PHYSICS

Paper 5054/11
Multiple Choice

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

General Comments

The results show that all the candidates had covered all parts of the syllabus, and had been well prepared.

The candidates found **Question 21** to be very easy, while **Questions 8**, **22** and **35** were the most difficult.

Comments on Specific Questions

Question 3

The weaker candidates chose **C**, perhaps thinking of increasing speed instead of the acceleration.

Question 8

The largest number of candidates, including many of the higher-scoring candidates, opted for **B**. A common misconception is that if two forces are to provide balance, there must be one on each side of the pivot.

Question 22

Most diagrams of a ray passing through a prism show refraction at both faces because the angle of incidence is usually not 90 ^{o}. Hence many candidates chose **C**.

Question 30

A large number of the more able candidates incorrectly opted for **A**.

Question 35

Many of the weaker candidates are not sure of the factors affecting electromagnetic induction, especially length.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

The results showed that the candidates had been well prepared across all parts of the syllabus.

Questions 4, 8 and **23** were found to be very easy. The most difficult one was **Question 7**.

Comments on Specific Questions

Question 7

A large number of candidates opted for **B**. A common misconception is that if two forces are to provide balance, there must be one on each side of the pivot.

Question 31

A surprising number of candidates chose **A**, with closing the switch making no difference.

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.
- 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; if their answer continues elsewhere on the paper this should be made clear.

General comments

The performance of the candidates in this year's paper reflected the standard that has been reached in recent sessions: many candidates had a clear understanding of what was expected and produced perfectly decent scripts revealing a familiarity with the topics on the syllabus and showing a certain adroitness in handling the information presented in the questions. There was, however, a range in the standard demonstrated by the candidates. Some performed less well and a very small number of candidates wrote very little indeed.

There did not seem to be any problem with the candidates' understanding of the questions as the overwhelming majority of candidates wrote fluently, clearly and showed a colloquial grasp of English. Likewise, there did not appear to be any candidates who were short of time; those few candidates who did not complete the paper gave the impression of having stopped writing long before the end of the examination.

Candidates are now on the whole much better, than was once the case, at including units with their final answer and at showing their working out.

Comments on specific questions

Section A

Question 1

(a)

(i) The overwhelming majority of candidates were able to read the graph and obtain the correct answer.

(ii) Most candidates were able to state that deceleration is a reduction in velocity but rather fewer went on to explain what is signified by the term *uniform*. Some candidates used the term itself in their answer which could not be credited. Other candidates used phrases such as *the velocity decreases at a constant speed*; the expression *constant speed* was particularly confusing in this context.

(b)

(i) Many candidates drew the initial, horizontal section of the graph accurately. Others needed to realise that the gradient of the second section of the graph was equal to the gradient of the corresponding section of the graph for the car.

(ii) Only a minority of candidates made any reference to the area under the graph and most of the candidates who gained credit did so by commenting on the higher initial velocity of the lorry.

Question 2

(a)

(i) Nearly all candidates correctly referred to force X as the skydiver's weight or as the gravitational force acting on the skydiver. Many candidates referred to the force Y as *upthrust* or *normal reaction*. Such candidates should realise that an upthrust is not simply a force that acts upwards; the term *upthrust* is not needed for this syllabus. Similarly, the term *resistance* on its own was not credited here.

(ii) Many candidates were able to gain credit by stating that Y opposed the *downward motion* of the skydiver. The candidates who stated that Y acted upwards because force X acted downwards or who referred to a Newton's third law pair of forces were not awarded credit.

(b)

(i) Many candidates stated that the effect of the unbalanced forces was an acceleration and some – though not all – of these explained that the cause was the larger value of the downwards force X.

(ii) There were a variety of answers here; many stated that the forces X and Y became equal in size. A common misunderstanding was to state that the size of X decreased and that of Y increased.

Question 3

(a)

(i) Many candidates performed this calculation completely correctly. Other candidates omitted the factor of a half or the conversion of one minute to seconds; candidates needed to be aware that important information may be supplied in words as well as in figures.

(ii) Many valid points were offered here and credit was commonly awarded. When candidates suggest that an energy loss is due to the production of thermal energy (heat), it is necessary to state where the thermal energy is to be found. Similarly, the location of a frictional force needs to be specified.

(b)

(i) There were many good answers here. Explanations that used only terms such as *renew*, *renewed* or even *renewable* itself, were not credited. Some candidates needed to be aware that *renewable energy* is not energy that can be recycled or used again.

(ii) Almost all candidates were able to state an appropriate source of energy here. Candidates should be aware that *burning wood* is a process that can be conducted both renewably and non-renewably; consequently, further details were required when this suggestion was offered.

Question 4

(a) A minority of candidates performed this calculation completely accurately; a larger number received partial credit for making relevant points or for quoting the two appropriate equations.

(b)

(i) Most candidates gained credit here; the appropriate physics was well understood.

(ii) This part of the question was answered correctly sometimes; some candidates realised what was being asked for and produced encouraging answers. Answers which made no reference to the molecules were not credited.

Question 5

(a) A minority of candidates were fully aware of the purpose of the fluorescent coating inside the tube. A very commonly offered explanation only referred to its absorbing of UV radiation and the consequent health and safety issues. This was only one part of the complete explanation.

(b) Most candidates answered this correctly.

(c) Almost all candidates quoted the relevant formula. Some candidates rearranged it incorrectly and obtained a wrong numerical answer as a consequence.

Question 6

(a) Most candidates produced an answer here that scored credit.

(b) Candidates' diagrams varied in the care with which they were drawn and in their accuracy. Candidates who wished to show that the amplitude of the echo has been reduced, should have made this very clear on their diagram.

(c)

(i) Many candidates were able to quote the commonly accepted range of audible frequencies. Other candidates were not. Some candidates quoted one frequency value and not a range as was asked for.

(ii) Many candidates knew this answer.

Question 7

(a) The direction of the force arrow was often correct. Other candidates drew it downwards, sideways or left this part out altogether.

(b) Very few candidates made any reference to the size of the force or attraction. Answers that only referred to the size of the magnetic field or the size of the current were not credited.

(c) There were a few detailed and accurate answers here. Most candidates were not able to explain the manner of operation of the circuit-breaker although some gained credit when details relevant to the process were described.

(d) There were a very few correct suggestions here. Candidates who had not explained how the device worked were rarely able to gain any credit here.

Question 8

(a) This part of the question was well answered and many candidates were familiar with the rule.

(b)

(i) Almost all candidates received partial credit by calculating a relevant moment or by quoting the formula defining it. A much smaller number of candidates obtained the correct answer – 80 N cm. The answer 160 N cm was far more commonly suggested.

(ii) A large proportion of the candidates were able to offer two appropriate suggestions. Candidates were not credited for repeating the suggestion offered in the question.

Section B

Question 9

(a)

(i) This part of the question was well answered. Some candidates should have been aware that explanations that only use the words from the question (*alternating* and *direct*) cannot be credited.

(ii) Many valid points were made here, although electromagnetic induction confuses some candidates. A small minority of candidates were able to suggest why the current was alternating; many more ignored this part of the explanation.

(iii) Many candidates offered two relevant suggestions here as required. Some candidates needed to be aware that a larger magnet is not necessarily a stronger one.

(b)

(i) This standard piece of the course is well known and well understood by many candidates. Other candidates should have been aware that stepping up the voltage of transmission does not affect the resistance of power lines.

(ii) Some candidates were able to calculate the correct ratio but a variety of other values were suggested. It was unfortunate that some candidates quoted the reciprocal of the correct ratio.

(iii) Many candidates stated a valid advantage; fewer suggested an appropriate disadvantage. Where a candidate suggested that the proposal is financially disadvantageous, it needed to be made clear that this concerned the cost of construction or the cost of building more or sturdier pylons or the cost of buying more material for the power lines.

(iv) Some candidates selected the right fuse and offered a correct explanation. Rather more suggested the 4 A fuse because its rating was the closest in value to the current in the drill.

Question 10

(a)

(i) This part of the question was rarely well answered.

(ii) Only very infrequently was the correct answer suggested here.

(iii) **1.** Few candidates offered a correct answer here; many stated that the resistor would reduce the current supplied to the television.
2. This was extremely rarely correct; a common answer suggested that the resistor would allow too much current to be supplied.

(b)

(i) Many candidates stated that both quantities are measured in volts and some realised that an e.m.f. is the property of a source of electrical energy. Very few candidates distinguished between the two quantities in terms of their definitions.

(ii) The symbol required was only very occasionally drawn; many candidates were credited for drawing a semiconducting diode in a direction that would have allowed a current to be drawn from the battery.

(iii) Many candidates were able to deduce the correct answers here.

(iv) Many candidates knew and applied the formula that defines resistance. Not all candidates correctly converted the current value from milliamperes into amperes and fewer still performed the necessary subtraction at any point in their answer.

Question 11

(a)

(i) This part of the question was almost universally well answered; most candidates wrote down the correct value.

(ii) Most candidates offered an explanation which was relevant to the question asked. Other candidates should have been aware that more was required than just repeating information that has already been given in the question.

(b)

(i) Many different energy changes were suggested here but just a few candidates scored both marks by simply stating, in the correct order, the two significant types of energy involved.

(ii) Many candidates were awarded full credit on this question. Very many candidates carried their value from **(a)(i)** forward to use as the nucleon number of the sodium isotope and most candidates attempted to produce a balanced equation. To calculate the proton number for the magnesium isotope, it was necessary to perform a subtraction involving –1 (obtained from the β-particle). Some candidates found this challenging.

(c)

(i) Some candidates plotted appropriate points on the graph and drew a smooth decay curve through them. Others should have been aware that a smooth line is not always a straight line.

(ii) Many candidates knew what was required here.

(iii) Many candidates were able to work backwards through two half-lives to obtain the correct answer.

(iv) Few candidates were able to draw a diagram of the apparatus used in this measurement. Many candidates should have been aware that in addition to the equipment needed to detect and measure radioactivity, a stopwatch or stop-clock was needed to measure the time that elapsed.

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.
- 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; if their answer continues elsewhere on the paper this should be made clear.

General comments

Some candidates consistently did not give units to numerical questions, even, for example, omitting the unit for amplitude in **Question 4(a)**. However, in general, candidates' work showed a good knowledge of basic units, although complex units such as J/(g °C) were often written incorrectly.

The numerical answers, shown in the comments on specific questions below, are generally given to the same number of significant figures as was given in the question. Candidates may give an answer to more significant figures and sometimes, where the answer is exact, to only one significant figure. Some candidates still find difficulty in writing their answer down correctly from the calculated value shown on a calculator. This was evident in **Question 11(b)(i)**, where the numerical answer to four significant figures is 4.469; yet many candidates wrote the answer down as 4.46 or 4.4, rather than 4.7 or 4.5. Candidates should be encouraged to write their answers to more significant figures in this theory paper or to ensure that their rounding is correct.

It is helpful if candidates confine their answers to the space available in each section; if their answer continues elsewhere on the paper this should be made clear. This may mean some planning before starting to write each section, but it does mean that the candidate's ideas are likely to be more logical and easier to find.

More candidates answered **Question 9** in **Section B**, than the other two optional questions. **Question 10** was the least popular question, although those candidates who answered this question sometimes produced very good answers indeed. Very few candidates were unable to complete the paper in the time available.

Comments on specific questions

Section A

Question 1

(a) The spring balance shown in the question was calibrated in newtons and most candidates sensibly suggested that the reading on the balance should be divided by the gravitational field strength or quoted the formula weight = mass × g. Some candidates did not notice the unit on the spring balance and suggested that the reading of the balance was itself the mass of the stone or that the weight should be multiplied by g to obtain the mass.

(b) Almost all candidates took readings of the volume of water in the cylinder before and after immersion of the stone. Some weak candidates gave a lot of detail about initial and final readings but did not explain that the two readings were subtracted to find the volume.

(c) The formula for density was well known and the calculation was nearly always correct, although some candidates gave the wrong unit or no unit at all. There was no necessity to convert mass to kg or volume to m^3 and some candidates made an error in the conversion.

(d) Answers to this section were usually correct, showing an understanding of the difference between mass and weight. A few candidates only stated that weight changed and did not specify that it decreased.

Question 2

(a) The question asks for the energy change while the cyclist is moving at constant speed up a hill. Many candidates described other changes as well, such as the movement down the hill, and this was sometimes confusing, particularly where it was not clear which part of the journey was being described. The increase in gravitational potential energy was usually understood, but less well understood was the fact that all of the energy comes from chemical energy in the cyclist and that heat or thermal energy is also produced. There was no penalty for mentioning kinetic energy, although this does not change.

(b) Many candidates clearly understood the law of conservation of energy but made little attempt to apply their knowledge to the whole journey; they merely described again the changes of energy that occur, and did not indicate how the law applies. Taking the journey as a whole, all of the chemical energy becomes thermal energy (heat) because the cyclist stops at the same height as at the start. Candidates only needed to explain how the law applied to one energy transformation at one particular place. The more able candidates produced logical and clearly explained answers. Weaker candidates gave lists of energy changes which did not make clear, for example, that, when the cyclist brakes, all of the kinetic energy changes to heat energy.

(c) The formula for potential energy was well known and very few candidates did not score at least partial credit in this section. Some answers gave the wrong unit, omitted the unit or gave the answer as 9 units, which was not accepted.

Question 3

(a)

(i) Most candidates suggested that the molecules have more kinetic energy or move faster, but relatively few gave enough information to explain why the balloon expands. Many answers just referred to the molecules moving further apart, rather than hitting the walls harder or more often.

(ii) Many candidates answered correctly by suggesting that the forces between water molecules limit expansion but many candidates only stated that water molecules are closer together or that gases expand more than liquids

(b)

(i) The formula involved was generally well known, but wrong answers were sometimes obtained by dividing the volume at the bottom of the lake by that at the top of the lake.

(ii) Many candidates merely stated that pressure is inversely proportional to volume or suggested that atmospheric pressure must be constant. The major assumption is that temperature should remain constant; otherwise the balloon will expand because of a change in the temperature.

Question 4

(a) Many candidates did not give the unit of the answer.

(b) Although many candidates drew a wave with the same period as the initial wave only the strongest candidates drew a wave exactly opposite to the one in the question. Many candidates drew a wave of twice the frequency.

(c) Wave formulae such as $f = 1/T$ in **(i)** or $v = f\lambda$ in **(ii)** generally earned credit, with strong candidates earning full credit. There are several ways to obtain the answer in **(ii)**, all of which were accepted.

Question 5

(a) Candidates were generally able to draw a circuit diagram showing lamp **A** on all the time and with an ammeter in series with the supply or with several ammeters sensibly positioned. However, many candidates found difficulty in drawing lamps **B** and **C** in series with one another, possibly because they were drawn one above the other in the question. Many candidates incorrectly drew lamp **A** as having three terminals rather than two.

(b)

(i) The formula for resistance was well known, although weaker candidates found difficulty in converting mA into A for the calculation.

(ii) Most candidates realised that the current is the same in components in series.

Question 6

(a) The majority of candidates gained partial credit for the idea that connecting the earth wire to the case prevents electric shock but the concept of the metal case becoming "live" was often missed, and many candidates incorrectly suggested that the earth wire carries "excess" current.

(b) Most candidates were able to use the equation $E = Pt$, but often did not convert the quantities involved to kilowatts and hours. A number of candidates quoted the unit for energy as J, even though the unit kW h was provided on the answer line.

Question 7

(a) Candidates found this answer difficult to express clearly. A number of candidates successfully made reference to thermionic emission, or to the fact that the filament emits electrons when heated, but they did not explain that heating, and therefore thermionic emission, would **still** occur when the direction of the current is reversed. Many candidates simply repeated the question and stated that there would be no effect with the reversal of current.

(b) Many candidates correctly suggested that there would be no electron beam produced. There were several commonly incorrect statements about the effect on the beam, such as it became weak or fuzzy or was scattered or deflected. More able candidates usually gave very clear and full explanations involving the electrons being attracted by the filament or repelled by the anode and therefore not being able to pass the anode to reach the screen. Weaker candidates thought that the electron beam would be made more powerful or the light it produced would be brighter.

Question 8

(a) Almost all candidates recognised that the process illustrated was fission. A few incorrectly wrote fusion, but then generally described correctly the process of fission in **(b)**.

(b) Many candidates did not describe the full sequence. The nucleus was often not mentioned specifically, reference being made instead to a uranium atom or "an element", and the part played by the incoming neutron was not always clear. The idea that the nucleus is split and forms smaller daughter nuclei with the production of more neutrons and energy was, however, generally known or worked out from the question. A small minority of answers confused fission with the production of alpha or beta particles.

(c)

(i) There were many vague answers to this section. Some candidates described the emission of specific particles, e.g. alpha, beta and gamma and gained credit relatively easily. Other candidates tried to keep their answers more general and were not specific enough. They tended to write about emitting radiation, which was not accepted unless it was clear that this radiation is emitted as a cause of the decay of a nucleus or atom.

(ii) The more able candidates gave clear accounts, but many candidates were vague in describing what quantity is halved in the half-life. They often described half-life as the time taken for the halving of particles, mass, amount, radioactivity or even a single nucleus or atom, rather than of the number of nuclei, atoms or the activity of the source.

Section B

Question 9

This was answered by a large proportion of candidates who found it the most accessible of the optional questions.

(a) Surprisingly few candidates achieved full credit in this section. The major error, even in stronger candidates' answers, was to draw a line where the gradient increases and decreases in the first 10 seconds, rather than drawing a line where the gradient decreases constantly. Candidates also found it difficult to draw the last two sections of the speed-time graph.

(b) It was encouraging that most candidates were able to refer to air resistance and could also explain why, at a steady speed, air resistance balances weight. However most candidates incorrectly stated that, after the parachute is opened, the air resistance increases until it equals weight. In fact, after the parachute is opened, the air resistance is larger than the weight and it decreases until it equals the weight.

(c) There were many correct answers to this section.

(d) Answers to all three sections were generally competent but some candidates did not use the change in velocity to calculate acceleration, did not give the correct unit for acceleration or halved the answer. In **(ii)** a significant number of candidates obtained the weight using the formula $F = mg$ rather than the resultant force using the formula $F = ma$.

Question 10

(a) Candidates were able to obtain credit from a diagram of an experiment to measure the critical angle. Strong candidates were able to give well-reasoned and comprehensive accounts of the experimental procedure. Weaker candidates also gained credit with only a little detail, such as the use of a ray box or pins and an adjustment to the angle of incidence for the critical angle to be established. Although this experiment is better undertaken with a semi-circular block, and not really possible with a rectangular block, any shaped block was accepted. Answers often did not make clear which angle was measured or which angle was the critical angle. The simplest approach was to label the angle clearly on the diagram.

(b)

(i) This section was very well answered, although a few candidates suggested that both a converging lens and a concave lens are used in a camera.

(ii) Most candidates drew a ray through the centre of the lens, but many could not draw a second ray, which only had to meet the first ray on the film. A large number of candidates did not mark or label the image on the film.

(iii) This was a disappointing section, and a significant number of candidates could not define linear magnification, although the calculation in **(iv)** often showed that they knew the correct formula but were unable to express it as a definition.

(iv) A wide margin of error was allowed in the answer to this section to allow those who understood the idea of magnification to earn credit. A large number of candidates gave the magnification as 2.5 rather than 0.4.

(v) A suitable property was given by most candidates, although a few only stated that the image was smaller than the object, but this was not an answer to the question.

(vi) Most candidates realised that the lens is moved towards the film to focus the image. Many answers also correctly suggested that the lens is moved to focus an object at a different distance. Few candidates suggested that the lens is moved towards the film in order to focus the image of a distant object on the film.

Question 11

This was a slightly more popular choice of question than **Question 10**, but the detailed argument and knowledge required, and mistakes made in the calculation or with the units, meant that most candidates found some difficulty.

(a)

(i) A common error was to omit the unit, or to give the unit as °. The fact that the graph scale started at 20 ˚C was missed by many candidates, leading to an error in the first answer.

(ii) Some candidates described the non-linear relationship between temperature and time, or between the heat going in and the temperature rise, but did not explain why. Candidates simply needed to recognise that evaporation or heat loss to the surroundings has a larger effect the higher the temperature is above the surroundings. References to boiling point, specific heat capacity and breaking bonds were usually irrelevant.

(iii) The answers to this section were more encouraging, since most candidates recognised that the temperature would eventually reach 100 °C. Candidates often gave very full explanations about the temperature reaching boiling point, becoming steady and causing the water to boil, so changing state to steam or gas. However, some candidates showed confusion between evaporation and boiling.

(b)

(i) Most candidates knew the formula for specific heat capacity but a large number of answers gave the incorrect unit for specific heat capacity. Common errors were the omission of the °C or confusion between g and kg.

(ii) Again, most candidates were able to quote the correct equation but a significant number did not square the velocity, even though they correctly gave the equation as $E = ½mv^2$. Many candidates did not convert the mass to kg for the calculation.

(iii) Most candidates appreciated the effects on the water molecules. Candidates tended to gain partial credit for the increase in vibration or speed of the water molecules, with the more able candidates also gaining further credit for more detail about what happens to the water molecules, such as moving further apart, moving throughout the liquid or having random motion. The vast majority of candidates did not recognise that the motion of the molecules of the bullet in connection with its kinetic energy was a motion in one direction – the tendency was to refer to increased vibrational motion within the bullet. Only very able candidates recognised that the water molecules move at random but the molecules in the bullet all move in one direction because of the extra kinetic energy they were given.

(c) A number of candidates drew liquid-in-glass thermometers and even tried to add wires to such a thermometer. Those candidates that drew a thermocouple often labelled the beaker, water and wires but did not label the important parts such as the different metals and a suitable meter, which could have been a voltmeter, ammeter or galvanometer. A number of candidates labelled the wires just as wire A and wire B, rather than suggesting they were different metals. Weaker candidates showed a cell in the circuit or drew the junction in water as though it was an electrolysis experiment.

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. kg when g was intended). Candidates should be encouraged to ensure that all answers are provided with units where needed, and to check that the unit is appropriate for the measured or calculated quantity.
- 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.
- 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

Overall the paper was of a comparable standard to the June 2010 paper. However there were differences in the marks for the 2 sections. In **Section A** this year a greater emphasis was put on the ability of candidates to obtain the correct measurements and to correctly process the results in order to obtain a good value for a known constant. This was particularly the case in **Question 2**, where Supervisors were asked to set up a simple pendulum of length 80.0 cm. When measuring the length of the pendulum, candidates were expected to obtain a value between 79.5 cm and 80.5 cm. Equally the period of oscillation of such a pendulum should have been 1.79 s, so only values in the range 1.75 s to 1.85 s were allowed. The value of g obtained from the processing of the results should have been 980 cm s^{-2} (9.8 m s^{-2}) so only a range of between 900 cm s^{-2} and 1100 cm s^{-2} was allowed. This wider range enabled those candidates who had made minor errors in the measurement of the length and time period to still obtain credit for the final answer provided they had done the calculation correctly. However those candidates who had made gross errors in the measurements were unable to obtain credit for a value of g that may have been several hundred times the actual value. This examining technique will be applied in future years so that a fairer indication of the candidates' practical ability is obtained. This approach generally resulted in candidates obtaining a lower score for **Section A** of the paper.

However a somewhat easier **Section B** than June 2010 counteracted this. Last year the **Section B** experiment involved discharging a capacitor through a resistor and this was a somewhat unfamiliar situation to candidates. This year the experiment involved measuring the power dissipated in a light emitting diode and candidates coped well with this. Even if they did not use the full range of resistors to get the maximum number of results, they were able to use the resistors singly and get enough results to plot a reasonable straight-line graph.

Comments on specific questions

Section A

Question 1

(a) Most candidates obtained a value for d in the range 48.0 cm to 52.0 cm. There were two common errors: either no unit was given with the value, or the value was quoted to the nearest cm e.g. 50 cm.

(b) Judging by the numerical values obtained, the majority of candidates had set up the apparatus correctly.

(c) Able candidates checked that PQ was vertical by aligning it with either the rod of the retort stand or the string supporting the suspended mass. A number of candidates used a set square either on the bench or on the horizontal metre rule, both of which were allowed. Candidates should be advised to follow the instruction on the question paper and add to the diagram. It is far easier to draw the position of the set square on the diagram than it is to describe where the set square is placed. A significant number of candidates, presumably recalling questions from earlier years, described how to check that the metre rule was horizontal and obtained no credit for this.

(d) Most candidates obtained reasonable values for x and y but lost credit either because units were omitted or because measurements were taken to the nearest cm. Examiners expect candidates using a metre rule to use mm precision. The value of the suspended mass was approximately 75% of the mass of the metre rule, hence for an x value in the region of 49.0 cm, the y value should have been in the region of 65.0 cm. Because of the tolerances involved, a range of 55.0 cm to 80.0 cm was allowed. Most candidates obtained sensible values for x and y, but in other cases y was less than 50.0 cm and in such cases credit for the calculation of the mass of the rule was not allowed.

(e) Generally the calculation of the mass of the rule was correct. The number of significant figures given in the answer was ignored, but Examiners insisted on the unit being present. There were 3 reasons why candidates were not awarded credit here:

- the unit was omitted or wrong (e.g. kg),
- the values of x and y were interchanged in the formula,
- the values of x and y did not make sense, i.e. were much less than 50.0 cm.

Question 2

(a) The Supervisors had obviously taken great care to set the lengths of the pendulums to exactly 80.0 cm. This was clear from the results obtained by the candidates for 20T. In the majority of cases, candidates were obtaining a correct value of 20T in the region of 36.0 s. However many candidates did not obtain a good value for the length of the pendulum. There were 3 types of incorrect answer:

- 80 cm; this did not gain credit because it was not measured to the nearest mm.
- 83 cm; this was often followed by a correct value for 20T. This possibly suggests that the length of the pendulum should have been 80.3 cm.
- 20.2 cm; this strange result was often followed by a correct 20T, which suggests that the candidate was either reading the scale of the metre rule from the wrong end or was possibly measuring the height of the bob above the bench.

(b)

(i) Many candidates obtained a correct value for 20T. There were 2 reasons why credit was not awarded:

- The measurement was not repeated. When the phrase 'take measurements to determine an accurate value of…' is used in the question paper, candidates are generally expected to repeat measurements and find an average.
- Some candidates had obviously timed 19 oscillations and obtained a value in the region of 34 seconds.

(ii) Candidates who had taken care doing their measurements obtained credit for an accurate value of T. Others, who had an accurate value of 20T, often attempted to measure the time of a single oscillation here and then obtained a value that was well outside the range of allowed values.

(c) The allowed range for g was between 900 cm s^{-2} and 1100 cm s^{-2}. Those candidates who had made minor errors in their measurements and had not gained credit in **(a)** and **(b)** could still score here provided their measurements were reasonable (effectively a combined error of about 10%.) Those who had made gross errors could not be awarded any credit in this section. The only other issue in this section was incorrect units, e.g. cm/s, m/s. Writing too many significant figures was not penalised because it was thought better to give credit for accurate answers.

Question 3

(a) This seemed to be the most difficult question on the paper. Despite the hint in Fig. 3.1, a large number of candidates drew an angle of incidence of 30°. This made **(b)** difficult because the ray would have been refracted out of the block near the top of the page. In these circumstances, candidates often showed a reflected ray with an angle of reflection of 30°. This would have been a partially reflected ray and should have been barely visible. It is suggested that on reading **(b)** many candidates drew in this line because they were expecting a reflected ray. Unfortunately they did not receive credit for this because they often wrote the angle of reflection as 60° rather than the 30° shown on their diagram.

(b) Providing the angle of incidence was correct, candidates correctly found total internal reflection and were awarded credit. Credit for technique for making the marks on the emergent ray as far apart as possible was only scored by the most able candidates.

(c) The key here was for the light to leave the block at M. A number of candidates placed the ray box in such a position that the angle of incidence at M was large so that the ray again underwent total internal reflection at M and was reflected close to MY. This did not get any credit. Those who reduced the angle of incidence so that the ray just left the block at M and passed close to MY, gained credit if the labelled points were in approximately the correct position and further credit if the angle of incidence in the block was in the range 38° to 43°. A number of candidates quoted an angle in this range, knowing that it was close to the critical angle, but the value was not consistent with their diagram. In this case, credit for the value was not awarded.

Section B

Question 4

(a) Most circuit diagrams were correct. A diode symbol was allowed for a light emitting diode and the polarity was ignored. The most common error was the use of an indicator lamp symbol for the LED. A small minority of very weak candidates had the voltmeter in series with the circuit or omitted items such as the ammeter or the resistor X.

(b) The measured values were normally in the correct range. The most common errors were:

- The omission of units or the wrong units, e.g. 12.2 A rather than 12.2 mA.
- Incorrect precision, e.g. 2 V instead of 2.0 V, or 11 mA rather than 11.0 mA.

(c) Most candidates obtained a correct value for the power. The units for the power had to be consistent with the units for I and V in the previous section, e.g. if V was written as 2.0 mV and I was written as 12.0 mA, then the correct value for the power would be 24.0 μW. Candidates frequently wrote the unit of mW, even though this was not consistent with the previous units.

(d) Good candidates obtained full credit for this section without any difficulty. They used all 7 possible values for the resistance and had a table, which showed that as the resistance increased the current decreased. Weaker candidates usually had the 3 single values of resistance and possibly a table without units and so only scored partial credit. A number of candidates used parallel combinations but these were not credited as the question specifically asked for series combinations. It was also evident from the results that a number of candidates thought that they were using series combinations but were actually using parallel combinations.

(e) Graph plotting skills were good with many candidates getting full credit for the graph. The most common error was the use of a graph scale that was based on 3 cm. By doing this two of the marking points cannot be credited as this is an inappropriate choice of scale and it is too difficult for the Examiner to check the plotting of points against such a scale.

(f) Most candidates demonstrated their ability to read a value off the graph line. A small number of candidates either omitted or gave the wrong unit for the power.

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. kg when g was intended). Candidates should be encouraged to ensure that all answers are provided with units where needed, and to check that the unit is appropriate for the measured or calculated quantity.
- 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.
- 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

Overall the paper was of a comparable standard to the June 2010 paper. However there were differences in the marks for the 2 sections. In **Section A** this year a greater emphasis was put on the ability of candidates to obtain the correct measurements and to correctly process the results in order to obtain a good value for a known constant. This was particularly the case in **Question 2**, where Supervisors were asked to set up a simple pendulum of length 80.0 cm. When measuring the length of the pendulum, candidates were expected to obtain a value between 79.5 cm and 80.5 cm. Equally the period of oscillation of such a pendulum should have been 1.79 s, so only values in the range 1.75 s to 1.85 s were allowed. The value of *g* obtained from the processing of the results should have been 980 cm s^{-2} (9.8 m s^{-2}) so only a range of between 900 cm s^{-2} and 1100 cm s^{-2} was allowed. This wider range enabled those candidates who had made minor errors in the measurement of the length and time period to still obtain credit for the final answer provided they had done the calculation correctly. However those candidates who had made gross errors in the measurements were unable to obtain credit for a value of *g* that may have been several hundred times the actual value. This examining technique will be applied in future years so that a fairer indication of the candidates' practical ability is obtained. This approach generally resulted in candidates obtaining a lower score for **Section A** of the paper.

However a somewhat easier **Section B** than June 2010 counteracted this. Last year the **Section B** experiment involved discharging a capacitor through a resistor and this was a somewhat unfamiliar situation to candidates. This year the experiment involved measuring the power dissipated in a light emitting diode and candidates coped well with this. Even if they did not use the full range of resistors to get the maximum number of results, they were able to use the resistors singly and get enough results to plot a reasonable straight-line graph.

Comments on specific questions

Section A

Question 1

(a) Most candidates obtained a value for *d* in the range 48.0 cm to 52.0 cm. There were two common errors: either no unit was given with the value, or the value was quoted to the nearest cm e.g. 50 cm.

(b) Judging by the numerical values obtained, the majority of candidates had set up the apparatus correctly.

(c) Able candidates checked that PQ was vertical by aligning it with either the rod of the retort stand or the string supporting the suspended mass. A number of candidates used a set square either on the bench or on the horizontal metre rule, both of which were allowed. Candidates should be advised to follow the instruction on the question paper and add to the diagram. It is far easier to draw the position of the set square on the diagram than it is to describe where the set square is placed. A significant number of candidates, presumably recalling questions from earlier years, described how to check that the metre rule was horizontal and obtained no credit for this.

(d) Most candidates obtained reasonable values for *x* and *y* but lost credit either because units were omitted or because measurements were taken to the nearest cm. Examiners expect candidates using a metre rule to use mm precision. The value of the suspended mass was approximately 75% of the mass of the metre rule, hence for an *x* value in the region of 49.0 cm, the *y* value should have been in the region of 65.0 cm. Because of the tolerances involved, a range of 55.0 cm to 80.0 cm was allowed. Most candidates obtained sensible values for *x* and *y*, but in other cases *y* was less than 50.0 cm and in such cases credit for the calculation of the mass of the rule was not allowed.

(e) Generally the calculation of the mass of the rule was correct. The number of significant figures given in the answer was ignored, but Examiners insisted on the unit being present. There were 3 reasons why candidates were not awarded credit here:

- the unit was omitted or wrong (e.g. kg),
- the values of *x* and *y* were interchanged in the formula,
- the values of *x* and *y* did not make sense, i.e. were much less than 50.0 cm.

Question 2

(a) The Supervisors had obviously taken great care to set the lengths of the pendulums to exactly 80.0 cm. This was clear from the results obtained by the candidates for 20*T*. In the majority of cases, candidates were obtaining a correct value of 20*T* in the region of 36.0 s. However many candidates did not obtain a good value for the length of the pendulum. There were 3 types of incorrect answer:

- 80 cm; this did not gain credit because it was not measured to the nearest mm.
- 83 cm; this was often followed by a correct value for 20*T*. This possibly suggests that the length of the pendulum should have been 80.3 cm.
- 20.2 cm; this strange result was often followed by a correct 20*T*, which suggests that the candidate was either reading the scale of the metre rule from the wrong end or was possibly measuring the height of the bob above the bench.

(b)

(i) Many candidates obtained a correct value for 20*T*. There were 2 reasons why credit was not awarded:

- The measurement was not repeated. When the phrase ‘take measurements to determine an accurate value of…’ is used in the question paper, candidates are generally expected to repeat measurements and find an average.
- Some candidates had obviously timed 19 oscillations and obtained a value in the region of 34 seconds.

(ii) Candidates who had taken care doing their measurements obtained credit for an accurate value of *T*. Others, who had an accurate value of 20*T*, often attempted to measure the time of a single oscillation here and then obtained a value that was well outside the range of allowed values.

(c) The allowed range for *g* was between 900 cm s^{-2} and 1100 cm s^{-2}. Those candidates who had made minor errors in their measurements and had not gained credit in **(a)** and **(b)** could still score here provided their measurements were reasonable (effectively a combined error of about 10%.) Those who had made gross errors could not be awarded any credit in this section. The only other issue in this section was incorrect units, e.g. cm/s, m/s. Writing too many significant figures was not penalised because it was thought better to give credit for accurate answers.

Question 3

(a) This seemed to be the most difficult question on the paper. Despite the hint in Fig. 3.1, a large number of candidates drew an angle of incidence of 30°. This made **(b)** difficult because the ray would have been refracted out of the block near the top of the page. In these circumstances, candidates often showed a reflected ray with an angle of reflection of 30°. This would have been a partially reflected ray and should have been barely visible. It is suggested that on reading **(b)** many candidates drew in this line because they were expecting a reflected ray. Unfortunately they did not receive credit for this because they often wrote the angle of reflection as 60° rather than the 30° shown on their diagram.

(b) Providing the angle of incidence was correct, candidates correctly found total internal reflection and were awarded credit. Credit for technique for making the marks on the emergent ray as far apart as possible was only scored by the most able candidates.

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Section B

Question 4

(a) Most circuit diagrams were correct. A diode symbol was allowed for a light emitting diode and the polarity was ignored. The most common error was the use of an indicator lamp symbol for the LED. A small minority of very weak candidates had the voltmeter in series with the circuit or omitted items such as the ammeter or the resistor X.

(b) The measured values were normally in the correct range. The most common errors were:

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(c) Most candidates obtained a correct value for the power. The units for the power had to be consistent with the units for I and V in the previous section, e.g. if V was written as 2.0 mV and I was written as 12.0 mA, then the correct value for the power would be 24.0 μW. Candidates frequently wrote the unit of mW, even though this was not consistent with the previous units.

(d) Good candidates obtained full credit for this section without any difficulty. They used all 7 possible values for the resistance and had a table, which showed that as the resistance increased the current decreased. Weaker candidates usually had the 3 single values of resistance and possibly a table without units and so only scored partial credit. A number of candidates used parallel combinations but these were not credited as the question specifically asked for series combinations. It was also evident from the results that a number of candidates thought that they were using series combinations but were actually using parallel combinations.

(e) Graph plotting skills were good with many candidates getting full credit for the graph. The most common error was the use of a graph scale that was based on 3 cm. By doing this two of the marking points cannot be credited as this is an inappropriate choice of scale and it is too difficult for the Examiner to check the plotting of points against such a scale.

(f) Most candidates demonstrated their ability to read a value off the graph line. A small number of candidates either omitted or gave the wrong unit for the power.

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 be encouraged to consider the position of all points. Simply joining the first and last points on the line does not usually give the line of best fit.

- Candidates can increase the accuracy of their straight lines on diagrams by using a sharp pencil and a ruler.

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 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 more able candidates followed instructions, recorded observations clearly and performed calculations accurately and correctly. Units were well known and usually included, writing was legible and ideas were expressed logically. All questions provided opportunities for differentiation, but particularly good were **Questions 3** and **4**.

Comments on specific questions

Question 1

(a)

(i) Only the more able candidates deduced that when the ammeter reading had reduced to zero, the capacitor had become (fully) charged. Common misconceptions were that the power supply was running down or that the resistor was 'using up' the current.

(ii) There was much evidence of guesswork here. Many stated correctly that the connection to Z would discharge the capacitor fastest, but were unable to supply a valid reason. Few realised that this path had lowest resistance so the discharge current would be largest. The fact that Z was closest to the capacitor was accepted as a creditworthy response.

(b) The reading on the ammeter was rarely stated incorrectly. When an incorrect answer was given, it was invariably 84 mA or 92 mA.

(c)

(i) The discharge curve for the capacitor was drawn very well by the majority of candidates. Suitable scales were almost always used; it was rare to see a graph which did not make maximum use of the given grid. Most candidates were able to make a reasonable attempt at the difficult skill of drawing a smooth curved line of best fit through the points. Fewer candidates this year spoiled their curves by making them too thick or by attempting a series of point to point straight line plots. Labels and units were occasionally missing, but most candidates are now well taught in graph drawing and presentation.

(ii) The relationship between I and t was poorly understood. Candidates were required to state that as t increased, I decreased. The fact that one variable was decreasing as the other increased prompted most candidates to deduce, wrongly, that they were therefore inversely proportional.

(iii) The majority of candidates were able to obtain the value of the current at time t = 40 s, but only the most able remembered to convert this current from mA to A before substituting in the formula $V = IR$. Many answers were incorrect by a factor of 1000.

Question 2

(a)

(i) This straightforward practical procedure was well understood by the majority of candidates. Most were able to describe the procedure of determining the volume of an irregular object using a displacement can. Where credit was not awarded, it was usually due to the omission of a statement to explain how the volume of displaced water could be measured.

(ii) The practical difficulties of using a displacement can that had a small diameter, or with a spout attached near the bottom of the can, were appreciated by most candidates. Some candidates did not relate their answers to the glass stopper in the question and gave vague answers which were far too general to be awarded credit.

(iii) At least one valid practical precaution was given by most candidates. Where answers relating to the avoidance of parallax are given, it is important to remind candidates to elaborate upon this, and to state what they would do to avoid it. The bold statement ‘avoid parallax’ does not earn credit, unless qualified. Candidates who opted for repeat measurements as a suitable precaution must go on to state that the repeat measurements must be averaged.

(b) Most candidates realised that if the density of the material of the stopper was required, then the mass of the stopper would need to be measured, and the majority of these were able to name the measuring instrument needed.

Question 3

(a)

(i) Candidates found great difficulty in describing a simple practical procedure to measure the force needed to make a block of wood move along a bench. Many were incorrectly under the impression that they needed to make use of all the apparatus in the given list. The best answers were almost always those which chose only the newton meter from the given list, attached it to the block, and read its scale when the block just started to move.

(ii) Only the more able candidates made a sensible suggestion as to how to make the experiment more accurate; this was perhaps due to the unfamiliar nature of the practical situation described in the question. It was expected that candidates would draw on their experience of performing other practical work during their course to suggest routine practical methods of increasing accuracy.

(b) Where a correct method for varying the surface area of the block in contact with the bench was given, the common response was to use a different face of the same block in contact with the bench. A minority of more able candidates suggested the novel method of placing the block near the edge of the bench, and allowing different areas of it to overlap the edge.

(c) Candidates were asked to complete the headings in a table of results. Although the variables weight *W* and frictional force *F* were almost invariably given, most candidates did not give their units, and consequently lost credit. The determination of the value of *k* from the graph was often incorrect. The more able candidates stated that a graph of *F* against *W* would yield a straight line graph of gradient *k*, but most suggested taking just one pair of values of *W* and *F* and dividing them, thereby defeating the object of plotting the graph.

Question 4

(a)

(i) A straight line from the lamp to the bench, just touching the top of the vertical card, was expected here. Many diagrams were spoiled by careless, inaccurate drawing, with lines (straight and curved) which missed the top of the card by some margin.

(ii) The region of shadow was not well drawn, with many candidates ignoring the instruction to draw a line on the surface of the bench in the given diagram.

(b) Very surprisingly, only a minority of candidates stated that the shadow would become longer when the card was moved away from the lamp. Most stated that the shadow would get shorter — a careful look at the geometry of the given diagram should have elicited the correct response.

(c) Most candidates thought wrongly that the shadow of the card in the laboratory was darker than the shadow of the candidate in the street because the street lamp was brighter or that the laboratory was darkened. Few realised that, in the street, there would be light from other sources, and that the street lamp itself is an extended source of light.

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 be encouraged to consider the position of all points. Simply joining the first and last points on the line does not usually give the line of best fit.

- Candidates can increase the accuracy of their straight lines on diagrams by using a sharp pencil and a ruler.

General comments

There were many excellent scripts with candidates using their knowledge of practical situations in answering the questions.

Descriptions of experiments, however, still cause problems for many candidates, with many resorting to theory rather than practical detail. This was particularly seen in **Question 2(b)** where candidates were asked to describe how to measure the focal length of a lens.

The graphical work again was good. However, drawing the best-fit straight line here caused problems. Candidates too often joined the first and last points, which was not acceptable as it gave no points above the line.

A significant number of candidates were unable to handle the calculation in **Question 3(c)(ii)** which involved both multiplication and addition. The candidates were also asked to give a calculated average to a suitable number of significant figures and few candidates were able to do this, simply quoting all the figures from the calculator.

There was an overall improvement of the ability of candidates to respond to practically based questions in a way that shows an appreciation of experimental procedure and gives detail of how the experiments are performed. However, many would benefit from further guidance in completing basic tasks such as drawing meters correctly in circuits, performing calculations or drawing labelled lines accurately.

The Alternative to Practical paper requires slightly different skills from the Theory paper. Candidates have to think around a practical situation which may be new to them, and imagine performing the experiment and the difficulties they would encounter. It is good that so many more candidates are showing these skills.

Comments on specific questions

Question 1

(a)

(i) The information in the stem informed the candidates that the distance to be measured here was between 1 and 2 metres. Many candidates did not pick up on this and simply stated 'a metre rule'. This was not accepted.

Correct responses involved using a measuring tape, two metre rules or explaining how one metre rule could be used by marking one metre on the floor and moving the rule to measure the remainder.

A significant number of candidates suggested measuring the time and speed of the car to enable the distance to be calculated. This was not credited. This may have been due to candidates remembering an experiment they had performed rather than carefully reading the question asked.

(ii) Most candidates gained partial credit here for making a mark on the ramp. Few candidates gained further credit for describing how the car was aligned with the mark. There were some excellent clear responses, such as '*always place the front wheels on the mark*' or '*place a rubber band round the track and place the car with the back wheels touching the band'*. The response *'repeat the experiment to see if the value of d is the same. If it is, then the car started from the same point on the ramp'* was seen several times and showed a lack of understanding of the experimental process here.

(iii) Marking the distance *h* on the diagram was often poorly done. We expected to see a vertical line, with arrows at the ends, drawn with a ruler.

Many answers were freehand, not vertical and the ends not clearly marked. There was some leeway given here and lines were accepted anywhere on the diagram that marked a distance to any point on the car.

Candidates should be encouraged to take care with labelling lines and ensure they are accurate with arrows at both ends.

(b)

(i) Most candidates were awarded partial credit for this part. Most candidates could average the five values given, but few correctly gave the answer to 3 significant figures. Four is not acceptable here because there is a large range in the values being averaged. It is unfortunate that even those who did give three significant figures often omitted the unit.

(ii) There were a range of possible answers here and most candidates gained credit. The most commonly seen correct response was parallax error in reading the ruler. Parallax error in reading a stopwatch was not accepted.

(c)

(i) The graph was generally well executed with many candidates gaining full credit. Almost all candidates labelled the axes correctly. Some candidates did not gain credit for the scales by ignoring the origin given on the graph and starting from (40, 10). Others used a zig-zag to represent a discontinuity in the scale. Although this is acceptable in some subjects, it is not in Physics, and especially here as the question later required them to comment on the graph near the origin. A few candidates still draw their own axes inside the graph grid. This often means their values do not fit easily into the grid. There were many fewer candidates writing the point values near each plotted point.

Many candidates who had completed the graph and plotting accurately then lost credit by drawing a line that was not the line of best fit. The best fit line must have points both above and below it. The most common error was to join the first and last point. Others incorrectly made the graph line pass through the origin.

(ii) Candidates have difficulty in describing a relationship shown by a line on a graph. Most were able to state that increasing *h* increases d_{av}. This is correct but requires further comment, such as 'linear'. Many candidates seem to think that any straight line with a positive gradient means the quantities are directly proportional. Negative comments such as 'they are not directly proportional as the line does not pass through the origin' are correct but insufficient as they do not tell us what the relationship is.

(d) Candidates were expected to refer to the car in their answer, not just state that $d_{av} = 0$ from the graph. Many clear answers were seen explaining that the car did not move, stopped on the ramp, or did not travel beyond position 2. A few candidates thought the car would travel backwards.

Question 2

(a)

(i) The candidates were required to draw a horizontal line from the centre of the lens to the screen. A large number drew freehand lines which curved down to the right and others stopped the line at the surface of the lens.

Many excellent answers were seen with candidates drawing a vertical line through the centre of the lens and then drawing and labelling *s* either above or below the lens.

Again candidates should be encouraged to use a ruler and sharp pencil and to take care with accuracy when drawing lines to show a distance.

(ii) Most candidates gained credit here for focal length.

(b) Although many excellent responses were seen, describing experimental detail always causes some problems for candidates. Many candidates described a different experiment to measure the focal length of a lens. These answers could gain full credit as the experimental procedure would be the same.

The two important details were repeating and averaging the measurement and adjusting the position of the lens/screen to obtain a clear image. Credit was awarded for clear labelled diagrams showing practical detail, such as the ruler perpendicular to the lens and screen or the lens in a holder. Candidates who described drawing a ray diagram gained no credit.

Question 3

(a) The majority of candidates knew that B and C were in parallel. There were many and various spellings of parallel which were accepted if they were phonetically correct. Some candidates were confused by the arrangement and responses such as 'B is in parallel and C is in series' were sometimes seen.

(b)

(i) The majority of candidates were able to draw the voltmeter correctly across the cell. Common errors were to draw the voltmeter across the resistor A or resistor C. Some candidates drew the voltmeter in the circuit rather than across a component. The voltmeter symbol must not have a continuous line through it. Some candidates drew the wire first then the voltmeter over the top which could not be awarded credit.

(ii) Very few candidates did not gain credit here. The X drawn to represent the ammeter needed to touch the line or have a dot on the line to indicate the position of the meter. An X drawn adjacent to the wire was not credited. Credit was given for an ammeter symbol drawn over the wire, but candidates should be encouraged to follow the instructions correctly.

(c)

(i) Most candidates were able to read the scale on the meter correctly as 1.5 V. 1.50 V was not credited as the meter cannot be read to this precision.

(ii) Although most candidates were able to manipulate the formula correctly, the calculation caused some difficulty. Candidates who tried to rearrange the equation before substituting the values for *R* often became confused and gave up. Some candidates used a value other than the given value of 10 Ω for the resistance of the resistors. A surprising error was that some candidates wrote out the formula without sufficient care and then confused their own writing, reading × instead of + in the denominator.

(d) The candidates were asked to identify circuit 2 as being different and then give an explanation as to why it was different. There were many excellent responses with candidates expressing themselves clearly and describing the arrangement accurately. Some candidates, however, found the description challenging. Simple responses that identified that there were two resistors in series in circuit 2 were accepted.

Question 4

(a) The important factor here was the amount of water in the test tube, and this was required for one of the marking points. A common error was to write the 'temperature of water'. Initial temperature was required here. Most candidates gained at least partial credit here.

(b) The labelling of headings in the table was well understood by most candidates who gave temperature and time. Unfortunately many did not give the units accurately enough. The unit for temperature as °C must be written correctly. The unit for time has to be minutes as the time measured is up to 20 minutes. The abbreviation m is not acceptable for minutes. Some candidates did not read the question carefully enough as it asked for the readings for test tube A. They used 'temperature of A' and 'temperature of B' in the two headings boxes.

(c) The cooling curves were not well drawn by most candidates, although some perfect graphs were seen. Many candidates forgot to label the axes, which was a requirement for the first marking point. Many drew the cooling curve to the *x*-axis which was labelled as 0. The curve should approach room temperature (which would be above zero) asymptotically. There should have been two curves of similar shape with A or B labelled and A initially cooling faster than B. A number of candidates drew cooling curves incorrectly showing a change of state. Many candidates drew the two curves cooling to different steady temperatures.