially plotting 1.05 s as 1.005 s),
- marking the points with dots that were larger than half a small square,
- curves drawn as lines joining all the points.

(ii) Candidates found this question very difficult. Most simply stated incorrectly that, since *t* decreases as *N* increases, they must be inversely proportional. Candidates should be reminded that, if the question asks them to use the data in their answer, then they must show the calculations in order to gain credit.

Some excellent answers were seen, with candidates taking two pairs of values from the table or graph and multiplying them together before stating that they are not inversely proportional because the results are different.

(c) This question required the candidates to think about the procedure and explain the practical detail. Some simply said they would hold the cup in the same place each time with no explanation as to how this was to be achieved. Examples of good responses seen are "holding the arm horizontal" or "lining up the cup with a mark on the wall".

(d) The majority of candidates correctly identified mass or weight as the correct response here. The most frequently seen incorrect response was time.

(e) Candidates answered this well, identifying either a change in a shape of the cup or the effect this has on air resistance. A few candidates thought it would change the mass/weight of the cup. This was not credited unless clearly explained that part of the cup could have broken off.

(f) Very few candidates appreciated that, as the weight of the cups increased, the effect of air resistance becomes small compared to the weight of the cups.

Question 2

This question concerned resistor combinations. Candidates were expected to be able to draw combinations of resistors and use the resistor colour code.

(a) (i) 1. Most candidates knew that a series combination of resistors was required here. However, some lost the mark for not using the correct circuit symbols. Additional components here were ignored provided the resistors were in series and the circuit would function correctly if used. Many drew a wire short-circuiting the resistors which was not acceptable.

(i) 2. Most candidates gave the correct value here even if their diagram above was incorrect. The correct unit was required.

(ii) Again most candidates knew the resistors were to be in parallel here. Only a few lost the mark by short-circuiting the resistors.

(b) A small number of candidates knew how to apply the resistor colour code. Most candidates resorted to guesswork with 181 Ω and 10 Ω being common incorrect responses.

Question 3

This question concerned a cooling curve for oil. The candidates were required to read a thermometer scale, consider the practical details of taking the reading and sketch the shape of the cooling curve.

(a) Most candidates were able to read the temperature correctly, although incorrect responses of 23 °C and 20.2 °C were seen.

(b) (i) Most candidates explained the need to heat the oil uniformly here. Some, however, incorrectly thought this arrangement was to prevent the oil spilling out when it boiled.

(ii) Most candidates explained that the temperature on the thermometer would initially rise. Few clearly explained that it would subsequently fall as the oil cools. Some candidates did not understand the context of the experiment, and gave responses such as "the value moves forwards and backwards until it reaches its constant temperature".

(iii) There were many good explanations of how to read the thermometer accurately. d "avoid parallax error" which gained the mark. Some candidates, however, described h parallax error incorrectly with comments such as "view perpendicular to the meniscus" o eye parallel to the scale". Candidates should be encouraged to use "line of sight" rathe vaguely referring to "the eye".

(c) Few candidates gained both marks. Many did not read the question carefully to note the long time-scale involved and only drew the initial temperature rise. Others drew straight lines of negative gradient taking the final temperature down to zero rather than room temperature.

On this time-scale it is the cooling that is the dominant feature and a concave curve tending to a value above zero was required.

Question 4

The candidates were required to describe a standard experiment to find the position of the centre of mass of a lamina. Many candidates described the experiment clearly and gained full credit.

Of those describing the correct experiment, marks were sometimes lost for not explaining that the lamina needs to be freely suspended, or failing to draw a diagram showing the plumb-line.

Candidates who used a simple balancing method were awarded some of the marks for clear explanations.

PHYSICS

Paper 5054/42
Alternative to Practical

Key Messages

- In practical work, units and significant figures are tested. Many candidates could improve their performance by ensuring that all numerical answers have units and are given to an appropriate number of significant figures.

- Candidates often lose credit for lack of care and attention to detail when drawing or annotating diagrams. Many would benefit from further practice at drawing diagrams. The accuracy of straight lines on diagrams could be improved by using a sharp pencil and a ruler.

- The command words used in questions are important and candidates should take note of exactly what the question requires. There is a clear difference between “measure” and “calculate”, for example.

General Comments

The overall standard was high and many excellent responses were seen.

Correct use of terms such as “parallel”, “vertical” and “horizontal” is important. Some candidates lost credit in **Question 3(a)(ii)** by using unclear wording such as “placing the eye perpendicular to the meniscus” or “looking at the reading vertically”.

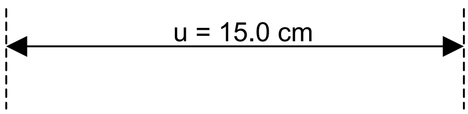
The quality of the written work continues to improve, with many candidates now giving practically based answers concerning the experimental situation and not relying on standard learnt responses. It is always important that the candidate takes time to read the question and understand the practical details of the experiment.

Comments on Specific Questions

Question 1

This question concerned using a simple convex lens to obtain a clear image on a screen. The candidates were required to show a practical understanding of the technique required to obtain the image, then to draw a graph of results and use the graph to obtain a value for the focal length of the lens.

(a) (i) Although most candidates knew the distance to label was between the object and the lens, many responses were not drawn accurately enough. The distance to be measured must be to the centre of the lens. Candidates should be encouraged to draw guide lines and make sure their labelling line goes accurately to the guide lines, for example:



(b) (i) Most candidates knew that the distances of object, image and lens could be varied to focus an image. In the experiment, however, candidates are told that the distance between the object and the lens is fixed at 15.0 cm. This means that, in this instance, the only part of the apparatus that can be moved to focus the image on the screen is the screen.

Many able candidates clearly stated “move the screen along the ruler”. Candidates who had not appreciated this practical situation suggested moving the lens or object. Candidates who had little understanding suggested raising or lowering any one of the three pieces of equipment.

(ii) The only acceptable response here was to raise the object. Candidates should be enc… use the diagram. A ruler placed on the question paper through the centre of the object… centre of the lens will hit the screen at the centre of the image. From this starting point it is … to see that raising the object produces the desired result.

(c) (i) Most candidates were able to read the position of the screen accurately from the diagram as 45.1 cm. The most common error here was to omit the unit. A few candidates read the back of the block or even the thickness of the block.

(ii) There were a wide range of answers here. Although the majority were able to subtract 15.0 from 45.1 correctly, some attempted complicated calculations and others gave responses that were difficult to understand such as 20.7 cm. Some candidates gave the unit on just one of parts **(i)** and **(ii)**.

(d) (i) This required the candidates to enter two values in the table, 15.0 cm and their answer to **(c)(ii)**. There were several reasons why some candidates did not gain this mark:

- the table was left blank,
- values were entered in the wrong spaces,
- incorrect values were entered (the candidate performing additional calculations),
- the values were not given to 1 decimal place.

Candidates should be reminded that, when taking readings and recording them in a table, all values should be given to the same number of decimal places.

(ii) The graph was generally well done with some excellent graph work seen. Common causes of loss of credit were:

- omitting to label the axes,
- using scales that were too small,
- ignoring the values given on the axes for the start of the scales,
- marking the points with dots that were larger than half a small square,
- incorrect plotting (especially plotting 30.1 as 31 on the vertical axis),
- not drawing a single smooth curve.

There were considerably fewer cases of the points being joined with straight lines, although two distinctly different curves were still seen on some scripts.

(e) Candidates were required to state two ways of making the measurement of *v* more accurate. A range of possible responses is given in the mark scheme.

It is good practice for candidates here to remind themselves of the practical situation by re-reading the stem of the whole question.

A common answer which was not acceptable was to repeat the experiment and find the average. Candidates needed to identify repeating a measurement of *v*, not the whole experiment.

Another common response was to avoid parallax error in reading the metre rule. Most who attempted this answer gained this mark.

Few candidates described how to find the position of the focused image accurately.

(f) Some candidates clearly drew a line on the graph joining points where $u = v$. They invariably gained the mark, identifying where their line crossed the curve. Some candidates lost the mark by not giving a unit.

Question 2

This question concerned a distance-time graph. Candidates were asked to draw the graph from in[...] given and answer questions on the practical details of how the data was obtained and could be used.

(a) (i) Most candidates were able to draw the graph.

Common mistakes were to draw the first section as a continuation of the given line or to draw the horizontal section too short. Candidates should be encouraged to add values on the axes to make the plotting of points easier and less prone to error.

(ii) Most candidates were able to give 1500 m as the distance travelled.

(b) Few candidates were able to identify a simple method of measuring the distance travelled such as use of a trundle wheel or measuring one pace then counting the number of paces and multiplying them together. Common incorrect responses were to use the graph or to multiply average speed by the time taken. These are not methods of measurement.

(c) Candidates were asked to explain how the fastest speed can be obtained from the graph. The majority of candidates were able to state that steepest gradient related to the fastest speed. Weaker candidates confused distance-time and speed-time graphs, and gave a response relating to the area under the line.

Question 3

This question required the candidates to describe a simple everyday experiment to find the volume of an irregular object, describe a practical technique to improve accuracy and extend the experiment to measure density.

(a) (i) This question was well answered with many candidates giving excellent descriptions and diagrams of the apparatus.

Some candidates tried to measure the dimensions of the glass stopper. This was not acceptable owing to its irregular shape. Some tried a displacement method with the first the bottle and then the bottle and stopper. This often led to very confused descriptions.

Candidates lost credit if they used a beaker for measuring the volumes involved.

Some candidates gave a learnt response and described an experiment to measure the density of the glass. This did not receive credit.

(ii) Many different suggestions were acceptable here. The commonest responses were to repeat the experiment and find the average and to avoid parallax in reading the volume. Just repeating or checking the reading was insufficient.

(b) Most candidates were able to identify mass as the quantity and give some sort of balance. This mark was not awarded if the candidates thought the weight was needed or measured.

Question 4

The candidates were required to draw a circuit diagram and show an understanding of polarity of electrical components. Practical details of using equipment accurately were tested.

(a) (i) Few candidates were able to draw a circuit diagram containing the three components given. Many lost credit by drawing additional components or by short-circuiting the solar cell.

A few candidates managed to draw the correct circuit but then lost the mark by careless drawing of the components. Some did not draw the correct symbol for a solar cell whilst others drew a line through the voltmeter.

(ii) The most common error here was to identify the fault as a zero error. The question clearly states that the needle moves backwards when connected in the circuit.

The majority of candidates realised that the solar cell and voltmeter have polarity, ... it difficult to explain. Some lost marks by not mentioning either the solar cell or the voltm... answers, but also some excellent responses were seen.

(iii) Most candidates were able to draw the needle of the meter to the correct position on the sc... Some were not accurate enough, either by making the needle pointer too short so that it stoppe... far from the scale or by missing the 0.96 mark. A few candidates incorrectly drew the needle to 0.096 V.

(b) There were many excellent responses here with candidates showing a clear understanding of the situation.

Candidates needed to be clear in their explanation that the student's movement blocked the light from reaching the solar cell. A wide range of responses were credited for a practical solution as to how to avoid this.