PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

The candidates sitting this paper varied in performance quite widely. Some chose the correct answer on the overwhelming majority of questions whilst the standard of the performance of a few others suggested that many answers had been obtained by guesswork. The former group have clearly used the course to gain a thorough understanding of the subject at this level and they have obviously worked hard. Many candidates produced an examination answer sheet somewhere between these two extremes and so it follows that nearly all the candidates had gained something from studying the subject at this level. Many can be very pleased with the standard they reached on the day.

The questions where many candidates were able to select the correct answers were **Questions 2, 7, 10**, **21**, **36**, and **40**. Some of these questions were asking candidates for a known fact but both **Question 36** and **40** required the application of knowledge in a particular case. The very significant number of candidates who selected the correct answer in **Question 1** may be pleased with themselves; this is not always properly understood.

Candidates are strongly advised to read the question carefully before answering it as it is very easy to make an assumption that is not in fact correct.

Comments on specific questions

Question 3

The wording of this question is specifically about the reading obtained from the measuring instrument. Calipers may be used to give a reading of the diameter of the golf ball and this, of course, may be used to calculate the circumference. The reading, however, is not the circumference; the correct instrument is the tape.

Question 11

Although most candidates gave the correct answer here, option B was also selected quite frequently. Perhaps, there are a few candidates who make certain assumptions about the question before reading it properly.

Question 15

Although the correct answer was also the most frequently chosen, answer **D** was chosen by a significant minority of candidates. Although point **D** is the lowest point shown, the depth of water above it is less than for point **C**. In all cases, the surface of the liquid is exposed to atmospheric pressure.

Question 16

This question proved to be very challenging with many candidates who performed well on the rest of the paper being confused by this question. The two most popular choices were **B** and **C** which both involved the use of a factor of two rather than the factor of three. The effect of atmospheric pressure on the pressure under the water was being ignored by the candidates who gave these answers.

Question 18

Answer **A** was a commonly known fact for many candidates and this was the correct and most usually chosen answer. There were candidates, who chose otherwise, although only the candidates who performed less well overall chose answer **B**.

Question 22

The uppermost of the three rays can be used to show that length **B** is the focal length of the lens. Candidates who chose length **D** misunderstood what is meant by the term *focal length*.

Question 24

Some candidates selected answer **C**. These candidates had probably omitted to work in terms of the sine of the angles and had simply divided the angle of incidence by the refractive index of the glass.

Question 27

Although the correct answer turned out to be the most popular selection, many candidates did not choose it. The only possible answer here is best selected by eliminating the three impossible answers. These are **A**, **B** and **D**. The needle of a compass placed in any of these positions would be horizontal on the page. It is, however, possible that the needle of a compass placed at position **C** would point in the direction asked for.

Question 31

Candidates who chose circuit **A**, were quite possibly somewhat uncertain of the effect on the total resistance of connecting two resistors in parallel. In the correct circuit, the resistance of the two parallel resistors is less than the resistance that would be produced by one of the resistors on its own.

Question 34

When ammeters and voltmeters are used, it is best to use as much of the full scale as possible. This is true of both analogue and digital meters. When the voltage is selected for the experiment, it is easy to choose a value that uses the full scale of the voltmeter. The resistance of R is approximately $5\,\Omega$ and only in the case of option **A** does the current that such a voltage produces cause a significant fraction of the meter scale to be used.

Question 37

Potential dividers are commonly found difficult and this is reflected in the large number of candidates who answered this question incorrectly. The smallest voltage across the LDR occurs when the resistance of the LDR is the smallest proportion of the total resistance in the circuit. This happens when the resistance of the LDR is as small as possible and when the resistance of the thermistor is as large as possible. This gives answer **B.** Option **A** was more frequently chosen than **B**.

PHYSICS

Paper 5054/12
Multiple Choice

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

General comments

Whilst many candidates gave the correct answer to all or very nearly all of the questions, there were also candidates who were very much less certain of the subject at this level and some of the answers given suggested that guesswork had played a part in selecting the answers offered. In between these two positions, the overwhelming majority of candidates gave answers that indicate that the courses followed had benefitted them to a significant extent and that useful progress had been made in coming to understand the subject at this level. Whilst there were questions to which many of the candidates gave the correct answer, other questions were more challenging and only the candidates who consistently gave correct answers elsewhere were able to select the answer required.

The questions to which very many candidates were able to choose the correct answer were **Questions 5**, **7**, **11**, **18**, **21**, **28**, and **40**. These were mainly questions where the correct answer was a known fact but a couple of them required the application of knowledge in an unfamiliar context for the correct answer to be deduced. **Question 37** was commonly correctly answered and this involved knowledge of two separate facts and a deduction; the candidates who did this can be congratulated.

Comments on specific questions

Question 1

The wording of this question is specifically about the reading obtained from the measuring instrument. Calipers may be used to give a reading of the diameter of the golf ball and this, of course, may be used to calculate the circumference. The reading, however, is not the circumference; the correct instrument is the tape.

Question 6

The majority of candidates deduced that it was necessary to apply an upward force to keep the plank balanced. Answer **D** was commonly selected, however, which suggests that some candidates did not take into account the fact that the vertical force applied at X is acting further from the pivot than are the 8.0 N or the 12 N weights.

Question 12

This question proved to be very challenging with many candidates who performed well on the rest of the paper being confused by this question. The two most popular choices were **B** and **C** which both involved the use of a factor of two rather than the factor of three. The effect of atmospheric pressure on the pressure under the water was being ignored by the candidates who gave these answers.

Question 15

Most candidates gave one of the two answers that included radiation. Convection in air, however, only transmits heat energy in an upward direction and so only answer **C** is easily excluded.

Question 20

The lens in position 1 acts on rays of light that are diverging. Although the rays continue to diverge after passing through the lens, they are diverging to a lesser degree and so the lens at this position was a converging lens. At position 3, the reverse situation occurs. Here, a diverging lens acts on converging rays and although they continue to converge, they converge more slowly.

Question 23

Although the correct answer turned out to be the most popular selection, many candidates did not choose it. The only possible answer here is best selected by eliminating the three impossible answers. These are **A**, **B** and **D**. The needle of a compass placed in any of these positions would be horizontal on the page. It is, however, possible that the needle of a compass placed at position **C** would point in the direction asked for.

Question 29

Many candidates selected the correct answer **A** but others options were also commonly selected. Those who thought that **B** was correct might have believed that the total e.m.f of 6.0 V was divided equally between the two parallel branches. Both branches, of course, receive the full 6.0 V.

Question 30

Although the correct answer was the most commonly selected, the incorrect answers **B** and **D** were also chosen quite frequently.

Question 31

Candidates who omitted to convert from watts to kilowatts obtain a numerical answer of 2 520; sometimes, this was converted to $25.20 even though it was already in dollars.

Question 33

Although the majority of candidates gave the correct option, the reverse option was also quite popular. Perhaps some candidates used the right-hand rule rather than the left.

Question 34

Again, the correct option was chosen by the majority of candidates but option **C** was selected by a significant minority. Candidates should not assume that, when the options are given in a table such as here, the options where the same word is repeated (such as *low*, *low*) are less likely to be correct.

Question 36

There were many correct answers here, but the potential divider is not always perfectly understood by candidates and so answer **C** was chosen by some candidates.

PHYSICS

Paper 5054/21
Theory

Key messages

Candidates must read each question carefully and answer the question that is set. To be successful in calculations candidates must organise their answers in a clear and coherent way making certain that the working out is clearly shown and explained.

General comments

Candidates did not always organise their answers to quantitative questions. They should be advised to show all the steps in a calculation so that credit can be given for the working when an answer is incorrect. It is helpful if candidates give, as a starting point, the formula that they have remembered, for example in **Question 12** speed = distance × time, as then any subsequent mathematical error is obvious, particularly if the formula is rearranged incorrectly.

Candidates must read the question carefully, looking, in particular, at the terms used in the question; for example in **Question 1** they needed to make sure that all the forces acting were considered and they needed to realise that a resultant force was to be calculated. In **Question 2** they needed to look carefully at the graph to realise that the extension of the spring is plotted and not the stretched length.

Comments on specific questions

Section A

Question 1

(a) Many candidates suggested successfully that the acceleration is the ratio of the weight of the sky-diver to his mass. Fewer candidates considered both the forces, for example by stating that the air resistance is negligible as the start of the fall.

(b) Most answers stated that the air resistance increases when the parachute opens. A good proportion of the answers then went on to suggest that air resistance is larger than the weight. A number of answers mistakenly suggested that the parachutist moves upwards as the parachute opens.

(c) To obtain the terminal velocity in **(i)**, the speed must be found when the air resistance is equal to the weight of 600 N. This was largely successful, although many answers quoted the largest speed on the graph or the speed when air resistance just appears to increase above zero. In **(ii)** candidates read the graph correctly to find the air resistance, but many gave this as their final answer and did not calculate the value of the resultant force.

Answer: **(c)(i)** 5.0 m/s **(c)(ii)** 120 N

Question 2

(a) The limit of proportionality was well known, although the elastic limit was sometimes quoted rather than the limit of proportionality. These two terms are not necessarily the same and the limit of proportionality is not a term that appears in the syllabus. In **(ii)**, the extension must be calculated and then the graph used to find the mass. A considerable number of candidates used the stretched length of the spring, rather than the extension, when reading from the graph. The formula for gravitational field strength was generally used correctly in **(iii)** but weaker candidates gave the unit of weight as kg or failed to use the mass in kg when multiplying by 10.

(b) Most candidates realised that the extension is less when using two springs and expressed themselves sensibly to explain that the load is shared by the two springs. Strong candidates were more quantitative and suggested that, because the load is shared equally, then the load on each spring is halved and thus the extension is also halved.

Answer: **(a)(ii)** 250 g **(a)(iii)** 2.5 N

Question 3

(a) A sensible definition of mass was given by the majority of candidates and the formula for density was well known. It was unusual to find a numerical error in this calculation and this topic appears to be well understood. Candidates found **(iii)** more of a challenge and a number of answers calculated the area of the paper, rather than its thickness. The values needed for a calculation sometimes need to be found from different parts of the question and, in this case, the volume needs to be used from **(a)(ii)**.

(b) The majority of candidates suggested that a micrometer screw gauge or calipers can be used to measure thickness accurately.

Answer: **(a)(ii)** 0.13 cm^3 **(a)(iii)** 0.022 cm

Question 4

(a) Many candidates realised that air expands the most and copper the least; however a number suggested that water expands the least.

(b) In **(i)**, many answers were very encouraging, showing an appreciation of range and low sensitivity. This was expressed in a variety of ways. In the most simple, range was given as the difference between 0 and 100 °C on the thermometer, and low sensitivity as causing a small movement of the liquid along the tube for a given temperature rise. A significant proportion of answers were incorrect in suggesting that a low sensitivity means that the thermometer takes more time to respond to a temperature change. The change suggested in **(ii)** that might improve sensitivity was usually related to the thickness, or area, of the bore of the tube. Some answers were not quite specific enough, for example suggesting that “it should be thinner” or “make the glass thinner”. References to the bore of the tube were most helpful in establishing which part of the thermometer was being changed.

Question 5

(a) It was expected that candidates would use expressions for the direction of vibration similar to that given in the example for light, and strong candidates did so answering this well. Weaker candidates attempted to describe the direction of vibration in different ways. These were sometimes successful and did not have to use the same terms as given in the example. However expressions such as “straight” or descriptions of the wave pattern were often not sufficient. It was surprising that many candidates did not know that sound is a longitudinal wave and that water is considered to be a transverse wave.

(b) In **(i)**, the amplitude of the wave was most often given as 1.29 m, which, unfortunately, does not measure the amplitude correctly, as it should be measured from the mean position. To answer the question in **(ii)**, candidates needed to use the graph. The strongest answers were that each wave takes 1.0 s. However many answers merely gave a definition of frequency and then added that this was constant, without using the graph in any effective way.

Answer: **(b)(i)** 0.29 m

Question 6

(a) The definitions given for the critical angle usually showed some understanding that a ray emerges along the surface. However, such definitions were often incomplete when they just described the situation and did not indicate that the critical angle was actually the angle of incidence, or the angle between the incident ray and the normal, when the ray emerges along the boundary. Other answers successfully described the critical angle as the smallest angle of incidence that causes total internal reflection.

(b) The formula n = 1/sin C, when quoted, was usually used successfully. However a number of candidates attempted to use the formula n = sini/sinr and sometimes obtained the refractive index passing from air into the diamond, a value less than 1. A variety of diagrams were given in **(ii)**. It was encouraging that most diagrams showed the correct refraction of the ray emerging into the air on the left-hand diagram. However there was some confusion evident in deciding in which diagram total internal reflection occurs, perhaps confusing the angle of incidence with the values of 70° and 45° marked on the diagram. Candidates need to recognise the angle of incidence on a diagram.

Answer: **(b)(i)** 2.5

Question 7

(a) This question provided a challenge to most candidates. Some candidates recognised that the coil becomes an electromagnet or has a magnetic field, but did not realise that the left-hand rule means that the force on the wire is towards the left or the right. Many candidates suggested that electromagnetic induction was occurring and that an induced current flows, sometimes this was stated to be in the paper cone itself.

(b) A significant number of answers suggested that the coil rotates and these answers appeared to be describing a motor. Other answers described the coil as moving up and down, sometimes being repelled and attracted by the poles of the magnet. In fact the poles are cylindrical and the north-pole is wrapped around the whole coil. Partial credit was often given for candidates who recognised that an alternating current reverses in direction and causes the oscillation of the coil and cone.

(c) The formula relating speed, frequency and wavelength was well known and applied.

Answer: **(c)** 0.64 m

Question 8

(a) In **(a)(i)**, the majority of candidates were able to recognise that the current was the same in the three components, either with a formula or in words. The most common incorrect answer was that $I_B = I_1 + I_2$, although some answer suggested that the current decreases as it moves around the circuit. Similarly in **(ii)**, most answers correctly stated that $V_B = V_1 + V_2$, but a significant number of candidates included other quantities in their relationship and failed to answer the question or merely quoted $V = IR$.

(b) The formula for current in terms of voltage and resistance was well known but many candidates did not use the total resistance 1500 Ω in their calculation but considered that the whole p.d. of the battery was to be found across the 500 Ω resistor.

Answer: **(b)** 0.0060 A

Question 9

EITHER

Those candidates who attempted this question did not, in general, seem very familiar with the controls of a cathode-ray oscilloscope.

(a) Although many candidates realised that they must use 5 V/divisions, which is the Y-gain setting, they did not always multiply this value by 2 divisions to obtain the correct answer.

(b) A few accounts were most encouraging, and it was common to see a number of divisions being measured on the screen, but it was less common to find this number of divisions multiplied by the time base setting (or 2 ms/division) in the explanation.

OR

(a) Although the transistor was correctly identified by a significant number of candidates, a diode was often given, incorrectly, as the answer.

(b) Many candidates appeared to answer this question without a significant knowledge of the action of a transistor. Partial success was gained when it was stated that the resistance of the LDR rises in the dark and that the p.d. across the base-emitter junction rises. However it was a minority of answers that described the full action of the circuit, including the transistor switching on. The most serious error was in assuming that the resistance of the LDR falls in the dark and that this increases the current that then flows to the lamp.

Section B

Question 10

(a) Melting was clearly identified as the transition between the solid and liquid, but a few answers failed to state that the melting point is the temperature where this occurs. Evaporation was almost always described as the escape of molecules from the surface; strong answers suggested that the more energetic molecules escape to leave less energetic molecules which have a lower average kinetic energy. Weaker answers suggested that molecules gain energy to escape, sometimes suggesting that heat was provided for this to happen or that the liquid was boiling, even though the question states that the liquid is below the boiling point.

(b) Correct descriptions of evaporation occurring at the top surface of the liquid nitrogen in **(i)** were fairly common but some candidates suggested that evaporation occurs at, or into, the glass walls, or were too vague by stating, for example, "at the top". A significant number of answers failed to realise that **(ii)** required an explanation in terms of conduction and convection. Descriptions of thermal transfer, where given, were sometimes more appropriate to a hot object rather than a cold object, as the flask was stated to "prevent heat loss from the liquid nitrogen". It is helpful if candidates apply common explanations to match the question.

(c) It was encouraging in **(i)** to find most answers correctly suggesting that nitrogen gas was found inside the bubbles. Weaker answers tended not to give the whole answer by stating either just "gas" or "nitrogen". The formula for specific heat capacity was well known in **(ii)1** but the unit of the answer for thermal energy was sometimes given as J/g °C.

Answer: **(c)(ii)1** 4200 J **(c)(ii)2** 21 g

Question 11

(a) Descriptions of an experiment to demonstrate an induced current were variable. The simplest described moving a bar magnet and included a voltmeter connected to the coil of wire. More complex situations involving an electromagnet or even a transformer were given and accepted in **(i)**. However a number of diagrams showed a cell in series with the coil and any current in this case is likely to have been largely caused by such a cell rather than induction. The changes suggested were commonly correct but sometimes did not apply to the apparatus described in **(i)**. Statements of Lenz's law were often fully correct, but omitted, on occasions, that the induced current is in such a direction as to oppose the change in flux or field. Where candidates clearly had an understanding of induction, the application of Lenz's law to the experiment was often encouraging and usually included the idea that the coil has poles which oppose the entrance or exit of the magnet causing the induced current. Weaker answers did not make clear that these poles at the end of the coil were produced by the induced current. Very strong answers were able to give the direction of the current in the coil that produces the correct poles at some point in the movement of the magnet.

(b) The formula for electrical power was well known in **(i)1**, and this question produced some good answers, perhaps because the more able candidates answered this question. The electrical energy in **(ii)2** was commonly given as 1.8×10^9 J but a significant number of correct answers for the energy were given as 500 kWh. In **(iii)**, most candidates recognised that using a high voltage for electrical transmission is associated with a low current. The most able candidates used the expression $P = I^2R$ to develop their argument further but a significant number of incorrect suggestions were made that a high voltage reduces the resistance of the transmission wires.

Answer: **(b)(i)1** 15 A **(b)(i)2** 1.8×10^9 J

Question 12

(a) The energy change required was that which occurs during the braking of a cycle. Many answers showed confusion with the idea of an energy change, or introduced other forms of energy which were clearly not involved with the braking, such as chemical energy, at some stage in the process. A significant number of answers suggested that kinetic energy changes to potential energy, earning some credit for the start of the transformation.

(b) The reaction time was usually given correctly in **(i)** and the correct speed was used with this time to calculate the distance in **(ii)**, although mathematical errors were made in rearranging the formula. Some answers in **(iii)** merely gave the time during which braking occurs rather than stating how the distance is found using the graph. The area under the graph was most commonly given as the correct answer. The graphs drawn in **(iv)** almost always showed the correct reaction time but many showed the cycle stopping at the same time as initially, rather than having the same deceleration. Those candidates who attempted to produce the same deceleration were generally successful in drawing a line with the same gradient as given in Fig. 12.2. The explanations of increased braking distance almost always recognised that friction is reduced but lacked significant extra details, linking this force to the increased distance, for example by stating that there is a reduced deceleration or increased time to stop. A few strong answers were observed where the reduced force was linked to the same amount of work needed to reduce the kinetic energy to zero.

(c) The formula that relates pressure, force and area was, in general, well known and applied in **(i)**. Even where candidates realised that the extra surface area of the brake pads was the cause of the increased force, the statement that the pressure is the same was often missing. A significant number of candidates gave a variety of answers that were not accepted, for example references to efficiency or friction.

Answer: **(b)(i)** 0.40 s **(b)(ii)** 2.8 m **(c)(i)** 60 N

PHYSICS

Paper 5054/22
Theory

Key messages

Candidates must read each question carefully and answer the question that is set. To be successful in calculations candidates must organise their answers in a clear and coherent way making certain that the working out is clearly shown and explained.

Units should be given for all numerical answers for quantities that have units. Candidates should learn not only the formulae involved in the syllabus, such as for specific latent heat but also the units of such terms. There was considerable success with electrical formulae and units.

Candidates should try to avoid writing over work that they have crossed out, or to write an answer in pencil and then write over it in ink.

General comments

Candidates should aim to start a calculation by quoting a formula. For example, in **Question 1(b)** those candidates who started the calculation with the formula for acceleration gained at least one mark, even if the numerical substitution was subsequently incorrect. Many candidates, however, started by writing down numbers obtained from a variety of points on the graph and did not produce the correct acceleration, making understanding their working very difficult. It is likely that many such candidates knew the formula relating acceleration, change in velocity and time but unless the formula is quoted credit can often not be given.

Candidates appeared to have sufficient time to answer the paper. However, a significant minority did not follow the rubric and answered all three questions in ***section B***, sometimes appearing to spend too little time on at least one of these questions and, possibly, reducing their overall performance by rushing to finish all three questions. In ***Section B***, more than three-quarters of the candidates answered **Question 9**, approximately two-thirds answered **Question 10** and slightly less than one half answered **Question 11**. The mean mark obtained in each question was similar.

The standard of handwriting in some cases left much to be desired and candidates should be advised that it is in their best interests to make their writing legible. They should cross out work and then rewrite it rather than try to write over an answer that they wish to correct.

Comments on specific questions

Section A

Question 1

(a) This question was answered correctly by the majority of candidates, although many neglected to label their point and sometimes the point was slightly outside the acceptable range. Some candidates elected to give a range, rather than a point, and such candidates tended to be even less careful with the end points of their range which sometimes fell outside 4.0 to 7.5 s.

(b) Stronger candidates recognised the link to the gradient of the graph, and realised that the acceleration is numerically equal to this gradient, including sensible values in their working. Other candidates did not use a difference in values of velocity and quoted only one value such as 27.5/3. Other answers used a correct range of velocity values but opted for a time interval that corresponded to a region of constant velocity on the graph. This was one of the few questions where the unit was often given incorrectly as ms^{-1} or m/s^{-2} rather than m/s^2 or ms^{-2}.

(c) Most candidates understood, and expressed, the idea that the forces are balanced at constant speed. However, the naming of the forces sometimes caused difficulty or confusion. In particular, the driving force acting on the car was sometimes referred to incorrectly as a speed, velocity, acceleration or even a resultant force. Good answers identified the forward force as being the thrust or engine force and recognised that this is equal to the backward force of air resistance and/or friction. A small minority of candidates failed to mention the force at all and merely stated that the speed is constant because the acceleration is zero or because the gradient of the graph is zero.

Answer: **(b)** 2.5 m/s^2

Question 2

(a) The increase in gravitational potential energy was usually calculated using the expression *mgh* rather than using force × distance directly. Many weaker candidates mistook the mass as 5.0 and obtained an answer 10 times too large.

(b) The question in **(b)(i)** asks specifically for efficiency to be quoted in terms of energy input and useful energy output. Occasionally candidates merely gave efficiency as output/input, or used other expressions such as "useful input energy", which it was difficult to interpret and accept. A significant number of candidates chose to write down the answer as a phrase rather than simply writing down the formula, which was acceptable. There was sometimes confusion with the inclusion of "× 100", without a % sign. The simple definition of efficiency is most readily stated as useful energy output/energy input without a % sign.

The calculation in **(b)(ii)** was usually correctly. However, rearrangement of the equation was a challenge to some candidates and the use of the percentage caused problems to others.

(c) Answers showed good understanding of why the motor efficiency was less than 100%, although some statements were not specific enough, for example "energy is lost" which did not indicate where or how the energy is lost.

Answer: **(a)** 17(.5) J **(b)(ii)** 27 J

Question 3

(a) Most candidates recognised in **(a)(i)** that spring C was stretched past the limit of proportionality, but many did not use the data properly to explain this in terms of what happened at higher loads. When asked to use data from the table, it is helpful to quote the numbers that are used. For example many good answers were similar to "the extension when each 0.5 N force was added is constant (0.8 cm) up to 2 N and after 2 N the extension is larger (1.8 cm or 2.8 cm) as each 0.5 N force is added". Weaker candidates merely explained that spring C stretches more than either spring A or B. A number of candidates in **(a)(ii)** worked out an incorrect answer for the unstretched length of the spring, the most common mistake leading to an incorrect answer of 5.3 cm.

(b) There were some excellent answers showing a variety of approaches. Amongst the most simple was the use of the table to find the weight of the rock by inspection or by drawing a graph. Other suggestions were to calculate the spring constant or to obtain the weight in N by dividing the extension in cm by 1.6. Generally, conversion of weight into mass was well understood as the formula W = Mg or W/10 was often quoted. However this conversion was sometimes ignored or stated as mass/gravity rather than mass/gravitational field strength. Some candidates described an entirely different experiment to determine the density of a rock.

Answer: **(a)(iii)** 4.5 cm

Question 4

(a) Only a minority of candidates gave a correct answer. Commonly “gas” was given as the answer without any idea that steam or water vapour was involved. Dissolved air does emerge at first when water is boiled, but the question states that the water boils for some time, and thus “air” and various other gases were not accepted.

(b) The majority of candidates correctly used 46 000 J in their calculation, but it was evident that the formula E (or Q) = ml is not well understood. Candidates who quoted the formula as “L = ml” sometimes did not seem to realise the meaning of L and l. Often the specific latent heat was calculated as mass × energy supplied. Even when the numerical answer was correct, the unit was often quoted incorrectly.

(c) Most candidates correctly identified that higher energy molecules escape and a significant majority of candidates also correctly stated that this leaves lower energy molecules or molecules with a lower average kinetic energy. It was not helpful when candidates described molecules gaining energy and escaping. This was evidently wrong when boiling was described, as the question is about evaporation and not boiling. A number of answers that were not successful described convection currents or only mentioned “hot” molecules evaporating and “cold” molecules remaining.

Answer: **(b)** 2300 J/g

Question 5

(a) The name of the eye defect was well known but complete explanations of why the image is blurred proved a challenge. Many answers successfully stated that the rays do not converge on the retina but did not explain why this happens, in terms either of the effect of the lens or the size of the eye. There some confusion with terminology, such as “image converging” or “object forming behind the retina”.

(b) It was surprising that a significant number of candidates failed to place a lens in front of the eye on the diagram, some lenses, indeed, were drawn inside the eye. Almost all diagram showed the three rays meeting at a point on the retina. The shape of the lens was usually drawn correctly and stated to be a convex lens.

Question 6

(a) The majority of answers showed an understanding that red and blue are at opposite ends of the spectrum, but three-quarters of the candidates placed red as having the larger wavelength.

(b) This section was well answered. It was unusual to find an answer that did not quote either X-rays, gamma rays or microwaves as two other components of the spectrum. It may be sensible for candidates to spell out “gamma rays” rather than to write out the symbol, which was sometimes difficult to interpret. The uses of these components were generally understood, with some excellent statements giving good detail. A few misunderstandings were evident, for example that X-rays are reflected by bones or used as ultrasound or to view a human foetus.

Question 7

(a) Materials such as plastic, wood or glass that act as insulators were well known, although a significant number of answers quoted a type of metal, e.g. copper.

(b) It was encouraging that most answers showed diagrams with the correct charge distribution, containing an equal number of negative charges on the top surface of metal P and positive charges on the bottom surface. It is helpful if only these charges are shown.

(c) This section proved more of a challenge. The majority of candidates correctly realised that metal P only has a net negative charge when the earth wire is connected. However it appeared that many candidates did not realise that the charge was being removed in **(c)(ii)1** but remains and spreads out in **(c)(ii)2**. With the earth wire still connected, metal P becomes neutral as the rod is removed. This is because of the movement of electrons or negative charge away from P to the earth.

Question 8

(a) Induction is an abstract idea and this question challenged the understanding of most candidates, producing some high quality answers but others of varying quality. Strong responses referred to the current in the primary coil setting up a varying magnetic field or flux that linked or cut across the secondary coil. Some candidates only mentioned that the current in the primary coil causes the core to be magnetized and did not mention anything further. Other candidates, while recognizing that the current was changing, made no mention of the change in the magnetic field or the cutting of this field across the secondary coil. Weaker responses simply restated the question or referred to less turns in the secondary coil, without explaining why there is an induced e.m.f at all. A common fault was to suggest that the induced current flows through the soft-iron core itself.

(b) Even though many candidates did not explain how a transformer works in **(a)**, yet they were familiar with its structure and recognised that the transformer shown was a step down transformer, with fewer turns in the secondary. Weaker candidates made vague references to energy being lost or the role of the soft iron core in reducing the voltage in the secondary coil. Had these answers developed the idea of eddy currents or the escape of flux they could have been acceptable, but were rarely judged adequate.

(c) Most answers correctly referred to steel as a hard magnetic material, being difficult to magnetize or demagnetize, or that steel becomes a permanent magnet. A small number of candidates stated, incorrectly, that steel was actually non-magnetic. Those candidates who believed that current flows through the core sometimes, unfortunately, referred to the ability of steel to conduct this induced current.

(d) This question provided a variety of possible acceptable answers. There was a general understanding that the diode only allows current to flow in one direction, or that it is used to convert a.c to d.c. A significant number of candidates made statements that were too vague, such as “the current passes safely” or “to help the current go the right way”. Some candidates recognised the diode symbol but confused this with a light emitting diode and described the purpose of the diode as to emit light and show that there is a current.

Section B

Question 9

This was the most popular question in ***section B***. Most candidates had success with some parts of the question and the knowledge of the various formulae and units involved was strong. The weakest section **(a)** and the strongest sections the calculations in **(b)**.

(a) Many correct explanations for EMF were seen, usually in the form of a definition as the work done or energy used moving unit charge around the circuit. Stronger candidates also made reference to the energy being a conversion from chemical to electrical in the battery. However, the majority of wrong answers referred to the force needed, usually to move a current or charge around the circuit.

(b) In **(b)(i)**, the majority of candidates were able to recognise that the current was the same in the three components, either with a formula or in words, with some going further to state that this was because the circuit is a series circuit. The most common incorrect answer was that $I_B = I_1 + I_2$. Similarly in **(b)(ii)**, most answers correctly stated that $E = V_1 + V_2$, but a significant number of candidates included other quantities in their relationship such as R, R_1 and R_2 and failed to answer the question. Many candidates gained maximum marks to the calculations in this section and a good knowledge was shown of the principles. Particularly encouraging was the ability to add together the resistances of the two components when finding the current.

(c) A majority of candidates were able to give a correct version of Ohm’s Law, and it was good to find some candidates sketching a graph to support their answer. However incorrect responses stated that resistance is proportional to either current or voltage. The limitation on Ohm’s law was often better expressed than the law itself.

(d) Most candidates realised, at least, that resistance increases with length and decreases with increasing cross-sectional area but the strongest candidates correctly expressed the proportionality and inverse proportionality involved.

(e) The colour coding for resistors was not, in general, well understood.

Answer: **(b)(ii)** 0.25 A **(b)(iii)** 4.5 V **(b)(iv)** 1.1 W

Question 10

(a) Most candidates correctly identified the components of the cathode-ray oscilloscope in **(a)(i)**. However, there was sometimes confusion between the anode and a grid, and between the filament or heater and a coil. This was also evident in **(a)(ii)** where the anode was described as changing the brightness of the screen rather than accelerating the electrons and even, in some answers as repelling the electrons. In general there was a good understanding of the parts of the c.r.o. The energy change in **(a)(iii)** was less well stated, usually because light was not identified at the end of the energy transformation or electrical or kinetic energy at the beginning. Part **(a)(iv)** proved to be the most challenging; there were a few excellent answers that used simple ideas to good effect, for example that charge on the X-plates, or an electric field between the plates, causes the electrons to be attracted or repelled and move across the screen. Most candidates recognised that the X-plates were involved in moving the spot backwards and forwards but were unable to explain why.

(b) The majority of candidates attempting this question were successful, although a common mistake was to fail to halve the peak-to-peak voltage in finding the amplitude in **(b)(i)1**. Finding the time for one oscillation proved the greatest challenge in this section, perhaps because two complete oscillations fall in three divisions or that the time base was expressed in ms/division. Most candidates showed an understanding that frequency = 1/time for one wave. A significant minority, however, did not convert the ms to s before calculating the frequency. The sketch in **(b)(ii)** was well answered, with virtually all responses correctly showing a smaller amplitude and a significant majority showing a lower frequency correctly.

Answer: **(b)(i)1** 1 V **(b)(i)2** 2.6–2.8 ms **(b)(i)3** 345–400 Hz

Question 11

(a) The meaning of the term “isotopes” was very well known with only a few candidates failing to give a complete account by omitting, for example, that isotopes have the same number of protons in the nucleus. Most answers were acceptable, but the very best correctly placed neutrons and protons within the nucleus of the atom.

(b) A good understanding of the diagram was shown. The weakest answers incorrectly stated that particle A is a proton or a helium nucleus.

(c) The answers to this section were disappointing, with a significant number of responses suggesting, incorrectly, that a high temperature is needed to break bonds rather than to overcome the repulsive force between the two nuclei.

(d) The answers to this section usually showed some understanding but often lacked enough detail of the process of star formation. Some answers gave a comprehensive account of gas and dust coming together under gravity, causing the temperature to rise and causing the start of nuclear fusion when the temperature becomes high enough. It was rare to see any mention made of equilibrium being established when the outward force caused by radiation being balanced by the inwards force of gravity and such explanation was not required for full marks. Misspelling of fusion as “fussion” caused some confusion, as it was not clear whether candidates were referring, incorrectly, to “fission” instead of fusion.

(e) The most successful answers were obtained by a sequence in which the number of atoms is halved four times. A number of candidates attempted to use complicated formulae, often with ½ to a power. When such candidates were able to deal mathematically with the formula involved this led to success but often the mathematical exercise involved was too difficult.

Answer: **(b)(i)** 2 **(b)(iii)** 2 **(b)(iv)** 4 **(c)(ii)** 1000

PHYSICS

Paper 5054/31
Practical Test

Key messages

- If a question says 'determine an average value for ….', then the examiner will expect to see repeated measurements correctly averaged.
- If repeat readings are taken always note them down even if they are the same.
- Always include a unit with any measured or calculated quantity.
- Always take measurements to the precision of the instrument being used, e.g. to the nearest mm if a ruler is being used or to the nearest 0.1 V or 0.01 V if a voltmeter is being used or to the nearest 0.1 s or 0.01 s if a stopwatch is being used.
- Always record raw readings to the same precision.
- When tabulating results, include units in the column headings rather than in the body of the table.
- When drawing a graph always label the axes with a quantity and a unit where applicable.
- When drawing a graph choose scales that occupy at least half of the graph paper each way and do not choose awkward scales, e.g. 3, 6, 11, etc.
- When marking the axes of a graph do not make the markings greater than 2 large squares or 4 cm apart.
- Always check any points on the graph which are some way from the best fit line.

General comments

Candidates performed well on the paper. There was less extended writing with no explanations. Question 3 was poorly answered with candidates presenting poorly labelled diagrams of their observations.

Comments on specific questions

Section A

Question 1

There was a good spread of marks on this question with candidates of all abilities able to score full marks.

(a) The majority of candidates obtained the 'dead space' ruler values in the acceptable range and were able to use these values to obtain the total length of the ruler. One of the two available marks was often lost by not recording all values to the nearest mm, especially for *L*.

(b) This part of the question involved the candidate balancing the ruler on a pivot and recording various values. Most candidates were able to obtain values within the mark scheme ranges but often lost a mark for either lack of units or inconsistent precision. They then had to use these values to determine designated distances from a diagram. Some candidates were unable to interpret the diagram and consequently obtained incorrect values for *x* and *y*.

(c) In this part of the question candidates had to use their *x* and *y* values to determine the mass of the ruler. Usually the calculations for the mass *M* of the ruler were correct and in the region of the expected mark scheme value or in the region of the centre supervisor's value. Those candidates who had misinterpreted *x* and *y* usually had values outside the acceptable value.

Question 2

This question was a straightforward investigation of an oscillating metre rule with added masses.

(a) Many candidates were unable to obtain a value for d_1 in the required range suggesting that they did not follow instructions and measure from the centre of the hole to the centre of the attached masses. Another common mistake was not recording the value to the nearest mm.

(b) The main difficulty with this section was a large number of candidates failing to repeat their values of t_1 and occasionally omitting the unit. A stopwatch reading to 0.1 s or better was required but there were many candidates who recorded to the nearest second.

(c) T_2 was meant to be smaller than T_1 and the majority of candidates found this to be true. A fairly common mistake for both T_1 and T_2 was to use a different set of repeated values other than t_1 and t_2.

Question 3

This question proved difficult for many candidates.

(a) Very few candidates realised they had to repeat the values of *h* to obtain the average value asked for in the investigation. This meant that any sensible value for *h* given to the nearest mm was usually penalised.

(b)(c) The most able candidates clearly followed the instructions and were able to draw correctly labelled diagrams and obtain the 2 available marks. This was rare however and many diagrams showed curved lines suggesting candidates had not taken their time when viewing at **A** and **B**. There were also candidates who omitted to draw what they saw **directly above the line** and so there was no reference point for the examiner to compare their responses.

(d) As with **(a)**, very few candidates realised that to find the average value for the distance *d*, they had to repeat their measurements.

(e) Although the calculations of h/d were mostly correct they were invariably outside of the required range indicating a lack of accuracy when candidates attempted to find a position of no parallax between the pin and the line on the bottom of the beaker.

Question 4

In this question candidates had to measure voltage values for individual resistors or resistor combinations.

(a) Most candidates were able to record a value for V_0 in the required range with an appropriate unit.

(b) In this part candidates recorded *V* with a 10 Ω resistor in the circuit and then calculated the current I using $I = V/R$. This was well answered although units were often missing.

(c) Common errors in the table of results were:

- Omission of units in the column headings.
- Omission of the original results from **(b)**.
- Failure to correctly calculate the resistance of 10 Ω and 22 Ω in parallel or leaving the answer as a fraction.
- Incorrect calculation of current values.
- Using other combinations of resistors not asked for.

(d) Where a good consistent set of results had been obtained the graph plotting was usually fine and a clear straight line with a negative gradient was obtained. Where the resistance of the parallel combination had been miscalculated there was often a plotted point that was some distance from the best straight line.

(e) Candidates occasionally used a small triangle when determining the gradient of their line while some chose tabulated points that did not lie on the drawn line. The triangle used to determine the gradient should have a hypotenuse that is greater than half the length of the drawn line. If tabulated points are used then they must lie on the line and be at least half the length of the line apart. The negative value of the slope was rarely seen but this was not penalised.

(f) The value of V at I = 0 was the e.m.f. of the supply although it was rare to find candidates who used the intercept on the y-axis to obtain this value.

PHYSICS

Paper 5054/32
Practical Test

Key messages

- If a question says 'determine an average value for ….', then the examiner will expect to see repeated measurements correctly averaged.
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- Always include a unit with any measured or calculated quantity.
- Always take measurements to the precision of the instrument being used, e.g. to the nearest mm if a ruler is being used or to the nearest 0.1 V or 0.01 V if a voltmeter is being used or to the nearest 0.1 s or 0.01 s if a stopwatch is being used.
- Always record raw readings to the same precision.
- When tabulating results, include units in the column headings rather than in the body of the table.
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- When drawing a graph choose scales that occupy at least half of the graph paper each way and do not choose awkward scales, e.g. 3, 6, 11, etc.
- When marking the axes of a graph do not make the markings greater than 2 large squares or 4 cm apart.
- Always check any points on the graph which are some way from the best fit line.

General comments

Candidates performed well on the paper. There was less extended writing with no explanations. Question 3 was poorly answered with candidates presenting poorly labelled diagrams of their observations.

Comments on specific questions

Section A

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(a) Many candidates were unable to obtain a value for d_1 in the required range suggesting that they did not follow instructions and measure from the centre of the hole to the centre of the attached masses. Another common mistake was not recording the value to the nearest mm.

(b) The main difficulty with this section was a large number of candidates failing to repeat their values of t_1 and occasionally omitting the unit. A stopwatch reading to 0.1 s or better was required but there were many candidates who recorded to the nearest second.

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Question 3

This question proved difficult for many candidates.

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(b)(c) The most able candidates clearly followed the instructions and were able to draw correctly labelled diagrams and obtain the 2 available marks. This was rare however and many diagrams showed curved lines suggesting candidates had not taken their time when viewing at **A** and **B**. There were also candidates who omitted to draw what they saw **directly above the line** and so there was no reference point for the examiner to compare their responses.

(d) As with **(a)**, very few candidates realised that to find the average value for the distance *d*, they had to repeat their measurements.

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Question 4

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(b) In this part candidates recorded V with a 10 Ω resistor in the circuit and then calculated the current I using $I = V/R$. This was well answered although units were often missing.

(c) Common errors in the table of results were:
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(e) Candidates occasionally used a small triangle when determining the gradient of their line while some chose tabulated points that did not lie on the drawn line. The triangle used to determine the gradient should have a hypotenuse that is greater than half the length of the drawn line. If tabulated points are used then they must lie on the line and be at least half the length of the line apart. The negative value of the slope was rarely seen but this was not penalised.

(f) The value of V at I = 0 was the e.m.f. of the supply although it was rare to find candidates who used the intercept on the y-axis to obtain this value.

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 <u>why</u> the accuracy has improved or <u>how</u> parallax error was avoided.

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

- Candidates should have as much personal experience of carrying out experiments themselves as possible.

- Candidates should be advised to read the questions through very carefully to ensure that they are answering the question as written, and not simply recalling the answer to a different question.

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

- Candidates should be aware that, as this paper tests an understanding of experimental work, explanations will need to be based on data from the question and practical rather than theoretical considerations.

- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.

General comments

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

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

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

Comments on specific questions

Question 1

(a) Most candidates were able to suggest one change to the apparatus in the given circuit so that the current would increase. The most popular correct answers were to insert another cell or to decrease the resistance of the variable resistor. The most commonly seen incorrect answer was to increase the number of turns on the coil.

(b) Candidates found the task of producing a table to display the results of the experiment quite straightforward. Full marks for this part were common. Where a mark was occasionally lost, it was usually the omission of a unit for the current in the table headings.

Question 2

(a) (i) The average value for the time of ten swings of the paperclip pendulum was usually calculated correctly. Many otherwise correct answers lost a mark because candidates did not heed the instruction given in the question to give the answer to one decimal place.

(ii) The period of the pendulum was usually calculated correctly. The occasional omission of a unit for the answer lost this mark.

(iii) Most candidates scored one of the two marks available here. Many realised that the time for one swing would be very small and difficult to measure. The second, more difficult mark to score required candidates to appreciate that the reaction time of the person represents a significant part of the time for one swing.

Many candidates incorrectly stated that by timing more swings, the reaction time of the person would be less.

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

(iii) Candidates continue to have difficulty describing the relationship between two quantities from a graph. All that was required here was to state that as N increases T increases. Many candidates went further than this and added 'linearly' or directly proportional' when the graph they had just plotted was an obvious curve!

(iv) Almost all candidates were able to use their graph and give a correct value for T when N = 5.

(c) Explaining the effect of using paperclips that were not identical proved to be troublesome for most candidates. The concept of a fair test was not well understood.

Question 3

(a) The mass of liquid P was usually calculated correctly, but many candidates lost the second of the two marks available by ignoring the instruction to give the answer to two significant figures.

(b) (i) The measuring instrument needed to obtain an accurate value for the volume of water was known by almost all candidates.

(ii) 1 Most candidates scored the first mark and identified liquid P as being the unknown liquid. Far fewer candidates gave a clear explanation as to how they arrived at their answer. The most common incorrect answer was that liquid P was denser than water, whereas in fact they needed to say that <u>only</u> liquid P was denser than water.

2 Answers to this part appeared to be guesswork with about half the candidates thinking that beaker A and its contents had the greater mass, and half thinking that it was beaker B.

(c) Candidates found this last part to be easy with a majority realising that the position of the block of wood in the beaker tells them that wood is less dense than water but more dense than oil.

Question 4

(a) The majority of candidates realised that in order to carry out the investigation, a stopwatch and a thermometer would be needed.

(b) Candidates who chose to take heed of the hint offered, and drew a diagram to help their description, did in general better than those who chose not to do so. There were many clear, well-organised descriptions which scored all of the available marks. On the other hand, there were many descriptions that lacked planning and sequence and were difficult to follow. Despite the instruction to state the readings taken, many candidates did not do this, and consequently were penalised by doing so.

A significant minority of candidates did not understand what was required, and placed both test tubes in a water bath and heated them, although the question clearly referred to the emission of infra-red radiation.

(c) Candidates fared better here and many were able to suggest two quantities that the student needed to keep constant during the experiment.

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 <u>why</u> the accuracy has improved or <u>how</u> parallax error was avoided.
- Candidates should be reminded that, when plotting a graph using data obtained from practical work, there will almost always be some scatter about the line of best fit. Forcing the line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.
- Candidates should have as much personal experience of carrying out experiments themselves as possible.
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- Candidates will need to have had a thorough grounding in practical work during the course, including reflection and discussion on the precautions taken to improve reliability, and control of variables.
- Candidates should be aware that, as this paper tests an understanding of experimental work, explanations will need to be based on data from the question and practical rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that these techniques will be tested at some point in the paper.

General comments

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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 realised that the stand was in danger of toppling if it was set up as shown in the diagram.

(ii) In spite of correctly answering part **(i)**, many candidates could not show the correct modification needed. The most common errors were when re-drawing the stand base, not placing the upright near to the end. Very few candidates chose to add a weight to the base, as an alternative method of providing stability. Many appeared not to realise that the rod/base could be turned. There were a surprising number of 'no responses' seen.

(b) (i) There were very few correct answers, with many candidates ignoring the instruction to use two set-squares and only using only one set square. Where two set-squares were used, they were almost invariably incorrectly placed. It was evident from the diagrams seen, that many candidates did not know what a set-square was.

(ii) The fact that the height of the rod above the bench would be the same in two different places if the rod was horizontal was generally not stated or implied. Many candidates contented themselves by just stating 'measure the height'. Quite a few candidates measured the height from the clamp and not the rod.

(c) (i) Not well answered. Candidates who decided to use another ruler to check if the ends of both rules aligned, needed to state that the ruler had to be placed vertically. This essential piece of information was usually missing. A minority of candidates described correctly how a plumb line could be used to align the rules.

(ii) The mean number of swings was usually calculated correctly, with only a minority of candidates ignoring the instruction to give the answer to two significant figures.

(d) (i)(ii) The graph proved to be straightforward with many candidates scoring 3/4 marks. Only a minority of candidates reversed the axes, and the scale mark was not challenging, although some candidates did choose scales that made too little use of the graph paper available. Scales which involved multiples of 3, 7, etc. were much less evident this year than in previous years. There were manyvery good attempts at drawing the best-fit curve through the points. The standard of plotting and of line drawing continues to improve and there was not as much evidence this year of large dots or thick lines.

(iii) Most candidates scored one of the two marks available for this part. Only in a few cases were points chosen from the graph or from the table without any indication of what to do with the chosen numbers.

The second marking point proved to be somewhat more elusive. Arguments and explanations were given and two *xy* products calculated without the mention of their inequality.

(iv) The obvious answer of using less card seemed too simplistic for most candidates, and was not often seen. Long involved explanations were given where candidates tended to disprove and contradict themselves when trying to say that only one piece of card needed to be used.

A small minority realised that you cannot make a small card larger unless you stick bits on it. Common misconceptions included, ‘easier that way’, ‘to get more swings’, ‘the student wanted to show that the graph is decreasing/inversely proportional’.

Question 2

(a) (i) This part was well answered by most candidates. Only a small number of candidates marked P on the wrong side or at the centre of the prism.

(ii) Most candidates knew what a normal was, and were able to draw the normal to the prism at point P. Where mistakes were made, it was usually because a vertical line was drawn through P.

(iii) The correct angle was usually drawn in the correct place outside the prism. A minority of candidates placed the incident ray inside the prism. The most common error made, was in the reading of the protractor scale and making the angle of incidence 50°.

(b) Most candidates met with varying degrees of success here, but only the most able obtained full marks. The marking point most often missed was the continuation of the emergent ray back to the prism. Many candidates also neglected to say that both rays should be joined inside the prism to show the path of the ray inside the prism.

Another common error was omitting to state that the rays needed to be marked somehow – either with a pencil or with pins.

Some candidates did not appreciate what they were expected to do, or became confused with dispersion and/or total internal reflection, with no mention or rays, marked or otherwise.

Question 3

(a) (i) The meter was read correctly by nearly everyone. There were very few missing units, either.

(ii) Most candidates realised that if the student did not stand still, the pointer would move and therefore the scale reading would change. Some candidates simply wanted to talk about accuracy, which is not relevant here. A surprising number of candidates incorrectly thought that if the student moved on the scale then his weight would change.

(iii) Answers to this part were, in the main, correct and made some reference to a parallax error. Otherwise answers were about accuracy and ease of reading, which were not relevant here.

(b) (i) There were very few correct answers to this more demanding part. There were relatively few who understood how the force of friction works. Most answers concentrated on accuracy or ease. Some candidates related this to the previous question, saying that the needle would overswing if the student pushed too quickly.

(ii) Again a difficult mark to score, with few correct answers. The expected answer seemed too simplistic for most candidates. 'So that the box is easy to push' was the most commonly given correct answer, though often wrapped around by florid comments. Very many candidates said 'in order to have more distance to move the box' or words to that effect, rather than to have easy access to the box. Some wrote that they could get more readings of force in order to take an average, which was not relevant here.

Question 4

(a) From the answers seen, it was obvious that many candidates had never seen, or used this type of callipers. It was often difficult for examiners to interpret from what was written, whether the cylinder was between the jaws rather than encircled by it. Some helped by drawing little sketches to remove any doubt. The most common error was stating the distance to be measured without mentioning or indicating A & B.

It seemed many students thought the external callipers are some sort of grip to keep the cylinder steady while they measure the diameter directly with the ruler.

(b) Some of the answers seemed to be answering a question of the type 'what can you do with a piece of thread, some Blu-tack, a metre rule and a pencil?' In many cases, the answer certainly was not finding the diameter of a cylinder via the circumference. Many and varied were the procedures described: wrapping the thread around the rule**,** attaching the thread to the ruler and the cylinder, suspending the cylinder and letting it oscillate.

Many candidates started well and managed to score the first marking point, but of those who did so, only a very small minority stated the exact number of times the thread should be wound. Saying just 'measure the string used' seemed too simple and great detail was given of various techniques. The fourth marking point was very often not scored because a very large proportion of candidates, once they had measured the length of the thread, thought that they had found the diameter, when they had, of course, found the circumference of the cylinder. The main use of the blue tack seemed to be to stick the string along the ruler or to use it to mark the end of the string (along or round the cylinder). A minority of candidates turned the thread around the cylinder once, removed it, arranged it into a circle on the bench and measured the diameter of that circle with the rule.