PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

The standard of the answers provided varied very significantly. The questions on this paper are selected to test many different sections of the syllabus and in order to score highly, a candidate must be familiar with every part of the syllabus. Similarly, many different skills are tested. These include: calculation, interpreting graphs, understanding written sentences and identifying the significance of information supplied in diagrams.

On this paper, there are 40 questions to answer in 1 hour which suggests an average time allocation of 1.5 minutes. Different candidates tackle the paper in different ways but a very common experience is that some questions take significantly more time than others and that provided the average time per question is not excessive, candidates should not be afraid of spending just a bit longer on some of the questions. This is most likely to be the case when a calculation is needed. It is always better to work towards the correct answer rather than to select an answer that seems in some way more likely.

There are times when a question is taking too long or the candidate is uncertain how to proceed. If some progress has been made, perhaps two answers have been eliminated, then this should be noted before moving on. When the question is looked at again, there will then be no need to eliminate incorrect answers a second time.

Comments on specific questions

Question 2

Most candidates were able to select the correct number of vectors from the sentence and clearly the distinction between scalars and vectors is well understood.

Question 4

Although this question was essentially about interpreting a distance-time graph with a uniform gradient, the correct answer *kinetic energy* required the candidate to realise that, for a car, constant speed inevitably results in constant kinetic energy. This was a second step and only a minority of candidates made it. The most popular answer *acceleration* was a quantity more usually encountered when such graphs are being discussed and this might have attracted some of the candidates.

Question 5

Many candidates struggled with this question and there were few correct answers. The resultant force that decreases to zero causes an acceleration that does the same. Since acceleration is represented by the gradient of a velocity-time graph, the original straight-line graph leads to the curved graph of the correct answer. Both option **C** and option **D** proved popular with many candidates, including those who scored highly on the rest of the paper.

Question 7

Although the correct answer was also the most frequently chosen, both answer **B** and answer **D** were selected by a significant number of candidates. The gravitational force on a satellite is towards the centre of its orbit as is the acceleration. This, however, is merely a specific example of the fact that an acceleration is always in the direction of the force that causes it.

Question 8

This question though set in the context of a satellite was primarily a test of the vector nature of acceleration. Since the force causing the acceleration changes direction so does the acceleration itself.

Question 10

The distinction between mass and weight and their different behaviours was clear to many candidates. The overwhelming majority chose the correct option.

Question 12

Although this question involved a calculation that was not entirely straightforward, it was well answered by a very large number of candidates.

Question 19

Both option **B** and **D** were graphs indicating that the pressure of a gas decreases as its volume increases. Almost all candidates chose one of these two answers. It was only the graph in option **D**, however, that corresponded to an inversely proportional relationship that the equation $p_1V_1 = p_2V_2$ demands. Rather fewer candidates chose this answer.

Question 24

Many candidates misunderstand the term *sensitivity* in the context of a liquid-in-glass thermometer. It is a measurable quantity that is equal to the distance moved by the thread for each degree Celsius rise in temperature. For candidates who were aware of this, it was readily apparent that option **D** was correct.

Question 25

This question was a direct test of knowledge and a very large number of candidates supplied the correct answer.

Question 28

The diagram supplied the complement of the angle of incidence rather than the angle of incidence itself. There are some candidates who find the application of the equation $n = \frac{\sin i}{\sin r}$ tricky. This resulted in option **A** being more commonly chosen than the correct answer.

Question 33

A permanent magnet can induce magnetism in an unmagnetised magnetic object. This, however, always results in an attraction and hence repulsion is the only true test for a permanent magnet. This was known to a significant number of candidates but a similar number chose option **A** which only involved attraction.

Question 34

Rubber was the only substance on the list that was not a conductor and many candidates chose it even though the question was about protecting equipment from magnetic fields.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

Many candidates scored well on this paper and it is clear that there is generally a very decent understanding of the subject at this level. There were, of course those candidates who performed less consistently and the questions where a majority of candidates did well, help to distinguish the candidates who performed less well.

The whole paper includes questions from nearly every part of the syllabus and most parts are tested somewhere. In much the same way, many different forms of approach and answer are included. A common skill that is tested is calculation and candidates need to be familiar with their calculator and need to be able to rearrange learnt equations accurately.

There is no substitute for being thoroughly familiar with the entire course, but even a well-prepared candidate can lose credit if the examination is not tackled in an appropriate manner. Although there is on average 1.5 minutes for each question, some questions, especially those that require the recall of learnt facts, are likely to take rather less time than this. This allows for a little more time to be spent on other questions; some of the calculations are more involved than others and take more time. As long as not too much time is spent on too many questions, this should enable candidates to determine the correct answer and to finish in time for a brief check of the less certain answers. Candidates should make a note of these as they proceed so that at the end, it is the answers about which they are less confident that are checked first.

Comments on Specific Questions

Question 1

A very noticeable majority of candidates was able to identify the scalar quantity.

Question 4

Although this question was essentially about interpreting a distance-time graph with a uniform gradient, the correct answer *kinetic energy* required the candidate to realise that, for a car, constant speed inevitably results in constant kinetic energy. This was a second step and only a minority of candidates made it. A very common answer *acceleration* was a quantity more usually encountered when such graphs are being discussed and this might have attracted some of the candidates.

Question 5

Although this question involved a calculation it was well answered by a very large number of candidates. The most common error was the omission of the factor of ½ when obtaining the area of the triangle.

Question 8

Most candidates were aware that a perpendicular force of constant magnitude is required when an object moves at constant speed in a circle. The incorrect option **A** was, however, a common choice.

Question 16

This question was essentially one of factual recall. It was answered correctly by the overwhelming majority of the candidates.

Question 19

In this question, the option **D** could be obtained by multiplying the three numbers in the question. This proved attractive for a minority of candidates. The height difference was given in centimetres, however, and this is a submultiple of the SI base unit for length rather than the unit itself. A majority of candidates, performed the conversion and supplied the correct answer.

Question 23

The overwhelming majority of candidates realised that the correct answer could be obtained using the equation $Q = ml_f$ but option **C** was chosen by a noticeable number of candidates.

Question 24

Many candidates found this to be a very challenging question and misunderstand the term *sensitivity* in the context of a liquid-in-glass thermometer. It is a measurable quantity that is equal to the distance moved by the thread for each degree Celsius rise in temperature. The overwhelming majority of candidates chose either option **A** or option **D** both of which used a narrow-bore capillary tube. Since the thermometer in **D** contained more mercury, the volume increase when heated is greater and so the thread moves further along the tube.

Question 25

This question was a direct test of knowledge and a large number of candidates supplied the correct answer.

Question 26

The fact that the wavelength in region P was larger than that in region Q was readily observed from the diagram and very many candidates gave an answer that was consistent with this observation. To distinguish between option **A** and option **B** was much less direct, however. Many candidates did proceed correctly but some went astray during this second stage and selected option **B**.

Question 27

A graph that showed an amplitude that had doubled was selected by a large majority of candidates. The relationship between the graph and the frequency, however, is not so direct and a minority of candidates opted for answer **B** which corresponds to half the wavelength.

Question 31

A very large number of candidates remembered that the coil needed to be connected to an a.c. supply although a small minority chose an option where the coil was connected to a d.c. supply. The majority of candidates selected the correct answer. It is the slow withdrawal of the bar magnet from the coil that causes demagnetisation.

Question 30

A permanent magnet can induce magnetism in an unmagnetised magnetic object. This, however, always results in an attraction and hence repulsion is the only true test for a permanent magnet. This was known to a significant number of candidates but a similar number chose option **A** which only involved attraction. A few candidates selected the answer that the magnetic property of the magnet was related to its conduction property.

Question 32

Rubber was the only substance on the list that was not a conductor and many candidates chose it even though the question was about protect equipment from magnetic fields.

Question 35

To answer this question, a candidate needed to understand the action of a variable potential divider although it can be answered by using $V = IR$ twice. It is then necessary to relate the values of the resistances that produce a 2.0 V potential difference to the physical conditions. Inevitably, some candidates did not get to the correct final answer but a majority did. The other three options were all chosen by a similar number of candidates.

PHYSICS

Paper 5054/21
Theory

Key messages

- When completing questions requiring calculations, candidates should set out and explain each stage in their working clearly. Credit is very often available for such working even if the final answer is wrong. If no working is shown Examiners are unable to give any credit if the answer is wrong.
- Where candidates are drawing or adding to a diagram the use of a protractor and/or ruler often helps to make the diagram clearer.
- Numerical answers should be shown to at least two significant figures and the unit given.

General comments

Candidates were, in many cases, able to demonstrate their knowledge and understanding of key concepts. The performance was quite consistent across the syllabus although a few topics such as the structure of a thermocouple, an experiment to show that sound obeys the law of reflection, linearity of a temperature scale, the reason why switches are placed in the live wire or why an object topples were some small topics that were found more challenging.

In many cases candidates showed knowledge of and applied standard equations in the syllabus correctly and were usually able to rearrange equations to calculate an unknown quantity, for example, resistance in **Question 5(a)**. However a significant number of candidates did not show the ability to handle the equation for resistances in parallel correctly.

There was very little evidence of candidates being unable to understand questions as a result of poor language skills and the vast majority of candidates were able to express their ideas appropriately. There was no indication of candidates having insufficient time to complete the examination paper, although in a small number of cases candidates left parts of a question unanswered where it was usually obvious that they had difficulty with an earlier part.

Although slightly fewer candidates answered **Question 11** than the other optional questions, the performance on this question was slightly better than in the other optional questions; the difference however was fairly small.

Comments on specific questions

Section A

Question 1

(a) Almost all candidates realised that force B is the driving force and force C the weight but some candidates were confused between the contact/normal reaction force and the air resistance/friction.

(b) The majority of answers in **(b)(i)** were correct and showed understanding of the equation $W = mg$ but some candidates incorrectly multiplied weight by g to find the mass or used the wrong force in their calculation, sometimes adding together all of the four forces. In **(b)(ii)** candidates clearly showed the ability to calculate the resultant force and in **(b)(iii)**, where candidates knew the correct formula, the working was straightforward and the answers encouraging.

(c) Most candidates found this straightforward. Some candidates started by writing an equation for acceleration and some started by calculating the change in speed to achieve the correct answer. A common error was to calculate the change in speed as 8 m/s and then add rather than subtract this from the final speed.

Answers: **(b)(i)** 800 kg **(b)(ii)** 400 N **(b)(iii)** 0.50 m/s^2 **(c)** 12 m/s

Question 2

(a) Almost all candidates recognised that the pressure increases when the chair tilts backwards. Usually this was explained simply as a reduction in the surface area but some answers gave more detail by explaining that pressure is inversely proportional to area or explained using the formula relating pressure, force and area in their argument.

(b) This question was one of the hardest on the paper. It was common for candidates to mention the force of gravity and, less commonly, the centre of mass but only the strongest candidates suggested that the centre of mass or the weight acts outside of the base and that this causes a turning effect or moment. Weaker answers tended to suggest that '*he does not have a wide base*' or show misunderstanding such as '*the weight falls outside of the centre of mass*'.

Question 3

(a) The majority of candidates showed a basic understanding of the two processes involved in this heat transfer. Some candidates gave too long a description of one process and left little room for the other and sometimes gave very good descriptions but failed to name either of the two processes.

(b) Answers generally suggested that there is less contact between the plate and the cup, although this was not always expressed well, for example by saying '*the cup is closer to the plate*'. Better answers stated simply that the air is a bad conductor, whereas weaker answers said that the trapped air between the cup and plate actually cools the cup.

(c) Many candidates stated that a black surface is best for the outside of a cup since black is a good absorber of heat. However heat is actually being lost and not gained from the outside surface. Where white was chosen as the colour the explanation that white is a poor emitter was usually given, although some candidates chose a white and dull surface rather than a white and shiny surface.

Question 4

(a) Linear magnification was commonly defined as the ratio of image height to object height or image distance to object distance, although some candidates were vague in suggesting that magnification is image size over object size. The term size might refer to area and a linear dimension was required. Less than half the candidates produced an adequate definition of a real image as being formed on a screen or occurring at the intersection of rays. Weaker candidates merely suggested that a real image is formed by a lens, even though virtual images can also be formed by a lens.

(b) The ray diagrams were encouraging and most candidates gave a sensible value for the focal length. Some candidates found drawing a third ray from the object to be a challenge. Any ray from the top of the object to the lens and then to the bottom of the image is acceptable.

Answer: **(b)(ii)** 2.4 cm

Question 5

(a) The majority of candidates were able to calculate the total resistance correctly, showing knowledge of the formula and the ability to use it correctly. However a significant number of candidates who calculated $\frac{1}{20} + \frac{1}{40}$ failed to invert the result to find the total resistance of the two resistors in parallel.

(b) The comparison of the three voltmeter readings appeared to show all possible combinations. A common error was to state that the reading on voltmeter V_1 was equal to that on voltmeter V_2 because they were connected across the same value of resistance, whereas the reading of voltmeter V_2 is equal to that of voltmeter V_3 because they are connected in parallel.

Answer: **(a)** 33 Ω

Question 6

(a) The majority of candidates added the power ratings correctly in **(a)(i)**. The answers to **(a)(ii)** were encouraging with a large proportion of the candidates realising that energy is power multiplied by time. A common error was to give the wrong unit or to actually work out the energy in joules. In **(a)(iii)** the power was generally well known in terms of voltage and current but a common error was to use the wrong power, often the total power rather than the power of one lamp.

(b) This question proved the most challenging on the paper. There were many misconceptions shown, for example that '*there is no current in the neutral wire so a switch cannot work if placed there*' or '*the current is largest in the live wire*'. Successful candidates generally realised that it is important that the switch is in the live wire when the switch is off because then the circuit will not be live and potentially unsafe.

Answers: **(a)(i)** 200 W **(a)(ii)** 0.60 (kW h) **(a)(iii)** 0.17 A

Question 7

(a) Most candidates recognised that the direction of the magnetic field was from the N-pole to the S-pole, slightly fewer appeared to recognise that the conventional current flows from the positive to the negative terminal and far fewer were able to draw the direction of the force according to the left-hand rule.

(b) Fewer than half the candidates were able to give a full answer in **(b)(i)**. A number recognised that an e.m.f. was induced but did not explain convincingly that this was because the rod cuts the magnetic field lines or the flux in the circuit changes. In **(b)(ii)** even fewer candidates gave the most obvious answer, move the rod faster. Suggestions such as '*reduce the resistance of the wire*' were not accepted as the voltmeter resistance is so much higher than that of the rod and the reading will not be affected. Weaker candidates gave general answers such as '*increase the induced current*' without saying how this is done.

Question 8

(a) Approximately half of the candidates suggested that a gamma ray is an electromagnetic wave. Weaker answers suggested that the ray is '*a radioactive emission*' or gave some of the properties of a gamma ray rather than stating what is meant by a gamma ray.

(b) Answers to this section were encouraging in that the superscript for the beta particle was generally well known and the atomic numbers calculated correctly.

(c) Explanations of why it is better for the doctor to inject iodine-125 into the patient often lacked detail and amounted to '*beta particles harm the patient*' without describing the harm caused or explaining why the gamma ray does not cause harm. Only a few candidates gave a really convincing argument that because gamma rays are weakly absorbed most of them will pass out of the body to be detected. It is essential in this application that particles do pass out of the body as the detector is outside.

Section B

Question 9

This was the most popular question in section B.

(a) A sensible description of the meaning of a non-renewable source was given by most candidates, usually such as '*it cannot be replaced*'. However a significant number of candidates stated that such a source '*cannot be used again*' or cannot '*be recycled*', which was not accepted. In **(a)(ii)** almost all candidates recognised that oil is the only non-renewable source in the list but few candidates effectively recognised that wind and hydroelectric energy are actually caused by the Sun, either by the evaporation of water and subsequent rain or by the convection currents which cause wind on the surface of the Earth. Answers to **(a)(iii)** and **(a)(iv)** were disappointing as statements such as '*oil produces harmful gases*', '*nuclear energy can cause damage*', '*nuclear energy produces more energy*' or '*nuclear energy is renewable*' were either wrong or lacked sufficient detail. The most common successful approach in **(a)(i)** was to mention global warming but a common misconception was that the gases emitted when oil is burnt harm the ozone layer.

(b) Over half of the candidates suggested successfully that the missing part is a generator in **(b)(i)**, sometimes also adding a transformer; a transformer on its own would be insufficient. The majority of answers were correct in **(b)(ii)** although other forms of energy such as chemical energy were sometimes given. The calculations in **(b)(iii)** were encouraging with the majority of answers being correct and showing understanding of density and a large number showing a good grasp of both specific heat capacity and latent heat. The answers to **(b)(iv)** often failed to explain fully why electricity is transmitted at a high voltage. It was common for answers to mention that using a high voltage reduces energy or power loss but not to explain that this is because the current is reduced and this causes less power loss in the resistance of the cables. A common misconception is that a higher voltage reduces the resistance.

Answers: **(b)(iii)1** 24 000 kg **(iii)2** 6.4×10^{10} J

Question 10

(a) Not all candidates took sufficient care in drawing the reflected rays in **(a)(i)**. Often the two rays were parallel or even converging after reflection at the mirror. Candidates should consider using a protractor to draw reflected rays so that the angle of incidence is equal to the angle of reflection. The image was often where lines along the reflected rays would meet if extended behind the mirror. The majority of candidates correctly suggested one of a number of possible characteristics in **(a)(ii)**. However a number of candidates suggested that the image is inverted, rather than laterally inverted.

(b) A reasonable number of candidates gave a correct definition of a wavefront in **(b)(i),** although it was clear that a significant number of candidates had little knowledge of this term. In **(b)(ii)** the results were encouraging, particularly where candidates took care to draw the wavefronts carefully, often using a ruler. It appeared that some candidates understood well what happens to the wavelength of the refracted and reflected waves and took care to ensure that these wavelengths were correct as well as drawing the wavefronts at the correct angles to the surface of the glass. Although many diagrams showed the refracted wavefronts at a smaller angle to the glass than the incident wavefronts, the refracted wavefronts were sometimes drawn in the completely wrong direction on the wrong side of the diagram.

(c) The formula for speed in terms of wavelength and frequency was well known in **(c)(i)** and it was encouraging that so many candidates handled the conversion from kHz to Hz successfully. There was no need to convert the answer into m/s and this caused some difficulties for some candidates. The audible range of frequency was known by most candidates in **(c)(ii)1**, but this was only used correctly by a minority to calculate the smallest audible wavelength in **(c)(ii)2** as the smallest frequency rather than the highest frequency was often used in the calculation. In **(c)(iii)** only a few candidates described an experiment in which an incident sound wave was produced along a single direction and where the reflected wave was, potentially, detected along different directions. This was most readily described using tubes with even a ticking clock at the end of one tube and an ear placed at the end of another tube. Far too many answers to this question merely described an experiment in which reflection of sound occurs, often to measure the time between a sound and its echo from a wall. Even this could be developed into a sensible experiment if distances are calculated from measured times and then compared with those for which the reflected wave obeys the law of reflection, but this is a more difficult explanation at this level.

Answer: **(c)(i)** 320 m/s

Question 11

This was the least popular question in **Section B**.

(a) The majority of candidates knew the symbol for a cell or battery and an ammeter, but fewer were able to draw a thermistor correctly. Often the thermistor was drawn incorrectly as a fixed or variable resistor.

(b) The formula relating resistance potential difference and current was well known and the majority of candidates used values obtained from the graph successfully in the calculations in **(b)(i)**. In **(b)(iii)**, where candidates first stated clearly the resistances at the three temperatures, they usually correctly calculate their differences and recognised that these differences were different. Many candidates did not realise how to answer the question and made general comments such as '*resistance decreases with temperature*'.

(c) Although the advantages of a thermocouple thermometer over a liquid-in-glass thermometer were generally well known in in **(c)(i)**, the actual structure of a thermocouple was not widely known in **(c)(i)**. Some reasonable thermocouples had wires connected to a voltmeter, an ammeter or a galvanometer in series but usually lacked labels or a description that two different metals are connected together at the point where the temperature is to be measured. Some candidates drew a variety of different types of thermometer and even liquid-in-glass thermometers.

Answers: **(b)(i)1** 12 V **(b)(i)2** 100 Ω

PHYSICS

Paper 5054/22
Theory

Key messages

Apart from improving their basic understanding of the material in the syllabus, candidates could improve their performance by:

- Taking time to read the question carefully and ensuring that they answer the question that is actually asked. Marks are only awarded for the specific answers to the question, not for irrelevant information or comments on related matters, for example, giving a description of the structure of the atom where only the structure of the nucleus is asked for.

- Setting out and explaining their working in any calculation. When the final answer is wrong and no working is shown, it is impossible to know where any mistake occurred. For example, when calculating resistances in parallel, the formula $1/R_t = 1/R_1 + 1/R_2$ at the start is far better than a series of numbers, particularly when the inverse of the correct answer is given without any working.

- Giving numerical answers to at least two significant figures with correct rounding and a unit. For example, in rounding 1.7857 correctly to 1.8 or 0.909 correctly to 0.91, whereas 1.7 or 0.9 was often given as the answer. If candidates cannot do this correctly they should be advised, in this paper, to give more figures to their answer, e.g. the full 1.7857 rather than incorrectly writing down 1.7 or 0.9.

General comments

It was clear that many candidates had prepared well for the examination and some answers showed a very good overall grasp of the ideas tested and some very mature and well thought out answers were produced by the strongest candidates. Good language skills were shown, in general more than appropriate for the level of this examination and there was no evidence of candidates having insufficient time to complete the examination. However, there was a small minority, who struggled to express themselves adequately.

The general knowledge and understanding of the equations tested in this paper was good and most candidates were able to use and apply standard equations such as $a = (v–u)/t$ and $P = F/A$. However, a significant proportion of candidates were unsure in some areas, for example about the real meaning of the terms in the equation $E = mc\theta$, where c was often wrongly used as energy and the wrong units for specific heat capacity were commonly given in the answer.

The choice of two out of three questions in **Section B** led to fewer answers to **Question 9** and the marks for this question were slightly lower than for the other two questions which were broadly similar. The slightly lower performance on this question may have been caused by weaker candidates choosing the question as there was good correlation between the marks obtained and the performance on the compulsory questions.

The greatest challenge was provided by **Q1(b)**, **Q5(a)**, **Q5(c)**, **Q9b(i)**, **Q10(b)(i)3** and **Q11a(iv)**.

Comments on specific questions

Section A

Question 1

(a) Most candidates correctly calculated the acceleration in **(i)**. The actual formula for acceleration was well known and usually stated correctly. However a number of candidates rounded their answer incorrectly as 1.7 m/s^2 or gave an incorrect unit, such as m/s, m/s^{-2} and m^2/s. In **(ii)** it was encouraging that many candidates were able to read the scales on the graph correctly and understood the link between acceleration and the gradient of the graph. The first section of the graph should be straight from the origin to (14, 25). The most common mistake was to read the scale of the *y*-axis incorrectly and plot a point at (14, 30). Weaker candidates tended to draw the graph incorrectly with a negative gradient after this point, perhaps to indicate that the acceleration was decreasing. Ideally the gradient of the graph should be positive and continuously decreasing after (14, 25) until reaching constant speed at 55 m/s. A large number of candidates drew a straight line from (14, 25) to (70, 55) and this was accepted.

(b) The question provided a variety of answers of varying quality and was a very good distinguishing question. Most candidates were able to attain some credit and showed some understanding of the forces acting on the driver. However this was one of the harder questions on the paper with many candidates incorrectly suggesting that a forwards force is needed to keep the bag in motion, with answers such as "*friction causes the bag to slide forward*" or "*the forward force on the bag is more than the backward force*". Stronger candidates recognised that there was no forwards force acting and commented on the opposing force of the seat belt on the driver, the lack of any noticeable forces on the bag or made some reference to the bag's inertia. Inertia was often mentioned but was sometimes incorrectly described as being a force. Weaker candidates tended to write very general statements, such as *"the seat belt stopped the driver but the bag was not fitted with a seat belt so slides forward",* making no reference to the forces acting.

Answer: **(a)(i)** 1.8 m/s^2

Question 2

(a) In describing a method to obtain an accurate measurement for the time for one complete swing, a number of candidates did not include any reference to a suitably accurate measuring instrument, such as a stopwatch or electronic timer. Accuracy is most readily obtained by the use of a sensible but large number of oscillations and most candidates, but not all, mentioned the use of at least 5 oscillations. A number of candidates lost credit by not stating a specific number of oscillations to be timed and a surprising mistake was for the time for one swing to be found from the number of oscillations divided by the measured time. The definition of one complete swing was sometimes stated to be just from A to C, rather than from A to C and back to A. When the timing was started at B, careful explanation is needed to describe one complete oscillation, e.g. B→C→B→A→B.

(b) The calculation in **(i)** produced some of the best answers on the paper and the formula for gravitational potential energy was very well known. A few candidates gave the wrong unit for mass, sometimes as g or N or confused gravitational potential energy with the weight of the child, but such mistakes were uncommon.

It was encouraging in **(ii)** that many candidates were able to make sensible references to the energy losses and forces involved. A few candidates gave very general answers such as "*it's at the centre*" or "*she loses energy whilst moving from A to B or C to B*" or gave incorrect interpretations such as '*some of the potential energy remains inside the girl or at the bottom of the swing*".

Answer: **(b)** 40 kg

Question 3

(a) Many correct definitions for the moment of a force were given, although a number of these definitions were incomplete, as perpendicular distance was not mentioned. A number of these definitions of moment were actually definitions of work and the difference between work and moment needs to be more carefully learnt. There is also a potential confusion in the use of the word “into”. Moment was often described as “*force into distance”*. On its own, this can be interpreted as being distance divided by force and a better definition is the product of force and perpendicular distance. However, even when defined poorly, many candidates went on to apply the principle of moments correctly.

(b) Most candidates were able to show some form of moment calculation. A common error was to use the distance from the brake pedal to the end of the piston, placing the “pivot” where the piston is situated rather than at the top. There were some errors in the unit given for the answer, sometimes given as Nm.

(c) The formula for pressure was well known but a significant number of answers used the force applied to the pedal rather than the force applied to the piston in the calculation.

Answers: **(b)** 15 N **(c)** 6.7×10^4 Pa

Question 4

(a) Although many candidates knew the correct formula and a large number obtained full marks, the formula mass × specific heat capacity × change in temperature was often misunderstood and effectively used as specific heat capacity = mass × energy × temperature difference. The unit for specific heat capacity was often incorrectly stated.

(b) Fewer candidates knew the formula for heat capacity than specific heat capacity and a significant number calculated energy/mass rather than energy/temperature difference.

(c) The concept of conduction as the passing on of energy from one molecule to another by collision, or by electron diffusion, was generally well known. Weaker candidates sometimes merely said only that molecules vibrate rather than describing how this vibration is involved in conduction.

Answers: **(a)** 0.91 J/(g °C) **(b)** 770 J/°C

Question 5

(a) Most diagrams were disappointing and merely showed an expanded solid with particles slightly further apart than in Fig. 5.1. Good answers showed a random arrangement of molecules with at least one molecule touching another and often included clusters with differing numbers of molecules. It was considered that some molecules should be touching in the liquid and that clusters should not all be of the same size or be far apart. Some candidates attempted to draw a beaker with molecules touching, close together and at random at the bottom and this was often successful.

(b) The question asks for a description of the motion of the particles and a number of candidates wrote at length about the arrangement of the molecules. However, most answers sensibly suggested that particles in a solid vibrate and that particles in a gas move randomly or have high speed as they move around. Fewer answers suggested that liquid molecules move throughout the liquid itself. The description of the motion of liquid molecules was often little different from that of the gas but descriptions of liquid molecules sliding over each other or moving in clusters were frequently seen and were encouraging.

(c) Most answers sensibly described the weak intermolecular forces between molecules in a gas or the strong forces between molecules in a solid. Fewer answers mentioned that molecules in a solid are moving too slowly to break free from the structure to fill the container.

Question 6

(a) There were some very detailed and concise answers to this part of the question. Where candidates used a labelled diagram, and referred specifically to compression/rarefaction and peaks/troughs, marks were more easily earned. Marks were occasionally lost by wrongly labelling an excellent description of a longitudinal wave as a transverse wave or vice versa. Most candidates showed a good understanding of at least some of the features of longitudinal and transverse waves. The clearest answers mentioned that the particles in a longitudinal wave were oscillating in the same direction as the direction in which the wave travels and gave a corresponding definition for a transverse wave. Less clear were answers that described a longitudinal wave as moving parallel to the wave and which did not mention any form of oscillation or vibration. The essence of a good answer was often in the description of the vibration involved and this vibration is easier to describe as the oscillation of a particle.

(b) (i) The formula was well known and applied, although a number of answers did not convert kHz to Hz.

(b) (ii) This was very well answered as most candidates quoted the hearing range as 20 Hz–20 kHz. A number of answers, having quoted the correct range, then suggested that a sound of 3.8 Hz could be heard and may have been confusing 3.8 Hz with sound of 3.8 kHz, mentioned earlier in the question.

Answer: **(b)(i)** 0.087 m

Question 7

(a) (i) The essence of a correct answer was to mention the current and the magnetic field caused by the magnets. A large number of students referred to the coil cutting magnetic field lines or even being attracted to the magnet and did not mention the current or even describe the production of an induced e.m.f. Candidates need to know clearly the difference between these two magnetic effects.

(a) (ii) The descriptions here were encouraging with a majority of answers suggesting correctly that the current changes direction every half turn. It was more difficult to explain how this caused the coil to continue to turn in the same direction. The most successful answers, in terms of the forces acting, suggested that the force on a particular side of the coil, e.g. side AB reverses each half turn.

(b) The formulae for energy and efficiency were well known in **(i)**, although some candidates were unable to combine the formula $P = VI$ and $P = E/t$. In **(ii)** the formula for efficiency was often inverted, sometimes, perhaps, because the energy value obtained in **(i)** was more than 140 J. Candidates should use values obtained from previous sections in the correct equation and they will be given credit.

Answers: **(b)(i)** 190 J **(b)(ii)** 73%

Question 8

(a) Many correct explanations were given of why the rod and cloth are uncharged. A number of answers correctly mentioned that the rod and cloth had both negative and positive charge without explicitly stating that the amounts of each of these charges were equal. Weaker candidates suggested that the rod and cloth had not been rubbed.

(b) (i) The majority of answers clearly stated that the negative charge had moved from the cloth to the rod and stronger answers also mentioned that it was electrons that move in this direction. Weaker answers wrongly referred to positive charges moving in the reverse direction.

(b) (ii) This section provided a variety of answers of varying quality to the question which asks for an experimental test that a rod is charged. The best answers gave a clear explanation or diagram of an experiment that would clearly work, e.g. a rod suspended by a thread being repelled by another negatively charged rod or attracting hairs on the head. The majority of candidates knew the repulsion or attraction test for a charged rod but often lacked the detail of a suspension. Merely trying to feel the force is unlikely to work. A significant number of answers described the rod being used to induce a charge in a metal object, but then did not describe how they could prove that the metal object was charged, and so this was not an experimental test. There was confusion with a small number of candidates who tested charge by using a magnet.

Section B

Question 9

This was the least popular question in **Section B**.

(a) (i) Candidates found the diagram challenging, often missing the point of the question, drawing any reflected ray, often a ray reflected from the middle section rather than the left-hand side of the mirror or drawing a ray that does not enter the eye. Insufficient care was often taken when drawing this ray, which then did not obey the law of reflection. It is sensible for candidates to use a protractor if they are unable to judge a reasonable reflection.

(a) (ii) To draw the angle of incidence and the angle of reflection, a normal must be drawn and this was often not at right angles to the surface of the mirror. Surprisingly, the angle of incidence was often shown incorrectly as the angle between the mirror and the ray.

(a) (iii) Most candidates stated that a virtual image cannot be formed on a screen, but did not explain this with reference to the rays not actually coming to a point. Often, in trying to explain what is meant by a virtual image, many of the characteristics were given instead. Fortunately there are many characteristics to choose from and so correct answers were common in **(a)(iii)2**. A number of candidates stated that a characteristic of a virtual image formed by a mirror is that the image is inverted, rather than laterally inverted.

(b) (i) Stronger candidates concentrated immediately on the fact that total internal reflection occurs from a more to a less dense medium and that the angle of incidence is greater than the critical angle. Weaker candidates were able to remember some key ideas from the syllabus, but were not able to construct their answers in a meaningful way. For example, some knowledge was shown of refraction or total internal reflection with answers such as "*total internal reflection is found at 90 degrees*", or, "in total internal reflection *the reflected angle is called the critical angle rather than the angle of incidence".* Other answers showed misconceptions in suggesting that virtual images are formed in reflection and real images in total internal reflection.

(b) (ii)(iii) An encouraging number of candidates knew both formulae n = 1/sin c and n = sin i/sin r, although the latter seemed more common. There are candidates who omit the sine in these formulae and show working such as 44/100 or 50/44. It is expected that a unit should be given for all answers and the degree symbol needs to be shown.

(b) (iv) Given a large number of possible correct responses for the advantages of optical fibres, it was surprising that more candidates did not score full marks. There was a tendency to just answer "*cheaper*" or "*lasts longer*". Sometimes more precision was required, where, for example, the answer given was "*less data is lost*", which may be referring to less energy loss, less noise or a lower possibility of the data being intercepted or hacked.

Answers: **(b)(ii)** 1.4 **(b)(iii)** 32°

Question 10

This was the most popular question in **Section B**.

(a) (i) The most common correct answer was a direct proportion between current and potential difference. Some answers gave less detail, such as "*I increases with V*".

(a) (ii) The question asks how the graph shows that temperature is constant and only about half of the answers actually referred to the graph, for example by suggesting that the line has a constant gradient. Other answers suggested that the resistance was constant without making any link between the graph and the resistance.

(a) (iii) Although the majority of answers correctly suggested that the resistance increases, the graph drawn did not always show an increase in resistance or correctly show that the resistance has doubled.

(b) (i) The calculation of the combined resistance was commonly done well, although a frequent mistake was to forget to invert the result of $1/R_1 + 1/R_2$ when calculating the combined resistance of the resistors in parallel. The calculation of the current was very good whilst the calculation of the p.d. across the 20 Ω resistance was the most challenging part of this question and causes significant difficulties. The majority of answers assumed that the current in the power supply was equal to the current in the 20 Ω resistance, rather than using the combined resistance of 16 Ω with this current. Some candidates attempted to divide the current in the ratio of 20:80, which was sometimes successful but often wrongly assigned the smaller current to the 20 Ω resistor.

(b) (ii) The majority of candidates were successful with a simple statement of the meaning of e.m.f. and drew four cells in series correctly. Almost all candidates knew the symbol for a cell and placed the positive terminal at the correct end. A number of candidates however drew a picture of a cell rather than the circuit symbol for a cell. The diagrams of eight cells in parallel were not so successful. One major problem was deciding where the ends of the battery were placed, as often, effectively, all the eight cells were drawn in series, without any external connections to the battery being marked. Often, also, the arrangement did not have a combined e.m.f. of 6 V. The simplest arrangement is to have two rows of four cells in series connected in parallel with each other.

(c) Most answers successfully suggested that the cells in parallel would last longer or that if one cell failed, the battery would still work. Some candidates confused the question with bulbs in parallel.

Answers: **(b)(i)1** 40 Ω **(b)(i)2** 0.15 A **(b)(i)3** 2.4 V

Question 11

(a) (i) This section was generally well answered, although sometimes "*nuclear radiations*", "*gamma rays*" or "*the Sun*" were given as an answer. The Sun was treated as producing cosmic rays rather than being another source of background radiation.

(a) (ii) The effect of background radiation in causing cancer or adding to experimental readings was widely quoted.

(a) (iii) Correct values were given by the majority of candidates although some gave the nucleon number for the alpha particle rather than the number of neutrons in an alpha particle.

(a) (iv) The intention of this question was for candidates to simply apply their knowledge that alpha particles are stopped by, absorbed by or cannot penetrate a few centimeters of air. However many candidates referred to the atmosphere "reflecting" or "deflecting" the particles and the most common misunderstanding was that the ozone layer alone was acting as a shield, again often reflecting or deflecting the particles. There were a number of answers that mentioned deflection by the Earth's magnetic field and, although this may have some relevance, the question asks how the earth's atmosphere reduces the number of particles reaching the surface and not the magnetic field. There was also some confusion when candidates mentioned that the "*air ionises the alpha particles*", rather than the air being ionised by the alpha particles.

(a) (v) Most candidates realised that the path of the alpha particle curves in the magnetic field and many drew the correct anti-clockwise deviation. Diagrams could have been clearer, avoiding straight line regions and showing arrows to make clearer the direction of travel of the particles.

(b) (i) The majority of answers showed understanding that half-life is the time for a quantity to halve, but a number referred to the "*mass*" , the "*amount*", the "*substance*" or the "*source*" halving, rather than the number of atoms, nuclei, activity or count.

(b) (ii) The strongest candidates clearly worked out and stated that the decay lasts for three half-lives. Weaker candidates merely showed the initial 200 000 atoms halving in a series of numbers.

(b) (iii) There were many references to the half-life being too low, or just that the sample is too old to date but it was encouraging to see some well-expressed answers that suggested there would be too few particles of carbon-14 left, although some candidates struggled to express this idea.

(c) (i) This was generally very well answered, with the majority of candidates knowing the correct definition of isotopes and applying it correctly to their answer. It was not expected that candidates should know that carbon-12 has six neutrons and carbon-14 has 8 neutrons, merely stating that there is a difference of two neutrons was sufficient.

(c) (ii) The question asks how the structure of the nuclei of the two isotopes are similar and, although the difference in the number of protons was very well known, a significant number of candidates stated that there were the same number of electrons. Where it was also described that these electrons are outside the nucleus this was ignored but otherwise such answers are implying that the electrons are found inside the nucleus.

Answers: **(b)(ii)** 17 100 years

PHYSICS

Paper 5054/31
Practical Test

Key messages

This was an examination of practical skills: using equipment to obtain a set of raw data and then to process it according to instructions; responses did not require the quotations of theories.

Good responses required good practical skills and the ability to present results well. Good responses indicated that candidates were good at following instructions, making observations, making measurements and recording and processing data according to the instructions given.

Good responses showed: repeated, then averaged measurements and all working for calculations, gave correct units for all quantities and final answers were given to an appropriate precision (usually two or three significant figures).

Readings taken from an instrument such as a voltmeter or ammeter should be recorded to the precision of the instrument.

When asked to calculate a ratio the answer should be in decimal form and not a fraction.

It is important that centres provide values for experiments as requested in the confidential instructions.

General comments

There were many good scripts. Many candidates would be able to improve their scores by improving their graph plotting, particularly labelling axes, choosing good, easy to use scales (i.e. those based on 2, 5 or 10) and drawing fine plot points and fine smooth best fit lines with a sharp pencil.

Some candidates often repeated the parts of the subject they remembered from their revision and this was not always relevant.

Comments on specific questions

Section A

Question 1

(a) Candidates were asked to start the rotation of a mass (800g) hung on the end of a wire by turning it through two complete turns and then finding an accurate value for the time taken for the mass to come to a halt for the first time. The better responses were in the region of four seconds, to two or three significant figures, with accurate values obtained by repeating two or three times and taking the average, with working shown and the unit stated. Some responses recorded the stopwatch display rather than the correct decimal notation for the time in seconds.

(b) New times were found using a 600g mass. Good responses listed repeated measurements which were averaged to obtain a shorter time than in **(a)**, rounded to two or three significant figures and the unit given.

(c) Candidates were asked to calculate the ratio of the two time values found in **(a)** and **(b)**. Correct ratios were in the range 1.80 to 2.20, and good responses gave the ratio to two or three significant figures and with no unit. Some candidates wrote down the ratio incorrectly as a fraction, or to an inappropriate number of significant figures, or stated a unit.

Question 2

(a) Candidates were asked to determine the length of a shadow cast along a given line by a cylindrical object placed 4 cm in front of a lamp. Good responses stated a length in the range of 8.0 to 11.0 cm (or centre values +/- 1.0 cm) to the nearest mm.

(b) (i) Good responses described of how the link between the position of the cylinder along the line XYZ and the length of the shadow along PZQ could be investigated. Many of the best responses indicated that the experiment had been carried out and provided actual measurements to aid the description. Good responses explained that the distance between the lamp and the object along XYZ would be increased, that it was important to keep the lamp in a fixed position, and then measuring (or comparing) the length of the shadow. There were many good responses. Some responses were often incomplete and only described the object being moved or the shadow measured.

(b)(ii) Good responses labelled the y-axis of the graph as 'length of shadow along PZQ' and drew a smooth curve with decreasing gradient. A straight line with a negative gradient was also accepted. Some responses labelled the y-axis 'length' which was too vague.

Question 3

(a) (i) A voltmeter was connected across a 330 Ω resistor (connected across points A and B) and the potential difference recorded. Good results were in the region 1.5 to 3.5 Volts, and (for all three parts) given to one or two decimal places with the unit stated. The best responses repeated their measurements and averaged the results. Some responses appeared to have connected the voltmeter across the wrong components, or misread the instrument or obtained poor results due to insufficient practical skills.

(a) (ii) The voltmeter was connected across an LED (connected across points B and C) and the potential difference recorded. Good results were in the region 1.5 to 2.2 Volts. The best responses repeated their measurements and averaged the results.

(a) (iii) The voltmeter was connected across both components in the series circuit (voltmeter connected in parallel across A and C) and the potential difference recorded should have been close to the sum of the two previous voltages. The best responses repeated their measurements and averaged the results.

(b) The current was calculated using a given formula and the result from **(a)(i).** The expected current was small and could have been given in A or mA. Some responses selected the wrong unit or omitted the unit.

(c) The resistance of the LED was calculated using the candidate's results and the given formula. Good responses showed a correct calculation and gave the answer to two or three significant figures, with values close to the centre value or in the range 150 Ω to 250 Ω. Many responses gave the final answer to an inappropriate precision (often to four or more significant figures).

Section B

Question 4

Candidates were asked to investigate the heating of a thermometer by a small electrical coil.

(a) Candidates were asked to record the room temperature. Values in the range 15°C to 45°C or the centre value were accepted with the correct name °Celsius ('°Centigrade' is incorrect) or symbol, °C. There were many good responses but in some incorrect responses the unit was omitted or incorrect. The room temperature should have been recorded when a steady reading was obtained, so repeats and averages were not required here or in the other parts of this question.

(b) Candidates were asked to close the switch so current flowed and the coil heated the thermometer. Some centres commented that the temperature rise was too rapid for the candidates to record, but most candidates produced a valid set of results.

(b)(i) Candidates were asked to record the current after 5 seconds and a value of less than 1 A should have been observed and recorded and given to at least 1 d.p. There were many good responses but some weaker responses confused the units A and mA.

(b)(ii) The power supplied to the coil was calculated using the given formula and the candidate's value of the current. Values in the range 0.1W to 4.0W were accepted. There were many good responses but some weaker responses showed a lack of appreciation of what would be a sensible value for a current or power with this circuit, and answers out by several powers of ten were written down.

(c) Candidates were asked to record the time for the temperature to increase by 2°C and to repeat this step to produce a set of 9 pairs of readings which were put in a table. Good responses put headings to the table (' temperature / °C' and ' time / s') and wrote temperatures and times in the correct notation (for the time. 00:00:45 is incorrect notation, 45 s is correct). Good responses listed the correct temperatures for each increase and the correct number of sets of results. Experiments that were carried out well gave a set of results showing an increasing time interval as the temperature increased.

(d) Candidate were asked to plot a graph of time (in seconds) on the y-axis against temperature (°C) on the x-axis. A line graph was required. A few incorrect responses were histograms. Good responses showed neatly, accurately plotted data on axes labelled with the quantity and unit and a good choice of scale (based on 2, 5,10). A smooth best fit curve should have been drawn as a single continuous line with increasing gradient. The curve was rather difficult to draw well as a smooth continuous line when a good scale produced a large graph and this was taken into account when marking scripts. Weaker responses produced untidy and inaccurate graphs, often on awkward scales (based on 3,6,7,9 or non-integers) and some poor line fitting (dot-to-dot lines are not acceptable). Some responses showed straight lines drawn through points which would be better fitted by a smooth curve.

(e) Candidates were asked to find the gradient of their line at a specific point, (θ_r +11)°C because a curved plot was expected. Good responses drew a long tangent to this point, constructed a large gradient triangle and correctly calculated the gradient. Some responses misplaced the tangent or used a small triangle or made errors in their calculations. There were some responses where a large triangle was drawn but a smaller triangle was actually used to determine the gradient and in these cases the large triangle cannot be credited with marks as the method is incorrect.

PHYSICS

Paper 5054/32
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Section B

Question 4

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(b) Candidates were asked to close the switch so current flowed and the coil heated the thermometer. Some centres commented that the temperature rise was too rapid for the candidates to record, but most candidates produced a valid set of results.

(b)(i) Candidates were asked to record the current after 5 seconds and a value of less than 1 A should have been observed and recorded and given to at least 1 d.p. There were many good responses but some weaker responses confused the units A and mA.

(b)(ii) The power supplied to the coil was calculated using the given formula and the candidate's value of the current. Values in the range 0.1W to 4.0W were accepted. There were many good responses but some weaker responses showed a lack of appreciation of what would be a sensible value for a current or power with this circuit, and answers out by several powers of ten were written down.

(c) Candidates were asked to record the time for the temperature to increase by 2°C and to repeat this step to produce a set of 9 pairs of readings which were put in a table. Good responses put headings to the table (' temperature / °C' and ' time / s') and wrote temperatures and times in the correct notation (for the time. 00:00:45 is incorrect notation, 45 s is correct). Good responses listed the correct temperatures for each increase and the correct number of sets of results. Experiments that were carried out well gave a set of results showing an increasing time interval as the temperature increased.

(d) Candidate were asked to plot a graph of time (in seconds) on the y-axis against temperature (°C) on the x-axis. A line graph was required. A few incorrect responses were histograms. Good responses showed neatly, accurately plotted data on axes labelled with the quantity and unit and a good choice of scale (based on 2, 5,10). A smooth best fit curve should have been drawn as a single continuous line with increasing gradient. The curve was rather difficult to draw well as a smooth continuous line when a good scale produced a large graph and this was taken into account when marking scripts. Weaker responses produced untidy and inaccurate graphs, often on awkward scales (based on 3,6,7,9 or non-integers) and some poor line fitting (dot-to-dot lines are not acceptable). Some responses showed straight lines drawn through points which would be better fitted by a smooth curve.

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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. Some candidates appear to come to the examination without pencils, rulers and protractors and so could not take accurate measurements. 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. The better candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly although many were unable to give an answer to the correct number of significant figures. Units were generally well known and usually included where needed. The writing of a small number of candidates was almost illegible and the standard of graph plotting for many could be improved upon.

Question 1

(a) This was intended to be an easy start to the paper and most candidates could identify that the car was decelerating. However, they struggled to explain this and usually just stated that the dots were getting closer. We needed to see an understanding that the distance travelled in equal times was decreasing.

(b) The candidates found it difficult to take measurements from the diagram and record them in a suitable table. Many lost marks for not having the quantity and unit in the headings for the table. This is good practice and should be encouraged when carrying out practical work. Many candidates also simply measured the distance between each dot instead of measuring the distance from A for each time period. The majority of candidates failed to include the starting point of (0, 1.000) in their table.

(c) Candidates were expected to use their data to find the average speed of the car and this was done well by those candidates who had recorded correct data.

Question 2

(a) This was well answered – the candidates had no problem in calculating the average time.

(b) The candidates were given the data and asked to plot a graph. The majority could use a suitable scale and plot the points correctly. 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'. There were very few who plotted the graph with the axes the wrong way round and the majority correctly labelled the axes with the quantity and unit. As usual, there were a few who used unsuitable scales but generally the graph plotting was done well. However, the majority made an incorrect assumption that this was a straight line graph despite being asked to draw a smooth curve of best fit. Those who did attempt to draw a curve generally drew it badly so the final mark for this graph was rarely awarded. A sharp pencil would be an advantage in drawing curves.

(c) The candidates were given an expression for the flow rate of the water and then asked to use this to find the flow rate for a particular value of *h.* Only the more able candidates were able to correctly do the substitution and get a correct answer. Many then omitted to give their answer to 2 significant figures as asked.

(d) The majority of candidates realised that if the hole in the bottle was bigger, the water would flow out more quickly and they could correctly draw a curved line of similar shape on their graph below the original line to demonstrate this. This was done well.

(e) Most candidates could suggest a sensible reason why the candidate did not measure the time taken for the bottle to empty completely.

Question 3

(a) (i) Candidates should remember that this is intended to be a practical paper and not a theory paper so they should read the instructions given carefully. Candidates were expected to draw a straight line through points P_1 and P_2 and then continue this to the mirror AB. Similarly they should have joined P_3 and P_4 and continued this line to mirror CD. They should then have joined their two lines together. A sharp pencil would again have helped in this task. Some candidates decided the pins were incorrectly placed and drew lines where they thought they should be and this lost marks.

(ii) Having drawn the lines, we were simply asking the candidates to explain what they did. Many tried to explain the experiment but this was not what was asked. The more able candidates did well here and clearly explained the steps taken in tracing the path of the ray whilst being reflected by the mirrors.

(iii) This question was poorly answered by the majority but more able candidates correctly suggested drawing the lines through the centre of the dots or the advantages of using a sharp pencil etc.

(b) This question required the candidates to follow a series of instructions in order to measure the angle of incidence and angle of reflection at Q. Very few candidates gaining all the marks available. The candidates made assumptions about the angles instead of measuring them as instructed. It is possible that very few had protractors with them.

(c) Candidates were asked to suggest a way of improving the positions of the pins to achieve a more accurate value for their angles. Many incorrectly talked about parallax error. Only the more able candidates scored a mark here for a sensible suggestion.

Question 4

This question was answered well throughout by all but the least able candidates. A few had the meters the wrong way round and some lost marks for not including units with their readings but the majority of candidates scored well on this question.

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.
- Candidates should have as much personal experience of carrying out experiments themselves as possible.
- Candidates should be advised to read the questions through very carefully to ensure that they are answering the question as written, and not simply recalling the answer to a different question.
- Candidates will need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability, and control of variables.
- Candidates should be aware that, as this paper tests an understanding of experimental work, explanations will need to be based on data from the question and practical rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.

General Comments

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

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

The 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) Only about half the candidature drew the position of the ball at its point of release in the correct position on the given diagram. Many candidates did not realise that if the ball is to fall through a vertical distance of 1.000 m, the bottom of the ball must be level with the top of the vertical metre rule.

(b) (i) The average time of fall was determined correctly by the majority of candidates. Many of these candidates, however, did not obtain full credit here because they ignored the instruction to give their answer to two decimal places. A mark was sometimes lost because the value calculated was incorrectly rounded.

(ii) It was pleasing to see that the response to this question produced better answers than to similar questions set in previous examinations. More candidates realised that it would be poor experimental practice to quote the mean time to more decimal places than the raw data that it was derived from.

(c) (i) A value for the acceleration due to gravity was usually calculated correctly. Credit was often lost either because the final answer was incorrectly rounded or the value was quoted to too many significant figures.

(ii) Very few completely correct answers were seen to this more demanding final part of the question. Many candidates realised that dropping the ball from a greater height would increase the time of flight, but far fewer stated that this would reduce the percentage error in the time or would reduce the effect of reaction time errors. Many candidates thought that the actual reaction time error would decrease if the ball was in the air for longer. There were many confused ideas expressed here, with a significant minority of candidates thinking that the acceleration due to gravity would increase if the ball fell for a longer time. Another common incorrect response often given, was that a longer time would allow the ball to reach its terminal velocity.

Question 2

(a) Most candidates knew the correct symbol for a voltmeter and connected it in parallel with lamp P. The scale of the given voltmeter was usually read correctly.

(b) (i)(ii) The reading on the ammeter scale caused more problems than that of the voltmeter. Common incorrect answers seen were 0.255 A and 0.3 A.

(iii) Many candidates incorrectly thought that if lamp Q was not lit then the voltmeter across lamp P would read zero. The expected answer was that the ammeter still showed a reading or that lamp P is lit.

(iv) It was pleasing to see that candidates were able to come up with sensible suggestions to this slightly more difficult final part of the question. Many candidates realised that the voltage across lamp Q was less than its working voltage, so that although there was a current through its filament, it did not light up.

Question 3

(a) Many candidates did not know how to use the given apparatus to investigate the effect of three different insulating materials on the cooling of hot water in a beaker. All that was expected was that the temperature of the hot water be taken at intervals as it cooled in the beaker with the three different materials used as lagging for the beaker. Many candidates placed the materials inside the beaker with the hot water, or poured hot water onto the materials and measured their temperatures as they cooled. Investigations such as this should not be outside the compass of candidates' experience in a physics laboratory.

(b) Most candidates were able to name a quantity that needed to be kept constant in this investigation. A common incorrect answer was the temperature of the water. Because the hot water was continuously cooling, candidates needed to say that the initial temperature of the hot water should be the same each time.

(c) Candidates' tables were poor, with units missing from the table headings or no mention of the different insulators in the tables.

(d) Most candidates did not heed the wording of the question which asked them to state how the readings taken could be used to reach a conclusion. Most answers indicated that candidates had done little practical work of this nature.

Question 4

(a) The height of the card that candidates were required to measure from the diagram given in the question was exactly 2 cm. Because candidates were using a ruler graduated in millimetres to measure this length, they were expected to give their answer to the resolution of the instrument. Correct answers of $H = 2.0$ cm were extremely rare.

(b) (i) The height of the shadow was usually correctly measured as 2.3 cm.

(ii) Most candidates realised that the edges of the shadow were not distinct, and that the shadow was curved and so its height would be difficult to measure accurately.

(c) The graph proved to be straightforward to plot with many candidates scoring 3 / 4 marks. Because the *y*-axis scale was given to candidates, the choice of x-axis scale was not challenging, although some candidates did choose a scale that made too little use of the graph paper available. The choice of scales which involved multiples of 3, 7 etc. were much less evident this year than in previous years. There were many very good attempts at drawing the best-fit curve through the points. The standard of plotting and of line drawing continues to improve and there was not as much evidence this year of large dots or thick lines.

(d) (i) The value for h_{40} was usually determined correctly from the candidate's graph and the value obtained was usually with the 2 mm tolerance allowed here.

(ii) Candidates had little trouble in calculating a value for H from the given equation.

(iii) Candidates were asked to compare the value of H calculated from the graph in **(d)(ii)** with that measured in **(a)** and expected to comment on the closeness, or not, of the two values. It was pleasing to see that many candidates who obtained values that differed by a millimetre, or so, commented that they were close enough to be considered equal if allowance was made for experimental error/uncertainty.

(e) (i) The majority of candidates were able to produce sensible extrapolations of their graph to determine the height of the shadow when *d* = 20.0 cm.

(ii) Only the more able candidates were able to give a reason as to why the distance between object and lamp should not be less than 10.0 cm. Only these candidates noticed the trend that the size of the shadow was increasing as *d* was decreasing and for values of *d* less than 10.0 cm, the shadow would be too big for the screen.

(f) Again, with this more demanding final part, most candidates did not realise that changing the lamp to screen distance would also change the height of the shadow and so it would not be a fair comparison.