PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

The multiple-choice paper can assess performance across the syllabus and so candidates are strongly advised to ensure familiarity with all the learning objectives. A thorough understanding is an essential requirement for a high-quality performance.

Comments on specific questions

Question 4

Although the correct option was chosen by more candidates than any of the others, all three incorrect options were chosen by a noticeable number of candidates. In particular, the shape of the distance–time graph when a car is accelerating was not always clear to candidates. Option **A** was often incorrectly selected.

Question 9

This question was a relatively standard question on moments although the beam was pivoted at one end rather than balanced at its centre. Most candidates calculated the correct answer and then selected the corresponding option. Of the incorrect options, only option **B** attracted many candidates. This arose from choosing a perpendicular distance of 20 cm for the 60 N force rather than the correct 50 cm. The distance 50 cm was not given in the question and it had to be calculated from the two distances that were supplied.

Question 11

A significant number of candidates chose option **D** here. Fewer selected the correct option **B**. The question concerned the useful work done on the stone and this is the force multiplied by the distance moved in the direction of the force. The weight acts vertically and so the appropriate distance is h rather than l. The total work done on the stone will be larger than the useful work and this would be calculated using the distance l. However, the question did not define the force exerted on the stone to move it along the ramp and so total work could not be calculated. Only a small number of candidates selected option **A** or **C**.

Question 28

Most candidates realised that the arrows on the field lines gave the direction of a force on a positive, stationary charge. Many candidates thought that the field was magnetic rather than electric. The shape of the field is not one that is created by moving charges or magnets.

Question 29

The correct answer was the most commonly chosen one and most candidates knew the main advantage of connecting cells in parallel. Although all the options seemed plausible, very few candidates chose option **B**. Option **C** was the second most popular choice but it is not consistent with the definition of electromotive force (e.m.f.).

Question 30

The numbers in this question were relatively straightforward and led directly to an answer of 10 000 W. Most stronger candidates answered this correctly. Weaker candidates tended to choose option **B**.

Question 31

All three of the statements given were correct and many candidates recognised this and selected the appropriate option. However, statement 3 required an understanding of potential differences across components in parallel and was less accessible to some candidates than the other two statements. Option **B** was commonly chosen.

Question 32

The correct option **D** was the most popular. It is the exact opposite of the movement described in the text and unsurprisingly, it leads to the reverse effect as required by the question. Both options **B** and **C** also seem to be the opposite of what the question describes but a more careful inspection reveals that they are not and although a minority of candidates chose them, stronger candidates answered this correctly.

Question 33

The two options consistent with calculating a voltage from the height of the trace displayed were widely chosen. The correct option was the most popular. The principal source of inaccuracy was to supply a value of 8.0 V. Candidates who gave this value had not realised that the central line represented the zero and that the alternating voltage that causes the trace is sometimes positive and sometimes negative. A few candidates selected option **D**, which was most likely a result of multiplying the total width of the trace on the *x*-axis by the Y-gain.

Question 38

This question needed to be read carefully as it asked for the mass of the tritium that decays in 36 years and **not** the mass that remains after that time. Many candidates selected option **A;** these candidates had deduced the mass that remains but had not continued to calculate the mass that had decayed. Stronger candidates answered this question well.

Question 39

The correct option was also the most frequently selected. The next most popular choices were **C** and **A**. The incorrect answer **C** arises as a result of dividing the two numbers in the question and ignoring both the factor of 2π and not converting from days to seconds. Option **A** was chosen by those who ignored the factor of 2p.

Question 40

This question was a matter of factual recall and many candidates were able to do this accurately. Other candidates should be clear about the difference between the words ‘fission’ and ‘fusion’ and where each process is likely to take place.

PHYSICS

Paper 5054/12
Multiple Choice

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

General comments

The multiple-choice paper can assess performance across the syllabus and so candidates are strongly advised to ensure familiarity with all the learning objectives. A thorough understanding is an essential requirement for a high-quality performance.

Comments on specific questions

Question 4

The correct option **A** was less popular than the incorrect option, **B**. The correct answer was obtained from the gradient of the graph. The incorrect option **B** was obtained from reading the distance from the graph at 10 s and dividing the distance by the time, giving the average speed for the journey between its start and 10 s. Very few candidates selected either of the other two options.

Question 5

The first two devices shown (W and X) rely on the use of springs to determine the weight of an object. In locations where the weight is different, the spring is affected differently, and the value obtained for the mass will not be the same. The other two devices work by comparing the weight (and hence the mass) of an object with the known weight and mass of a standard object. With these devices, both the weight of the object and the weight of the object that it is being compared with vary in the same way in different locations. These balances always supply the correct value for the mass.

Question 8

The third law of motion is often misunderstood and the most popular option chosen for this question illustrated a common confusion. The correct option was **C** but option **B** was more frequently selected. The confusion arises as a normal contact force is sometimes referred to as a *normal reaction* by non-physicists and the third law is expressed in terms of an *action* and a *reaction*. In each of these cases, the term *reaction* is used slightly differently. Candidates should be made aware that the pair of forces described as an *action* and r*eaction* in the context of Newton's third law should always be of the same type.

Question 15

In this question, candidates needed to recognise that after the pressure is doubled, the figures supplied are not inversely proportional and are therefore inconsistent with the equation $p_1V_1 = p_2V_2$. The final two volumes are smaller than inverse proportion would suggest and the only option consistent with this is option **B**, as both option **A** and option **D** would lead to a volume greater than that suggested by inverse proportion.

Question 20

The question provided the complements of the angle of incidence and the angle of refraction, rather than the angles themselves. Candidate who used the angles supplied calculated the correct answer as the number given by option **A**. The correct option, **C,** was chosen by many candidates. Few candidates chose either **B** or **D**.

Question 22

The correct answer here was **B** as this suggests the use of a gamma emitter with a significant half-life. The vast majority of candidates realised that an alpha emitter would not work at all as the metal would absorb the alpha-particles. Those who chose option **D** neglected to consider the practical problems that would be associated with a very short half-life.

Question 24

Only a permanent magnet can repel another permanent magnet as in magnetism, repulsive forces only exist between like poles. A magnetic material exhibiting induced magnetism will be attracted to a permanent magnet. Apart from the correct option, only option **A** was chosen by a significant number of candidates. Although this may have seemed plausible, it was incorrect because it concerned itself with attraction.

Question 28

The final incorrect option, **D,** was chosen by a sizeable number of candidates and it is possible that these candidates confused what is meant by series and parallel connections. The advantage of using cells in parallel is a fact that can be learnt and candidates who did this would have chosen the correct option very quickly. Those who had not learnt the correct reason might have deduced that the other options were incorrect and inconsistent with the behaviour of electric cells.

Question 30

Although the circuit appeared to be complicated, it should have soon become clear that it was not that difficult to understand. As the resistance of R increases, so does the resistance of the lower half of the circuit and therefore so does the voltage across it. Most candidates realised that as one voltmeter reading increases, the other decreases and only a small minority chose options **A** or **D**. The correct option **B** was the most frequently selected.

Question 33

The correct option **D** was the most commonly chosen but some candidates selected option **B**. Neither option **A** nor option **C** was especially popular.

Question 38

This question required the factual knowledge of the operation of a nuclear reactor and many candidates had learnt what the moderators in a reactor are for. The correct answer was the most commonly chosen one but option **C** was a commonly selected incorrect choice.

Question 40

This question assessed a part of the syllabus that essentially needs to be learnt as well as understood. The order of events as described in the syllabus, makes it clear that option **D** is correct. The most commonly selected answer was **B** in which the initial collapse and the reaching balance are reversed.

PHYSICS

Paper 5054/21
Theory 21

Key messages

Candidates are advised to read each question fully before starting their answer to make sure that their response is relevant and does not include answers to later questions.

The working for answers to calculation questions should ideally start with the relevant formula followed by the substitution of numerical values into the formula with the use of units to match the unit on the answer line and the conversion of prefixes, if necessary.

Answers should be given to at least the number of significant figures given in the data for the question, usually two significant figures.

If a question asks for an explanation, candidates should ensure that they have applied and used a relevant physical explanation

General comments

Content from the updated syllabus was assessed in this examination, in particular the conservation of momentum, pressure producing a force at right angles to a surface, temperatures measured in kelvin, diffraction and the solar system. Knowledge of the solar system was stronger than that of momentum or diffraction. Apart from this, candidates were generally well prepared for this examination.

Calculations were generally performed well. Most candidates were able to quote a relevant formula, either in words or symbols and substitute correctly into it.

Many candidates gave detailed explanations for questions, whilst others stated answers rather than explaining them and applying the physical principles.

Comments on specific questions

Question 1

(a) Almost all candidates recognised that the glider was accelerating for the first 6 s and then had a constant speed. A very few answers confused the graph with a graph of distance against time. Stronger candidates gave detailed descriptions, for example, stating that the acceleration was uniform.

(b) Almost all candidates used the formula $F = ma$ in their answer. A few successfully used the fact that force is equal to the change in momentum per unit time. There were some errors in reading from the graph to obtain the initial acceleration. Those candidates who used an incorrect value of acceleration with no explanation as to their method could not be given as much credit as other candidates who stated that acceleration is equal to change in speed divided by time and who explained each step.

(c) Although most candidates knew that distance is speed multiplied by time, far fewer candidates knew that the speed to be used is the average speed or that the area under the speed-time graph should be used.

(d) (i) Many candidates did not understand how a convection current acts on a glider in the air. A significant number of candidates misread 'convection' as 'conventional' and gave a description of a conventional electric current, whereas the answer required a description of the circulation of air caused by regions of different temperature, e.g. hot air rises and cold air falls.

(ii) This question was only answered well by stronger candidates who gave the primary cause as a high temperature spot on the Earth's surface perhaps caused by solar heating or above a town.

Question 2

(a) (i) A significant number of candidates could not define momentum or confused momentum with the moment of a force.

(ii) Those candidates who gave a correct definition of momentum were usually able to give the unit correctly as kg m / s or N s. A number of answers incorrectly suggested the unit as kg / m s^{-1}.

(b) Although there were many good attempts to apply the principle of conservation of momentum, it was common for the final mass of the combined body to be given as the mass of the van only, i.e. 3000 kg rather than 4100 kg.

(c) (i) The formula for kinetic energy was well known. A few candidates implemented the formula incorrectly, usually by failing to square the velocity.

(ii) This question asks for the transfer of energy that occurs in the collision. The simplest answer was that kinetic energy of the car becomes kinetic energy of the van and some thermal energy. Candidates gave many answers that described other situations, e.g. 'chemical energy to heat' or, more commonly, 'kinetic energy to potential energy'.

Question 3

(a) The formula relating current, voltage and resistance was well known. However, most answers assumed that the e.m.f. of 12 V was across the 400 Ω resistor rather than the total resistance of 700 Ω. Candidates needed to use the total resistance to find the current in the circuit.

(b) To calculate the power in the resistor, the formula $P = I^2R$ was the most suitable to use. Candidates who used $P = VI$ had first to determine V for the 400 Ω resistor and the greater number of stages in the calculation gave greater opportunity for error

(c) Only stronger candidates realised that all resistors should be in parallel with the power supply for the current to be a maximum in all of them, with the ammeter connected into the branch containing the 100 Ω resistor.

Question 4

(a) (i) The formula relating force, pressure and area was well known and well applied. Problems with dealing with the powers of ten were evident in only a few answers.

(ii) Most answers incorrectly stated that the force exerted by the pin on the board is much larger than the force that it exerts on the finger. Since the mass of the pin is very small these two forces are the same.

(iii) Even when the answer to **(ii)** was incorrect, it was very common to find good answers that explained that the pressure exerted by the pin on the board is larger because the surface area of the tip of the pin is smaller.

(b) (i) There were a number of possible answers to this question. Stronger candidates described the pressure in the water and that this provides a force at right angles to the surface. A number of candidates gave sensible suggestions such as "pressure acts in all directions".

(ii) Most answers correctly stated that pressure increases with depth.

Question 5

(a) Most answers correctly described either the increased distance between particles in a liquid or the weaker forces between particles in a liquid. Stronger candidates then developed the argument and explained, for example, that when the temperature increases, molecules were able to separate even further because of the extra spaces or because of the weaker forces.

(b) (i) The conversion of 100 °C to 373 K was known only by stronger candidates.

(ii) The majority of candidates successfully mentioned that bonds need to be broken or energy is needed to separate the particles in a liquid.

(c) Many candidates were able to apply the formula for specific heat capacity at the same time as the formula for power, energy and time in a two-stage calculation. Those candidates who set out their explanations logically, starting with the correct formulae were the most successful.

Question 6

(a) (i) Candidates were imprecise in the wording of their answers. The strongest answers suggested, for example, that the display should be between the lens and the principal focus. Other answers such as “before the focal length”, “behind the focal length” or “in front of the focus” were too ambiguous to be awarded credit. It was helpful when candidates used the term ‘principal focus’ and did not interpret the focal length as a point but as a distance.

(ii) A number of stronger candidates were successful in explaining that a virtual image is formed from divergent rays that do not meet on a screen, but only appears to do so when the rays are traced back.

(b) (i) Most candidates were able to score some credit by drawing a ray from the top of the object straight through the optical centre of the lens. A second ray was more challenging to draw but the most common second ray drawn was parallel to the principal axis, refracted as though it came from the top of the image.

(ii) Those candidates who had drawn the correct ray diagram were able to locate the principal focus on their diagram and measure the focal length. A significant number of candidates used the lens formula to calculate the focal length. This was rarely successful as the image distance in the usual convention had to be a negative number. There is no need to teach the lens formula in this redeveloped syllabus.

Question 7

(a) Candidates had some difficulty in expressing their answers here. The most commonly seen answers were that the crests on the right of the gap are too far apart, further apart than on the left or that the wavelength has appeared, incorrectly, to have increased. That the straight portion of the two crests furthest from the gap are too long and that the curved portion should start at the same level as the top and bottom of the gap was less commonly seen.

(b) Completely accurate drawings were rare. Three crests on the right of the gap, approximately the same distance apart as on the left of the gap, were often drawn with some bending but the shapes of the crests were not always semicircular with their centre at the centre of the gap.

(c) (i) The definition of wavelength was well known and stronger candidates were able to define this as the distance between successive crests or between one point on a wave and the next identical point further along the wave.

(ii) There were many correct answers for the frequency. The formula was well known.

(iii) In calculating the wavelength in the shallow region, candidates had to realise that the formula needed to be applied with the same frequency.

Question 8

(a) (i) The definition of efficiency as 'useful output energy divided by total input energy' was known by many candidates. There was sometimes confusion when efficiency was defined as 'total energy output divided by total energy input' and many variations were seen such as "useful energy output divided by useful energy input".

(ii) Many answers suggested that the efficiency of the lamp was low because it did not give much light output relative to the input energy, but the strongest answers gave the reason as the thermal energy produced and wasted in the filament lamp.

(b) The calculation required candidates to recognise that the power output of the two lamps is the same, 120 × 0.062 or 7.4 W. Many candidates were able to think through what was happening and gave the correct answer.

(c) (i) The question asked what happens after the live wire touches an earthed metal surface. Weaker answers gave an account of what does not happen, i.e. that there is no electrocution, whereas more relevant answers recognised that the fuse blows as a high current passes to the ground so that the current stops and the lamp goes out.

(ii) Most answers correctly suggested that the person is not protected as a current can flow through them to the ground and cause electrocution. Some candidates incorrectly suggested that the fuse does not blow, whereas the fuse does blow and cuts off the connection to the earth so that current does not flow to earth and current can flow through the person or that the metal surface is live.

Question 9

(a) The cutting of magnetic field, or the change in magnetic flux within the coil, was generally given as the answer.

(b) Most answers showed that when the coil is horizontal with AB on the right, a negative value of the voltage is produced. Some answers only showed that the voltage is zero with the coil vertical in one of the positions, rather than in both.

(c) (i) Although some diagrams for the connections to the coil in a d.c. motor showed a single split ring, many diagrams were difficult to interpret and seemed to show two rings. Even where one split ring was clear, the connections to the coil were often outside rather than inside the ring.

(ii) The idea that the current in a magnetic field causes the force on the side of the coil was the most common answer. A few answers correctly suggested that the coil itself generates a magnetic field which interacts with the magnetic field of the magnet.

Question 10

(a) Radioactive decay was usually described as involving the emission of a radioactive particle, an alpha particle, a beta particle or gamma radiation. Fewer candidates explained that this emission is from the nucleus.

(b) The general shape of the decay curve with time was well known but many candidates could have improved their answers by taking the time to plot the points accurately before drawing the curve. The simplest method was to halve the value every 6000 years. A number of candidates took the half life to be 4000 rather than 6000 years, perhaps because the horizontal axis of the graph was marked every 4000 years. A common error was to halve the count rate in 6000 years and to then mistake the time needed in a subsequent halving, for example from 400 to 200 counts/min taking 12000 years.

(c) The Geiger-Muller tube was well known as the apparatus used to measure radiation from the sample of wood. Other apparatus was possible, for example a cloud chamber or a spark counter, but they were rarely seen. In describing how the G-M tube is used, many candidates earned credit by describing how to correct for the background count but other sensible answers correctly described how the number of counts in one minute can be measured, even by listening to the number of clicks obtained in that time. Weaker candidates gave explanations of what is happening inside the tube, which was not required by the question.

(d) The explanation of how the age of a sample is found consisted of several stages, obtaining the count from a fresh equivalent sample of wood, comparing it with the count from the actual sample and then explaining how the half life is multiplied by the number of times one has to halve the count from the initial sample to match the actual sample. The latter stage was effectively answered by many candidates, but not the overall process.

Question 11

(a) The order of the planets in the solar system was well known with only a few candidates confusing Jupiter and Uranus or introducing Pluto (which is now classified as a dwarf planet).

(b) Many candidates recognised that the orbital speed is calculated using distance/time with the distance as the circumference of the orbit. However, many candidates took the distance as the distance of the planet from the Sun rather than the circumference.

(c) The relationship between the distance and the orbital period can be simply expressed by stating that as the distance increases so does the orbital period. A number of candidates incorrectly suggested that these two quantities are proportional. If that were the case, then doubling the distance would double the period; comparing, for example, Venus and Earth or Saturn and Uranus, this is not the case.

(d) A description of the simple relationship that increasing the distance (or moving further from the Sun) decreases the average surface temperature was very often seen. Venus as the exception was also commonly given, but candidates neglected to say how or why Venus is the exception (by stating that Venus is hotter than Mercury or that Venus is hotter because of the greenhouse effect).

PHYSICS

Paper 5054/22
Theory

Key messages

Candidates are advised to read each question fully before starting their answer to make sure that their response is relevant and does not include answers to later questions.

The working for answers to calculation questions should ideally start with the relevant formula followed by the substitution of numerical values into the formula with the use of units to match the unit on the answer line and the conversion of prefixes, if necessary.

Answers should be given to at least the number of significant figures given in the data for the question, usually two significant figures.

If a question asks for an explanation, candidates should ensure that they have applied and used a relevant physical explanation.

General comments

Content from the updated syllabus was assessed in this examination, in particular momentum, temperature measured in kelvin, diffraction and some aspects of Stars and the Universe.

Some candidates appeared to be unfamiliar with the new topics. For example, some candidates answered **Question 10**, the question on astronomy, really well to the extent of knowing detail in the syllabus such as the diameter of the Milky Way. Other candidates performed less well on this question than on other questions in the paper.

Comments on specific questions

Question 1

(a) This question was answered well with most candidates expressing themselves clearly and giving relevant detail, e.g. that speed is constant for the first 10 s. Candidates used the term ‘deceleration’ correctly to mean a decrease in speed in their accounts, with the strongest candidates recognising that the deceleration is non-uniform. Weaker answers suggested that the car is at rest at the beginning or gave vague statements such as “the car is in constant motion”. Candidates should take care when reading values from a graph as the initial speed was not always given correctly.

(b) (i) This was also answered well, with the majority of candidates correctly suggesting that friction and air resistance are the two forces involved. Other forces were sometime suggested, for example weight or the upwards force on the car but these are not involved directly in causing the deceleration.

(ii) Most candidates recognised that the graph is a curve because the deceleration is not uniform. Stronger candidates explained why the deceleration varies by describing the decrease in air resistance as the car slows down.

(c) (i) This is a new topic and many candidates knew the formula for momentum. A number of candidates confused change in momentum with force. Many candidates gave the correct unit with only a few suggesting that the unit of momentum is kg / m / s or kg m / s^2.

(ii) This part question was completed more successfully than **(c)(i).** The answer could be calculated using the formula $F = ma$. Alternatively, the answer could be calculated by the change in momentum from **(c)(ii)** by the time and a few candidates chose this route.

Question 2

(a) (i) The name of the energy store in the battery, chemical energy, was well known.

(ii) The energy stores were given in the question which asked for a description of the transfer between the stores in terms of the work done. In this case, energy was stored as chemical energy at the start and became kinetic energy of the scooter. In general, energy is transferred by forces (mechanical work done), electrical currents (electrical work done), heating, and by electromagnetic, sound and other waves. In this case, electrical work is done on charged particles to move them through the wires to form an electrical current and then mechanical work is done when the motor accelerates the scooter or keeps it moving at a constant speed.

Many answers stated that electrical energy was involved, and this was accepted as a form of electrical work done but ideally answers would have invoked the work done or the force on the electrons which are made to move. Fewer answers related how the electrical current enabled work to be done to increase the kinetic energy of the motor or the scooter.

(b) The formula for kinetic energy was widely known. Only a few candidates did not use the formula correctly, sometimes not squaring the value of the speed.

(c) (i) The definition of a kilowatt-hour was a challenge for most candidates. Many candidates did not realise that this quantity is a unit of energy. Simply, it is the energy transferred in 1 hour if the power supplied is 1 kW.

(ii) Although the correct answer was commonly seen, there was confusion in changing 70 W to 0.70 kW or 0.35 kW h to 350 W h. Those candidates who started with the correct equation $P = E / t$ were very often successful by then placing numerical values into the equation, ensuring the same units on both sides.

Question 3

(a) (i) Only stronger candidates answered this correctly. There were some vague answers, e.g. that there is more surface area when the tube is horizontal. Only a few candidates realised that when the tube is vertical, the weight of the mercury pushes down on the air, increasing its pressure. Many candidates gave a kinetic theory explanation in terms of the particles involved, effectively answering **(ii)**, rather than indicating what has caused the pressure to increase.

(ii) Stronger answers clearly stated that the particles collide with the wall less frequently and so less force is exerted on the walls. Many answers stated that the particles have more space and are free to move around, which does not explain why pressure decreases if volume increases. Some candidates mentioned fewer collisions between particles.

(b) Many candidates started with the correct equation, pressure = density × *g* × height. The value of the gravitational field strength *g* was not specified in this question as it is provided on the front page of the question paper. Some candidates took *g* as the atmospheric pressure rather than calculating the pressure due to the mercury and adding atmospheric pressure at the end. A significant number of candidates did not add on atmospheric pressure at the end of their calculation or subtracted the pressure due to the mercury column instead of adding it.

(c) Most candidates produced a curve with a downward slope from left to right, but the drawing of the shape was not well done, ranging from a complete straight line, to a curve which started or finished as a straight line, sometimes even becoming horizontal. Those candidates who plotted the points at P_0 and $\frac{1}{2}P_0$, as suggested by the question, were often the most successful, as these points clearly indicated the curvature of the graph.

Question 4

(a) (i) Many candidates had little or no idea of the lowest possible temperature or how to convert between K and °C. In some answers −273 and 0 were the wrong way round or the minus sign was not given.

(ii) Many candidates correctly recognised that the particles gain kinetic energy or move faster. Most candidates also recognised that the particles in a solid are vibrating but the effect of this extra energy on the vibration was not always convincing, with statements that there is “more vibration” rather than that the vibration had larger amplitude, frequency or is more vigorous in some way as the temperature increases. Many answers stated that extra energy started the particles moving or started them vibrating whereas they were vibrating before any extra energy is given to them.

(iii) Only stronger candidates answered this correctly. All combinations of the possible answers were seen. Some candidates did not appear to understand the difference between an increase in internal energy and an increase in temperature or that the temperature of a solid does not change as it melts.

(b) (i) Most candidates knew the equation and many gained full credit.

(ii) Stronger candidates were able to answer this well. The best approach was to write down the equation and to think carefully about the numerical values to substitute into the equation. Errors were made by some candidates in rearranging the equation or in choosing data from the question to substitute into the formula.

Question 5

(a) Many candidates correctly chose X-rays as an example of transverse waves. Fewer knew that seismic S-waves (but not P-waves) are also transverse.

(b) (i) The formula relating frequency, wavelength and speed was well known. Even where the frequency was incorrectly calculated, partial credit was given where the calculation clearly showed that the correct method was used.

(ii) It was unusual to find an example where the crests in the shadow region past the block were semicircular or where the crests in the unobstructed region were straight and that the wavelength shown was unchanging. In drawing diffraction, candidates should ensure that the wavelength shown in their drawing does not change. A number of answers appeared to show crests in the region covered by the glass block, even though the question said that the block has a greater height than the water.

(iii) Many candidates correctly suggested that the wooden bar should be moved up and down more frequently but some answers were not clear. For example, when the given answer stated that the bar should be “moved more”, it was not clear whether the bar was moved more frequently or with a greater amplitude.

(iv) The candidates needed to state that the amount of diffraction would decrease if the wavelength decreased. Very few candidates did this.

Question 6

(a) (i) Slightly more candidates recognised that the voltmeter reading was 9 V than those who recognised that the reading on both ammeters was 0.25 A.

(ii) The formula relating resistance, voltage and current was well known and applied. A few candidates used the wrong current or voltage.

(iii) Many candidates stated that current is proportional to voltage or potential difference but fewer suggested that this is only true if the temperature is constant. Other answers also mentioned resistance and suggested that resistance is inversely proportional to current. Resistance, as such, is not mentioned in Ohm’s law.

(b) This question proved more of a challenge to candidates. Many candidates did not realise that the question involved a new situation with a new e.m.f. and that only the value of the resistance of R calculated in **(a)** should be used in this section. The most straightforward method was to calculate the voltage across R as 12.6 V and then add this to the voltage across the lamp. However, many candidates were equally successful by calculating the new resistance of the lamp and then the total resistance of the circuit as 53 Ω before finding the e.m.f. of the second battery.

Question 7

(a) (i) X-rays and gamma radiation were well known as the components of the electromagnetic spectrum required.

(ii) Useful applications of ultraviolet radiation included detecting forged banknotes and sterilisation. The use of sunbeds or tanning the skin were very popular answers.

(iii) Some answers to this question were rather vague, with answers such as ‘damage to the lens’, without stating the type of damage but rather stating the place where damage occurred.

Other answers seen, such as ‘Mutation of the cells in the eye’ or ‘formation of cancer’ or mention of the formation of cataracts in the lens of the eye or the death of cells in the retina were awarded credit as they mentioned the type of damage.

(b) (i) The critical angle was stated correctly by the majority of candidates.

(ii) The formula for refractive index was well known as 1 / sin c or sin i / sin r. The value of refractive index was expected to be greater than 1 but a number of candidates calculated sin 40 / sin 90.

Question 8

(a) Iron or soft iron were the most common answers with a number of candidates suggesting copper or just metal.

(b) Candidates showed a good knowledge of how an alternating voltage is produced and the workings of a transformer and usually included the idea that the magnetic field cuts the secondary coil. More complete answers also mentioned that the current or applied voltage to the primary needed to be alternating and the magnetic field is also alternating or changing in some way. Weaker candidates tended to concentrate on the fact that the transformer is a step-down transformer or incorrectly stated that current passes from the primary to the secondary coil through the core.

(c) This question was answered well. Most answers started with the correct formula. Where the answer was incorrect, the formula or the calculation was incorrect.

(d) The usual answer was to suggest that there is an increase in the number of turns in the secondary coil so that there are more turns on the secondary coil than on the primary coil. A significant number of candidates only stated that the number of turns in the secondary coil should be increased without any reference to the number of turns in the primary coil. A few candidates sensibly suggested reversing the input and output connections.

Question 9

(a) (i) Usually alpha radiation or the symbol for alpha was given as the answer, but gamma and beta were sometimes incorrectly mentioned.

(ii) Beta radiation was usually given as the answer, but alpha was sometimes mentioned.

(b) (i) Many candidates just stated that beta radiation must be stopped by the metal or that gamma radiation passes through the metal but did not comment on the significance of the actual readings. Most credit was awarded for describing that gamma radiation passes though the metal or for saying that beta radiation is absorbed. However, stronger answers made it clear that the fall from 800 to 200 was proof that beta radiation is present and that a count of 200 was proof that gamma radiation was present. Many candidates spent too much time at the start of the question describing why the radiation could not be alpha, which was not asked in the question.

(ii) There were a number of vague answers that alpha particles do not travel far in air or are stopped by paper. There were good answers that noticed the distance between the source and the GM tube and made it clear that this is larger than the range of alpha particles in air.

(c) This question was usually answered well with the mention of handling with tongs or transporting the source in a lead box. Weaker answers gave general laboratory protections such as using gloves, goggles or laboratory coats. Some candidates suggested storage using only a box rather than a lead or thick metal box.

Question 10

(a) (i) Answers such as “the time it takes light to travel” were common as many candidates did not recognise that a light-year is actually a distance, the distance travelled by light in one year. Few answers stated what a light year is clearly.

(ii) The syllabus mentions that the diameter of the Milky Way is approximately 100 000 light-years but this figure was known by only a few candidates.

(b) (i) This question was either answered very well with supernova in the first box and neutron star and nebula in the second box or the choices from the list appeared to be random. Nebula and white dwarf were popular incorrect choices for the second box.

(ii) The choice of supernova as the stage where heavy elements are formed was the obvious choice. However, red giant and protostar were popular choices. With the first of these answers, the heaviest elements are unlikely to be formed and with the second answer fusion has yet to take place.

(c) This question was answered well with most candidates showing some understanding. Most answers correctly mentioned red shift as proof that galaxies and stars are moving away from the Earth. The strongest answers stated that the further a galaxy is from the Earth, the larger the redshift is and so the further a galaxy, the larger its velocity away from Earth is. This then indicates that the universe is expanding and has started from a small, dense state.

A few candidates mentioned the cosmic wave background radiation which is observed to be constant from every direction. This is left over radiation, red-shifted to microwave wavelengths and formed at the start of the Big Bang. Being nearly equal in all directions suggests the universe was initially small and has since expanded.

Weaker candidates did not appear to have studied the Big Bang Theory and gave answers about planets moving, collisions in space or the formation of Earth, Moon and asteroids.

PHYSICS

Paper 5054/31
Practical Test 31

There were too few candidates for a meaningful report to be produced.

PHYSICS

Paper 5054/32
Practical Test

Key messages

Some centres provided equipment that did not conform to the specifications described in the Confidential Instructions and centres are reminded of the importance of ensuring all equipment is suitable.

It is important that Supervisors send in a complete set of results for the three practical questions.

Measurements and final answers should be rounded to an appropriate number of significant figures, usually two or three for final answers, with readings from analogue instruments such as ammeters and voltmeters recorded to the precision of the instrument being used.

The correct symbol for units of quantities should always be written beside a numerical answer.

Candidates are advised to check all their calculations and discard or retake any measurements that appear to be unrealistically large or small.

For the planning question, candidates should ensure the experiment they describe actually refers to the exact investigation featured in the question and then focus on giving details, answering the questions that are listed in the bullet points.

General comments

Stronger candidates demonstrated that they were able to read and understand the questions and perform the required tasks by following the instructions well, making accurate, careful observations and measurements and recording them accurately.

Measurements should be repeated whenever possible, and their average taken. When measurements are repeated it is clearer if one of the readings is incorrect giving the candidate the opportunity to repeat the suspect reading.

It is preferred that raw readings are recorded to consistent numbers of decimal places and calculated quantities are recorded to consistent numbers of significant figures in a table of results. Stronger candidates were able to construct tables of results with appropriate headings, with the name of the quantity and the unit, for each column.

In many cases, the plotting of graphs required improvement.

A number of otherwise good responses to questions involving the plotting of graph used impractical non-integral scales based on the difference between the first and last values in the results table and impossible to plot without using a calculator. Candidates who used non-integral or other difficult scales were far more likely to make errors in plotting and interpreting their graphs.

It is far better to choose a scale which produces a graph that may be a little smaller but still is large enough (occupies over half the grid in the x and y directions) and is based on a scale of 2, 5, or 10 units corresponding to 10 small grid lines. These scales are much easier to use. Scales based on 3, 6, 7 and non-integers should be avoided.

The plotted points on graphs should be marked with small and visible crosses and placed accurately. The Cartesian axis system should be used, with increasing positive values from left to right along the x-axis and upwards along the y-axis.

A best fit straight line or curve should be a carefully drawn thin line, suitably placed with equal numbers of points either side of the. A line drawn from the first plot to the last plot is rarely a suitable best-fit line.

Comments on specific questions

Question 1

(a)(i) The height of a disposable cup, its maximum and minimum diameters were measured and for the initial credit to be awarded they should have been recorded to the nearest millimetre (0.1 cm). The values of the dimensions recorded should have been the same or close to the Supervisor values and the magnitudes of the values for each dimension should compare so that $h > D > d$. The majority of candidates gained full credit. A few candidates recorded their results to an unrealistic level of precision or to only one significant figure.

(ii) The average diameter of the cup was calculated and rounded correctly using *D* and *d*. A few responses were not awarded credit because calculations used *h* instead of one of the diameters.

(iii) The most common reasons for not awarding credit here were because candidates had omitted to calculate the square of the average diameter or missed dividing by four in their calculation.

(b)(i) Common errors were to use the string to measure either the diameter of the cup, then use πd to calculate the circumference, which is a less accurate process, or to wrap the string around the cup from top to bottom.

(ii) The formula provided was used to calculate the volume. This value and the value calculated in **(a)** should have been in close agreement if practical work was done carefully.

(c) A measuring cylinder was used to determine the volume of the cup. Some candidates had difficulty with this question because the total volume of the cup was larger than the volume of the measuring cylinder. When faced with this situation, stronger candidates who were familiar with using measuring cylinders overcame the problem by recording values and refilling the measuring cylinder and showed this in the working. It was important that the water level did not rest within the upper or lower portions of the measuring cylinder where there are no graduations.

(d) In method 2, the main causes of inaccuracy were due to factors involving the string. For many of the cups used the thickness was probably less important if they were made from thin card or thin plastic, but if they were made from a material such as expanded polystyrene it could have been a significant factor. Credit was not awarded for references to parallax error, a measuring cylinder or water.

For method 3, the causes of inaccuracy were due to the filling of the cup, the transfer of the water or reading the scale of the measuring cylinder. When filling the cup, it was difficult to decide when the cup was actually completely full because there was no graduation on the cup. The cup could look full and yet have a some more water added before water overflowed from it. When pouring water from the measuring cylinder, water may have splashed out onto the bench, been stuck onto the sides or rim of the measuring cylinder or cup. When taking readings of the water level, there may have been a parallax error due to readings not being taken at right-angles to the scale, or an error because the reading was not taken from the bottom of the meniscus.

Question 2

(a)(i) The potential difference V_1 across the combination of resistors should have been less than 3.0 V and measured and recorded to at least one decimal place. The current should have been less than 1.00 A and measured and recorded to at least two decimal places. Many responses were awarded credit. Some candidates recorded very low current values, suggesting they had either used the wrong scale on the meter, misread the scale or had very poor electrical connections somewhere in the circuit.

(ii) The formula should have been used to calculate the resistance. Then the answer should have been rounded correctly to at least 2 significant figures. Most responses were correct and were awarded credit.

(ii) Stronger candidates suggested that the switch was opened in order to allow the resistors (or the circuit, but not just the switch) to cool down or to ensure that they would not overheat. An alternative accepted response was to state that energy or power would be saved or the running down or depletion of the cells would be prevented.

(b)(i) The second set of readings should have been written down for the new arrangement of the resistors and the second current should have been larger than that for the first circuit.

(ii) The new resistance, R_2, should have been calculated and then multiplied by two to obtain $2R_2$. The majority of responses were awarded credit.

(c) Only stronger candidates answered this correctly. Candidates may have had results where it was obvious that the values were sufficiently close or were too different, but unless they were exactly equal (which was very unlikely) there should have been a calculation (as instructed), demonstrating whether or not the results lay within the percentage error margin of 10 per cent. Candidates then needed to give a statement comparing the values and whether they could be regarded as being identical.

A valid calculation could have been presented in different ways. Many of the strongest candidates calculated the difference between R_1 and $2R_2$ (larger R – smaller R), divided this by the larger R value and then expressed the answer as a percentage. The answer was then compared with 10 per cent (one tenth) of the larger resistance and a decision made on whether the two resistors could be considered to be identical. Other good responses calculated 110 per cent and 90 per cent (+/–10 per cent) of the larger resistance value (either R_1 or $2R_2$) and then listed the four values of resistance in order of size in order to make their judgement and statement. Similar calculations using 10 per cent of the smaller value were also accepted. Some weaker responses showed that candidates had misunderstood the question and compared the wrong quantities, for example, R_1 with R_2 or R_2 with $2R_2$.

(d) Credit was awarded if the readings of voltage and current were present and the resistance R_3 had been calculated.

(e) Credit was awarded if the readings of voltage and current were present and the resistance R_4 had been calculated, with working shown, was less than the value for R_3 and was not zero.

(f) Strong responses described the observation of the lamps glowing brighter (or being hotter) in the circuit where all the lamps were in parallel (when R_4 was calculated). Explanations were not required. There were very few good responses.

Question 3

(a) The object used in this experiment should have been an equilateral triangle with side length 3.0 cm and its height, *H*, should only have been 2.6 +/– 0.3 cm. Values larger than 2.9 cm could not be awarded credit as they indicated either poor skills in measuring the height or not taking the correct measurement.

(b)(i) In stronger responses, the height of the image was measured, recorded and was in the correct range, based on the focal length specified for the test. The unit for *h* was not provided, so candidates should have written it in (because it would have helped them to prepare answers for other parts of the question) but credit was awarded if it was not present.

(ii) The value of $1 / h$ (h^{-1}) should have been calculated, rounded and written to 2 significant figures only (again, writing down the unit would have helped to prepare answers for other parts of the question, but credit was awarded if the unit was not present).

(c) Those candidates who had written in the units for quantities in the earlier parts found it easier to complete the headers of the table and gain the initial credit. In order for this to be awarded, the table should have been completed with the quantities and correct units. The equivalent units in millimetres were also accepted, provided the numbers in the table were also in millimetres. Further credit was awarded for a good set of results showing the correct trend of *h* decreasing as *u* increased and full credit was awarded if there was consistency in recording the results, with *h* written to 1 decimal place and all $1 / h$ values to two significant figures.

(d) Many candidates found this question challenging with data which led to plots occupying only a small portion of the grid even when the most suitable scale was used. In addition, many candidates made errors in the scale. Stronger candidates produced a neat graph with axes used for the specified quantities ($1 / h$ on the *y*-axis and *u* on the *x*-axis), with clear plotting and a single best-fit straight line drawn using a ruler.

(e)(i) Stronger responses showed two indications of points on the best-fit straight line and these two marks well separated along the line. Weaker candidates used the plotted values in the table. Credit was awarded for performing the tasks correctly rather than for the actual value for the gradient.

(ii) Stronger candidates carried out the experiment carefully and obtained a focal length within tolerance of the true focal length of the lens. Weaker candidates often gave a final focal length that was unrealistic. Conventional convex lenses used in a school laboratory are extremely unlikely to have a focal length shorter than 5 cm or longer than 50 cm, so answers outside this range should have indicated to candidates that there was a need to check through the work they had done.

(f) Stronger responses described how the screen could be modified and how the measurement would be made, for example by putting a scale on the screen, using graph paper, marking the top and bottom of the image and then taking the measurement. Using a translucent screen so that the measurements could be made from the reverse side of the screen was also a good response. The screen could also have been marked using a pencil to mark points at the top and the bottom of the image and the vertical distance between them measured once the lamp had been removed. Weaker responses often described only the modification of the screen or stated that a larger ruler should be used.

Question 4

There were some very good attempts at this new style of question. Most candidates understood the brief and described a suitable method.

Credit for describing the experimental set-up was awarded for a well-labelled diagram. Further credit was awarded for candidates stating that the time for the ice cubes to melt must be measured with a stopwatch. A sizeable majority did not follow the brief and described a cooling-time experiment, often with the melting time of the ice being incidental. Full credit for method was awarded much less often. Many candidates stopped after performing the experiment with no insulation on the beaker and then with one sheet of insulation. It was expected that candidates would repeat the experiment with at least four different thicknesses of insulation if any meaningful conclusion was to be drawn or if a graph was to be plotted.

Identifying a key variable to keep constant presented no difficulty to the majority of candidates. Candidates who chose the temperature of the hot water as their key variable, often omitted to say that it was the initial temperature of the hot water.

Drawing a table of results presented problems for many candidates. All that was required was a table containing two columns with headings ‘thickness (of insulation)’ and ‘time’ with appropriate units. Candidates should be reminded that the unit for the second is ‘s’ and that sec(s) was not accepted. Many tables had extra columns headed with irrelevant information such as the initial temperature of the water. Any extra columns were ignored.

Many candidates seemed unaware of the meaning of the term ‘conclusion’ and instead made predictions based upon their knowledge e.g., the thicker the insulation, the quicker the ice cubes will melt.

Stronger candidates plotted a graph of thickness (of insulation) or number of sheets (of insulation) against time (taken to melt) and described the trend indicated by the graph. An equally acceptable method of drawing a conclusion was to compare the results to see if or how changing the thickness of the insulation had any effect on the time taken to melt the ice cubes.

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 should pay 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 set 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 would benefit from practice in making suggestions on where improvements could be made to practical methods.
- 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.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.
- Candidates should be advised to read the questions through very carefully to ensure that they are answering the question as written, and not simply recalling the answer to a different question.

General comments

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

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

- choosing the most effective way to use the equipment provided.

Candidates need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability, and control of variables.

There were some strong responses to questions but some candidates approached this paper as they would a theory paper, and not from a practical perspective. Most candidates attempted all the questions and there was no evidence of candidates suffering from lack of time. Stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately. However, some candidates were unable to round their numerical answers correctly or to give an answer to a sensible number of significant figures. The standard of graph drawing was poor in a small number of cases.

Comments on specific questions

Question 1

(a) Most candidates had no difficulty in reading the thermometer correctly as 18 °C but a few weaker candidates read it as 10.8 °C.

(b)(i) Here candidates needed to read another thermometer and then calculate the temperature difference. Although most candidates had no difficulty with this, there were a significant number of incorrect answers.

(ii) Candidates were asked how they would ensure their readings were as accurate as possible. This should be standard practice in the laboratory. However, many candidates were unable to give two good responses.

(iii) Many candidates understood that the beaker needed to be resistant to heat.

(iv) Those candidates who had read the thermometers correctly had no difficulty in using the equation to get the correct answer. Some candidates who struggled to read the thermometers correctly also sometimes could not use the equation correctly.

(c)(i) Candidates were asked to describe possible sources of error in the method used. This was intended to test practical methods and was not well answered overall. Taking a reading incorrectly is not an error in the method used.

(ii) Many candidates were then unable to suggest two improvements either.

Question 2

(a) Most candidates gained at least partial credit here. However, a number did not know all the correct electrical symbols, particularly the symbol for a thermistor. There were some well-drawn circuits and candidates usually knew to put the voltmeter in parallel with the thermistor.

(b) This question was very well answered.

(c) Most candidates answered this correctly.

(d)(i) Again, this was answered well but some candidates gave an incorrect unit.

(ii) Very few candidates were able to compute a correct answer here.

(iii) Candidates were given a value of 0.80 V to compare with their answer from **(i)**. This was clearly a very different answer, and these two values could not be said to be the same within the limits of experimental accuracy (usually taken as 10 per cent). Many candidates gave a general answer with no calculation to support it.

Question 3

(a)(i) Candidates were told that the metre rule was placed with one end on the floor and the other end near to the mass hanger. Most candidates took a reading from the mass hangers and stated that the mass hanger was 1.0 cm from the ground or 7.0 cm (by calculating the 8.0 – 1.0 cm seen on the diagram). The fact that this was an unlikely answer was not recognised. The correct answer of 99(.0) cm was rarely seen.

(ii) Candidates were expected to provide a practical problem with the method and an improvement consistent with this stated error but many answers were theoretical.

(b)(i) Finding the average of three times given on the stopwatches was done well but many candidates then gave their answer to one significant figure. Three significant figures were given in the raw values so at least two significant figures were expected in the answer.

(ii) This was answered well with most candidates scoring at least partial credit. Some candidates gave the average time again to one significant figure even though all the other values in the table were given to two significant figures. Some omitted to give the units in the headings.

(b) The graphs were generally done well. This was a best-fit curve and some candidates seem to think that their curve must go through every point, which produced a wobbly curve.

(c) Most candidates could give a correct trend for the graph and this was well answered.

Question 4

Writing a plan for an investigation is a relatively new skill and only stronger candidates scored full credit here. While most candidates scored partial credit, a few left the question blank.

Repeating the question and redrawing the apparatus did not gain credit but many candidates did this. The diagram explained the experiment so candidates were expected to just state that the voltage would be varied, and readings taken from the balance.

Candidates were expected to do carry out the experiment at least five times to get suitable range of results. They could have gained credit by suggesting taking results at 2 V, 4 V, 6 V, 8 V, 10 V etc.

Candidates needed to state the variables which would be kept constant. The most important one was the distance between the propeller and the balance, but they could then give a range of possible answers for further credit here.

The results table needed to show two columns – one for the voltage and one for the reading on the balance. For the reading on the balance, Mass or Force was accepted. However, units were expected as well and many candidates failed to put these in their column headings.

Finally, some conclusion was required, but as candidates had not carried out the experiment, the outcome of the experiment was not expected. Stronger candidates indicated that they would look to compare the results in the table or possibly to draw a suitable graph of their data stating which variable goes on each axis. Weaker responses such as “plot a graph of the data” were not sufficient.

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 should pay 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 set 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 would benefit from practice in making suggestions on where improvements could be made to practical methods.
- 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.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.
- Candidates should be advised to read the questions through very carefully to ensure that they are answering the question as written, and not simply recalling the answer to a different question.

General comments

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

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- manipulating data to obtain results
- drawing conclusions
- understanding the concept of results being equal to within the limits of experimental accuracy
- dealing with possible sources of inaccuracy
- control of variables
- choosing the most effective way to use the equipment provided.

Candidates need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability, and control of variables.

The level of competence shown by the candidates was good but some candidates approached 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. 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.

Comments on specific questions

Question 1

(a)(i) The required dimensions of the drinks cup were recorded correctly in centimetres to the nearest millimetre by the majority of candidates. Occasionally, an extra zero was added to the recorded dimension. Many candidates did not recognise the significance of adding an extra zero to the measured value of a length.

(ii) The average diameter of the cup was almost always calculated correctly.

(iii) Substitution of values into the given equation for the capacity of the cup was usually correct and most candidates obtained a volume which was within the tolerance allowed.

(b)(i) The calculation of the circumference of the cup presented no problem to the majority of candidates. When the answer was incorrect, candidates had usually multiplied the length of the string by 5 instead of dividing by 5.

Some candidates, who had correctly calculated the average circumference to 3 significant figures as 17.6 cm, then proceeded to write 17.60 cm on the answer line. This was not credited, as the exact answer was 17.58.

(ii) Substitution of values into the given equation for the capacity of the cup was usually correct, and most candidates obtained a second value for the volume of the drinks cup which was within the tolerance allowed.

(c) (i) The reading on the measuring cylinder (32 cm^3) was almost always recorded correctly. The most common incorrect values seen were 30.2 and 26.

(ii) This exercise in the subtraction of two volumes to calculate the volume of water poured from the measuring cylinder into the cup caused problems for many candidates. Some candidates attempted to calculate the volume, using one of the two volume formulae used in earlier parts of the question.

(d) Candidates were asked to compare two of the methods for determining the capacity of the drinks cup and to suggest reasons why the volumes calculated were not accurate. Candidates had more trouble stating reasons for method 2 than for method 3. In method 2, few mentioned that the circumference of the cup was not uniform over its length, or that the external and not the internal diameter was being measured. Credit was given to such comments that the string wound around the cup might stretch/has thickness/might overlap. In method 3, most candidates realised that there would be water droplets left in the measuring cylinder on transfer, or that water may be spilled on transfer. Some candidates mentioned that it is possible to overfill a drinks cup.

Question 2

(a)(i) The readings on the scales of the voltmeter and the ammeter were almost always recorded correctly.

(ii) The calculation of the resistance of the combination of resistors was performed correctly by most candidates.

(iii) Many responses were not precise enough. Often references to ‘it’ were made and credit could not be awarded as it was unclear what was being referring to. Instead of stating that the switch is opened between readings to prevent the circuit/wires/resistors overheating, statements such as “to prevent it overheating” were frequently seen.

(b) Most candidates substituted the given values of current and potential difference into the given equation and obtained the correct answer. Occasionally the answer was incorrectly rounded.

(c) Candidates were asked to state whether the values of R_1 and $2R_2$ could be considered to be equal within the limits of experimental accuracy, having been told that this is true if their values are within 10 per cent of each other. Many candidates were able to do so. The easiest way to show this was to calculate the ratio of the smaller of the two quantities to the larger. If the value obtained is 0.9 (90 per cent) or greater, then the quantities can be considered to be equal.

(d) Many candidates correctly suggested an observation to indicate that the resistance of the lamp filaments change during the experiment, namely because the brightness of the lamps changes, or that the lamps become hot.

(e) Candidates were expected to draw three lamps in series between X and Y.

Question 3

(a) The height H of the triangular object (2.6 cm) was usually recorded correctly to the nearest millimetre. However, a number of candidates read the scale of their ruler incorrectly and 2.6 was read as 2.1.

(b)(i) The height h of the image (7.8 cm) was usually recorded correctly to the nearest millimetre. Again, a number of candidates read the scale of their ruler incorrectly and 7.8 was read as 7.3.

(ii) Most candidates calculated the value of $1 / h$ correctly, but many then went on to round it incorrectly or to quote it to 3 or more significant figures when the question asked for 2 significant figures.

(c)(i) The unit for $1 / h$ was almost always incorrect with cm instead of 1 / cm given.

(ii) Most candidates computed and entered the values of $1 / h$ correctly and entered them in the table. There were some rounding errors.

(d) Many candidates studied the data in the table and arrived at a sensible suggestion as to why values of object distance u less than 20.0 cm were not used in the experiment. Most candidates were able to deduce that the image would be too large to fit on the screen.

(e) Graph-plotting skills were of a reasonable standard, but many responses failed to score full credit. The most common sources of error were:

- Awkward scales, such as 3 or 7. Choosing such scales makes the points much harder to plot.

- Missing labels and/or units on the axes
- Choosing scales so that the plotted points did not span at least half of the given grid
- Failure to use linear scales

There were, however, still many excellent, carefully plotted and drawn best-fit lines produced by candidates.

(f) (i) As expected, candidates who drew a large triangle to determine the gradient of their graphs obtained the most accurate values for the gradient of the line. However, in many cases there was no clear indication on the graph of how the information used to determine the gradient had been obtained, despite the instruction given to do so.

(ii) Most candidates substituted correctly into the given equation and arrived at a value for the focal length of the lens. A common error was the failure to find the reciprocal of the value of mH, as indicated by the equation.

(g) Many candidates were able to suggest an improvement to the procedure to prevent the student's hand obstructing the light when measuring the height of the image on the screen. Acceptable answers included using graph paper or a scale on the screen, using a translucent screen and measuring from the back or using a transparent ruler.

Question 4

There were some very good attempts at this new style of question. Most candidates understood the brief and described a suitable method.

Credit for describing the experimental set-up was awarded for a well-labelled diagram. Further credit was awarded for candidates stating that the time for the ice cubes to melt must be measured with a stopwatch. A sizeable majority did not follow the brief and described a cooling-time experiment, often with the melting time of the ice being incidental. Full credit for method was awarded much less often. Many candidates stopped after performing the experiment with no insulation on the beaker and then with one sheet of insulation. It was expected that candidates would repeat the experiment with at least four different thicknesses of insulation if any meaningful conclusion was to be drawn or if a graph was to be plotted.

Identifying a key variable to keep constant presented no difficulty to the majority of candidates. Candidates who chose the temperature of the hot water as their key variable, often omitted to say that it was the initial temperature of the hot water.

Drawing a table of results presented problems for many candidates. All that was required was a table containing two columns with headings 'thickness (of insulation)' and 'time' with appropriate units. Candidates should be reminded that the unit for the second is 's' and that sec(s) was not accepted. Many tables had extra columns headed with irrelevant information such as the initial temperature of the water. Any extra columns were ignored.

Many candidates seemed unaware of the meaning of the term 'conclusion' and instead made predictions based upon their knowledge e.g., the thicker the insulation, the quicker the ice cubes will melt.

Stronger candidates plotted a graph of thickness (of insulation) or number of sheets (of insulation) against time (taken to melt) and described the trend indicated by the graph. An equally acceptable method of drawing a conclusion was to compare the results to see if or how changing the thickness of the insulation had any effect on the time taken to melt the ice cubes.