PHYSICS

Paper 5054/11
Multiple Choice

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

General Comments

The candidates who entered for this paper demonstrated a range of understanding of the topics covered. Some candidates displayed a clear insight into what was expected in nearly every question whilst others seemed to be less familiar with some of the topics being tested.

In questions **2**, **3**, **7**, **10**, **13**, **32**, and **33**, candidates were required to demonstrate their knowledge of a variety of scientific facts and, in question **10**, perform a simple calculation of pressure. Most candidates selected the correct answer for these questions.

Comments on specific questions

Question 4

Many candidates found this question challenging. More candidates selected answer **C** than the correct answer **A**, which suggested a lack of understanding of speed-time and distance-time graphs. Since the speed is increasing, the gradient of a distance-time graph must also be increasing.

Question 12

In this question, each of the four possible answers attracted some of the candidates, although the most frequently selected answer was the correct one. The question required candidates to deduce that the volume increased by a factor of three during the expansion of the air.

Question 17

Many candidates chose the correct option, but some chose answer **C**, possibly overlooking the location of the ice point temperature shown on the thermometer.

Question 20

This question proved to be challenging for many candidates and each of the four possible options was chosen by a significant number of candidates. More candidates chose the incorrect answer **C** than the correct answer **B**, possibly believing that the light had to reflect off the centre of the mirror.

Question 21

This question demanded careful thought. Firstly, the diagram does not give the angle in the medium relative to the normal, but relative to the surface of the medium. Secondly, the light is passing from the denser medium into the less dense medium where the angle relative to the normal is 90°.

Question 22

Many candidates chose the correct answer **D**, but there were many others who opted for **B** and **C**. This question is best answered by drawing the ray diagram for the object and lens arrangement shown.

Question 26

Although most candidates chose the correct answer, some of the other answers were common choices. The information given in the question means that bar PQ is made from a material that can be permanently magnetised as it always points north. The bar XY is made from the same material, but happens not to be magnetised.

Question 31

The correct answer was commonly chosen, but the other options were all chosen by a significant number of candidates.

Question 38

The correct answer **C** was the most frequently selected, but both **B** and **D** chosen by a many candidates.

Question 40

This question needed careful reading. It asked for the number of nucleons. Many candidates calculated the number of neutrons and gave this as the answer.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

Many candidates were able to demonstrate a thorough knowledge and understanding across the full range of topics assessed in this paper. Some candidates seemed less familiar with the topics assessed.

Most candidates were able to select the correct answers for questions **4**, **6**, **7**, **9**, **24**, **26**, and **28**. These questions required candidates to demonstrate their knowledge of a variety of scientific facts, with some questions involving calculations.

In question **3**, the overwhelming majority of candidates realised that a factor of three was involved, but a significant number of these chose the incorrect answer **A** rather than **C**. In question **35**, the resistance of the LDR decreases and so the current in L_2 and its brightness increase.

Comments on specific questions

Question 12

This question proved to be quite challenging and each of the four possible options was chosen by a significant number of candidates. The air above the ice is cooled by the ice and its density increases. Consequently, it there is no convection in the air. This ensures that answer **D** is correct as it alone does not include convection. The air is warmer than the ice and so there will be some infra-red radiation passing from the air to the ice and this, of course, is the second mechanism in answer **D**.

Question 16

Candidates found this question challenging and two facts concerning total internal reflection are needed to arrive at the correct answer. For total internal reflection to occur at the boundary between the tube and the liquid, the critical angle must be less than the angle of incidence. Many candidates chose the incorrect answer **D**, failing to realise that refractive index of the plastic must be greater than that of the surrounding liquid.

Question 18

This question involves two stages. Firstly, candidates were required to calculate the mean time from the five results. Secondly, candidates needed to calculate a distance and realise that this was twice the distance between the student and the cliff.

Question 20

Although most candidates chose the correct answer, some of the other answers were common choices. The information given in the question means that bar PQ is made from a material that can be permanently magnetised as it always points north. The bar XY is made from the same material, but happens not to be magnetised.

Question 22

Answer **C** was chosen by a significant majority of candidates. The proximity of the charged rod ensures that some negative charge is held on the sphere when it is earthed.

Question 23

The overwhelming majority of candidates selected either **B** or **C**. Both of these answers are consistent with the basic law of electrostatics and it is then only a case of using the distribution of charge to determine the correct answer. In **C**, the two spheres are shown attracting, but the charges that cause this attraction repel each other to the far sides of the spheres, which could not happen.

Question 31

The phenomenon described here can be deduced from the motor effect and the direction of the magnetic field around a wire.

Question 34

More candidates chose the incorrect answer **A** than chose the correct answer **C**. Increasing the rotation speed of the generator increases frequency of the a.c. produced and a very large number of candidates gave one of the answers where this was occurring. The coil also cuts the magnetic field lines at an increased rate and so the maximum e.m.f. induced is also increased.

Question 40

More candidates chose the incorrect answer **D** than chose the correct answer **A**. Candidates may have ignored the number of protons in the two nuclei (since it was not asked for) and did not then determine the number of electrons in the two atoms correctly.

PHYSICS

Paper 5054/21

Theory

Key Messages

- A small number of candidates write their answers in pencil before writing over the answer in ink. This often leads to the answer being less legible and more difficult to interpret.

- Units should always be given with the final answer to numerical questions. Candidates should also be reminded to give answers to an appropriate number of significant figures. Fractions are not accepted.

- A carefully drawn diagram can often show what the candidate intends to convey much more accurately than just words. Whenever a diagram is asked for or suggested, it is advisable to include one, carefully and neatly drawn and clearly labelled.

- The credit allocation shown and the amount of space provided give a guide to the length of the answer required, and candidates should use this in order to try to avoid giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided. If an answer has to be crossed out and rewritten elsewhere, candidates should make a simple reference to the location of the new answer. Answers must not be written on the front cover of the question paper.

General Comments

The questions were accessible to all candidates and correct answers were seen for all questions, although **Question 7** proved to be the most challenging, indicating that candidates were unfamiliar with the production of an induced electromagnetic force by cutting the lines of flux between the poles of a magnet. Only a few candidates gave correct answers to **Questions 9(b)(ii)** and **11(a)**.

The standard of written English was high as was the quality of expression, even among the weaker candidates, although the underlying physics was sometimes inaccurate.

Where a question calls for extended prose, candidates should take time to plan their answer, and not list everything that they know about a topic. For example in **Question 9(c)(i)**, many answers lacked structure and the reasons given for high voltage transmission of electrical power were often not made clear. The more able candidates expressed themselves eloquently and succinctly, confining their answers to the question asked, and gaining full credit.

Calculations were generally performed well, apart from **Question 9(b)(ii)2** which many found difficult. Most candidates were able to quote a relevant formula, either in words or symbols, and substitute correctly into it. Occasionally candidates who had performed a correct calculation lost credit by either omitting to give a unit or by giving an incorrect unit.

A minority of candidates ignored the rubric for ***Section B*** and answered all three questions.

Comments on Specific Questions

Section A

Question 1

(a) (i) Most candidates knew how to calculate the acceleration of the motorcycle, but the graph was frequently misread when the change in velocity was being calculated.

(ii) The resultant force was calculated correctly by most candidates. Those who had calculated the acceleration incorrectly in **(i)** were still awarded credit if the correct method was used here.

(b) (i) This part was not answered well, with only the better candidates being able to describe how the acceleration of the motorcycle was changing. Most candidates incorrectly thought that because the speed was increasing, the acceleration of the motorcycle was increasing.

(ii) Most candidates attempted to give the required explanation. The most common sources of error were not stating the name(s) of the resistive forces acting on the motorcycle, or stating that these forces increased as the speed of the motorcycle increased.

Question 2

(a) (i) The law of moments was usually selected and used by candidates to determine the weight of the oil in the cylinder. Where errors were made they were mostly due to the use of incorrect distances.

(ii) The mass of the oil was usually deduced correctly from its weight. The unit of mass was frequently omitted.

(b) Most candidates were able to calculate the density of the oil. Candidates who tried to convert the given volume to m^3, in order to express their density value in kg/m^3 frequently used an incorrect conversion factor.

Question 3

(a) The explanation of the pressure exerted by the air inside the cylinder being caused by molecular collisions was poorly explained. Common omissions were not stating with what the molecules were colliding or that the molecular collisions caused a <u>force</u> to be exerted on the walls.

(b) The increase in pressure caused by a decrease in volume at constant temperature was very poorly explained. Many candidates stated incorrectly that the speed of the molecules increases.

Question 4

(a) Only a small number of the more able candidates were able to give an accurate description of what was meant by *wave motion* in a ripple tank. Few candidates related this to the transfer of energy by vibrating particles without the net movement of the medium.

(b) The meaning of the terms *frequency* and *wavelength* were well known and most candidates gained some credit here.

(c) There were very few fully correct diagrams seen and the standard of drawing was not good. Most candidates did not know the correct direction of the reflected wavefronts and very few took enough care with their diagrams to show that the wavelength of the wave remained constant upon reflection.

Question 5

(a) The meaning of the term *ultrasound* was well understood, although a number of candidates incorrectly stated that ultrasound waves are electromagnetic.

(b) Most candidates knew how to calculate a distance from the given information, although many did not realise that the distance that they had calculated was twice the required distance as the ultrasound had travelled to the wall and back to the builder.

Question 6

(a) The principles of electrostatic induction required to explain why the negatively charged cloud induced a positive charge on the ground beneath it were understood by a minority of the stronger candidates only. Electrons were very rarely mentioned in candidates' explanations. Most incorrectly described the movement of protons/positive charge, for which no credit could be given.

(b) Very few candidates gave an adequate description of what is meant by an *electric field*.

(c) The average current produced by the lightning strike was calculated correctly by most candidates.

Question 7

(a) Few candidates were able to state why the needle on the ammeter deflected when the copper wire was moved between the poles of the magnet. Of those candidates who did realise that magnetic flux was being cut by the wire, only a few went on to state that this produced an induced current/e.m.f./voltage.

(b) Although most candidates realised that the deflection of the needle would be in the opposite direction, only a few stated that this deflection would be larger that the previous one.

(c) Most candidates correctly stated that there would be no deflection of the needle.

Question 8

(a) Partial credit was awarded to most candidates. The standard of diagram drawing was generally poor and it was difficult to ascertain whether the protons/neutrons were inside or outside the nucleus of the candidate's drawn atom. A minority of candidates omitted to label their diagrams.

(b) This was well done by most candidates. The nucleon number of the new atom was given correctly by more candidates than the proton number.

Section B

Question 9

(a) Most candidates were able to state at least one renewable energy source.

(b) (i) 1 Most candidates were unable to use the given electrical power output of 6.8×10^9 W to calculate the energy output per year. The relationship between power and energy was not well known. Many candidates who knew what to do calculated the number of seconds in a year incorrectly.

2 Only the most able candidates were able to make a sensible suggestion. Few candidates realised that the amount of water arriving at the power station would vary throughout the year.

(ii) 1 Although most candidates were able to calculate the gravitational potential energy, credit was often lost for omitting the unit in the answer or giving an incorrect unit – often W instead of J.

2 This proved to be very difficult and only the most able candidates were able to answer correctly. Although many realised that they had to calculate the ratio of the power/energy output to that of the input, a number did not work with a consistent set of units and attempted to divide power by energy and vice versa.

3 This was the least well answered question on the paper. Very few candidates could suggest even one reason. Friction was frequently mentioned but without specifying where the energy loss due to friction was taking place.

(c) (i) This part of the question was answered well. Candidates were aware that there would be less energy loss because high voltage transmission of electrical power resulted in lower transmission currents. Fewer candidates then went on to state that there would, therefore, be less heat generated in the wires.

(ii) Although many candidates knew that a transformer is used to increase the voltage of transmission of electrical energy, there was much evidence of guesswork here, with candidates claiming that diodes, rectifiers and voltmeters could all be used.

(iii) This was very poorly answered, with only a small number of correct explanations seen. The majority of candidates did not realise that power station generators have to be a.c. generators, because transformers only work with an a.c. supply.

Question 10

(a) (i) This was well answered, with most candidates realising that the mechanism of heat transfer through the water was convection. There were many good descriptions of convection, but in some cases the cause of convection, namely that the heated water expands/becomes less dense, was omitted.

(ii) Although there were many good descriptions and explanations of convection, candidates found it difficult to apply what they had written in part **(i)** to explain why the heating element of a kettle has to be situated at the bottom of the kettle.

(b) (i) Most attempted the calculation. The most common error was to not convert the time to seconds before substituting in the formula. The unit of the energy supplied was often quoted in watts instead of joules.

(ii) Most candidates attempted to calculate the temperature rise of the water, but many failed to realise that this temperature rise had to be added to the initial temperature to determine the final temperature of the water.

(iii) Only the more able candidates were able to explain why the final temperature reached by the water would be less than the value they had calculated in the previous part. General statements such as 'heat losses' are insufficient; candidates are expected to state where or how the heat is lost.

(c) (i) The reason for using plastic for the casing of an electric kettle was well understood by the majority of candidates.

(ii) The reason for choosing white as the colour of the outside of the casing was not well understood, with only a minority of candidates gaining credit here. Few candidates stated that white is a poor emitter of radiation. Many answers were incorrectly expressed in terms of absorption and reflection of radiation.

(d) (i) This was not well answered. The word *temperature* rarely appeared in answers.

(ii) This more difficult final part was beyond the scope of all but the most able candidates. Of those who did state that the thermal energy supplied during boiling is used to overcome the forces between molecules, only a few went on to state that the molecules gained potential energy, or that their separation increased.

Question 11

(a) (i) Very few candidates were able to explain the meaning of the term *electromotive force*. Some candidates realised that it was related to the energy required to drive electric charge around a circuit, but only a minority referred specifically to unit charge or the energy per coulomb.

(ii) The advantage of connecting cells together in parallel was not well known. Many candidates thought incorrectly that connecting cells in parallel would increase the e.m.f. provided to the circuit.

(b) (i) Fewer than half of the candidates were able to calculate the total resistance of the circuit, even though it only involved adding the resistance of the parallel combination, which was given, to the series $2.0\,\Omega$ resistor.

(ii) Most candidates used the correct formula for the combined resistance of two resistors connected in parallel, but many were unable to carry out the subsequent mathematics. Correct answers to this calculation were rarely seen.

(c) (i) Although most candidates chose the correct equation to calculate the value of the current, few correct answers were seen. Many answers were spoiled by the use of incorrect values of voltage and/or current.

(ii) Very few were able to suggest an appropriate range for the ammeter. Most answers only gave a single current value.

(d) Only the more able candidates understood the relationship between the currents in the branches of the parallel circuit. Correct equations relating the three currents were rare.

(e) (i) Fewer than half of the candidates gave the potential difference across the $2.0\,\Omega$ resistor.

(ii) There were very few correct responses to this part; in most instances, the combined potential difference across the $2.0\,\Omega$ and $3.0\,\Omega$ resistors was greater than the e.m.f. of the battery.

(f) (i) Only a small minority of candidates realised that if the potential difference across the metal filament lamp decreased, then its temperature would decrease, and as a consequence of this the resistance of the lamp would decrease.

(ii) Many answers to this final part appeared to be based on guesswork, and bore no relation to what had been written in part **(i)**.

PHYSICS

Paper 5054/22

Theory

Key Messages

The numerical value of a physical quantity almost always requires a unit in order for the numerical value to make sense. The omission of the correct unit may result in the answer not being given full credit.

Candidates need to be reminded that answers that are indecipherable cannot receive any credit and whilst every effort is made to read what has been written, there are very rare occasions when an answer given is impossible to interpret and therefore cannot be credited. The practice of writing an answer in pencil, writing in ink over the top and then rubbing out the pencil marks should be strongly discouraged.

If a candidate wishes to change an answer, it is best to cross out the original answer with a clear, single line and to write the new answer. If there is not enough answer space remaining, the answer should be written on a blank section of the paper and reference should be made in the original answer space to the location of the new answer. Answers must not be written on the front cover.

General Comments

Some candidates struggled with many of the questions whilst others were familiar with all of the topics being examined and gave answers that included the points required.

Comments on Specific Questions

Section A

Question 1

(a) A small majority of the candidates gave the correct answer here, even though this is just factual recall. Although the term *elastic limit* is not in the syllabus, it was the answer given by some candidates. Although, the point on the graph that represents the elastic limit is very frequently close to the point representing the limit of proportionality, they are not identical.

(b) (i) The unstretched length of the spring corresponded to the intercept on the *y*-axis. Many candidates gave the correct answer.

(ii) Many candidates gave the total length of the spring rather than its extension. A small number added the unstretched length to the total length, suggesting a reliance on formulas rather than the direct application of understanding.

(c) A significant minority of candidates obtained the correct answer.

Question 2

(a) (i) Many candidates performed this calculation correctly and the correct unit was usually included. A few gave the incorrect unit N / m in some form.

(ii) Only the most able candidates realised that the moment depended on the angle between the force and the distance from the pivot. Even candidates who had given the word *perpendicular* in **(a)(i)** rarely deduced what was happening.

(b) Many candidates showed an understanding of the inverse relationship between force applied and the distance from the pivot. Others suggested a direct relationship, or did not give an answer that dealt with the point being assessed.

Question 3

(a) This was generally well answered and the correct answer was commonly supplied. Some candidates made errors with powers of ten, and those who did not state the formula used did not receive full credit.

(b) (i) This part of the question was also well answered. Some candidates made errors with powers of ten and the correct unit was sometimes omitted.

(ii) There were several sensible suggestions here. Few candidates, however, stated that the fact that the weight of the helium is much less than that of the cylinder ensures that the answer will have a much greater percentage uncertainty.

Question 4

(a) (i) Many candidates gave creditworthy answers.

(ii) A common answer that did not obtain any credit was the suggestion that friction between the road and the tyres was a form of heat loss.

(b) Many answers obtained full credit here. A frequently seen answer was *chemical energy to kinetic energy to gravitational potential energy*, which suggests that the kinetic energy is decreasing as the car gains height.

Question 5

(a) (b) The horizontal line was often given at the correct temperature with the letter H at roughly the mid-point. The correct curves that represent the cooling of the liquid wax and the cooling of the solid wax to room temperature were less commonly drawn correctly. Straight or very nearly straight lines were seen fairly regularly.

(c) This was well answered with many candidates obtaining full credit. Some, however, gave the wrong unit, with J/g an especially common mistake. Others attempted to include one of the given temperatures in the calculations.

Question 6

(a) This was answered correctly by many.

(b) (i) Some candidates answered this question easily, whilst others gave a variety of lengthier explanations which were not always awarded any credit.

(ii) This was rather poorly answered; the most common suggestion was that the strong breeze would blow water molecules out of the liquid.

Question 7

(a) (i) This part was well answered by most candidates.

(ii) Most answered this correctly, although some candidates gave the answer 4.5 V.

(b) (i) This part was quite well answered but a significant number of candidates did not subtract the resistance 6.0 Ω in order to obtain the final answer.

(ii) The answer “the reading decreases” obtained some credit, but the question required an explanation.

Question 8

(a) The majority of candidates gave answers which were awarded full credit. The components of the generator were widely known and clearly labelled.

(b) Many candidates recognised that a magnetic field was involved and many answers involving the cutting of the magnetic field and the induction of an e.m.f. were given.

(c) This part proved challenging and only a few candidates achieved full credit. The use of the time base setting was only occasionally mentioned.

Section B

Question 9

(a) Many candidates gave an accurate definition of acceleration and were credited.

(b) Many answered this correctly, although answers such as "a vector has magnitude and direction" do not make it clear how a vector quantity differs from a scalar.

(c)(i) Many candidates labelled the line correctly and were awarded full credit. The most significant reason for losing credit was the inaccurate positioning of the letters X, Y or Z.

(ii) 1 Although some candidates obtained full credit, a very common error was to take the velocity at 25 s and to divide it by 25. Other errors arose in stating the unit of acceleration.

2 Many candidates answered this correctly.

(iii)1 The answers here revealed a few common misconceptions; the arrow representing gravitational force was very often drawn vertically down the page and the air resistance arrow was not always drawn in a direction opposite to that of the velocity arrow.

2 This was also poorly answered with many answers referring to the changing gravitational field. It appears to be commonly thought that there is no gravitational field beyond the atmosphere.

(iv) This was answered by a number of candidates, as not all noticed that the speed of the rock became zero at this time.

Question 10

(a) Only a minority of candidates gave the correct value for the speed of light in air.

(b) (i) Many candidates stated that the speed of light decreased as the light entered the glass but the effects on the frequency and wavelength were less well understood.

(ii) These angles were often marked correctly.

(c) (i) Although not all candidates made it through to the final answer, many obtained some credit for the correct formula or the correct numerical substitution.

(ii) In this part, some candidates referred to the critical angle and erroneously suggested that its value prevented the angle of refraction exceeding 45°. Very few candidates made any reference to refraction or to the angle of refraction as the angle of incidence approached 90°.

(d) (i) In this part also, some answers made reference to the critical angle and few answers achieved full credit.

(ii) Although the first reflection, which took place at the base, was very commonly correct, some added a refracted ray. The second reflection was more commonly shown as a reflection.

Question 11

(a) There were some good answers here with many candidates giving a good definition.

(b) These two calculations were correctly performed by many candidates.

(c) This equation was correctly completed by some candidates, but numbers to be used with the beta-particle symbol and their effect were not always correctly indicated.

(d) (i) This calculation was performed accurately by some candidates but errors such as dividing the original number of radioactive atoms by three were often seen.

(ii) Although the use of a suitable detection device was often indicated in a satisfactory manner, the description of a method that would show that only beta-particles are present was much less commonly given. Many answers concentrated on a general description of the penetration properties of the three types of radioactive emissions. Full credit was awarded relatively infrequently.

(iii)1 The meaning of *random* was often understood and good answers were common.

2 This part proved more challenging and many candidates were clearly uncertain as to what was expected.

PHYSICS

Paper 5054/31
Practical Test

Key Messages

- The unit of the quantity that is being measured should always be given.
- Measurements should always be taken to the precision of the instrument that is being used, e.g. 0.1 V if a 5.0 V voltmeter is being used.
- If a question says "Determine an average value for...", then repeated measurements correctly averaged are expected.
- If measurements are repeated, the repeated values should be given, even if they are the same as the initial value.
- If units are given on the paper, ensure that measured quantities are converted to these units before the answer is given on the answer line.

General Comments

Question 2 was not well answered, either because candidates were unfamiliar with optics experiments or because they had difficulty understanding the instructions.

Comments on Specific Questions

Section A

Question 1

(a) Candidates were expected to take repeat measurements for each of the three values and then to determine the correct average for each. Very few candidates repeated the measurements. Other errors included the omission of units and recording of measurements to the nearest cm rather than the nearest mm, e.g. 7 cm rather than 7.0 cm.

(b) Generally S_1 and S_2 were recorded and e was calculated correctly. However, not all candidates obtained a value for e in the correct range of 5.0 cm to 10.0 cm. As in part **(a)** units were sometimes omitted and values were given to the nearest cm rather than the nearest mm.

(c) Most candidates correctly found that e_N was less than e.

(d) More able candidates correctly calculated the mass of the block and found a value for the density that was in the range 0.45 to 0.95 g / cm^3. However, some candidates gave the density to too many significant figures.

Question 2

(a) Although the question stated that the line L should be drawn at an angle of 60° to the normal, a number of candidates incorrectly drew L such that the angle of 60° was between L and MX. More able candidates correctly extended the line L into the block. However, a significant number reflected the line L in the line XY rather than extending it into the block and beyond.

(c) (iii) In order to draw the emergent ray accurately, the two points P_1 and P_2 should be as far apart as possible. Ideally the point P_1 should have been marked at the point where the ray emerged from the block and the point P_2 close to the edge of the page. Very few candidates did this.

(d) Most candidates drew the line MN across the block and measured its length, l, correctly. More able candidates correctly extended the line L into the block. However, again a significant number reflected the line L in the line XY rather than extending it into the block and beyond. This meant that they could not measure the perpendicular distance *d* between the two parallel lines. Even those who drew two parallel lines often measured the vertical distance between the lines rather than the perpendicular distance. Thus only the most able candidates gave the ratio of the distances in the correct range.

Question 3

A number of candidates used non-SI units in this question despite the fact that units had been given for a number of the quantities to make the calculations easier.

(a) If the mass hanger is only just below the pulley then the value of *s* should be slightly less than the height of the bench. A range of 0.700 m to 0.900 m was therefore allowed. A number of Supervisors reported that their laboratories have small bench heights and in such cases the range was extended downward. Typical mistakes made by the candidates included:

- an answer of, for example, 75.0, which is incorrect because the unit of metres was given in the question, and hence the correct answer should have been 0.750
- an answer of, for example 0.75, which is wrong because the height had not been measured to the nearest mm (0.001 m).

Similar errors were made when the height *h* was determined.

(b) (i) Similar errors occurred when the masses *m* and *M* were recorded. Because the unit of kg had been given, answers such as 150 were clearly not correct. The values of mass given in the confidential instructions allowed a maximum value of *m* as 0.300 kg. However, some candidates wrote down values that were in excess of this.

(ii) More able candidates determined an average value for *t* by repeating their measurements and obtaining a correct average. However, a large number of candidates only took one measurement.

(c) Errors in values for *s*, *h, m*, *t* and *M* were carried forward so that substitution into the equations was often correct. A number of candidates confused *m* and *M* in **(i)** and **(ii)**. Others confused *s* and *t* in **(i)** and **(iii)**. Only the most able candidates were able to give a correct value for *F*.

Question 4

This question was generally answered well. Graph plotting skills were mostly good and candidates coped with some quite difficult processing.

(a) (i) Most candidates were awarded credit. The most common errors were to omit the unit or to give the answer to an incorrect precision, e.g. 2 V rather than 2.0 V.

(iii) *K* was sometimes only calculated to 1 significant figure, despite the fact that both V_0 and *L* were measured to at least 2 significant figures.

(c) (ii) Most candidates were awarded credit. In addition to the reasons described above, the only other error was that the value was outside the range, possibly because a good connection had not been made on the length of wire.

(d) Many candidates obtained full credit for their observations. Errors included omission of units from the table headings, not including the answer to **(c)(ii)** in the table or recording an insufficient spread of data.

(e) Graph plotting was generally good.

(f) More able candidates obtained a correct value for the gradient; weaker candidates used a small triangle in their determination of the gradient, or used (change in *x*)/(change in *y*) to find the gradient. In other cases candidates chose points that did not lie on the line when trying to determine the gradient and so could not be credited.

(g) **(i)** Recording R proved difficult for many candidates despite the fact that it was given on a card that had been provided by the Supervisor.

(ii) Some candidates seemed to confuse R with R_X and tried to calculate a value for R. Only the very best candidates obtained a correct value for R_X.

PHYSICS

Paper 5054/32

Practical Test

Key Messages

- The unit of the quantity that is being measured should always be given.
- Measurements should always be taken to the precision of the instrument that is being used, e.g. 0.1 V if a 5.0 V voltmeter is being used.
- To reduce the error in a measurement, always measure the largest possible quantity, e.g. the width of 5 gaps rather than the width of one gap as in question 2.
- If a question says "Determine an average value for...", then repeated measurements correctly averaged are expected.
- If measurements are repeated, the repeated values should be given, even if they are the same as the initial value.
- If units are given on the paper, ensure that measured quantities are converted to these units before the answer is given on the answer line.

General Comments

The descriptive elements of **Question 2** seemed to cause candidates the most difficulty.

Comments on Specific Questions

Section A

Question 1

(a) Supervisors were asked to provide a piece of wire that was 99.0 cm long and hence candidates were expected to obtain an answer that was in the range 98.0 cm to 100.0 cm. Some candidates gave measurements outside the range, gave answers that were not to the nearest mm or better, or omitted to give units in their answers.

(b) Candidates were expected to be able to wind 16 turns of wire around the dowel provided; a range of between 14 and 18 turns was allowed. Most candidates obtained answers in this range. In some cases the range was changed because dowel of a different diameter had been used and detailed in the Supervisor's Report. If the specified wire diameter had been used then *x* should have been in the range 0.4 cm to 2.5 cm. Answers were often obtained beyond the top of this range because the candidates had not pushed the turns of the coil close enough together. Since errors in *N* or *x* were carried forward, the value of *d* was usually credited, although some candidates did omit the unit.

(c) Only the most able candidates obtained a value for the density that was in the correct range. A number of candidates omitted or gave an incorrect unit, gave their answer to too many significant figures or gave an answer which was outside the acceptable range.

Question 2

(a) Very few candidates measured the distance across all five gaps and then divided by 5 to determine an average value for the separation of the lines. Candidates were credited for measuring all five gaps individually and then working out the average. Some obtained the total gap distance but then incorrectly divided by 6 rather than 5 to obtain the average separation of the lines.

(c) (i) Most candidates correctly stated that the image had been magnified.

(ii) Only the most able candidates stated that the magnification increased as the height of the lens above the page increased. A number of candidates raised the lens to a height beyond the focal length of the lens and commented on the image becoming blurred and even that it was becoming diminished.

(d) (ii) Many candidates mentioned the idea of repeating readings but showed no evidence of having done so and so did not gain the credit. The use of a set square was mentioned by some but not described. A wide range of values was allowed for the accurate value of *x* to allow for the many possible heights of the eye above the lens.

Question 3

A number of candidates used non-SI units in this question despite the fact that units had been given for a number of the quantities to make the calculations easier for the candidates.

(a) If the mass hanger is only just below the pulley then the value of *y* should be slightly less than the height of the bench. A range of 0.700 m to 0.900 m was therefore allowed. A number of Supervisors reported that their laboratories have small bench heights and in such cases the range was extended downward. Typical mistakes made by the candidates included answers of, for example, 75.0, which is wrong because the unit of metres had been given in the question and hence the correct answer should have been 0.750 or an answer of, for example 0.75, showing that the height had not been measured to the nearest mm (0.001 m).

(b) (i) Similarly, for mass *m*, for which the unit of kg had been given, answers such as 150 were not correct. The values of mass given in the confidential instructions allowed a maximum value of *m* as 0.200 kg. However, some candidates wrote down values that were in excess of this.

(ii) More able candidates determined an average value for *t* by repeating their measurements and obtaining a correct average. Many candidates, however, only took one measurement.

(d) Errors in values of *y*, *m*, *t* and *M* were carried forward so that substitution into the equations was often correct. A number of candidates confused *m* and *M* in **(iii)**. The value of *F* was only obtained by the most able candidates.

Question 4

Candidates generally answered this question well. Graph plotting skills were good and candidates coped with some quite difficult processing.

(a) (i) Most candidates were awarded credit, but the most common errors were omitting the unit or giving the value of V_0 to an incorrect precision, e.g. 2 V rather than 2.0 V.

(ii) The unit on the question paper caused difficulty for some candidates as they gave answers such as 99 rather than 0.99.

(iii) *K* was sometimes only calculated to 1 significant figure despite the fact that both V_0 and L were measured to at least 2 significant figures.

(b) (ii) Most candidates were awarded credit for this part. In addition to the reasons described above, the only other error that lead to the loss of credit was that the value given was outside the range, possibly because a good connection had not been made on the length of wire.

(c) Units were often omitted for values of $1/V$ and $1/l$ in the table. Also some candidates used a range of less than 0.500 m.

(d) Graph plotting was generally good, although units were frequently omitted from the axes of the graph.

(e) More able candidates obtained a correct value for the gradient, but less able candidates often used a small triangle in their determination of the gradient, or used (change in *x*)/(change in *y*) to find the gradient.

(f) The more able candidates successfully substituted into the formula to find the value of R_X but only the very best candidates obtained a value in the correct range.

PHYSICS

Paper 5054/41
Alternative to Practical

Key Messages

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

- graph plotting;
- tabulation of readings;
- manipulation of data to obtain results;
- drawing conclusions;
- dealing with possible sources of error;
- control of variables.

General Comments

The level of competence shown by the candidates was sound, although some candidates approached this paper as they would a theory paper rather than from a practical perspective. Almost all of the candidates attempted all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Many candidates dealt well with most of the practical skills required but the majority found it challenging to plan an investigation using suggested apparatus. The better 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) The majority of candidates correctly explained how to ensure that the rule was horizontal by measuring its height above the bench at both ends of the rule and adjusting to obtain the same result. Some explained the process but neglected to state that the two measurements must be the same so could not be credited. Others correctly suggested using a spirit level or placing a small ball on the rule.

(b) The majority of candidates knew which length needed to be marked, although a number marked an incorrect length as *x*. To gain credit at least one complete horizontal line going from A to B had to be marked clearly on the diagram, and *x* then shown as being from one point on A to the same point on B, e.g. from the bottom of A to the bottom of B. Many lost credit for not having a horizontal line to refer to so that their line representing *x* was hanging without clear reference to both strings A and B.

The second part was misunderstood by many. The majority of candidates just explained that the two lengths should be measured and the difference found. The accuracy of the measurement was the requirement here and there were a number of ways to gain credit, e.g. ensuring that the measurement was made to the same point on each bob or ensuring that the bob did not move whilst the measurement took place. A number of candidates stated that parallax error should be avoided but this was not sufficient for credit to be awarded as an explanation was required.

(c) The standard of graph plotting was good. Most candidates drew correct, labelled axes, and used sensible scales which maximised the use of the given grid. Points were mostly plotted accurately but many lost credit due to lack of accuracy in the placing of their points. The majority of candidates attempted to draw a smooth curve of best fit through the points. Credit lost could often have been avoided if candidates had used a sharp pencil to plot their points and draw the curve.

(d) Not all candidates realised that having A and B close together made it easier to observe both pendulums at the same time. However, the second part was answered well and the majority of candidates understood that the strings/bobs could collide or become entangled.

(e) The majority of candidates had no difficulty in correctly taking a reading from their graph to find a value for *N*. Similarly, the numbers were substituted into the given equation and the majority did the calculation correctly, although a number lost credit for not giving their answer to two significant figures.

In the final part of the question, many simply stated "yes" or "no" which could not be credited. The correct response depended on their results, as candidates should be encouraged to consider the possible experimental error when carrying out an experimental procedure. If the two values were close (within 10% of each other), it would be reasonable to say "yes because the values are within experimental error". Similarly, widely differing values would differ by more than reasonable experimental error. Some discussion about the closeness or difference in their results was expected and very few candidates were awarded credit.

Question 2

(a) The majority of candidates correctly named a suitable instrument to find the height of a stool. A small number lost credit for suggesting a ruler or a tape rather than a measuring tape.

(b) Candidates found great difficulty in explaining the meaning of *parallax error*. More able candidates could explain how it should be avoided but this was not the task here. Only a very few of the more able candidates were able to explain that it was an error in taking measurements due to the position of the observer taking the measurement or the incorrect positioning of the eye when taking a reading from a measuring instrument.

Similarly, difficulty was encountered in explaining how parallax error should be avoided in measuring the height of the stool. Many candidates referred to the necessity of keeping the line of sight perpendicular to the metre rule but they did not include the stool in their explanation so could not be credited. The best answers referred to keeping the line of sight perpendicular to the mark on the ruler corresponding to the height of the stool. Other good responses involved the use of a ruler across the top of the stool to the metre rule.

(c) Very few candidates realised that the metre rule must have been upside down to get this incorrect measurement. Many talked of zero errors or the rule being tilted but these were impractical in view of the magnitude of the error.

Candidates were more successful in determining the average height of the stools and the majority correctly omitted the incorrect reading from their average. Credit was lost by those candidates who either included the incorrect reading, failed to give their answer to three significant figures or gave their answer without a unit.

Question 3

(a) The method of finding the position of 0 °C on the thermometer was well known although some candidates lost credit for not stating that it must be placed in *melting* ice. To find the position of 100 °C, the most common answer was to place the bulb in boiling water which was not credited. Relatively few candidates knew that the bulb should be placed above boiling water in contact with steam.

(b) This was answered well, with more able candidates showing sensible working to find a value for room temperature. The candidates were expected to measure the length of the mercury thread between 0 °C and room temperature on the diagram and also measure the distance between 0 °C and 100 °C. Room temperature could then be found by a method of proportion. This was intended to be a practical exercise that could have been carried out by the candidates.

The candidates were then asked for one assumption made in carrying out this calculation. Very few candidates scored credit here. Common incorrect answers included that room temperature was constant or that the values given in the question were correct. Very few realised that they needed to refer to the mercury expanding uniformly or the bore of the thermometer being uniform.

Question 4

(a) Candidates were expected to suggest a method of finding the diameter of a thin wire using only the equipment suggested in the question. A large proportion of candidates scored no credit as their methods were impractical. The most common response was to wrap a piece of string once around the wire, mark and cut the string and then measure its length. Many candidates did not seem to realise that this would give them the circumference and not the diameter. Even those who did go on to calculate the diameter did not score as this method would give a very imprecise measurement for such a small length. Only a small proportion of candidates suggested a method of measuring multiple diameters and finding the average. This could have been done by cutting the wire up and having several lengths horizontally aligned and measuring ten or more diameters. It could also have been done by wrapping the wire tightly around a rod or ruler and then measuring across ten or more diameters.

(b) The majority knew that a micrometer was the best instrument to use.

PHYSICS

Paper 5054/42
Alternative to Practical

Key Messages

- Candidates should be reminded to include units when quoting the values of physical quantities and should be encouraged to check that the unit they have provided is appropriate for the calculated or measured quantity.
- 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.
- Credit is often lost due to lack of care and attention to detail when drawing or annotating diagrams. The accuracy of straight lines on diagrams could be greatly improved by using a sharp pencil and a ruler.
- Candidates should be advised to avoid using rote phrases, such as, 'to make it more accurate' or 'to avoid parallax error'. These comments need to be linked to the practical situation being considered and candidates should state why the accuracy has improved or how parallax error was avoided.
- When plotting a graph using data obtained from practical work, there will almost always be some scatter about the line of best fit. Forcing the line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.

General Comments

The level of competence shown by the candidates was sound, although some candidates approached this paper as they would a theory paper and not from a practical perspective. Almost all candidates attempted 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 awarded partial credit here, but there were few well-structured accounts which unambiguously described the steps involved in using a plotting compass to plot the shape of the magnetic field around the given magnet. Despite the hint given that a diagram might be helpful, only about half of the candidates drew a diagram, and these were able to score most of the available credit if their diagrams clearly showed how the shape of the field was plotted. Many candidates who understood what was required of them, missed out vital parts of the process, such as stating that the dots they had plotted needed to be joined so that the shape could be seen. Only a minority of candidates realised that to plot the shape of the field, more than one line had to be drawn, and so the process of dot plotting had to be repeated with the compass placed at different starting points.

A number of candidates ignored the instruction to use a plotting compass, and instead described sprinkling iron filings around the magnet. No credit was awarded for this.

(b) Candidates found it difficult to give a valid reason as to why the plotting compass should be small. Statements such as 'to make the field more accurate' did not receive credit. Many candidates thought that if the plotting compass were large, it would either fall off or go through the paper.

(c) This was done well with the most common correct answers stating that the direction and/or the strength of the magnetic field could be deduced using the given apparatus.

Question 2

(a) (i) Only the more able candidates realised that the candidate pulls the newton meter at a constant speed so that the pulling force is constant and the newton meter gives steady reading. Most answers merely repeated words used in the stem of the question and stated that otherwise the force used would not be a minimum.

(ii) Again, candidates found difficulty in suggesting a reason why a slow, constant speed needed to be used. All that was required here was for candidates to state that it would allow time to read the meter, or that the meter would be easier to read. Once again, there were many vague references made to improving the accuracy of the experiment, which did not receive credit.

(b) (i) It was apparent from candidates' answers that many of them were unsure from which end of the pointer to take the scale reading. Of those candidates who gave the correct reading of 0.45 N, many were not credited because they omitted to give the unit.

(ii) Most candidates correctly marked the position of the eye of the student when taking the reading, so that parallax was avoided.

(c) (i) The standard of graph plotting continues to improve. Most candidates used correct, labelled axes, and chose sensible scales which maximised the use of the given grid. Points were generally accurately plotted. Although the instruction given to candidates was to draw a straight line of best fit, many candidates attempted to draw a point to point series of straight lines through their plotted points, and occasionally, even a curve was drawn.

(ii) Most candidates were able to use their graphs correctly to find the value of F when $W = 0$.

(iii) Only a small number of the more able candidates realised that the graph did not pass through the origin because a force is needed to lift the weight of the lower pulley. Credit was also awarded here to candidates who stated that the graph did not go through the origin because F was not (directly) proportional to W.

(d) Most candidates made reasonable attempts at determining the gradient of their lines. It is worth reminding candidates that when choosing coordinates on the line to draw a gradient triangle they should choose points that are far apart – at least half the length of their drawn line. Many candidates, having correctly calculated the gradient, lost credit here by ignoring the instruction to give their answer to 2 significant figures.

Question 3

(a) Many candidates were unfamiliar with the technique of using the resistor colour code to predict the colours on the bands of resistors of given values. Most answers appeared to be guesswork, and many incorrect colour combinations were seen.

(b) (i) Nearly all candidates knew that to give the smallest possible combined resistance, resistors should be connected in parallel.

(ii) This was answered well. Most candidates were awarded at least partial credit here. Occasionally, the same combination of resistors was accidentally drawn twice.

(iii) This was again answered well by most candidates. Many were able to identify the combination of resistors that gave an effective resistance of $36\,\Omega$ by inspection, whilst others calculated the resistances of their combinations until they identified the correct one.

Question 4

(a) Answers to this question were generally poor, with very few candidates obtaining full credit for their description of how they could obtain an accurate value for the outside diameter of a beaker using items of apparatus selected from a given list. Many candidates thought that all the items in the apparatus list supplied had to be used.

Despite the help given in the stem of the question, where candidates were taken step by step through the stages they would need to describe in their accounts, many ignored this advice and produced accounts which lacked structure and were difficult to follow.

Candidates who placed the beaker between the blocks of wood and used the 30 cm ruler to measure across them fared best. Candidates who wrapped the string around the beaker whether once, or several times, invariably thought that the length of string that passed once around the beaker was its diameter. If this method was described, candidates were expected to state that the measured length of the string was the circumference of the beaker, and proceed to describe how the diameter of the beaker could then be determined.

Any method that would work without additional apparatus being needed was awarded credit, but to obtain full credit, candidates had to fulfil the requirements listed in the five statements listed in the guidance given.

(b) Candidates met with more success here and many were able to make a sensible suggestion as to why it would be more difficult to measure the internal diameter of the beaker.