PHYSICS

Paper 5054/11
Multiple Choice

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

General Comments

As is often the case, the answers offered by the candidates revealed a wide variety of standards of understanding. A wide range of marks was the result with the majority of candidates obtaining a mark somewhere between the two extremes.

Comments on Specific Questions

Question 28 proved especially straightforward with the majority of even the weakest candidates offering the correct response. **Question 35** was also very well answered.

Question 15 was also well answered with very few candidates believing that the molecules themselves move. **Question 3** proved to be a question that was accessible to many candidates. Likewise, **Questions 1**, **4** and **5** were well answered. **Question 1** was factual recall but the other two tested, at least to some extent, an understanding of the subject of gravity.

Question 33 dealt with resistors in parallel which is a topic which is not always completely understood by all candidates. This question was well answered, however, and some of the weaker candidates who gave the correct response can be pleased to have done so.

At the other extreme, **Question 11** proved challenging for most candidates. The speed of the cyclist is constant and so his kinetic energy does not change. Despite this, answer **A** proved to be the most popular choice. The candidates who chose either **B** or **C**, might have realised that the work done cannot be equal to a force as the two quantities have different units. The best candidates were the most likely to get this question correct. All the answers attracted a significant number of candidates, however, and it is possible that a certain amount of guesswork was taking place.

The most commonly chosen answer to **Question 7** was **D**. This highlights a confusion concerning velocity and acceleration. The ball is speeding up as it falls and as air resistance increases, its acceleration decreases. The difference between speeding up at a decreasing rate and slowing down is not always clear to all candidates.

In **Question 39**, the count-rate on the detector includes the background count-rate. Two common errors were to ignore the background count-rate altogether or to subtract it initially and then not to add it at the end. In **Question 38**, the alpha-radiation would not penetrate even very thin plastic sheets and so could not be used here. Secondly, a factory would not wish to keep changing the source and so a longer half-life is desirable.

Question 22 involved more than one stage in the calculation and many good candidates chose the correct response. The most commonly chosen answer was **B**. Perhaps there were candidates who omitted the final stage having forgotten what had been asked for.

In **Question 40**, answer **D** was chosen almost as frequently as the correct answer **C**. Perhaps these candidates read the second heading as *nucleons* rather than reading it correctly as *neutrons*. Alternatively, these candidates might have simply performed the more usual alpha-decay calculation without noticing what was being requested.

The answer **B** offered to **Question 26** and answer **D** to **Question 30**, draw attention to misunderstandings.

Question 27 was an unusual question. The correct answer **A** was more popular than any other but candidates who suspect that the answer containing all the possibilities cannot be the correct one will have chosen other answers.

The candidates who performed best on the whole test performed better on all of the questions.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

There was a fairly wide range of scores on this paper with some candidates scoring highly and others performing less well. There was the expected spread of marks between these two extremes.

Comments on Specific Questions

Question 14 was well answered with very few candidates believing that the molecules themselves move. **Question 19** was also correctly answered by a large majority of the candidates. The molecular structures of solids and liquids are well understood. **Questions 32** and **35** were also very commonly answered correctly. Questions which are well answered tend not to discriminate very clearly between the better candidates and the lower scoring candidates and this is the case here where the candidates who scored more highly on the rest of the paper only scored slightly better here.

The most commonly chosen answer to **Question 6** was **D**. This highlights a confusion concerning velocity and acceleration. The ball is speeding up as it falls and as air resistance increases, its acceleration decreases. The difference between speeding up at a decreasing rate and slowing down is not always clear to all candidates.

The correct answer to **Question 5** was the most commonly chosen but a significant minority ignored the upward force and selected the incorrect answer **C**. In **Question 7**, a minority selected the answer which gave the two arrows the wrong way around; these candidates possibly thought that the acceleration was in the direction of motion. In **Question 11**, the two-stage calculation, some candidates gave the incorrect answer **C**.

In **Question 23**, there were candidates who confused *heat capacity* and *specific heat capacity* and selected answer **B**.

Question 28 tested a matter of factual knowledge and although both **A** and **B** proved popular choices, only answer **A** was correct.

All the answers to **Question 33** attracted some candidates.

Question 26 involved more than one stage in the calculation and although many good candidates chose the correct response, the most commonly chosen answer was **B**. Perhaps there were candidates who stopped just short of the final stage and had forgotten what had been asked for.

In order to answer **Question 9**, a calculation was required and although more candidates chose the correct answer **B** than any other, answers **C** and **D** were also commonly chosen.

The answers offered to **Question 31**, draw attention to a misunderstanding. Answer **B** was chosen by fewer candidates than the correct **C**.

A minority of candidates chose answer **D** for **Question 12**. This ignores the squaring of the velocity in the kinetic energy formula which is a common source of error.

The candidates who did not consider the initial 2.0 cm in the thermometer in **Question 17** chose answer **B** instead of the correct **C**.

The volume of the container in **Question 20** is fixed and so the molecules cannot, on average, get closer to each other as the temperature decreases. The correct answer is **D**.

The candidates who scored highly on the paper as a whole also scored more highly on each of the questions. As is expected, however, the more highly scoring questions discriminated less clearly between candidates.

PHYSICS

Paper 5054/21
Theory

Key messages

- Candidates should set out answers to numerical questions giving a formula, numerical working, the answer to a sensible number of significant figures and finally the unit. Examiners will often be able to give partial credit where stages are shown in the working even if the final answer is incorrect. There were examples of candidates, of a range of abilities, omitting units more than once throughout the paper. This can have a serious effect on the overall mark for the paper and sometimes these units are very likely to have been known. Candidates should be trained to automatically include the unit for every numerical answer.
- Many higher scoring candidates were able to demonstrate that they had been well prepared for questions that applied their knowledge and understanding of physics to a variety of situations.
- The layout of the question on the examination paper provides a clear indication of the length of answer expected by Examiners. Candidates should be reminded to read questions carefully, noting the marks allocated and the space available for responses. For questions that have one line and one mark, a short and concise response is expected.
- It is vital that candidates read questions from beginning to end very carefully, particularly in the optional questions in ***section B***. It was sometimes apparent that an optional question was started but then abandoned when a later part of the same question proved unfamiliar. More careful reading and planning might have allowed more time to be spent on the optional questions that were completed.

General comments

It is apparent that many teachers have a sound appreciation of the syllabus requirements, as demonstrated by a good proportion of candidates who were prepared well for the questions. Candidates were, in many cases, able to demonstrate their knowledge and understanding of key concepts.

There was very little evidence of candidates being unable to access questions as a result of poor literacy skills and in only a few cases were responses to parts of a question illegible and credit could not be given.

Examination papers were completed by the vast majority of candidates, indicating that sufficient time had been allowed for the paper. Candidates should be reminded to check carefully all their responses. Errors such as failing to answer part of a question, or the omission of a unit would then be avoided

The three optional responses produced similar average performances, although less able candidates appeared to find **Question 10** harder

Comments on specific questions

Section A

Question 1

(a) The majority of candidates were able to analyse the distance-time graph successfully.

(b) Most answers showed the cyclist having travelled 200 m in 40 s, although a number of answers appeared to show that the time was 30 or 50 s. In calculating the average speed most candidates used the formula speed = distance/time but often failed to use the total distance and the total time but, instead, calculated two speeds and found an average. This does not yield the correct answer.

Question 2

(a) It was encouraging that most answers mentioned force and the distance moved by the force in explaining why work is done. A number of answers, however, merely mentioned the force itself.

Although chemical energy was often quoted correctly as the answer in **(ii)**, other examples such as kinetic energy, or a series of energy transformations were given, even though the question asks for just a form of energy.

(b) Few correct calculations of the moment were produced, and even with a correct numerical calculation, the unit was often quoted incorrectly, as, for example, N/m rather than N m. It was apparent that candidates were familiar with the idea of a moment calculation involving a product of force and perpendicular distance, but often the distances were not taken to the toes of the candidate.

Question 3

(a) A possible unit for pressure was well known, with the majority of answers choosing the Pa or N/m^2.

(b) It was disappointing that many candidates drew a straight line graph upwards from the origin. They should realise that, as pressure increases, volume decreases. The best answers successfully plotted the two points and drew a curved line between these points.

(c) Although the question asks for an explanation in terms of molecules, many answers merely stated that the pressure increases or that the molecules were closer together, without explaining how the molecules could support the weights on top of the syringe.

Question 4

(a) The majority of answers successfully gave a description of the transverse movement of the particles in the wave. A significant minority, however, failed to mention that the particles oscillate or vibrate.

(b) Although the correct wavelength was often quoted, a value equal to half the wavelength was sometimes given as the answer.

(c) The formula for the speed of a wave was well known and applied. Only the most able candidates were successful in drawing the string in **(ii)**. Most answers attempted to draw an extra part of the wave at the end of the string, rather than drawing the whole wave as it appears 0.10 s later. Those candidates who did draw the wave often drew a wave of a different wavelength.

Question 5

(a) The formula for refractive index was well known, with only a few candidates making a numerical mistake or confusing the angles of incidence and refraction.

(b) Comparatively few candidates gave a full account of why total internal reflection occurs. The idea that the angle of incidence is larger than the critical angle was fairly well known, but the idea that the ray must travel from a more dense to a less dense medium was often stated wrongly as the ray must pass from a less dense to a more dense medium.

(c) The question itself states that optical fibre is cheaper and carries more data per second and so these were not accepted as answers, although some candidates did give these statements as their answer. It was encouraging that a whole range of other possibilities were seen, the most common being that the signal travels further without the need for boosting or that there is less interference or noise.

Question 6

(a) The formula for resistance and electrical power was generally known, although sometimes applied wrongly. The main mistake in **(ii)** was to calculate the current in the lamp and fail to add the current in the resistor, as the question asks for the current in the power supply.

(b) The circuit diagram required is fairly easy and straightforward, and the majority of drawings were correct. In **(ii)** most answers suggested that the current in the lamp or the voltage across the second lamp were lower. However there was sometimes no attempt to explain why the series resistor reduced these values.

Question 7

(a) Induction proved a difficult concept. Many candidates failed to suggest that it is the magnetic field lines of the magnet that cut the coil to produce the induced e.m.f. Sometimes it was suggested that the field lines of the coil cut the magnet.

(b) There were a reasonable number of answers that suggested that the current reverses and then explained the action of an LED.

(c) Although many answers were able to suggest that the induced e.m.f. is larger, there were few answers that explained this, in terms of a rapid cutting of the field lines or the increased rate of change of flux in the coil.

Question 8

(a) The simple idea of the emission of electrons from a hot surface was well known.

(b) Many answers wrongly suggested that it was the high temperature of the filament that enabled the electrons to travel at high speed. The correct action of the anode in attracting the electrons was, however, given by a small number of candidates.

(c) Most candidates attempted to draw at least one set of plates, but only the best answers included two sets of plates that were correctly labelled. The orientation of the plates was difficult to draw and no artistic skills were expected.

Section B

Question 9

(a) Although most candidates suggested that mass and speed are scalar quantities in **(i)**, a significant minority included, incorrectly, one other term as a scalar, often acceleration.

In the context of circular motion, only just over half of the candidates produced a completely successful statement in **(ii)1** about the meaning of velocity, often describing acceleration or producing vague descriptions, such as velocity is the change in displacement in a certain time, rather than in unit time or in one second. It was encouraging to find in **(ii)2** many answers that made the simple statement that the direction changes. In **(iii)** most answers recognised that there was a force towards the centre of the circle but fewer answers stated that this was a force of gravity. There were a few very good answers that also suggested that it is not only a force towards the Earth but the velocity of the satellite at right angles to this force that causes the circular motion.

(b) Fewer than half of the candidates successfully added the two forces in **(i)** to find the thrust, even though the directions of the forces are shown in the diagram. The formula $F=ma$ was well known in **(ii)**. However many candidates used the thrust force of the engine as the force F in the formula, rather than the resultant force.

(c) A significant number of candidates gave a definition of acceleration in **(i)** rather than explaining what is meant by a uniform acceleration. Successful candidates suggested, for example, that there is the same increase in speed in the same time interval. The graphs in **(ii)** usually showed a linear increase at the start and a constant speed at the end but decreasing acceleration in the middle section was often confused with deceleration. Decreasing acceleration is shown as an increase in speed but with a decreasing gradient on the graph. The majority of candidates showed a deceleration where the speed of the rocket decreases.

Question 10

(a) Some good suggestions were made relating the regularity of the molecular arrangement and the direction of movement to the actual motion of liquid molecules. A number of candidates were unable to express this sufficiently well.

(b) The escape of molecules in evaporation was well described and many candidates realised that the more energetic molecules escape. However not all candidates were able to explain that those molecules that remain have less kinetic energy on average because of the escape of those with most energy.

(c) Although many answers successfully explained why convection occurs in **(i)**, it was unusual to find an answer where there was the suggestion that the water in the gas state will condense onto the thermometer in **(ii)**. The calculations in **(iii)** generally showed knowledge of the formulae for specific heat capacity and specific latent heat. However the values used for mass were sometimes incorrect with, in particular, the wrong mass being used in the equation involving latent heat.

Question 11

(a) The majority of candidates gave the correct answer in **(i)**. The best answers in **(ii)**, as well as stating that neutrons are neutral, suggested that there are an equal number of protons and electrons, with a charge of +1 and –1 respectively, and so the charge cancels. The best answers in **(iii)** gave some suggested values for the number of protons and electrons, although general statements about isotopes were accepted. The most common error was for candidates to include electrons as though they were in the nucleus.

(b) The majority of candidates were successful with both parts of this question.

(c) The best answers in **(i)** included technical details about the alpha particle, such as its small range or that it ionises the air. Candidates should avoid vague answers such as the air interferes with or obstructs the electrons and try to use ideas from the course. In **(ii)**, only a few candidates stated that the emission of particles from the source is in random directions and so few particles will travel towards the slit. Less than half of candidates successfully drew the path of alpha-particle B. Most often the path drawn was less deviated than that of alpha-particle A, even though particle B passes closer to the nucleus and should be deviated more. The most successful answers in **(iv)** suggested that only a few particles are deflected significantly and that as most particles pass straight through the foil, the nucleus must be small. Many candidates explained why the particles are defected by the nucleus, in terms of the charges involved and did not answer the question itself.

PHYSICS

Paper 5054/22

Theory

Key messages

- Candidates should set out answers to numerical questions giving a formula, numerical working, the answer to a sensible number of significant figures and finally the unit. Examiners will only then sometimes be able to give partial credit even if the final answer is incorrect. Candidates should be trained to automatically include the unit for every numerical answer.
- There is often no need to convert from one unit to another within the question. If, for example, a wavelength in cm and a frequency in Hz are used to calculate speed in cm/s, there is no need to give the answer in m/s and possibly make a mistake in a conversion.
- The layout of the question on the examination paper provides a clear indication of the length of answer expected by the Examiners. Candidates should be reminded to read questions carefully, noting the marks allocated and the space available for responses. For questions that have one line and one mark, a short and concise response is expected. For questions that ask for an explanation, the basic principles should be used and applied to the situation clearly and logically.

General comments

It is apparent that many teachers have a sound appreciation of the syllabus requirements, as demonstrated by a good number of candidates who were prepared well for the questions. Candidates were, in many cases, able to demonstrate their knowledge and understanding of the key concepts. In order to improve the performance of lower scoring candidates, teachers should provide further opportunities for candidates to apply what has been learnt in a range of unusual contexts.

The scripts were answered in good English apart from only a few and the candidates' work was generally neat and tidy.

The popularity of the optional questions in part B may have been dependent on what had been taught, with **Question 9** being slightly less popular, perhaps because the experiment on refraction of sound was not well known. The overall performance of the candidates in the three optional questions was, however, very similar.

Examination papers were completed by the vast majority of candidates, indicating that sufficient time had been allowed for the paper. Candidates should be reminded to check carefully all their responses.

Questions that ask for an explanation, as in **Question 10a(ii)**, require the physical principles to be both stated and applied to the actual question. Most successful candidates appeared to have thought through their answers logically. They presented the basic syllabus principles and then applied them to the actual question, often throughout the paper. This produced well answered and succinct accounts. However, other candidates appeared to feel the need to fill all the available answer space, and to write down anything that might be relevant.

Comments on specific questions

Section A

Question 1

(a) Although the majority of candidates correctly suggested that either the force of gravity or the weight pulls downwards on the mass, a number of answers only referred to gravity. They did not mention any force or pull or stated that the mass pulls downwards without mentioning gravity or weight.

(b) The concept of vectors was well understood, with most answers quoting magnitude and direction as the key features of a vector quantity.

(c) In **(i)1**, it was encouraging that many candidates were successful in stating the simple formula that relates the extension, original length and the stretched length of a spring. A number of answers tried to introduce the equation $F = kx$, which is not relevant to the question. Fewer candidates were successful in **(ii)2**, where many correctly used the graph to find the stretched length but failed to subtract 40 cm, while many others misinterpreted the scale on the graph. The majority of lines drawn in **(ii)** showed the correct bending. Steeper straight lines after the limit of proportionality were accepted although ideally the lines drawn should be curved.

Question 2

(a) Only a handful of candidates failed to suggest that a tape measure was used to measure the distance shown.

(b) In **(i)**, many candidates who tried to describe density in words gave an incorrect answer, despite being able to quote the correct formula in the calculation. Common errors were to suggest that density is the mass in a certain volume, rather than in unit volume or even in 1 m^3. In **(ii)**, a significant number of candidates calculated the volume incorrectly or tried to convert mass into grammes or volume into cm^3 and failed to do so correctly, when there was no need to make the conversion at all. In **(iii)** the formula $P = F/A$ was well known, although the area of the base was often calculated incorrectly. A small number of candidates used the formula $P = dgh$, which can also obtain the correct result. In **(iv)**, although the number of candidates who achieved success was small, their answers were encouraging, correctly identifying that both area and weight both increase to keep pressure constant. A large number stated that only one of the factors, either weight or area increased but not the other, or that neither weight nor area increased.

Question 3

(a) It was encouraging that the formula for efficiency was usually stated or used correctly in the calculation in **(i)**, but there were often mistakes when rounding the final answer to a sensible number of significant figures. It was helpful where candidates quoted the formula before starting the calculation, as sometimes energy output and energy input were misread from the table. Fewer correct answers for power were seen in **(ii)**, with many answers dividing energy by one or even by 3600 rather than dividing by 60. Many answers subtracted the energy values to obtain the wasted power rather than the useful power. Again, credit could still be given where candidates started their calculation with a clear formula for power.

(b) Most answers correctly stated that the electric kettle boils the water first, but in the explanation, a significant number of candidates missed the idea of time by stating that more total energy was provided or that the electric kettle was more efficient.

(c) This section was well attempted. There were a number of possible sensible differences, with the majority of answers stating that the steam molecules are further apart. There were, however, a number of candidates who incorrectly suggested that steam molecules are moving faster than water molecules at the same temperature.

Question 4

(a) The calculation involving specific heat capacity was usually correct, but there was sometimes confusion between thermal energy and specific heat capacity in the formula. Some candidates used a temperature rather than a temperature difference in the calculation.

(b) This section proved to be a problem for many candidates. There were some good descriptions of heat being absorbed to melt the ice or to overcome molecular forces. Good answers made it clear that the ice takes in heat in order to melt and that the ice/water mixture remains at a constant temperature during melting, whilst the water in the jug warms up. Most candidates failed to give enough relevant information, rather than showing major misconceptions. However a significant number appeared confused about the direction of energy flow, suggesting that the ice gives out energy as it melts. Some answers confused the various thermal processes involved and even wrote about evaporation although the liquids involved are very cold.

(c) Most candidates made a clear statement that a metal is a good conductor and followed this with further details. Sometimes these extra details were vague or irrelevant and even showed misconceptions, such as 'metals conduct cold' or 'evaporate'. Extra detail, such as the conduction of energy by free electrons was welcome, if described well, but was often poorly phrased. Radiation was also often involved in the arguments, even though radiation is likely to be absorbed by the cold surfaces in an ordinary room environment, rather than being lost by the cold surfaces.

Question 5

(a) There were many clear statements that electrons move from the hair to the balloon. Some answers omitted to mention that charge moves from the hair to the balloon and thus failed to gain full credit. Although most candidates demonstrated a good understanding of the charging process, some appeared to have some misapprehensions, for example that the hair or balloon was initially charged or that positive charges move from the balloon to the hair.

(b) The majority of answers suggested correctly that the hair was positive and that opposite charges attract. This general principle was well known. Candidates who gave long, vague accounts with vague phrasing and repetition would have improved by thinking carefully and applying this simple principle directly.

(c) This section produced the weakest overall performance in the question. Although an insulator does not conduct current was obvious in many answers, this idea was not applied to the actual situation. Many candidates failed, for example, to suggest that the charges will not flow off the balloon if it is an insulator. A number of answers suggested that if the balloon is a conductor the charge would cause an electric shock or burst the balloon.

(d) Examples of static electricity were well known, with the electrostatic precipitator, photocopier and car spraying being the most common answers. It was not clear that the example was useful in a number of answers, for example the Van der Graff generator or in a demonstration that charged rods pick up pieces of paper. There was, in a minority of cases, real confusion between magnetism and static electricity.

Question 6

(a) The answers to **(i)** were generally encouraging, with understanding being shown in most answers that the magnetic field lines of the magnet cut the coil. In a small number of cases the magnetic field of the coil was stated as cutting the magnet, but these were the exception. However, the idea of the cutting of flux or the change in flux within the coil was rarely carried forward into **(ii)**. The idea that the coil cuts field lines or flux in one direction and then in the reverse direction was often confused, particularly with expressions such as 'the coil rotates clockwise then anticlockwise'. Many answers suggested that the current is alternating; unfortunately this is a consequence and not a cause of the positive and negative values of the e.m.f.

(b) Candidates generally recognised that the answer to each section should be 'increase', 'decrease' or 'stays the same'. The increase in the maximum value of the e.m.f., when using stronger magnets or more turns, was generally known. Unfortunately answers often stated that the frequency of the e.m.f. changes whereas it stays constant unless the coil is turned faster.

Question 7

(a) Although many correct answers suggested that the neutral wire provides a return path for current, there was often confusion with the current being stated as being zero in the neutral wire or that the neutral wire neutralises the charges.

(b) At least one of the two aspects of this question was usually understood and explained, either that the earth provides a passage for current, so that the metal case is not charged, or that the fuse blows, disconnecting the circuit.

(c) It was encouraging that many answers suggested that the hairdyer is doubly insulated or that the case is made of plastic. A number of answers suggested that the whole of the hairdyer was an insulator, rather than just the outside case.

(d) Amongst several correct answers, the most popular was that a circuit breaker can be reset and does not have to be replaced. Some very good answers compared the speed of action of the circuit breaker and the fuse to good effect.

Question 8

(a) The majority of candidates gave the correct number of protons and neutrons in the two isotopes. Errors were most often made in the calculation of the number of neutrons, where sometimes the number of nucleons rather than the number of neutrons was given as the answer.

(b) A number of candidates wrote at length giving answers that referred to filled electron shells or explaining that an electron must be removed from an atom to make it charged. Such answers were often not very relevant to the question. There were, however, a number of very logical and well explained answers which stated the charge on the proton, neutron and electron and compared the number of protons and neutrons in each atom to come to the conclsion that the positive and negative charges cancelled.

Section B

Question 9

(a) Although the majority of answers correctly gave a definition of frequency, a number of candidates referred to frequency as being the 'inverse of periodic time' or stated that frequency was the 'time for one wave'.

(b) A surprising number of candidates failed to obtain the wavelength correctly in **(i)**, the most common error was to take the distance of 6.0 cm as covering five rather than four wavelengths. The wave equation was well known in **(ii)** but a significant number of candidates either failed to give a unit at all or quoted the unit as m/s without converting the wavelength into metres.

(c) The decrease in wavelength as speed decreases was well known. However this was often merely stated without any explanation. Correct explanations suggested that frequency remains constant or that the wave travels a shorter distance in the time for one wave. The diagrams drawn in **(ii)** were quite encouraging, but a significant number of diagrams showed the wavefronts sloping upwards from the interface rather than downwards or introduced extra wavefronts.

(d) Most answers gave a reasonable difference between longitudinal and transverse waves in **(i)** when describing the difference between sound and water waves. Some good accounts were given of the difference in the direction of vibration of the two types of waves. A number of answers failed to complete both sides of the difference, giving, for example a statement that sound contains compressions/rarefactions and that the particles in a water wave move up and down, perpendicular to the motion of the wave itself. The answers to **(ii)** appeared to show that many candidates were unfamiliar with an experiment to demonstrate the refraction of sound. There were some successful descriptions, often involving a balloon or other shaped object containing carbon dioxide or the refraction of sound on a cold night where sound 'travels further'. However those candidates prepared to use their knowledge were often partially successful by describing a sensible source of sound and a shape containing carbon dioxide that would refract and change the direction of a beam of sound. Answers were generally less successful in establishing that refraction takes place as they often failed to move a detector to show that the sound had been deviated. There were, unfortunately, a large number of answers that were demonstrations that sound travels in a bell jar or where the speed of sound was measured in air and carbon dioxide.

Question 10

(a) In general a good understanding of the basic action of magnetism was shown. Almost all candidates placed the S-pole correctly on the iron core and on the N-pole of the armature in **(i)**. Many correct answers placed the S-pole on the far left of the armature or on the right side. A number of answers incorrectly placed more than one N-pole or more than one S-pole on the armature. In **(ii)**, most answers correctly stated that the poles are reversed on the iron core when the current is reversed. Sometimes the poles were not reversed on the armature and the armature was stated incorrectly as being repelled by the iron core. Candidates tended to give very brief answers to **(iii)**. Such answers amounted to 'iron is easily magnetised and demagnetised', without applying this idea to the actual situation. It was clear that most candidates recognised that the 'demagnetisation' properties of iron are important in the action of a relay but more candidates could have explained that when the switch is open the iron loses its magnetism and the armature can return to its original position. A number of candidates appeared to confuse a closed switch with an open switch.

(b) The majority of answers correctly identified the thermistor in **(i)**. The best answers in **(ii)** followed a clear sequence with a reduction in resistance of the thermistor, an increase in the current in the coil, attraction of the armature, the closing of the switch, and finally, with current in the bell, the ringing of the bell. Many candidates were content to just state that more current flows and did not explain the action of the relay at all, often implying that the current in the thermistor flows in the bell.

Where the understanding of the circuit was good in **(iii)**, this question proved reasonably straightforward. However, many candidates failed to recognise that the thermistor is in series with the coil and has the same current or that the 12 V of the battery is shared between the coil and the thermistor. However some credit could be often be given in **(iii)1** if the equation was stated. Many candidates attempted to find the total resistance of the circuit to answer **(iii)3**, and this part of the question produced the fewest correct answers, although the most able candidates were able to use their understanding of circuits to good effect. The most direct route to the answer is to find the current in the bell and add it to the 1.5 mA in the other arm of the parallel circuit. Where candidates attempted to find the total resistance they often failed to include the resistance of the coil.

Question 11

(a) In **(i)**, many candidates gave a correct definition and even those candidates who had not memorised a standard definition used their own words and were often successful. There was, in a small number of answers, confusion between velocity and acceleration. The most succinct answers were 'rate of change of displacement', 'change in displacement per unit time' or 'speed with a direction'. It is helpful if candidates realise that rate of change of displacement itself means change in displacement per unit time and that 'rate of change of displacement divide by time taken' is not correct. The answers to **(ii)** merely had to mention the opposite directions involved with positive and negative velocity; many answers described this effectively in the candidates' own words, often mentioning forwards and backwards or up and down. However there was confusion in a significant number of answers, where negative velocity was linked to deceleration and positive velocity to acceleration. The answers to **(iii)1** were encouraging, showing understanding of the formula for acceleration and the ability to use values from the graph in the formula. The final units of acceleration were the main source of error, often being stated incorrectly as m/s. Candidates found difficulty in commenting upon the acceleration obtained in **(iii)2**. The best answers suggested that this value was the same as the acceleration due to gravity or the same as the gravitational field strength. The most common confusion was to equate acceleration with the force of gravity.

Many answers in **(iv)1** suggested that the man is at the lowest point at 5.4 s, which is where he has the largest negative velocity. The man should actually have no velocity, instantaneously, at this point and it was encouraging that a good proportion of able candidates were able to locate this correctly. The question in **(iv)2** asks for an explanation in terms of the forces involved on the man and able candidates were more than capable of describing these forces clearly. However many candidates gave an explanation in terms of energy conversions, which is not what was required. Candidates attempting force questions might improve their performance by drawing a free-body diagram and thinking clearly about the forces involved. In this situation, the upward force is not air resistance and this appeared to confuse many candidates who attempted to describe terminal velocity.

(b) The answers showed good general knowledge of the conservation of energy in **(i)** and of the formula for gravitational potential energy in **(ii)**. A number of wrong answers suggested that the kinetic energy at C was equal to gravitational potential energy rather than being equal to the loss in gravitational potential energy between A and C. A very few candidates attempted to use the kinetic energy at C to find the distance between A and C, and a few were successful. The most common answer was to use the difference in gravitational potential energy between A and C. Many answers found the height of A or C alone.

PHYSICS

Paper 5054/31
Practical Test

Key messages

- Candidates should ensure that they are familiar with all the equipment listed in the syllabus and that they are able to use all the equipment in order to obtain accurate measurements.
- Candidates should be given opportunities to practice following instructions in practical tests.
- The majority of measurements should be taken to two or three significant figures, so that the answers to calculations should be quoted to the same precision and units should be included with any measured or calculated quantity.
- The data plotted on a graph should always occupy as much of the page as possible, but the scale used should be easy to follow so that Examiners can easily read data from the graph. Candidates should avoid using a scale such that the data fills the whole page if the scale is based on 6, 7, 13, 17, etc.
- Candidates should draw the best fit line and smooth curve or best fit lines and avoid dot-to-dot lines.
- Candidates should always check plotted points that are some way from their best fit line.

General comments

Candidates found the paper accessible, especially **Question 3**, where a large number of candidates scored full marks.

Comments on Specific Questions

Section A

Question 1

There was a good spread of marks on this question with most candidates able to score marks for the measurement of mass and the density calculation and the most able candidates able to score full marks.

(a) The majority of candidates obtained correct values for the masses. Very occasionally units were omitted. Candidates were expected to use a large volume of salt solution in order to find a more accurate value for the volume and the mass. Only a few candidates did this.

(b) The majority of candidates did not show the upper and lower levels of the meniscus in their diagrams. However, candidates were given credit for showing the eye level with the lowest point on the single line that was drawn. A number of diagrams were not labelled, but if the correct arrangement was described in the text, the mark was given.

(c) As a general rule, the calculation of density was correct and the majority of candidates used the correct unit.

(d) The question asked for an explanation of an advantage of using a large volume and so an answer that simply stated that it was more accurate, did not gain the mark.

Question 2

Many candidates obtained expected values for the ratios and easily obtained four out of five marks for this question. Candidates were expected to give the unit of Volts (V) for at least one of the voltage measurements and no unit for the ratio. The majority of candidates found the description of the potential divider difficult.

(a) (i) Since the instructions specified a 4.5 V to 5.0 V d.c. power supply, it was expected that candidates would obtain a value for V_{AC} in the range 3.5 V to 5.5 V. A number of candidates obtained values outside this range, possibly because they misread the voltmeter or the resistors were not placed in the correct position.

(ii) V_{BC} should have been approximately a half of V_{AC} and a range of 1.7 V to 2.8 V was used. The majority of candidates obtained a value in this range.

(iii) The expected a ratio should be given to an appropriate number of significant figures so the following were not accepted:

- a value that was quoted as a fraction,
- a value that was only given to one significant figure, e.g. 0.5, since the measurements were generally taken to two or more significant figures,
- a value that was given a unit since ratios do not have units.

(b) The value of V_{AC} should have been approximately the same as in **(a)(i)**. If anything, because of the increased resistance in the circuit V_{AC} should have been slightly greater than the value in **(a)(i)** because of the smaller potential difference across the internal resistance of the power supply. The results of some candidates illustrated this difference. The new value for V_{BC} should have been approximately a third of the value of V_{AC}.

(c) One of two approaches was required here.

Either the increased resistance lead to a reduction in current which then produced a smaller value for V_{BC}.

Or the increased resistance had an increased share of the voltage which meant the V_{BC} had a smaller share of the voltage.

Only some candidates were able to describe one of these approaches. Many descriptions did not refer to the points across which the voltage was measured, e.g. an increase in resistance lead to a decrease in voltage (because $V = I \times R$).

Question 3

This proved to be the easiest question on the question paper. Many candidates obtained full marks, although a significant number made some errors.

(a) Generally, measured volumes were sensible and the value of the mass was numerically equal to the volume. Candidates lost marks due to:

- the omission of units from the volume or the mass,
- attempts to calculate the mass from the density, which often lead to a value for the mass that was not numerically equal to the volume.

(b) (c) Temperatures were frequently measured correctly and gave a sensible value for the rise in temperature. Candidates lost marks due to:

- the omission of, or incorrect unit for temperature, ° rather than °C was a popular answer,
- incorrect recordings of temperature, e.g. 20.9 °C rather than 29 °C.

(d) (ii) The majority of candidates correctly substituted into the expression for the specific heat capacity and obtained a sensible value. The most common error was either the omission of, or the wrong expression for, the unit.

Section B

Question 4

Generally candidates obtained satisfactory results for this experiment, but did not describe or use techniques that would have improved the accuracy of their results.

(a) (i) Candidates were asked to place the object at the 0.0 cm mark on the rule and the lens at the 20.0 cm mark. It was therefore expected that u would be 20.0 cm. Some candidates obtained such a value but many lost marks due to:

- using a value that was outside the allowed range of 19.5 cm to 20.5 cm,
- the omission of units from the value,
- by quoting a value of u to the nearest cm rather than the nearest mm, e.g. 20 cm rather than 20.0 cm.

(ii) Candidates should realise that in order to determine an accurate value for a physical quantity, they need to take repeat measurements and an average value found. Very few candidates took repeat measurements.

(b) Very few candidates explained the idea that the position of the sharpest image should be approached from smaller values of v and then larger values of v.

(c) In the table of results units were frequently omitted from the column headings for (uv) and ($u + v$). Also, where units were given the heading for the (uv) column was frequently given as cm rather than cm^2. Results were generally correct but some candidates did not use the full length of the rule, e.g. did not have any results close a ($u + v$) value of 100.0 cm.

(d) There were the same problems labelling the axes of the graph as there were when compiling the table of results, namely the omission of units. There were two problems with the choice of scale for the graph:

- since the minimum value of ($u + v$) was 60.0 cm, the ($u + v$) axis of the graph should have stared at this value rather than at 0.0 cm.
- many candidates seemed to have taken the range of their results and divided it by the available length of the axis to produce a scale. This led to scales that were based on 6, 7, 13, 17, etc. Such scales will lose both the scale and plotting marks. Candidates should use a scale that is easy to follow based on 2 or 5, e.g. 5 cm of ($u + v$) is equivalent to 1 cm on the grid.

(e) Candidates, who gave values for f often lost marks due to:

- the omission of the units of f,
- an answer to four or more significant figures. The majority of measurements in the experiment were made to either two or three significant figures so no more than this is justified in the answer.
- the use of a small triangle when determining the gradient of the graph. The triangle used to determine the gradient of the line should have a hypotenuse that is greater than half the length of the line.

PHYSICS

Paper 5054/32
Practical Test

Key messages

- Candidates should ensure that they are familiar with all the equipment listed in the syllabus and that they are able to use all the equipment in order to obtain accurate measurements.
- Candidates should be given opportunities to practice following instructions in practical tests.
- The majority of measurements should be taken to two or three significant figures, so that the answers to calculations should be quoted to the same precision and units should be included with any measured or calculated quantity.
- The data plotted on a graph should always occupy as much of the page as possible, but the scale used should be easy to follow so that Examiners can easily read data from the graph. Candidates should avoid using a scale such that the data fills the whole page if the scale is based on 6, 7, 13, 17, etc.
- Candidates should draw the best fit line and smooth curve or best fit lines and avoid dot-to-dot lines.
- Candidates should always check plotted points that are some way from their best fit line.

General comments

Candidates found the paper accessible, especially **Question 3**, where a large number of candidates scored full marks.

Comments on Specific Questions

Section A

Question 1

There was a good spread of marks on this question with most candidates able to score marks for the measurement of mass and the density calculation and the most able candidates able to score full marks.

(a) The majority of candidates obtained correct values for the masses. Very occasionally units were omitted. Candidates were expected to use a large volume of salt solution in order to find a more accurate value for the volume and the mass. Only a few candidates did this.

(b) The majority of candidates did not show the upper and lower levels of the meniscus in their diagrams. However, candidates were given credit for showing the eye level with the lowest point on the single line that was drawn. A number of diagrams were not labelled, but if the correct arrangement was described in the text, the mark was given.

(c) As a general rule, the calculation of density was correct and the majority of candidates used the correct unit.

(d) The question asked for an explanation of an advantage of using a large volume and so an answer that simply stated that it was more accurate, did not gain the mark.

Question 2

Many candidates obtained expected values for the ratios and easily obtained four out of five marks for this question. Candidates were expected to give the unit of Volts (V) for at least one of the voltage measurements and no unit for the ratio. The majority of candidates found the description of the potential divider difficult.

(a) (i) Since the instructions specified a 4.5 V to 5.0 V d.c. power supply, it was expected that candidates would obtain a value for V_{AC} in the range 3.5 V to 5.5 V. A number of candidates obtained values outside this range, possibly because they misread the voltmeter or the resistors were not placed in the correct position.

(ii) V_{BC} should have been approximately a half of V_{AC} and a range of 1.7 V to 2.8 V was used. The majority of candidates obtained a value in this range.

(iii) The expected a ratio should be given to an appropriate number of significant figures so the following were not accepted:

- a value that was quoted as a fraction,
- a value that was only given to one significant figure, e.g. 0.5, since the measurements were generally taken to two or more significant figures,
- a value that was given a unit since ratios do not have units.

(b) The value of V_{AC} should have been approximately the same as in **(a)(i)**. If anything, because of the increased resistance in the circuit V_{AC} should have been slightly greater than the value in **(a)(i)** because of the smaller potential difference across the internal resistance of the power supply. The results of some candidates illustrated this difference. The new value for V_{BC} should have been approximately a third of the value of V_{AC}.

(c) One of two approaches was required here.

Either the increased resistance lead to a reduction in current which then produced a smaller value for V_{BC}.

Or the increased resistance had an increased share of the voltage which meant the V_{BC} had a smaller share of the voltage.

Only some candidates were able to describe one of these approaches. Many descriptions did not refer to the points across which the voltage was measured, e.g. an increase in resistance lead to a decrease in voltage (because $V = I \times R$).

Question 3

This proved to be the easiest question on the question paper. Many candidates obtained full marks, although a significant number made some errors.

(a) Generally, measured volumes were sensible and the value of the mass was numerically equal to the volume. Candidates lost marks due to:

- the omission of units from the volume or the mass,
- attempts to calculate the mass from the density, which often lead to a value for the mass that was not numerically equal to the volume.

(b) (c) Temperatures were frequently measured correctly and gave a sensible value for the rise in temperature. Candidates lost marks due to:

- the omission of, or incorrect unit for temperature, ° rather than °C was a popular answer,
- incorrect recordings of temperature, e.g. 20.9 °C rather than 29 °C.

(d) (ii) The majority of candidates correctly substituted into the expression for the specific heat capacity and obtained a sensible value. The most common error was either the omission of, or the wrong expression for, the unit.

Section B

Question 4

Generally candidates obtained satisfactory results for this experiment, but did not describe or use techniques that would have improved the accuracy of their results.

(a) (i) Candidates were asked to place the object at the 0.0 cm mark on the rule and the lens at the 20.0 cm mark. It was therefore expected that *u* would be 20.0 cm. Some candidates obtained such a value but many lost marks due to:

- using a value that was outside the allowed range of 19.5 cm to 20.5 cm,
- the omission of units from the value,
- by quoting a value of *u* to the nearest cm rather than the nearest mm, e.g. 20 cm rather than 20.0 cm.

(ii) Candidates should realise that in order to determine an accurate value for a physical quantity, they need to take repeat measurements and an average value found. Very few candidates took repeat measurements.

(b) Very few candidates explained the idea that the position of the sharpest image should be approached from smaller values of *v* and then larger values of *v*.

(c) In the table of results units were frequently omitted from the column headings for (uv) and ($u + v$). Also, where units were given the heading for the (uv) column was frequently given as cm rather than cm^2. Results were generally correct but some candidates did not use the full length of the rule, e.g. did not have any results close a ($u + v$) value of 100.0 cm.

(d) There were the same problems labelling the axes of the graph as there were when compiling the table of results, namely the omission of units. There were two problems with the choice of scale for the graph:

- since the minimum value of ($u + v$) was 60.0 cm, the ($u + v$) axis of the graph should have stared at this value rather than at 0.0 cm.
- many candidates seemed to have taken the range of their results and divided it by the available length of the axis to produce a scale. This led to scales that were based on 6, 7, 13, 17, etc. Such scales will lose both the scale and plotting marks. Candidates should use a scale that is easy to follow based on 2 or 5, e.g. 5 cm of ($u + v$) is equivalent to 1 cm on the grid.

(e) Candidates, who gave values for *f* often lost marks due to:

- the omission of the units of *f,*
- an answer to four or more significant figures. The majority of measurements in the experiment were made to either two or three significant figures so no more than this is justified in the answer.
- the use of a small triangle when determining the gradient of the graph. The triangle used to determine the gradient of the line should have a hypotenuse that is greater than half the length of the line.

PHYSICS

Paper 5054/41
Alternative to Practical

Key Messages

- Candidates should be reminded to include units when quoting the values of physical quantities. They should be encouraged to check that the unit they have provided is appropriate for the calculated or measured quantity.

- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule should be given to the nearest millimetre. If a measured length is, say, exactly 5 cm, the value should be quoted as 5.0 cm.

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

- Candidates should be advised to avoid using rote phrases, such as, 'to make it more accurate' or 'to avoid parallax error'. These comments need to be linked to the practical situation being considered, and candidates should state why the accuracy has improved or how parallax error was avoided.

- Candidates should be reminded that, when plotting a graph using data obtained from practical work, there will almost always be some scatter about the line of best fit. Forcing the line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.

General Comments

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

Comments on specific questions

Question 1

(a) (i) Correct responses were only given by the stronger candidates. Most candidates were unable to offer a sensible suggestion as to how the candidate could check that the metre rule was vertical. Set squares, plumb lines and spirit levels were rarely mentioned, and when they were, the candidate was usually unable to explain how he/she would use these pieces of apparatus.

(ii) Only about one half of candidates stated that the bottom of the ball should be used when measuring *h*, and of those who did, many did not go on as instructed to explain why they would use the bottom of the ball. The clue to the answer was in the diagram, namely that the release height was measured to the bottom of the ball.

(iii) (iv) Even with the allowance of an error carried forward from part **(ii)**, for candidates who thought that *h* should be measured to the top of the ball, poor drawing, often without the use of a ruler penalised many. The position of the candidate's eye, when measuring the height was usually drawn correctly.

(v) Candidates met with more success here with many being able to give two sensible reasons as to why it is difficult to measure the height accurately. Most candidates realised that it is difficult to keep track of the position of a moving ball and that the ball bounce height was variable and the ball was not very close to the ruler.

(b) (i) Most candidates completed the table and inserted the average bounce heights for the different release heights. Where marks were lost it was nearly always due to rounding errors, or ignoring the instruction to give the values to three significant figures.

(ii) The standard of graph plotting continues to improve. Most candidates had correct, labelled axes, and had used sensible scales which maximised the use of the given grid. Points were generally accurately plotted. Although the instruction given to candidates was to draw a straight line of best fit, some candidates attempted to draw a point to point series of straight lines through their plotted points, and occasionally, even a curve was drawn. There was less evidence this year of scales on the axes which were multiples of 3, 7 etc. The use of such scales, makes it difficult for the candidates to plot their points accurately, and difficult for the Examiner to check the accuracy of these plots.

(iii) This was well done by most candidates. Most were able to choose two points from their graphs and insert the coordinates of these points into the given equation to obtain two values for *e*. Most then made the correct deduction and stated that within the limits of experimental error the values were the same so that *e* was constant. It was disappointing to see candidates obtaining values for *e* which differed in the second decimal place by one-hundredth stating that *e* was not constant because the values were not exactly the same.

Question 2

(a) (i) About half of the candidature was able to describe what was meant by a non-linear scale. Most of the incorrect responses referred to the shape of the rain-gauge and the fact that its diameter was increasing.

(ii) Candidates found this part very difficult and only an extremely small number of them had any idea why the non-linear scale was useful in a rain-gauge. What was required here was that the rain-gauge, by having the non-linear scale would be able to measure small amounts of rainfall more accurately.

(b) (i) Most candidates were able to show the required water level in the rain-gauge correctly.

(ii) About half the candidates were able to supply a sensible reason as to why picking up the rain-gauge to read it could lead to error. All that was required here was that the water inside it may be tipped, might stick to the walls or that the water level might move. Most incorrect answers made some vague reference to parallax error, without qualification.

(c) (i) Only about half of the candidates gave the obvious answer that the rain-gauge needed to be transparent so that the water level inside it could be seen.

(ii) Most candidates realised that the rain-gauge had a spike so that it could be firmly held/held upright in the ground.

Question 3

Good well explained descriptions of the experiment were rare. Despite the structure given in the stem of the question, which it was hoped that candidates would use when planning their answers, most candidates did not take time to plan their answers, but proceeded to write down everything that they knew about refraction, without paying due attention to what they had been asked to do. Although asked to do so, many candidates did not state the equipment that they would use, and statements such as ‘measure the angles of incidence and refraction’ were common – candidates did not state what they would use to do this and subsequently lost a mark. There was much confusion between the angles of incidence and refraction, and on many diagrams, they were marked the wrong way around.

Of those candidates who scored the mark awarded for making the experiment accurate, most, invariably scored the mark by mentioning repeats. Other relevant practical points such as using a fine pencil, using pins that were far apart, viewing the bottoms of the pins, varying the angle of incidence, were rarely seen.

Occasionally reflection experiments were described – these were awarded no credit.

Question 4

(a) (i) A disappointingly large proportion of candidates drew the symbol for a variable resistor incorrectly. The most common errors were the omission of the arrow head, not drawing the arrow through the rectangle or using the obsolete zig-zag symbol. Some cells started and ended with a large or small stroke. Very few candidates used a ruler for the straight lines when drawing the circuit, and some demonstrated a failure to read the question correctly by adding extra components.

(ii) Most candidates were able to identify the equipment that would be needed to measure the three given quantities.

(iii) Candidates found this demanding part of the question difficult, and only the more able made any headway here. Most attempts at this question met with partial success, but very few candidates were able clearly and unambiguously able to explain why the 0 to 1 A meter would be the most suitable.

(iv) This was perhaps the most difficult question on the paper and only one or two of the most able candidates were able to explain how the current in the circuit could be kept constant. Candidates did not realise that as time went on, the cell would run down and its voltage decrease, so the rheostat resistance needed to be reduced to compensate for this and keep the current constant.

Most candidates contented themselves by stating that the rheostat should be adjusted, without stating in which direction.

(b) Many candidates struggled to suggest a sensible hazard of using a much larger current. The heating effect of an electric current did not appear to be well known.

PHYSICS

Paper 5054/42
Alternative to Practical

Key Messages

- Candidates should be reminded to include units when quoting the values of physical quantities. They should be encouraged to check that the unit they have provided is appropriate for the calculated or measured quantity.

- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule should be given to the nearest millimetre. If a measured length is, say, exactly 5 cm, the value should be quoted as 5.0 cm.

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

- Candidates should be advised to avoid using rote phrases, such as, 'to make it more accurate' or 'to avoid parallax error'. These comments need to be linked to the practical situation being considered, and candidates should state why the accuracy has improved or how parallax error was avoided.

- Candidates should be reminded that, when plotting a graph using data obtained from practical work, there will almost always be some scatter about the line of best fit. Forcing the line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.

General Comments

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

Comments on specific questions

Question 1

(a) (i) Most candidates were unable to mark and label the length of one stride correctly. A common error was to mark from the heel of the back foot to the toe of the front foot. The standard of drawing was poor because many candidates did not use a ruler to indicate the correct distance, but drew a freehand arrow whose length was invariably outside the tolerance allowed. Any straight line drawn from the back shoe to the same point on the front shoe was given credit.

(ii) Realistic estimations for the length of a stride were rarely seen. The question was commonly misread as 'measure the length you have drawn', rather than to estimate the actual stride length of a person. Examiners were looking for a sensible estimate within the range 40 cm – 90 cm. Actual estimates seen from candidates ranged from 1 cm to several metres – a very popular incorrect answer being 1.4 cm, which was the stride length they had measured on the diagram.

(iii) The calculation of the number of strides that the candidate would make in walking 100 m was well done. Even candidates who had made an incorrect estimate of the length of one stride were successful here, with the allowance of an error carried forward. There was some confusion between centimetres and metres, and consequently, candidates were often out in their calculation by a factor of 100.

(b) (i) Most candidates understood how a trundle wheel worked, or were able to work it out from the description given, but answered the question too generally. A large number of answers ended without the candidate stating that 100 m corresponded to 100 or 200 clicks.

(ii) The fact that the stride length could vary was correctly given by most candidates. Common incorrect responses to this part included reference to human reaction error, parallax error or forgetting how many clicks had been counted.

Question 2

(a) (i) Most candidates calculated the average correctly and gave their answer with a unit. The most common errors made by candidates were rounding the final answer incorrectly, omitting the unit and ignoring the requirement to quote their answer to two decimal places.

(ii) The most common correct responses were that the average time was not given to more than two decimal places because the original measurements had been to this precision, or that this was the precision of the stopwatch. A common misconception was that greater precision/accuracy was not needed, or that it would be more difficult to plot the graph.

(iii) There was much general talk here of reducing human errors. The essential point of having a longer time to measure was seen less often. A common misconception was to have an increased time for starting/stopping the watch or to have an increased time to record the reading. Only a small number of the more able candidates discussed the fact that it would minimise the <u>effect</u> of reaction error. Candidates were also given credit here for realising that it would allow the parachute to reach terminal velocity.

(iv) Most candidates calculated the area of the paper sheet correctly. Occasionally candidates forgot to give the units, or wrote cm instead of cm^2.

(v) Candidates found this part difficult and many found difficulty expressing themselves clearly, or merely repeated the question. The best answers showed good understanding of the fact that a square of side larger than 21 cm cannot be cut from a sheet of A4 paper. Common misconceptions were that an even bigger sheet would now take too long to fall or that 21 cm was the longest <u>length</u> of an A4 sheet.

(b) (i)(ii) Most candidates transferred values into the table correctly and completed the calculations. Occasionally numbers, whose provenance was difficult to determine, appeared in the table.

(iii) Most axes were correctly labelled with quantity and unit. Scales were generally chosen sensibly, so at least half of the grid provided was used. Occasionally scales were chosen that were too small or candidates ignored the figures printed on the graph paper. The candidates who had the biggest problem with scales, were those who had miscalculated the values in the table, some of whom found that they could not fill half the grid on the x-axis when they used the 100 starting point they had been given. Some of these candidates drew the scale increasing from right to left on the x-axis. Perhaps candidates should be reminded that if the scale does not work out sensibly, it is good practice to check their data again. The plotting of the points, although not easy, was well done. Many candidates lost the last mark, because they joined the first and last points instead of drawing the best fit line.

(iv) The most common incorrect answer here was that the time and the area were not directly proportional. Only the more able candidates realised that even without a parachute, a time of fall would still be recorded. Few candidates appreciated that it was possible to have zero area but not to have zero time.

Question 3

(a) A disappointingly large proportion of candidates drew the symbol for a variable resistor incorrectly. The most common errors were the omission of the arrow head, not drawing the arrow through the rectangle or using the obsolete zig-zag symbol. Some cells started and ended with a large or small stroke. Very few candidates used a ruler for the straight lines when drawing the circuit, and some demonstrated a failure to read the question correctly by adding extra components.

(b) Most candidates were successful here. Where the mark was lost, the CRO was connected across the variable resistor instead of the fixed resistor.

(c) Many answers appeared to consist of guesswork. There was much confusion between Y shift and Y gain. Quite often, more than one of the control knobs on the c.r.o. was listed.

(d) (i) A good proportion of candidates were successful in the calculation of the voltage. There was no apparent pattern to incorrect answers, but many were unable to interpret the given scale. Even when the answer was correct, a mark was needlessly lost by the omission of a unit with the numerical answer.

(ii) There were a range of responses here, with as many stating that the spot would go down, as were stating that the spot would go up. A surprising number of candidates correctly stated the spot would move, but did not say in which direction.

Question 4

(a) Nearly all candidates stated correctly that the additional apparatus needed to plot a cooling curve were a thermometer and a stopwatch. Examiners generally had to search for these two pieces of apparatus because candidates had written a long list consisting of many other irrelevant pieces of apparatus.

(b) The general standard of diagram drawing was poor. Although there were many neat, well labelled diagrams showing clearly the thermometer with its bulb in the water, and the eye level with the thread in the thermometer, there were many poor diagrams with very little evidence of a ruler having been used. Too many candidates did not show the position of the thread in the thermometer, did not have the bulb in the water, or in some cases, did not have water in the test tube at all. Some candidates wasted time by adding beakers of ice, drawings of stopwatches and clamp stands, which were unnecessary.

(c) Most candidates completed the table headings correctly. Common errors were writing the units for temperature and time incorrectly e.g. C° and secs. A minority of candidates wrote temperature change, instead of just temperature.

(d) This was usually well answered with candidates giving at least one suitable way to make the readings accurate. Some candidates interpreted the answer as how the apparatus would be used rather than arranged. Parallax error was often mentioned, but unless it was qualified with a statement of how parallax could be avoided, it was not credited. Common comments that did not score were to use more accurate equipment, to place the bulb in the water, to use a digital thermometer and to repeat and average.