# PHYSICS

**Paper 5054/11**
**Multiple Choice**

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

## General Comments

The results show that all parts of the syllabus had been covered well.

The candidates found **Questions 10**, **16** and **37** to be relatively easy, while **Question 17** was the most difficult.

## Comments on Specific Questions

### Question 4

The movement of the ball falling through the oil is the same as that of a free-fall parachutist – the faster it goes, the greater is the resistant force.

**Question 5**

The majority of candidates incorrectly chose option **A** instead of **B**. On impact, the ground has to support the weight of the stone and also provide the stopping force.

**Question 13**

Many candidates forgot that, because the height of the stopping point of the ball was less than that of the starting point, there was not perfect energy transfer between potential and kinetic energies, and hence some other energy form was involved.

**Question 17**

More than half of the candidates chose option **D** instead of **C**. Collisions between free electrons do not make a significant contribution to conduction; the free electrons collide with atoms further along the rod.

**Question 34**

The statistics suggest there was some guessing by the weaker candidates.

# PHYSICS

**Paper 5054/12**
**Multiple Choice**

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

## General Comments

All parts of the syllabus had been covered and the candidates had been well prepared.

The candidates found **Questions 13**, **16**, **31**, **38** and **39** to be very easy. **Question 12** was the most difficult.

## Comments on Specific Questions

### Question 4

As the ball falls, its velocity increases; this increases the air resistance causing a decrease in the acceleration as the resultant force decreases. Hence the favourite response, option **D**, was incorrect.

**Question 11**

Many candidates chose option **D**, most likely because they did not realise the need to convert 20 cm to 0.2 m before substitution into $\rho gh$. Candidates should be encouraged to check that units are consistent before making substitutions.

**Question 12**

More than one third of the candidates, including a large number of the higher scoring candidates, chose option **D**. The volume of the gas increases from 200 $cm^3$ to 300 $cm^3$, so the pressure must decrease from $P$ to $2P/3$.

**Question 37**

The popularity of option **B** suggests that many candidates were aware that conventional current and electron flow are opposite in direction, but had not realised that conventional current is from the positive terminal of the cell to the negative terminal.

# PHYSICS

**Paper 5054/21**

**Theory**

## Key Messages

- To gain full credit, candidates should always give units when answering numerical questions. If a unit is complex (for example J / (g °C) for specific heat capacity), they can use the relevant formula together with basic units that they do know, in order to work out the unit.

- Candidates should be encouraged to write down any formula that is used in a calculation. This ensures that credit is gained, even if substitution of the data is wrong or the calculation is incorrect.

- Although candidates need to know the subject content from the syllabus, they also need to be able to read each question carefully and apply the ideas to the actual question being asked.

- 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

The candidates sitting this paper produced answers that scored a wide range of credit, some very high. It was clear that some candidates had an easy familiarity with the topics being examined but others, whose understanding of the subject included significant areas of weakness, found the examination very challenging. Candidates are getting used to the structured question format for the whole paper and very few candidates wrote answers anywhere other than the expected locations. A high proportion of the candidates correctly followed the rubric to answer exactly two questions in ***Section B***. A small number of candidates answered some parts of all three ***Section B*** questions, but did not answer all parts of any question. This is an approach that can only lead to reduced credit as the paper can only be marked in accordance with the rubric.

The three ***Section B*** questions were almost equally popular; slightly more candidates chose to answer **Question 9** than **Questions 10** or **11**. These last two questions were chosen by roughly equal numbers of candidates. The three ***Section B*** questions were designed to be equally accessible and the credit scored by candidates was very similar on each of the questions. All of the questions contained both descriptive and mathematical parts and also both easier and harder parts. A similar balance is maintained within ***Section A***.

## Comments on specific questions

### *Section A*

### Question 1

**(a) (i)** A minority of candidates correctly continued the straight line to the point (6.0, –4.8). Others took the line down to (3.0, 0) and then drew a second line going upwards. There were many other incorrect variations.

**(ii)** This part also caused some confusion, and again a significant number of candidates did not give the correct answer.

**(b)** This calculation was better understood and better answered. Many candidates wrote down the formula for acceleration in some form and were able to obtain the correct answer. A few candidates, who approached this question in an entirely correct manner, lost credit by misreading the values from the graph.

**(c)** This part caused uncertainty for some candidates and very few scored full credit. The question asks about the ways in which the graph differs and many candidates gave answers relating to the motion of the stone rather than to the graph itself. In some cases it was possible to award credit but some candidates were penalised for not answering the question asked.

**Question 2**

**(a)** Many candidates knew the correct formula and were able to use it to obtain the required answer. An error that arose several times was for the candidate to write $\frac{1}{2}mv^2$ initially but then to omit the index when substituting the numerical values or when calculating the answer. Some candidates used the formula *mv* and so did not score on this part.

**(b) (i)** There were few correct answers here. Only a few candidates realised that because the sail and board are driven forward by the wind, air resistance would not be the most significant resistive force. Water resistance was rarely referred to, and even the absence of any resultant force was only mentioned by a few candidates.

**(ii)** Many candidates were able to quote the principle of the conservation of energy but rather fewer were able to apply it to this specific example. The candidates who scored credit here were generally the candidates who realised and stated that the work done by the wind on the sail would end up as thermal energy.

**Question 3**

**(a)** There were some excellent answers here. The majority were able to use proportions and to obtain the correct answer.

**(b)** This part of the question was also well answered. Many candidates knew the definition of pressure and were able to use it and so obtain the correct answer. Many of those who did not divide correctly by the negative power of ten or who, more commonly, ignored it, were still able to score some credit by quoting the formula for the definition of pressure directly or by implying it by numerical substitution.

**(c)** This part caused a degree of uncertainty for some candidates, many of whom suggested that increasing the area of the piston would have the required effect. Candidates who concentrated on the spring's properties were much more likely to get the answer correct; a stiffer spring would be appropriate.

**(d)** Many candidates realised that molecules would escape from the tyre when using the pressure gauge but rather fewer were able to describe why this would lead to a reduction in the pressure of the air. Given the wording in the question, answers that did not include any reference at all to the molecules were very unlikely to score full credit.

**Question 4**

**(a)** It is very tempting in a question such as this to refer to just one of the words in the phrase whose meaning is required. Many candidates did just this but only those answers which made it clear that the melting point is the temperature at which the solid turns to a liquid were awarded credit. Neither 'the temperature at which the substance melts' nor 'the point at which the solid becomes a liquid' were acceptable answers.

**(b) (i)** Most candidates realised what was occurring at this stage and were able to answer correctly.

**(ii)** This part was less well answered and some candidates stated that the wax was turning into a gas at this stage. This was especially true of those candidates who had erroneously stated in part **(b)(i)** that the wax was melting during the first four minutes.

**(c)** This part proved to be something of a challenge. Very few candidates realised that the direct statement 'solids expand less than liquids' or 'liquids expand more than solids' was all that was required.

**Question 5**

**(a) (i)** A large majority of candidates gave the correct answer here.

**(ii)** A large majority of candidates gave the correct answer here.

**(b)** Many candidates knew one property shared by all electromagnetic waves and some were able to suggest two properties. Although the property of polarisation is dependent on the transverse nature of electromagnetic waves, candidates were still allowed to score full credit if these two points were made.

**(c)** Only a minority of candidates answered this correctly; the most popular incorrect answer was 'radio waves'.

**Question 6**

**(a) (i)** This part was well answered and it was encouraging to see so many candidates using the correct term *amplitude* in the answer.

**(ii)** Again, this part was very commonly well done and most candidates were able to describe the feature of the graph which indicates a constant pitch, or to refer to the constant frequency of the sound. Although the horizontal distance on the graph between adjacent crests is not a wavelength (it represents a periodic time), it was clear what was meant by candidates who used this term here, and many scored credit in this way.

**(b) (i)** Most candidates were able to state accurately the meaning of *frequency*.

**(ii)** This calculation was tackled well by a significant number of candidates. Full credit was very commonly awarded.

**(iii)** This part was well answered by only a small number of candidates. The diagram shows that the amplitude halves after three cycles but a value of four times 0.02 s was the most common answer offered, suggesting that these candidates had counted crests inclusively.

**Question 7**

**(a)** Only a minority of candidates stated the correct name of this component.

**(b)** This definition is one of the harder sections of the course and so, although many candidates did not offer a correct definition, it was pleasing to see that a significant minority were able to do so.

**(c)** Very few candidates noticed that one of the cells in the battery was reversed and even fewer stated that some of the potential difference would appear across the LED.

**(d) (i)** This comparatively straightforward part of the question was well answered. Some candidates, however, lost credit by drawing three bulbs or other components in parallel.

**(ii)** Few candidates stated an advantage of connecting cells in parallel.

**Question 8**

**(a) (i)** Many candidates were able to suggest that the rod is made from iron. There are other magnetically soft materials that could be used but, although it is magnetic, nickel is not one of them.

**(ii)** Many answers that might have scored some credit were spoiled by the candidate referring to charges on the magnet; in some cases, the charges were described as being negative or positive. Candidates should only use the term 'pole' when referring to magnets.

**(b) (i)** There were some good answers here with many candidates realising that the magnetic field lines are circular and clockwise.

**(ii)** A significant number of candidates scored credit here.

***Section B***

**Question 9**

**(a) (i)** This part of the question generated a wide variety of responses; some candidates drew the correct fuse symbol in the correct location whilst others did neither.

**(ii)** Only a few candidates knew where the earth wire of a heater is connected. A significant number suggested that it is connected to the live wire and many other suggestions were also given.

**(iii) 1.** A significant number of answers here suggested ideas that were not faults; 'switching the heater on' or 'a large current' were each given by many candidates. Only a minority offered an acceptable suggestion.

**2.** Very few candidates stated that a large current in the earth wire causes the fuse to blow and so, whilst many candidates scored initial credit in one way or another, very few indeed were awarded full credit.

**(b) (i)** Most candidates concentrated on a more colloquial use of the term *efficient* with suggestions such as 'it warms the room quickly'. Some of those who did refer to the strict definition of efficiency did not apply it in this specific case where the useful energy output is thermal energy.

**(ii)** This description produced answers of varying standards. Some candidates knew and described exactly what was required and scored full credit simply and easily. Others were less certain and perhaps forgot to explain why the hot air rises. A significant minority of candidates described the process of conduction which did not answer the question asked.

**(c) (i)** Very many candidates answered this correctly.

**(ii) 1.** Some candidates knew exactly what was required here and their very succinct answers scored full credit. Others were less certain, and whilst some omitted to convert to kilowatts, others multiplied the time by 60 or, perhaps, divided the power by the time.

**2.** Here there were many different approaches but many correct answers were given.

**Question 10**

**(a) (i)** Many candidates gave the correct answer here.

**(ii)** This calculation was well known and understood by many candidates. A significant number were awarded full credit here. A few candidates, who had correctly given $\sin i / \sin r$ and then $\sin 45° / \sin 29°$, gave as the final answer the number obtained by calculating $45 / 29$.

**(iii)** A significant number of answers referred to 'total internal reflection' but many fewer explained in terms of the *critical angle* why total internal reflection takes place. Some answers were spoiled by the phrase 'total internal refraction'.

**(iv)** Many candidates drew a correctly refracted ray at C but many fewer scored full credit. Most candidates allowed the ray to refract out of the prism at the lower face and some of those who drew it reflecting, drew diagrams where $i$ was not equal to $r$.

**(b) (i)** This ray diagram produced answers of many different standards. Some diagrams were very simple and scored full credit by including just what was needed and nothing else. Other diagrams tended to be over-complicated and inaccurate.

**(ii)** In order to obtain the correct answer here candidates needed to have drawn the diagram in **(ii)** with care, which many had.

**(iii) 1.** Some candidates knew this difference and stated it clearly.

**2.** Only a few candidates knew this answer and many of these only obtained partial credit; for full credit an explanation of how to view the image was also needed.

**Question 11**

**(a)** Many candidates were able to explain why a gamma-ray source would be unsuitable.

**(b) (i)** A significant number of candidates were able to draw diagrams that scored full credit here; many others had some idea of what was required and scored some credit.

**(ii)** Very many candidates were awarded full credit here. The direction of the deflection was very frequently correct and the explanation given was appropriate in many cases.

**(c)** This part was also well answered with many candidates simply stating that gamma rays are undeflected because they are uncharged.

**(d) (i)** This question was commonly well answered and even those candidates who did not give completely correct answers, very frequently scored some credit.

**(ii)** This part caused some confusion with many candidates thinking that it would not be sufficiently strongly ionising, or unsuitable for some more complicated reason.

**(iii) 1.** Many candidates knew and stated two appropriate similarities here.

**2.** Whilst this proved slightly harder than the previous part, most candidates were able to offer one appropriate difference and many offered two.

# PHYSICS

**Paper 5054/22**
**Theory**

## Key messages

- To gain full credit, candidates should always give units when answering numerical questions. If a unit is complex (for example J / (g °C) for specific heat capacity), they can use the relevant formula together with basic units that they do know, in order to work out the unit.
- Candidates should be encouraged to write down any formula that is used in a calculation. This ensures that credit is gained, even if substitution of the data is wrong or the calculation is incorrect.
- Although candidates need to know the subject content from the syllabus, they also need to be able to read each question carefully and apply the ideas to the actual question being asked.
- 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

Overall, the paper was well answered and there was no evidence that the questions were misunderstood. The standard of the English and the presentation of the answers were good in the majority of cases, and there were some excellent responses, although the performance of some candidates would improve if they planned their answers before starting to write.

In several questions, being able to describe the method used in an experiment, understanding the difficulties encountered in a practical situation or understanding the factors involved were all helpful in obtaining credit. Practice in describing methods during ordinary teaching may provide the necessary experience.

In ***Section B*** slightly more candidates answered **Question 8** than either of the other two questions. **Question 9** was the least popular, although those candidates who answered this question sometimes produced very good answers indeed.

Numerical questions were answered well, as in previous examinations, although units were often omitted. It is helpful if working is set out clearly, particularly where there are several steps involved such as in **Question 8(b)(iv)**. Candidates who do not obtain the correct answer may still be awarded credit if they show the working in a clear manner.

## Comments on specific questions

### *Section A*

### Question 1

**(a) (i)** Most candidates gave a satisfactory answer, the most popular response being ‘the amount of matter’ or ‘the amount of substance’. Less common, and not acceptable on their own, were ideas about the number of molecules or definitions of mass in terms of density or weight.

**(ii)** Some candidates were very confident in describing how to use the scale to find the extension of the spring. Others made no reference to the scale, or alternatively obtained readings but failed to say what they would do with them, such as finding the difference between the two readings.

**(b) (i)** Most candidates answered the question well by using values from Fig. 1.2, for example by making reference to the two forces at 4 cm extension or to the two extensions at 15 N force. Other candidates may well have been able to give a suitable answer but they did not refer specifically to values in Fig. 1.2, as was required in the question.

**(ii)** The majority of candidates made sensible references to the shape of the lines in Fig. 1.2. There was a tendency in some answers to refer to spring B without any reference to spring A and it would appear from their answers that some candidates confused the limit of proportionality with elastic limit.

**(iii)** Although most candidates gave the correct response, some gave 4 N which was obtained from the force axis when the extension of B is 1.0 cm or the difference in extension is 1 mm.

**Question 2**

**(a)** Almost all candidates could make at least one relevant point about friction, either that it was a force, opposed motion, or that it existed between sliding or rubbing objects.

**(b) (i)** The majority of answers correctly suggested that balanced forces result in constant speed or velocity. Some candidates failed to realise from the question that the car is travelling along the road and suggested that the car was stationary. Some candidates were confused by speed and acceleration and gave answers such as "accelerate at constant speed".

**(ii)** The formula involving force, acceleration and mass was applied well, with only a minority of candidates attempting to use, for example, the wrong mass in the calculation. It was encouraging that most candidates, having found the resultant force, attempted to find force B, and a large number were successful.

**(iii)** Most candidates realised that the resistive forces increase but comparatively few explained that this was because the speed increases.

**(c)** This was another well answered question with only a minority making a careless error in the power of 10 or failing to provide a unit.

**Question 3**

**(a)** Simple statements that the outside of the house was hotter than the main room, or that there was a larger temperature difference between the outside and the bedroom compared to the main room were very common and showed a good understanding of the cause of the transfer of thermal energy. Weaker responses made reference to the window and door of the bedroom, or that there was 'more thermal energy outside', which was considered irrelevant.

**(b) (i)** Most candidates were able to correctly add up the energy values supplied in the table but occasionally the unit was omitted or candidates did not appreciate that the values given in the table were energy inputs in one hour.

**(ii)** There was a general appreciation that energy = power × time and most candidates scored some credit for this, but some errors were seen, usually where candidates had mistakenly calculated an hour as 60 s. Answers were acceptable in J or kW h.

**(c)** The majority of candidates gave a sound explanation of the circulation of air in convection involving the cold air sinking and the hot air rising, but reference to density was occasionally missing or incorrect and it was not always appreciated that it was the cold air sinking that was the driving force for this convection current.

**Question 4**

**(a)** This section was very well answered. Some candidates gave an incorrect unit or gave the answer as 100 °C.

**(b)** Although the formula involving specific heat capacity appeared to be well known, many candidates used a time rather than a temperature difference within the formula, or did not read the temperature difference correctly from the graph. This led to many incorrect answers.

**(c) (i)** Many candidates explained why energy is required to change state from solid to liquid, rather than why energy is given out in changing from liquid to solid. A good number of answers were successful in suggesting that bonds between molecules are made, but the best answers involved a description of latent heat being given out. Many candidates incorrectly suggested that the kinetic energy of the molecules decreases during solidification.

**(ii)** This part was very well answered, with candidates providing detail about how molecules move into a fixed position and vibrate about that position in a solid, whereas in a liquid molecules move throughout the liquid. Some candidates merely wrote about the solid phase and did not attempt to describe any change.

**Question 5**

**(a)** There were a large number of correct responses, including the ability to send more data per second, less attenuation or energy loss, the possibility of transmission over longer distances or even less noise or interference. The most common misconception was to suggest that light, or the signal, travels faster. It is more helpful to suggest that the total data or information arrives in a shorter time, than that the signal travels faster, as an electrical signal travels along a copper cable at the speed of light in the medium between the conductors.

**(b) (i)** Most candidates drew the correct normal and angle of incidence. Weaker candidates drew a normal that was vertical, down the page, rather than being at right angles to the surface at P.

**(ii)** A good explanation of total internal reflection was produced in many answers, although sometimes the critical angle was incorrectly stated as being larger than the angle of incidence.

**(c)** The formula for refractive index was well known and it was encouraging that most candidates could rearrange the equation readily. Some candidates, however, made no attempt to use the sine of the angles. The data in the question was given to two significant figures; although candidates may give their answer to more figures, it is expected that they round their answer correctly. Many candidates rounded incorrectly, for example giving an answer as 35.2° rather than 35.3° to three significant figures but would have been correct if they had given the answer as 35° to two significant figures or if they had written more figures.

**Question 6**

**(a)** More able candidates described the oscillation involved in wave motion and also mentioned the transmission of energy without any net movement of the medium. Although the syllabus suggests that candidates should be able to describe what is meant by wave motion, many candidates merely gave a description of transverse or longitudinal vibration.

**(b)** Many candidates incorrectly drew an arrow showing that the molecule at X moves sideways rather than up or down.

**(c) (i)** The equation was well known, but many candidates gave the wrong unit, not noticing that the question gives the wavelength in centimetres rather than metres.

**(ii)** It was expected that candidates would mark a distance somewhere on the diagram that was equal to two wavelengths. Many answers showed just one wavelength.

**Question 7**

**(a)** The shape of the electric field was generally drawn well but occasionally parallel lines were drawn between the two spheres. There were comparatively few major errors showing crossing of lines and the direction of the field, from positive to negative, was well understood.

**(b)** The formula was well known and the main difficulty that some candidates faced was in the mathematics or use of a calculator when dividing by a negative power of ten.

***Section B***

**Question 8**

**(a) (i)** In order to gain full credit here, candidates had to convey three distinct characteristics: the correct components, the ammeter in series with the wire, and the voltmeter measuring the voltage across the wire. Most candidates drew the correct symbols for the components and placed the ammeter correctly but others failed to place the voltmeter across the wire whose resistance was to be measured or failed to label the wire W.

**(ii)** Although most candidates recognised the need to make the basic measurements, the answers would have improved if the complete set of results to fulfil the aim of the experiment had been described. Many candidates did not recognise that the length had to be measured or at least altered.

**(iii) 1.** The idea that temperature affects resistance was the most popular correct response. The idea that the wire becomes hot, melts or burns was also acceptable, and given in some answers.

**2.** Some knowledge of how to maintain a steady temperature was required, such as using a water bath, low current or allowing the circuit to cool between readings. Some candidates appeared to have very good practical experience and came up with acceptable solutions; others made poor references to setting the air conditioning or using insulation.

**(b) (i)** The formula involving resistance, current and voltage was well known and applied.

**(ii)** The knowledge of how current splits in a parallel circuit was well known.

**(iii)** Most candidates explained that there was a lower current through Z, but fewer mentioned that the p.d. was the same across components in parallel. Some candidates would have produced better answers by referring directly to components in the question, rather than saying 'as the resistance rises the current falls'.

**(iv)** It was encouraging that most candidates recognised, in outline, that they had to calculate the combined resistance of two resistors in parallel and then add the result to the series resistance. Most candidates made some attempt to use the correct formula for two resistors in parallel but some needed to take more care to use the formula correctly and to invert the answer they obtained. Similarly, others needed to take care to produce an answer that did not involve a fraction.

**Question 9**

**(a) (i)** The direction of the conventional electric current is from the positive side of the battery towards the negative side. A number of candidates marked the current in the wrong direction.

**(ii)** It was encouraging to see some candidates draw magnetic field lines in the iron core that pass round the ring. Candidates who drew lines leaving the core needed to consider what happens to these lines. Others needed to mark the direction of the field lines correctly with reference to the current direction in the coil.

**(b) (i)** Many candidates understood the ideas of 'changing field' or 'induced current', but the concept of induction was not understood by all.

**(ii)** Many candidates correctly suggested that the voltmeter deflects in the opposite direction but did not explain this correctly. A significant number of answers suggested that the reading goes to zero immediately the switch is opened.

**(iii)** Nearly all candidates made a sensible suggestion as to how to increase the deflection. There were some vague statements such as 'stronger' or 'bigger battery' which were not credited.

**(c) (i)** Many candidates knew and correctly applied the equation for electrical power.

**(ii)** This part was more of a challenge, where either candidates needed to apply the equation $P = I^2R$ or to state and apply both $P = VI$ and $V = IR$. Many candidates were successful, although a significant number considered the two $2.5\,\Omega$ resistors to be in parallel rather than in series, but this lost little credit.

**Question 10**

**(a) (i)** It was encouraging to find many fully correct answers that stated that an alpha-particle is a helium nucleus with the correct charge and mass. Some candidates gave other details which were not required, such as the properties of these particles rather than what the particles actually are. There was confusion in some answers, where the alpha-particle was described as a helium atom, particularly where it was stated to contain two electrons as well as two protons and two neutrons.

**(ii)** Many correctly stated that a gamma-ray is a high frequency electromagnetic particle, ray or wave.

**(b) (i)** It was apparent that many candidates knew the reason for both parts of this section but sometimes had difficulty in explaining the principles. Alpha-particles were often correctly identified as being responsible for working within a few centimetres of the source but it was less common to find that this was linked to the range of the particles and often it was 'so that they are detected' or 'to avoid deflection'. Candidates with a clear idea of the range of the particles and those who could express their knowledge scored well.

**(ii)** Many answers correctly suggested that using a source with a short half-life means that the source will have lost its activity too quickly or that the source will need to be replaced too often. Weaker answers defined half-life and did not relate this definition to the actual situation.

**(c)** This section was relatively well answered. There was a general knowledge of which particle was stopped by each absorber but some answers would have been improved by applying the data, for example by relating the change in count to the absorber used, rather than merely stating, for example, that 'alpha-particles are stopped by paper'. A small number of candidates incorrectly stated that they could not conclude whether gamma-rays were present because lead had not been used as an absorber. They did not realise that anything passing through the thick aluminium must be a gamma-rays.

**(d)** Many possible sources of background radiation were correctly given. A few suggestions were vague or were clearly not correct, such as 'television' or 'ultraviolet in sunlight'; the two suggestions given by some were too similar such as 'cosmic rays' and 'outer space'.

**(e)** The effect of radiation on the human body was well known. A few suggestions were too vague, such as illness, but the most common successful suggestion was the development of cancer.

# PHYSICS

**Paper 5054/31**
**Practical Test**

## Key messages

- A common cause of lost credit on this paper is the omission of units, or use of inappropriate units (e.g. V when mV 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.

- 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.

- Candidates should be encouraged to repeat their measurements when answering questions in **Section A** in order to obtain full credit.

- It is important to choose a sensible scale for the graph in **Section B**. Scales based on intervals of, for example, 3 cm, are difficult to use and will lose credit both for the scale and for the plotting of points.

## General comments

There were a number of difficulties related to precision, which became particularly evident in **Question 1**: it is important that candidates realise that measurements made with a metre rule should be given to the nearest millimetre, and that the precision of calculated quantities should be consistent with the precision of the raw data.

Candidates seem to have found **Question 4** slightly easier this year than in June 2011. The majority of candidates were able to take at least 8 good readings, and the average mark for the observations section was probably in the region of 4-5 marks. Some candidates, however, found difficulty using the voltmeter and ammeter and recorded unrealistic values (e.g. 65 V instead of 65 mV).

The greater emphasis on correct answers started last year was continued this year. There was an element of this in all 4 questions, in which marks were available for careful practical work that led to accurate final answers.

Supervisors should ensure that a note is made on the "Report on Practical Physics" if there is any deviation from the apparatus specified in the Confidential Instructions. This was particularly important in Question 4, where different wires could cause the candidates to obtain different gradients in **4(e)**. The "Report on Practical Physics" should always be included in the envelope with the scripts.

## Comments on specific questions

### *Section A*

### Question 1

**(a)** Most candidates obtained a value for the position of the knife-edge in the range 48.0 cm to 52.0 cm. However, credit was often lost, either because no unit was given with the value, or the value was quoted to the nearest cm, e.g. 50 cm was a popular incorrect answer.

**(b) (i)** Judging by the numerical values obtained, the majority of candidates had set up the apparatus correctly. In order to make the results as accurate as possible, a large value of $x$ should have been chosen, by placing the modelling clay close to the end of the metre rule. Most candidates did this, but some positioned the modelling clay so that $x$ was less than 40 cm. Because of the diameter of the modelling clay, $x$ was expected to be less than 50.0 cm and again this was not always the case. The precision of measurements on a metre rule should always be to the nearest mm or 0.1 cm. Some candidates took measurements to the nearest cm and others failed to include a unit with their measurements.

**(ii)** Good techniques were described in order to ensure that $y$ was measured to the centre of mass of the 50 g mass. Sometimes the diameter and then radius of the mass were found, but it was not then made clear how this was used to ensure that the measurement was to the centre of the mass. The radius should have been added to the distance from the knife-edge to the nearest edge of the 50 g mass. A number of candidates correctly measured the distances from the knife-edge to the nearest edge of the mass, and from the knife-edge to the furthest edge of the mass, and then found the average of the two.

**(iii)** The majority of candidates obtained an answer in the required range. The main reasons for credit being lost in this section were either the omission of a unit, or quoting the mass to four or more significant figures, which was not appropriate because all measurements were generally taken to three significant figures.

**Question 2**

**(a)**,**(b)** Many candidates obtained appropriate values for $t_1$ and $t_2$ from which they successfully deduced the values $T_1$ and $T_2$. The most frequent reasons for credit being lost were:

- The measurement was not repeated; the phrase, 'take measurements to determine an accurate value of…' usually indicates that candidates are expected to repeat measurements and find an average.
- The stopwatch had been misread, e.g. a reading of 11.03 s was written as 0.1103 s, where the 0 represented 0 minutes.
- Some candidates found correct values of $t_1$ and $t_2$ but then, rather than calculating $T_1$ and $T_2$ by dividing the $t$ values by 20, they attempted to actually measure the time taken for one oscillation. This produced a very inaccurate result, which often lead to a value for the ratio that was outside the expected range.
- A unit was not given at any point in **(a)** and **(b)**.

**(c)** Many candidates obtained a good value for the ratio. The most frequent errors were to give the ratio a unit, or to give the ratio to only one significant figure, when the measurements had been taken to two of three significant figures.

**Question 3**

**(a)**,**(b)** Generally, the temperature measurements given were in the expected range. There were a number of reasons for loss of credit:

- The unit of temperature was given as ° rather than °C.
- The thermometer reading was recorded incorrectly, e.g. 20.9 °C instead of 29 °C.
- The value for $\theta_2$ was too low, which suggested that either the hot water had cooled before it was added to the beaker or the 100 g mass had been left in the hot water for more than the one minute specified.
- The temperature rise when the 100 g mass was transferred to beaker C was too small. This could only be because the mass was not transferred quickly enough to beaker C. Sometimes the temperature rise was too high, which suggested that some hot water was transferred to beaker C with the 100 g mass.

**(c)** Many candidates obtained a good value for the specific heat capacity of the metal. Some candidates did not give a unit, or gave an incorrect unit. Answers to one significant figure were acceptable here because the temperature rise was only of the order of a few °C.

***Section B***

**Question 4**

**(a)** The values of the measurements were often correct but a number of candidates had problems with the units. For example they wrote 65 V instead of 65 mV, or 135 A instead of 135 mA. Candidates should have realised that 135 A was not a sensible value because it would have melted the wire, and 65 V seems unlikely from three dry cells. In other cases units were omitted.

**(b)** Error carried forward from incorrect units was allowed when the resistance was calculated; the most frequently seen incorrect answer for which credit was given was in the region of $0.065/135 = 4.8 \times 10^{-4}\,\Omega$. Other candidates, who gave a correct answer in the region of $0.48\,\Omega$, sometimes lost credit because they did not give a unit.

**(c)** Most candidates had at least eight good results. Errors that had been made in **(a)** and **(b)** were not penalised further but other popular mistakes included:

- It was expected that measurements would be taken across the full range of the metre rule. A number of candidates took readings between 5 cm and 50 cm at 5 cm intervals. This gave ten readings, but the range was less than the minimum of 80 cm expected.
- Sometimes readings were distributed unevenly, with, for example, a gap of 30 cm in the middle of the chosen range.
- Some candidates who had correctly included units in **(a)** and **(b)** omitted to include them in the table.

**(d)** Graph plotting skills were good with many candidates gaining full credit for the graph. The most common error was the use of a graph scale that was based on 3 cm. This was an inappropriate choice of scale and made accurate plotting of the points very difficult. A further complication arose for those candidates who thought that the readings that they had taken in mA were actually in A. The resistance values for such candidates ranged from approximately $4 \times 10^{-4}\,\Omega$ to $4 \times 10^{-3}\,\Omega$. Unfortunately, when the resistance values were written in this form the candidates did not know how to deal with the resistance scale. Typically a scale of $2\,\text{cm} = 1 \times 10^{-4}\,\Omega$ was used up to $10 \times 10^{-4}\,\Omega$ and then a scale of $2\,\text{cm} = 1 \times 10^{-3}\,\Omega$ was used above this point. Such candidates did not realise that they had changed scales half way along the axis. This effectively produced two straight lines, which in most cases were interpreted as a single curve. The gradient of either straight line would probably have given a good value for the gradient in **(e)**, but most candidates drew a line of best fit or curve fitted to all of the points so usually obtained a value that was outside the range. Better candidates who realised that they had a problem with the scale, converted all their resistance values to mΩ and produced the expected straight line graph.

**(e)** Good candidates used a large triangle when determining the gradient of the graph, but a significant number used a very small triangle. In some cases the base of the triangle drawn by such candidates was only 1 cm or 2 cm. Good candidates obtained a value in the correct range, but those who had had unit problems in the earlier part of the question often obtained a value that was incorrect by a factor of 10.

# PHYSICS

**Paper 5054/32**

**Practical Test**

## Key messages

- A common cause of lost credit on this paper is the omission of units, or use of inappropriate units (e.g. V when mV 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.
- 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.
- Candidates should be encouraged to repeat their measurements when answering questions in **Section A** in order to obtain full credit.
- It is important to choose a sensible scale for the graph in **Section B**. Scales based on intervals of, for example, 3 cm, are difficult to use and will lose credit both for the scale and for the plotting of points.

## General comments

There were a number of difficulties related to precision, which became particularly evident in **Question 1**: it is important that candidates realise that measurements made with a metre rule should be given to the nearest millimetre, and that the precision of calculated quantities should be consistent with the precision of the raw data.

Candidates seem to have found **Question 4** slightly easier this year than in June 2011. The majority of candidates were able to take at least 8 good readings, and the average mark for the observations section was probably in the region of 4-5 marks. Some candidates, however, found difficulty using the voltmeter and ammeter and recorded unrealistic values (e.g. 65 V instead of 65 mV).

The greater emphasis on correct answers started last year was continued this year. There was an element of this in all 4 questions, in which marks were available for careful practical work that led to accurate final answers.

Supervisors should ensure that a note is made on the "Report on Practical Physics" if there is any deviation from the apparatus specified in the Confidential Instructions. This was particularly important in Question 4, where different wires could cause the candidates to obtain different gradients in **4(e)**. The "Report on Practical Physics" should always be included in the envelope with the scripts.

## Comments on specific questions

### *Section A*

### Question 1

**(a)** Most candidates obtained a value for the position of the knife-edge in the range 48.0 cm to 52.0 cm. However, credit was often lost, either because no unit was given with the value, or the value was quoted to the nearest cm, e.g. 50 cm was a popular incorrect answer.

**(b) (i)** Judging by the numerical values obtained, the majority of candidates had set up the apparatus correctly. In order to make the results as accurate as possible, a large value of *x* should have been chosen, by placing the modelling clay close to the end of the metre rule. Most candidates did this, but some positioned the modelling clay so that $x$ was less than 40 cm. Because of the diameter of the modelling clay, $x$ was expected to be less than 50.0 cm and again this was not always the case. The precision of measurements on a metre rule should always be to the nearest mm or 0.1 cm. Some candidates took measurements to the nearest cm and others failed to include a unit with their measurements.

**(ii)** Good techniques were described in order to ensure that $y$ was measured to the centre of mass of the 50 g mass. Sometimes the diameter and then radius of the mass were found, but it was not then made clear how this was used to ensure that the measurement was to the centre of the mass. The radius should have been added to the distance from the knife-edge to the nearest edge of the 50 g mass. A number of candidates correctly measured the distances from the knife-edge to the nearest edge of the mass, and from the knife-edge to the furthest edge of the mass, and then found the average of the two.

**(iii)** The majority of candidates obtained an answer in the required range. The main reasons for credit being lost in this section were either the omission of a unit, or quoting the mass to four or more significant figures, which was not appropriate because all measurements were generally taken to three significant figures.

**Question 2**

**(a)**,**(b)** Many candidates obtained appropriate values for $t_1$ and $t_2$ from which they successfully deduced the values $T_1$ and $T_2$. The most frequent reasons for credit being lost were:

- The measurement was not repeated; the phrase, 'take measurements to determine an accurate value of…' usually indicates that candidates are expected to repeat measurements and find an average.
- The stopwatch had been misread, e.g. a reading of 11.03 s was written as 0.1103 s, where the 0 represented 0 minutes.
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- A unit was not given at any point in **(a)** and **(b)**.

**(c)** Many candidates obtained a good value for the ratio. The most frequent errors were to give the ratio a unit, or to give the ratio to only one significant figure, when the measurements had been taken to two of three significant figures.

**Question 3**

**(a)**,**(b)** Generally, the temperature measurements given were in the expected range. There were a number of reasons for loss of credit:

- The unit of temperature was given as ° rather than °C.
- The thermometer reading was recorded incorrectly, e.g. 20.9 °C instead of 29 °C.
- The value for $\theta_2$ was too low, which suggested that either the hot water had cooled before it was added to the beaker or the 100 g mass had been left in the hot water for more than the one minute specified.
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**(c)** Many candidates obtained a good value for the specific heat capacity of the metal. Some candidates did not give a unit, or gave an incorrect unit. Answers to one significant figure were acceptable here because the temperature rise was only of the order of a few °C.

***Section B***

**Question 4**

**(a)** The values of the measurements were often correct but a number of candidates had problems with the units. For example they wrote 65 V instead of 65 mV, or 135 A instead of 135 mA. Candidates should have realised that 135 A was not a sensible value because it would have melted the wire, and 65 V seems unlikely from three dry cells. In other cases units were omitted.

**(b)** Error carried forward from incorrect units was allowed when the resistance was calculated; the most frequently seen incorrect answer for which credit was given was in the region of $0.065/135 = 4.8 \times 10^{-4}\,\Omega$. Other candidates, who gave a correct answer in the region of $0.48\,\Omega$, sometimes lost credit because they did not give a unit.

**(c)** Most candidates had at least eight good results. Errors that had been made in **(a)** and **(b)** were not penalised further but other popular mistakes included:

- It was expected that measurements would be taken across the full range of the metre rule. A number of candidates took readings between 5 cm and 50 cm at 5 cm intervals. This gave ten readings, but the range was less than the minimum of 80 cm expected.
- Sometimes readings were distributed unevenly, with, for example, a gap of 30 cm in the middle of the chosen range.
- Some candidates who had correctly included units in **(a)** and **(b)** omitted to include them in the table.

**(d)** Graph plotting skills were good with many candidates gaining full credit for the graph. The most common error was the use of a graph scale that was based on 3 cm. This was an inappropriate choice of scale and made accurate plotting of the points very difficult. A further complication arose for those candidates who thought that the readings that they had taken in mA were actually in A. The resistance values for such candidates ranged from approximately $4 \times 10^{-4}\,\Omega$ to $4 \times 10^{-3}\,\Omega$. Unfortunately, when the resistance values were written in this form the candidates did not know how to deal with the resistance scale. Typically a scale of $2\,\text{cm} = 1 \times 10^{-4}\,\Omega$ was used up to $10 \times 10^{-4}\,\Omega$ and then a scale of $2\,\text{cm} = 1 \times 10^{-3}\,\Omega$ was used above this point. Such candidates did not realise that they had changed scales half way along the axis. This effectively produced two straight lines, which in most cases were interpreted as a single curve. The gradient of either straight line would probably have given a good value for the gradient in **(e)**, but most candidates drew a line of best fit or curve fitted to all of the points so usually obtained a value that was outside the range. Better candidates who realised that they had a problem with the scale, converted all their resistance values to m$\Omega$ and produced the expected straight line graph.

**(e)** Good candidates used a large triangle when determining the gradient of the graph, but a significant number used a very small triangle. In some cases the base of the triangle drawn by such candidates was only 1 cm or 2 cm. Good candidates obtained a value in the correct range, but those who had had unit problems in the earlier part of the question often obtained a value that was incorrect by a factor of 10.

# PHYSICS

**Paper 5054/41**
**Alternative to Practical**

## Key Messages

- Units are important in practical work. Candidates should be encouraged to ensure that all answers are written with units, except where quantities are dimensionless and this has been carefully considered. It may be useful for candidates to do a final check of the paper to ensure that units are all included where they are needed.

- When drawing lines of best fit, candidates should consider the position of all points. If the trend is linear, simply joining the first and last points on the line does not usually give the line of best fit. If the trend is curved, joining adjacent points does not usually give a smooth curve.

- Candidates should be encouraged to draw diagrams as part of the explanations of experimental methods, in particular where this is explicitly noted in the question. The accuracy of straight lines on diagrams could be improved by using a sharp pencil and a ruler.

## General Comments

The general level of competence shown by the candidates was sound, although some candidates continue to approach this paper as they would a theory paper, and not from a practical perspective. Very few candidates did not 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, but fewer were able to derive conclusions backed up by evidence, or to present well thought out conclusions or suggest sensible precautions to make their results more accurate. The better candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were well known and usually included, writing was legible, and ideas were expressed logically.

## Comments on Specific Questions

### Question 1

**(a) (i)** Most candidates realised that the wire had to be clamped tightly at one end so that it was secure and would not slip when the load was applied.

**(ii)** All candidates knew that the purpose of safety glasses was to protect the eyes. This answer alone, did not gain credit. Candidates needed to relate the wearing of safety glasses to the hazards presented by this particular experimental set up. Reference had to be made to the possibility that the wire might break under the load applied, and so the eyes needed to be protected.

**(b) (i)** Although many candidates made reference to the wire stretching, far fewer actually stated that the extension is the <u>increase in the length</u> of a wire due to the application of a load.

**(ii)** Only a small proportion of the most able candidates were aware that, the further away from the support the marker was placed, the greater would be the extension.

**(iii)** About half of the candidates understood the need to leave some distance between the marker and the pulley in order to allow for the movement of the marker as the wire extends.

**(c) (i)** Many candidates ignored or missed the instruction that the left-hand side of the marker was used as the reference point. Of those candidates who had taken note of this, a number misread the scale as 53 cm instead of 50.3 cm.

**(ii)** Only the most able candidates were able to explain why a small initial load was used before the initial reading of the position of the marker was found.

**(iii)** Candidates found difficulty in explaining why it would be difficult to read the position of the marker accurately, even though the diagram clearly showed that the marker was some distance above the wire.

**(iv)** Many of the candidates suggested changes that were impractical. A common answer, for which no credit could be awarded, was to raise the bench.

**(d) (i)** The standard of graph plotting continues to improve. Most candidates drew axes the correct way around, with the axes correctly labelled with quantity and unit. Almost all chose scales that made maximum use of the grid provided. Points were plotted neatly and accurately. However, few could be credited for their lines of best fit. Most candidates tried to force their graphs to pass though the origin. As a consequence of this, in many cases the line drawn was not a best fit for the points that had been plotted.

**(ii)** Candidates stated correctly that the relationship between force and extension was a linear one. A common misconception was that if the graph is a straight line, then the quantities are directly proportional. Candidates should realise that this is only correct if the straight line graph passes through the origin.

**(e)** Most candidates were aware that if the load was increased still further, a point would be reached where the behaviour was no longer linear and the wire would eventually break. A common misconception was that the wire would stop extending.

**Question 2**

**(a)** The instruction to give the measured distances in metres was frequently ignored, despite the unit being given on the answer line. A tolerance of 1 mm was allowed for the measured values, but many candidates wrote down answers which were out of range. Most candidates were able to substitute their measured lengths in the given equation to obtain a value for the acceleration due to gravity. Many candidates, including some of the more able ones, ignored the instruction to give the answer to two significant figures and consequently lost credit.

**(b)** Few candidates were able to give a sensible reason as to why their value for acceleration due to gravity differed from the accepted one.

**Question 3**

**(a)** The idea of conduction was well understood, and the majority of candidates realised that the wax would melt and the pea would fall off.

**(b)** Most candidates were able to give one factor that should be the same for all rods in the experiment, but many struggled to come up with a second.

**(c)** The answer to this part was almost invariably correct.

**(d)** Very few candidates related the new set-up to the fact that results could be obtained more quickly, or that the peas could be timed falling off.

**Question 4**

**(a) (i)**,**(ii)** The path of the ray emerging from the block and the path of the ray through the block presented little difficulty to the majority of candidates. Diagrams were clear and neat.

**(iii)** Few candidates were able to measure the angle of incidence when the ray passed from glass to air correctly. The angle was usually measured to the surface of the glass block, and not to the normal.

**(b)** There were many excellent answers to this part. Candidates wrote clearly and coherently, and descriptions were often accompanied by very good ray diagrams showing how the critical angle for glass could be measured. Occasionally, candidates who understood what was required neglected to say how the student would adjust the apparatus. It needed to be clear from the description that the angle of incidence was being increased.

**(c)** This final part to the question caused difficulty, and only a minority of candidates gave correct answers. What needed to be made clear in the explanation was that the incident ray was now not along the normal and would therefore be refracted upon entry to the glass.

# PHYSICS

**Paper 5054/42**
**Alternative to Practical**

## Key Messages

- Units are important in practical work. Candidates should be encouraged to ensure that all answers are written with units, except where quantities are dimensionless and this has been carefully considered. It may be useful for candidates to do a final check of the paper to ensure that units are all included where they are needed.

- When drawing lines of best fit, candidates should consider the position of all points. If the trend is linear, simply joining the first and last points on the line does not usually give the line of best fit. If the trend is curved, joining adjacent points does not usually give a smooth curve.

- Candidates should be encouraged to draw diagrams as part of the explanations of experimental methods, in particular where this is explicitly noted in the question. The accuracy of straight lines on diagrams could be improved by using a sharp pencil and a ruler.

## General Comments

There were many excellent responses and many candidates showed an understanding of practical techniques and applying them to novel situations. There were fewer instances of vague explanations such as 'to improve accuracy', and candidates are giving more detail in their answers. However, when asked to describe improvements to an experiment, candidates should be encouraged to suggest actual experimental changes rather than simply doing the same experiment more carefully.

Graph drawing is generally good, but many candidates still find it difficult to draw a smooth curve of best fit and instead resort to joining the dots. Many lost credit for drawing 'blobs' rather than dots or crosses.

In numerical work, candidates should be reminded to use the value of $\pi$ from their calculator and not $\frac{22}{7}$.

Many candidates lost credit by intermediate rounding of values in calculations, and this practice should be discouraged.

Many candidates still find significant figures (s.f.) difficult. In **Question 2(c)** many appeared to ignore the instruction to give their answer to 2 s.f.

## Comments on Specific Questions

### Question 1

**(a) (i)** The main feature of the thermometer required in the diagram was a bulb. Although most candidates gained credit here and a few excellent representations were seen, the quality of the diagrams was often poor. The main omission here was failure to draw a discernible bulb, and in many instances just a tube or a stick was drawn. The bulb needed to be drawn in the centre region of the water in the beaker. Some candidates lost credit by drawing the bulb touching the base or too close to the sides of the beaker, or even in the air above the water.

**(ii)** The most common correct response here was to prevent the bulb from touching the sides or base of the beaker. Surprisingly few candidates mentioned that use of a clamp enables the hands to be free for starting the stopwatch, stirring the water and writing down readings. One misconception seen was that heat would transfer from the hand and affect the readings. Weaker candidates gave vague answers such as 'to keep it upright' or 'to get accurate results'.

**(iii)** Although most candidates gained credit here, many found it difficult to explain in words how to avoid parallax error. The simplest way was to draw the eye position on the diagram. Those who did this correctly were awarded credit, even if the explanation in words was not clear. Candidates who simply stated that 'the eye' was perpendicular to the thermometer were credited, although 'line of sight' is a preferred description. There was some confusion between parallel and perpendicular.

Responses not credited included references to the eye being 'perpendicular to the meniscus', 'vertical to the thermometer' and 'opposite the reading'. The line of sight should be perpendicular to the thermometer or scale rather than to the reading or mercury level.

**(b) (i)** This question was well answered by many candidates. The more common correct answer was that the time was measured in minutes so timing to 0.01 s was not required. Others simply stated that the experiment takes a long time. Many candidates confused accuracy and precision, but this was not penalised here.

**(ii)** Many candidates showed a lack of understanding of the experiment by referring to 'stopping the stopclock' and therefore did not gain credit. Some excellent answers were seen, such as 'to observe the stopclock and thermometer simultaneously'. Common errors included vague answers such as 'to make it easier' or 'to avoid human reaction error'.

**(c) (i)** The graph was generally well executed with many candidates gaining full credit. Almost all candidates labelled the axes correctly. The errors that were seen included 0 for temperature, and an incorrect unit, e.g. $\theta°$ / C and $\theta$ / C° or m for minutes.

Only very few candidates ignored the axis labels 40 and 0. Some candidates drew their own axes inside the graph grid, and this usually resulted in loss of credit. There were many fewer candidates who wrote the point values near each plotted point.

The points were almost always plotted correctly but some candidates lost credit because their plot points were too large, occupying more than half a small square. The preferred method of marking the points is a small neat cross. Dots are acceptable, but must be clearly visible.

Many candidates drew the line passing through all the points, which did not produce a smooth curve.

**(ii)** This question tested an understanding that during cooling the temperature will not fall below the temperature of the surroundings. Responses that referred to the water not freezing or 0 °C being the freezing point were ignored. Some excellent answers were seen, but many struggled to express themselves clearly. Some candidates thought that if enough time was allowed then the temperature would eventually reach zero.

**(iii)** The value read from the graph had to be correct to within half a small square.

Candidates lost credit for reading the scale incorrectly or giving an incorrect unit, e.g. 1.3 s instead of 1.3 minutes.

**(d)** Most candidates gained credit for explaining that the temperature falls faster. Weaker answers such as 'the water cools faster' were accepted, but candidates should be encouraged to answer the question, i.e. the effect on the time. Fewer candidates understood that the heat was being lost faster due to the larger surface area. The most common error was to simply state that more heat was lost.

**Question 2**

**(a) (i)** Most candidates correctly labelled the length of the pendulum on the diagram. Many, however, did not draw a line to the centre of the bob, choosing instead either the top or the bottom. Some marked it on top of the string, and it would have been clearer shown to the side. Others measured the actual length in cm. Good answers showed a measuring to a horizontal line through the centre of the bob.

**(ii)** Relatively few candidates were able to answer this question well. Many focused on the word 'accurately' alone rather than on the requirement to measure $l$. The question required a named measuring instrument and a description of how it should be used. Many simply stated 'use of a set square' which was insufficient. Again those who drew on the diagram usually gained credit, ether for showing correct use of a set square or for drawing the ruler close to the bob. Some candidates described use of a micrometer or vernier caliper to measure the diameter of the bob but then did not explain how the radius would be obtained to add to the length of the string.

**(b)** The candidates were required to use the information given in the question. Many were not awarded credit because they omitted to use the fact that the reading was repeated three times, and simply stated 'divide the time for 20 swings by 20'. Others simply gave the relationship $T_{av} = T_N / N$.

**(c)** Few candidates were able to complete this calculation and score full credit. A common error was to write down intermediate steps in the calculation and then use rounded figures to calculate the final answer, which was not acceptable. Others used various values for $\pi$ (including $\frac{22}{7}$) which also gave values outside the acceptable limits. The final answer was required to three significant figures. Only a few candidates gave this correctly; most gave the answer to four or five significant figures.

**(d)** There were some excellent answers from able candidates explaining how increasing the length of the string improved the experiment. Others described how to take a series of readings for $l$ and $T$ then plot a graph to find $g$. However, many simply gave a list including more repetitions, use of fiducial markers and avoidance of parallax errors.

**Question 3**

This question required the candidates to draw circuits containing series and parallel components, then show an understanding of current in series and parallel circuits.

**(a) (i)** Most candidates were able to draw the two resistors, cell and switch in series. Drawing a third resistor in parallel with the cell proved to be more difficult. Common errors, for which some credit was lost, included: incorrect circuit symbols, gaps in the circuit, omitting the switch and drawing resistor C across a connecting lead. Some candidates lost credit for not labelling the resistors.

Credit was not deducted for drawing a power supply or battery, but candidates should be advised to follow the instructions given.

**(ii)** Most candidates correctly drew the voltmeter across resistor A. Some, however, drew the voltmeter in series and others omitted it altogether.

**(b)** Most candidates gained at least some credit here. Many incorrectly ticked the first box.

**Question 4**

**(a) (i)** Most candidates were able to deduce that A was a S pole.

**(ii)** The answer required was the same as **(a)(i)**. Many candidates were unable to accept this and frequent crossings out were seen here.

**(iii)** Many candidates made good attempts to explain the unusual answers to **(i)** and **(ii)**. Able candidates simply stated that the magnet had lost its magnetism; some went on to say that the domains were misaligned. Those who had given different poles in their previous answers were unable to score here.

**(b)** Describing this experimental technique is not easy, but many candidates gained credit for a clear diagram. Many scored full credit. Some lost some credit for not explaining clearly how the dots were continued around the magnet, or for drawing compasses placed far apart round the magnet. Some candidates did not continue the lines from pole to pole.

No credit was awarded to candidates who suggested sprinkling iron filings and did not use a compass.