PHYSICS

Paper 5054/11
Multiple Choice

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

General Comments

The responses to this paper show a variation in achievement with some candidates scoring very highly on most questions and other candidates who only obtained the correct answer on a much smaller number. Many candidates had made a real effort to tackle this subject seriously and should be pleased with the progress made and the outcome as reflected in this paper.

The questions which proved the most accessible were **Questions 3**, **10**, **12**, **15**, **17**, **20** and **27**. These are primarily testing knowledge of specific facts. It is encouraging to observe that these are questions on a wide variety of topics from several different sections of the syllabus.

Comments on Specific Questions

Question 6

A large number of candidates found this question on gravitational field problematic. Many candidates opted for answer **B**. This highlights a common misunderstanding. Candidates should be reminded that the Earth's gravitational field does not stop where the atmosphere appears to end; it continues deep into space getting ever smaller but never disappearing.

Question 13

This question required some thought. In order to keep the temperature of the house constant, the thermal energy lost must equal that supplied and so the difference must be lost by some other means (most obviously through the doors or through the escape of hot air). The correct answer is therefore **A**. Many of the weaker candidates chose answer **B**.

Question 29

This was a difficult question. A significant minority gave answer **A**. This answer assumes the resistance of two 3.0 Ω resistors in parallel can be obtained by addition, which is not correct. Two resistors of resistance 3.0 Ω in parallel have a combined resistance of 1.5 Ω. The effect of switch S_3 was widely recognised.

Question 30

The most frequently chosen answer was the correct one, but there were only slightly smaller numbers of candidates giving each of the other answers. The way in which currents in circuits split and the way in which potential differences combine is not always clearly understood. The potential differences across the two resistors in parallel are equal but, because their resistances are different, the currents through the two resistors are different.

Question 31

The energy or power in the primary coil and in the secondary circuit need to be calculated before the efficiency is obtained. Many candidates gave the correct answer, but the other three answers were chosen by similar numbers of candidates, so these candidates may have been guessing. The primary power is 25 W and the secondary power is 24 W, so the efficiency is 0.96 (answer **C**).

Question 36

Many candidates chose **D**, which is the reverse of the correct answer. One way to remember the behaviour of LDRs and thermistors is to consider that the resistance decreases as the incident energy increases.

PHYSICS

Paper 5054/12
Multiple Choice

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

General Comments

Many candidates produced answers that showed a certain familiarity with the ideas being tested. Some candidates had studied well and were familiar with topics included in the syllabus.

The questions that proved the most accessible were **Questions 2**, **4**, **6**, **19**, **21**, **25** and **27**. These are primarily testing knowledge of specific facts. It is encouraging to observe that these are questions on a wide variety of topics from several different sections of the syllabus.

In questions such as **Questions 28** and **33**, there are two different stages to complete before the answer is obtained, and it unsurprising that, on such questions, candidates in general score less highly. The three dimensional arrangement in **Question 32** made that question rather less accessible for some candidates.

Comments on Specific Questions

Question 3

There were two stages here: candidates needed to realise that the straight section of the graph represented the region where the object was travelling at its terminal velocity, and then that the gradient had to be used to determine its value. Although the most frequently chosen answer was the correct one, there were significant numbers of candidates who chose each of the other options.

Question 7

Nearly all candidates chose **B** or **C** here but more chose the incorrect **B** than the correct **C**. When a candidate realises that the moment due to the weight W has been reduced, then the route to the answer is fairly direct.

Question 10

Although the base area of beaker S is smaller than that of beaker T, the weight of liquid contained by S is less. These two effects cancel and show that the pressure depends only on the depth of the liquid, which is the same in both cases. Stronger candidates were generally able to get this answer correct.

Question 13

This question revealed that there are some candidates for whom the exact significance of efficiency is misunderstood. The most commonly chosen answer was the correct one, but significant numbers of candidates chose the other answers as well. **A**, **B** and **C** all describe a less efficient cell.

Question 25

This is a relatively straightforward question that deals with speed, distance and time. Most candidates obtained the correct answer, but a few candidates were tempted into dividing by two and gave answer **B**. This would be appropriate for an echo but not in this situation.

Question 29

This was a difficult question. A significant minority gave answer **A**. This answer assumes the resistance of two 3.0 Ω resistors in parallel can be obtained by addition, which is not correct. Two resistors of resistance 3.0 Ω in parallel have a combined resistance of 1.5 Ω. The effect of switch S_3 was widely recognised.

Question 30

More candidates chose the correct answer **A** than any other, but there were some candidates who opted for **B** and **C**. Graph **B** would be more appropriate for a resistor.

Question 31

This question required careful reasoning and candidates found it difficult. If the current in the cell and in resistor **A** is I, the currents in resistors **B**, **C** and **D** will be $3I/4$, $I/4$ and $I/2$ respectively. The smallest current is in resistor **C**.

Question 32

Many candidates chose the correct answer **A**, but the number who chose **B** was high. This arrangement would have given an upward force.

Question 33

The correct answer **D** was the most popular. Some candidates chose **B** and this suggests that the effect of the rotation rate on the amplitude of the output was being forgotten by some.

Question 35

Many candidates chose **D**, which is the reverse of the correct answer. One way to remember the behaviour of LDRs and thermistors is to consider that the resistance decreases as the incident energy increases.

PHYSICS

Paper 5054/21

Theory

Key Messages

- To gain full credit, candidates should always give units when giving the final answer to numerical questions. They should also be encouraged to give answers to an appropriate number of significant figures (usually at least two), and for this reason fractions are not accepted.
- A few candidates write some answers out in pencil before writing over the pencil in ink. This frequently leads to the answer being less legible and, when combined with crossings out and uncertain expression, the answer can be extremely difficult to interpret.
- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided. Sometimes, the need arises to cross out an answer to part of a question and replace it with a new answer elsewhere. If this is done, candidates should make a simple reference to the location of the new answer. Candidates must not, however, write answers on the front cover sheet.
- 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 usually worth drawing it carefully and neatly and then labelling it, so that its intention is clear.

General Comments

The questions were accessible to all candidates and there was no section of any of the questions where a correct response was not seen, although **Question 4** almost invariably produced very low scores, indicating the unfamiliarity of candidates with the methods of heat transfer inside an electric grill. **Question 11(c)** was also found difficult. The standard of written English was high and there was no evidence of a language problem, even for the weaker candidates. The quality of expression, even among the weaker candidates, was good, even if 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 8(a)**, many candidates produced a list of the properties of different absorbers of radiation without describing how they could show that a given radioactive sample does **not** emit alpha-particles. The more able candidates expressed themselves eloquently and succinctly, confining their answers to the question asked, and were awarded full credit.

Calculations were generally performed well, except for **Question 7(b)** which was 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 a mark 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) The mass of the water in the swimming pool was determined correctly by the majority of candidates.

(b) (i) Most candidates knew the method required to calculate the thermal energy needed to raise the temperature of the water, and also used the correct equation. Many subsequently encountered difficulties because the specific heat capacity of the water was given in units of J / (g °C), but the mass they had calculated in **(a)** was in kg.

(ii) A large number of candidates were aware that, in practice, more energy than that calculated would need to be supplied to the water during the heating process. Although many candidates mentioned heat losses, credit was only gained if candidates stated a specific example where heat was being lost or gained.

Question 2

(a) The law of moments was usually selected by candidates to determine the weight of the boy. Where errors were made, it was because incorrect distances were used.

(b) Only the more able candidates produced logical and sequenced arguments to describe and explain what happened as the boy and girl moved away from each other. Many candidates picked up one of the three marks available by stating that the see-saw tips down on the girl's side. Far fewer candidates went on to explain correctly why this should happen. Most candidates ignored the instruction given in the stem of the question, which was to describe <u>and</u> explain.

Question 3

(a) The explanation of the pressure exerted by a gas being caused by molecular collisions was well known. A common omission was to neglect to state what the molecules were colliding with.

(b) (i) Most candidates used Boyle's law correctly to determine the pressure of the compressed air. A significant number of candidates ignored the fact that the pressure units here were kPa, and lost credit because they used an incorrect unit in their answer.

(ii) Candidates had no difficulty in obtaining the size of the force, but many answers were out by a factor of 10^3 because they forgot to convert the kPa to Pa.

(iii) Candidates met with varying degrees of success here. The stronger candidates realised that the new pressure would be greater than before and went on to explain in terms of molecules why this should be so. Weaker candidates realised that the air molecules would be travelling faster, but did not explain carefully enough that this would increase their collision rate with the walls of the pump.

Question 4

(a) Candidates found great difficulty in explaining what the word 'radiation' meant in the context of this question. Only a minority of the most able candidates realised that, in the electric grill, the radiation concerned was infra-red. Partial credit was awarded to those candidates who realised that the radiation was an electromagnetic wave or that it could travel through a vacuum.

(b) (i) This question was found by candidates to be very difficult. Only a small number of candidates were able to state that very little thermal energy travelled to the food by conduction because the air inside the grill is a poor conductor.

(ii) This was answered slightly better than **(i)**, but the majority of responses showed that candidates did not understand why thermal energy from the grill did not reach the food by convection. Any indication by candidates that hot air rises, and therefore would not reach the food, was sufficient to gain credit.

Question 5

(a) The standard of diagram drawing was not generally high. Whilst there were many neat, correct carefully drawn diagrams making use of a ruler, there were also many untidy freehand-drawn diagrams which did not show the main parts of the structure of a clinical thermometer. A common error was to omit a constriction in the diagram. The presence of a liquid inside the capillary tube was often absent.

(b) Very few candidates obtained full credit here. Many candidates were aware that, when the thermometer is removed, the thread of liquid would break at the constriction so that the thermometer would continue to show the maximum temperature reached. Only a small minority of candidates went on to say that this was due to the liquid contracting (suddenly) on cooling.

Question 6

(a) This question was done well. The most popular correct answer here was steel, and the most popular incorrect answer was iron.

(b) Fully correct answers were rare, with most candidates gaining partial credit for correctly drawing one of the compass needle directions correctly. Many diagrams which had both compass needles drawn with the correct orientation were spoiled by mixing up the north and south poles.

(c) About half of the candidates were able to describe correctly an electrical method of demagnetising a magnet. Common misconceptions were that a direct current could be used, and/or the magnet could be left inside the solenoid and the current then switched off.

Question 7

(a) (i) This calculation of the electric current in a heating element was done well. When credit was lost, it was usually because candidates had neglected to convert the power of the heater to watts before determining the ratio, and/or neglecting to give a unit in their answer. More seriously, a significant minority of candidates used the inverse of the correct formula to determine the current.

(ii) Many candidates who had correctly determined the current in the heating element could not proceed to give an appropriate rating for the circuit breaker. The rating given by many candidates was the same as the current they had determined in **(i)**.

(b) The calculation of the cost of using an electrical appliance caused great problems for candidates. Only the more able candidates met with success here. Many candidates simply multiplied all the given numerical data together. Candidates were unable to cope with the fact that the time of use of the appliance was given in minutes and they either did not convert this time to hours or converted it to seconds instead.

Question 8

(a) Candidates would have had much more success here if they had taken care to think and organise their answers before starting the experimental description. Many candidates lost sight of the fact that their description needed to show that the sample did <u>not</u> emit alpha-particles. Most answers were based on the absorption properties of radiation, but many of them just consisted of a list which bore no relevance to the question being asked. There were some excellent descriptions given by the stronger candidates based upon both absorption and deflection experiments.

(b) Answers to this standard question were generally poor. Many candidates gave one relevant precaution, but most struggled to give two. A correct answer which was very rarely seen was to minimise the time of exposure when working with radioactive substances.

Section B

Question 9

(a) The difference between speed and velocity was well known. Weaker candidates often reversed the difference and stated that speed was the vector.

(b) (i) The calculation of the weight of the skydiver was done correctly by the majority of candidates.

(ii) Candidates found this question difficult. Only the better candidates realised the significance of the time range quoted and then went on to reason that, during this time, the speed was constant and therefore the size of the air resistance force was equal to the weight.

(c) (i) Most candidates read the graph correctly to determine the speed of the skydiver between 0 and 12 s. Weaker candidates misread the speed scale and a speed of 52 m / s was often incorrectly quoted.

(ii) Again, candidates found little difficulty here with most realising that the area under the graph between 0 and 12 s gave the required distance.

(iii) Many candidates found this calculation difficult. Some candidates were unsure what value to substitute for *h* in the equation PE = *mgh*. The stronger candidates realised that the value required was that of the distance they had calculated in **(ii)**.

(d) Many candidates incorrectly stated that the gravitational potential energy of the skydiver would change to kinetic energy, despite being told that the skydiver was falling at constant speed. A very small minority of candidates stated correctly that the potential energy would be converted to heat/internal energy.

(e) (i) Although many candidates stated correctly that the air resistance force would increase upon opening the parachute, far fewer gave the reason for this, namely that the area of contact had increased.

(ii) The effect on the motion of the skydiver of opening the parachute was poorly explained. Although many candidates stated that the skydiver would slow down, far fewer gave the reason for this. Only the better candidates went on to say that there was now a net upward force on the skydiver. A sizeable minority of candidates thought that, upon opening the parachute, the skydiver would start to move upwards.

(f) Few candidates used the graph to note that, after *t* = 15 s, the speed was decreasing and so the size of the air resistance force would also be decreasing. Most candidates stated that it was equal to the weight of the skydiver.

Question 10

(a) (i) This was well answered with most candidates stating that light travels faster than sound.

(ii) Most candidates realised that the time delay between the lightning and the thunder needed to be measured. Not all went on to say that the speed of sound could then be calculated by dividing the distance to the hillside by the time delay.

(b) (i) About half of the candidates were able to state the speed of light in air correctly. Many correct answers lost credit because no unit was given. Common incorrect answers seen were 3.8×10^8 m / s and 300 m / s.

(ii) Most candidates used the correct form of the wave equation to determine a value for the wavelength of the light. Power of ten errors were very common. Again, many correct answers were spoiled by the lack of a unit.

(iii) This was done well by most candidates. The most common error was to state the colours in order of decreasing wavelength, which was contrary to the order asked.

(c) (i) The angle of refraction in the glass was usually marked correctly. Where mistakes were made, the complement of this angle was marked.

(ii) Only a small minority were able to describe how the path of the ray in the glass could be drawn. It was evident from the responses of the candidates that many of them had not seen an experiment of this type demonstrated, or indeed had not done it themselves.

(iii) This part of the question was well answered. Most candidates were able to state the required formula and then use it to calculate the refractive index of glass.

(iv) Most candidates achieved at least partial success with this standard refraction drawing. To obtain full credit, the direction of refraction of the red light had to be correct at both faces of the prism and the deviation of the red ray needed to be less than that of the blue ray at both faces. A very common error was to ignore the instruction given in the stem of the question that the red light travelled along the same path as the blue light before entering the prism. Many candidates drew a separate red beam at a different initial angle of incidence to the given blue beam.

Question 11

(a) (i) The current measured by the ammeter was usually correctly calculated. The most common error was to forget to include the resistance of the variable resistor when determining the total circuit resistance and to use a total resistance of 4.0 Ω instead of 12 Ω.

(ii) The potential difference across the 4.0 Ω resistor was usually calculated correctly.

(b) Candidates found this question (both **(i)** and **(ii)**) difficult, and answers to these parts appeared often to consist of guesswork.

(c) Only a minority of the strongest candidates understood what was required here. Most candidates were unaware that the line on the c.r.o. screen would move up or down. A very common incorrect answer was that a waveform would be seen on the screen.

(d) (i) Very few candidates were able to write five correct names in five correct corresponding boxes. Most candidates were aware of the names of the different parts of a c.r.o., but were unable to identify where these are located in the device.

(ii) Many candidates were unaware that the electron beam was produced by heating the filament and that electrons were attracted by the anode.

(iii) The need for an evacuated tube was not well known.

(iv) **1.** Only the more able candidates stated that electrons are charged particles and thus a flow of them constitutes an electric current.

2. Many candidates stated incorrectly that the direction of the conventional current due to the electrons was in the same direction as the electrons were travelling, i.e. towards the screen.

PHYSICS

Paper 5054/22

Theory

Key Messages

- To gain full credit, candidates should always give units when giving the final answer to numerical questions. They should also be encouraged to give answers to an appropriate number of significant figures (usually at least two), and for this reason fractions are not accepted.
- A few candidates write some answers out in pencil before writing over the pencil in ink. This frequently leads to the answer being less legible and, when combined with crossings out and uncertain expression, the answer can be extremely difficult to interpret.
- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided. Sometimes, the need arises to cross out an answer to part of a question and replace it with a new answer elsewhere. If this is done, candidates should make a simple reference to the location of the new answer. Candidates must not, however, write answers on the front cover sheet.
- 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 usually worth drawing it carefully and neatly and then labelling it, so that its intention is clear.

General Comments

A recent reminder on the importance of the correct unit when stating a numerical answer seems to have been noted: although some candidates forget to include units, many more realise that they are essential and include them wherever they are required. A very small number of candidates, however, do omit the units and sometimes are lose credit in several places on the examination paper for doing so. This is unfortunate when, elsewhere, the answers reveal a satisfactory understanding of the topics being examined.

There were some occasions when an answer given would be a good answer to a question that was asked in a previous paper but which does not quite deal with the specific points being tested in the current question. Whilst a familiarity with the sort of answer that is considered correct is to be encouraged, candidates might also be advised to make sure that the answer given deals with the exact points being raised in the question.

There was a wide range of marks scored and some candidates have a clear and insightful understanding of the subject at this level. The rearrangement of formulae caused problems for some candidates. When using a calculator, candidates might be advised to check that the answer obtained is a likely value. It is very easy to press the wrong key and to multiply rather than to divide or to omit a decimal point.

Comments on Specific Questions

Section A

Question 1

(a) Some candidates were uncertain about the direction of the tension in the chain. Many answers were offered here and many different directions were suggested. Part **(ii)** was more commonly well answered in one way or another and most candidates drew an arrow downwards from the traffic lights.

(b) Many candidates were awarded full or nearly full credit here. The candidates who clearly understood what was required drew the correct scale diagram and almost always measured its length with sufficient accuracy to obtain a value for the resultant force that was within the specified limits. A common reason for not obtaining full credit was for a candidate to draw the wrong diagonal of the rectangle for the scale diagram. Although this has the correct magnitude, it does not point in the correct direction.

Question 2

(a) The answer given here was almost always correct and a large majority of candidates were awarded full credit. A few of the weaker candidates could not recall the exact definition of density and were not awarded any credit here as a result.

(b) This was less well answered, although some candidates did give exactly what was expected. Many answers centred on the increased weight of the wheelbarrow rather than its increased mass and the link to inertia was only made in a minority of cases.

Question 3

(a) (i) The majority of candidates were familiar with the definition of pressure and were able to obtain full credit for the answer. Some candidates, who realised what was expected, used the wrong piston area in the formula and did not then calculate the correct answer.

(ii) This part of the question was also well answered either because the correct answer was obtained or because an erroneous answer from the previous part was correctly used. A few candidates did not give the answer the unit (newton) even though this was given in the question as the unit of force.

(b) This was rarely correctly answered. Very few candidates made any reference to the atmospheric pressure which is the principal reason for the resultant force being less than the calculated value. A few candidates talked in terms of the friction between the oil and the walls of the piston, but most made some reference to the differing areas of the pistons which is not a relevant response to this part.

(c) The correct formula was very commonly used by candidates here and the correct answer was frequently obtained and given the correct unit. Amongst those who did not get the correct answer, the most common misunderstanding was the use of a force or pressure that was calculated in **(a)** instead of the appropriate value given earlier in the question.

(d) Only a minority of candidates gave the correct answer to this part.

Question 4

(a) The majority of candidates gave the correct answer here with the correct unit. Candidates should be advised that the correct unit of temperature is the degree Celsius (°C); the degree (°) is a unit of angle. Some candidates lost this mark as a result of confusion with the scale. The side of one 2.0 mm square represented 2.0 °C not just 1.0 °C. Scales of this sort are commonly used and candidates need to be familiar with their interpretation.

(b) This was often correctly answered. The candidates who were not awarded full credit revealed a variety of misunderstandings. Some attempted to use the 13 minutes which the wax took to solidify and some others divided the mass by the specific latent heat of fusion value.

(c) (i) More candidates incorrectly stated that the wax was melting than stated that it was solidifying. A few candidates used the term ‘condensing’.

(ii) Given that many candidates had misinterpreted the direction of the phase change, it was practically inevitable that the same misunderstanding would be apparent here. Many candidates who are used to dealing with the molecular explanation for melting found it difficult to reverse the argument and apply it to the case of solidification.

Question 5

(a) Many candidates knew exactly what was needed here and gave an encouraging and accurate response. Candidates who talked merely in terms of the motion of the particles without reference to their vibrations did not obtain full credit.

(b) (i) Acceptable values were very often given here and this part of the question was well answered.

(ii) Most candidates were able to quote and use the correct formula but many candidates substituted the lowest audible frequency rather than the highest. Candidates who quote the formula in the form $w = f\lambda$ are possibly confused and are certainly not being clear as to whether w represents wavelength or velocity. It is best when quoting formulae to use the usual notation.

Question 6

(a) The particles that move during electrostatic charging are electrons and, without referring to them, candidates were unable to obtain any credit here. Some candidates referred to positive electrons, suggesting that this topic is poorly understood.

(b) There were many correct answers here, but there were also candidates who were unsure of what problems might arise when an aeroplane is charged.

(c) Most candidates obtained full credit in both parts.

Question 7

(a) This question was well answered by many candidates and most candidates had some idea of what was required. Various combinations of the numbers in the question revealed that some candidates were unsure of how this calculation should be approached.

(b) Only the strongest candidates were able to answer this question in the fashion expected. Very few candidates made any reference to the role of the fuse in the protection of the workman, but it was still possible to obtain full credit with other answers.

Question 8

(a) (i) Many answers here were sensible but imprecise. Very few candidates suggested restricting the time of exposure as an appropriate precaution.

(ii) Few candidates made any reference to the random nature of radioactive emission here. Some of those who did also mentioned that the process is spontaneous. These terms have different meanings which candidates are expected to know.

(b) Many candidates were able to make one or two general points about the properties of beta-particles and gamma-rays that were relevant here, but only a few candidates were able to apply these points to the specific case of the smoke detector.

Section B

Question 9

(a) Many candidates gave the definition of moment and obtained full credit for the answer.

(b) (i) 1. Many candidates calculated this answer correctly and included the correct unit. Some candidates multiplied both the distance and the force by a factor of six and calculated an answer that was six times too large. Although the unit joule is dimensionally equivalent to the newton metre, it is not considered an appropriate unit for moment.

2. The correct answer was very commonly given by candidates.

(ii) To obtain full credit here, candidates were expected to explain how the energy was wasted as well as stating how it was wasted. Only a minority of candidates, who referred to friction, suggested a surface or an object upon which it was acting.

(iii) Many candidates stated that the sailors are doing more work when the anchor is being lifted faster. This is not the case unless it is clear that a constant time interval is being considered.

(c) Many candidates were able to state the principle of moments and to draw a diagram of an appropriate arrangement of apparatus for its verification, but only a minority obtained full credit for supplying a full description of the procedure necessary.

Question 10

(a) (i) This graph was frequently well drawn and many candidates scored highly. Some stronger candidates did not receive full credit here, because the initial section of the curve was straight for too long.

(ii) Many candidates made a correct reference to the area under the curve, but fewer added that it was the area beneath the section of the graph for the period when the train was accelerating (not the total area under the graph) that was the significant area in this case. This is an example of where careful reading of the question is needed.

(b) (i) Although many candidates stated that this effect was caused by air resistance, a smaller number explained that it is the increasing air resistance that is significant.

(ii) A considerable number of candidates stated correctly that two forces cancel out, but it was unfortunate that some of these candidates stated that it was the weight rather than the driving force that is equal to the air resistance.

(c) (i) Although this is a standard calculation, it is also a somewhat involved one and it is encouraging to see this part answered so well by so many candidates. It is worth reminding candidates that the power of two that is included in the formula must not be forgotten when the numbers are substituted into the formula.

(ii) This calculation caused some problems. Most commonly, the previous answer was multiplied by the efficiency rather than divided by it. Candidates might be reminded that the definition of efficiency includes the terms energy or power. The ratio output/input does not, on its own, score credit.

(iii) This question needed to be read carefully. First, it restricts answers to the stages between the energy being present as chemical energy and its being transformed into electrical energy. Secondly, it is concerned with the places where the energy transformations occur. There were candidates who gave answers which were not relevant because they had not read the question carefully.

Question 11

(a) Several candidates were able, when explaining the meaning of e.m.f., to quote the ratio energy/charge in some form. Only a minority of these candidates, however, added the further detail concerning the forms of the energy transformed that are involved in this case.

(b) (i) Many candidates drew the correct symbol in a correct position. This simple piece of knowledge was very widely understood.

(ii) Candidates found this marginally more testing that the positioning of the ammeter but, even so, a very large number of candidates obtained full credit here.

(c) (i) This was well answered. The number was usually accurately read from the graph and most candidates gave the correct answer and the correct unit, and choose an appropriate number of significant figures.

(ii) Most candidates scored full credit here.

(d) This calculation was commonly performed accurately.

(e) (i) Many candidates realised what was expected here and scored well, though there were candidates whose answers stated that the term applied to the emission of electrons but which supplied no further details. These answers did not obtain full credit.

(ii) 1. An appropriate answer was commonly offered here.

2. Many candidates struggled in this part. There were some candidates who stated, in some way, that a vertical motion of the trace would be the effect, but very few candidates explained why this would happen.

PHYSICS

Paper 5054/31
Practical Test

Key Messages

- Candidates should be aware that it is important to record measurements to the correct precision. In particular, measurements from a metre rule should be given to the nearest millimetre to gain full credit. Measurements of time from a digital stopwatch should be given to 0.01 s.

- A common cause of lost credit on this paper is the omission of units, or use of inappropriate units (e.g. kg when g was intended). Candidates should be encouraged to ensure that all answers are provided with units where needed, and to check that the unit is appropriate for the measured or calculated quantity.

- If asked to determine an accurate value for a particular measurement, then the measurement should be repeated and an average should be taken. The repeat measurements should always be shown, even if they are identical to the original measurement. Time measurements are generally less accurate so at least 3 measurements should be taken.

- When using a meter with a dual scale, candidates should ensure they know which scale to use when the meter is on a particular range.

General Comments

In addition to the Key Messages given above, stronger candidates could further improve their answers by following these instructions:

- If the graduations on a scale are widely spaced, attempt to interpolate between the divisions.

- In calculations, ensure that the data used in the calculation matches the data that you have taken during the course of the experiment.

- Apply your knowledge of physics theory to the practical experiment that you are performing.

The paper seemed to have been found particularly difficult by the very weakest candidates, particularly **Question 4**. In this question, weaker candidates confused the mass that was placed on the block and the mass that was added to the mass hanger with the result that some of their results did not make sense.

Comments on Specific Questions

Section A

Question 1

(a) Weaker candidates either omitted units from the three quantities d_1, d_2 and h or quoted one of the values to the nearest cm rather than the nearest mm, e.g. 2 cm rather than 2.0 cm. Only the very strongest candidates repeated their measurements of d_1, d_2 and h.

(b) The most obvious precaution was to repeat the measurement of one of the diameters by measuring in a direction that was perpendicular to the original direction, but very few candidates stated this precaution. If avoiding parallax error was stated as a precaution, then candidates had to state how this was ensured, e.g. by having the stopper in contact with the rule. Generally only the best candidates scored this mark.

(c) Weaker candidates tended to make the following errors:

- Calculating an incorrect value for *z* resulting in an incorrect value for the density.
- Omitting units from the value of the density.
- Quoting the density to more than 3 significant figures.

Question 2

(a) Most candidates were awarded credit for *V* and *m*. The main reason for the loss of the mark was the omission of the unit from the value of *V*.

(b) Most candidates successfully recorded the initial temperature of the water in the beaker.

(c) Generally candidates recorded the highest temperature reached by the water in the beaker correctly. The following errors led to the loss of the mark:

- The units of temperature were occasionally quoted as ° (a unit of angle) rather than °C, or the units of temperature were omitted.
- Only a small number of candidates attempted to interpolate between the divisions of the thermometer.
- Some candidates recorded only a very small rise in temperature, possibly because the beaker was too far above the top of the candle flame. A small rise in temperature was sometimes due to an incorrect reading of the thermometer. For example, the Examiners suspected that a temperature rise recorded as 20.2 °C to 20.7 °C was actually a temperature rise from 22 °C to 27 °C.

(d) Stronger candidates calculated the power correctly and gave the correct unit. Some candidates did the correct calculation but used the wrong unit. Popular incorrect units were J and J / (g °C). Weaker candidates either omitted the calculation or used a mass value that was not consistent with **(a)**. Typically a mass of 1 g was used.

(e) Many candidates were able to state that heat was lost to the surroundings. Very weak candidates tended to leave this question blank.

Question 3

(a) Generally candidates recorded a correct value for *V*. The most common errors were:

- The omission of units both here and in **(c)**.
- Not recording *V* to the nearest 0.1 V or better, e.g. 3 V rather than 3.0 V.

Generally candidates recorded a correct value for *I*. The most common errors were:

- The omission of units both here and in **(c)**.
- Wrong units both here and in **(c)**, in particular the use of A rather than mA, e.g. 50 A rather than 50 mA.
- A value of current that was not in the correct range, probably because a dual scale meter was used and the candidate used the wrong scale, e.g. 140 mA rather than 70 mA.

(b) The resistance was usually calculated correctly. The most common errors were the omission of units or the lack of conversion from mA to A.

(c) When the flying lead was connected to A, the resistor X was short-circuited so there was less resistance in the circuit. This led to a higher current which should have resulted in a decrease in the terminal potential difference of the cell. The results of stronger candidates showed this effect and they obtained a value for I that was in the correct range. The results of some candidates indicated that Y had been short-circuited rather than X, i.e. the flying lead had been connected to C rather than A. This was because the current was not in range because it was too high.

(d) The resistance R_Y was generally calculated correctly, and it was expected that it would be less than R because X had been short-circuited so the total circuit resistance was less. Many candidates could successfully calculate R_Y but were unable to calculate R_X because they did not realise that they could apply the series resistance formula to the circuit. Others obtained a negative value for R_X because of errors made in the reading of the current or voltage.

Section B

Question 4

(a) Despite the fact that the kg unit was at the end of the answer line, a number of candidates recorded M in g. Repeat results were often not shown even though the average value of M was different suggesting that the results had been repeated. The errors made by some candidates in the calculation of W included:

- The omission of units.
- The use of kg or g as the unit.
- The use of the mass in g rather than kg. It was hoped that the use of kg at the end of the answer line for M would encourage candidates to do the conversion to kg so that the correct value for W would be obtained.

(b) The results table produced good discrimination between candidates. Weaker candidates confused M and P. Examiners expected that P would increase in increments of 100 g and that M would increase in increments of 10 g, but it was clear that some candidates had placed 10 g masses on top of the wooden block with little significant change in the values of M. Stronger candidates obtained at least 5 corresponding values of P, M and W with W increasing as P increased and P increasing in increments of 100 g. An additional problem in the table was that very few candidates showed repeated values of M at a given P, even though the idea of repeats had been given in **(a)**.

(c) Because the data from **(a)** represented $P = 0$, it was expected that most candidates would start the graph at the origin. This made the choice of scale slightly easier than in some years and many candidates obtained the scale mark.

(d) (i) Good candidates accurately read a triangle that used more than half the drawn line and produced an accurate value for the gradient of the line. Weaker candidates tended to use small triangles or misread the sides of the triangle.

(ii) The majority of candidates read the intercept correctly but often omitted the unit.

PHYSICS

Paper 5054/32
Practical Test

Key Messages

- Candidates should be aware that it is important to record measurements to the correct precision. In particular, measurements from a metre rule should be given to the nearest millimetre to gain full credit. Measurements of time from a digital stopwatch should be given to 0.01 s.

- A common cause of lost credit on this paper is the omission of units, or use of inappropriate units (e.g. kg when g was intended). Candidates should be encouraged to ensure that all answers are provided with units where needed, and to check that the unit is appropriate for the measured or calculated quantity.

- If asked to determine an accurate value for a particular measurement, then the measurement should be repeated and an average should be taken. The repeat measurements should always be shown, even if they are identical to the original measurement. Time measurements are generally less accurate so at least 3 measurements should be taken.

- When using a meter with a dual scale, candidates should ensure they know which scale to use when the meter is on a particular range.

General Comments

In addition to the Key Messages given above, stronger candidates could further improve their answers by following these instructions:

- If the graduations on a scale are widely spaced, attempt to interpolate between the divisions.

- In calculations, ensure that the data used in the calculation matches the data that you have taken during the course of the experiment.

- Apply your knowledge of physics theory to the practical experiment that you are performing.

There seemed to have been an improvement in the practical skills required to carry out the optical experiment (**Question 4**) compared to previous years. However, the calculation in **Question 2** seemed to produce more difficulty than similar calculations in previous years.

Comments on Specific Questions

Section A

Question 1

The large variety of stands used in this experiment made it difficult to give marks for accuracy, but the Examiners were able to test the precision with which candidates took readings and whether the readings taken were sensible.

(a) The majority of candidates obtained a length between 1.5 cm and 3.0 cm, quoted the value to a precision of 1 mm and used an appropriate unit. A small number of candidates did not use the correct precision (e.g. 2 cm) and a small number omitted the unit.

(b) In the majority of cases the value of x was sensible. Some credit was lost where the value was quoted to the nearest cm or units were omitted.

(c) The value of y should have been greater than x, z should have been less than x and L should have been greater than l. The results of the majority of candidates showed this correct trend. As in the previous sections, incorrect precision in the measurements or omission of units was a common cause of lost credit.

(d) Most calculations of W were correct. In some cases the mark was lost either because the unit was incorrect or because the answer was quoted to too many significant figures. Typical incorrect answers for the unit included kg, g or N / cm. Since the majority of measurements were taken to 2 or 3 significant figures, the Examiners expected no more than 3 significant figures in the final answer.

Question 2

(a) Generally candidates recorded the temperatures correctly. The following errors led to the loss of marks:

- The units of temperature were occasionally quoted as ° (a unit of angle) rather than °C.
- Only a small number of candidates attempted to interpolate between the divisions of the thermometer.
- Some candidates delayed starting to record the temperature when the hot water was poured into the beaker. This resulted in a relatively small θ_2 value.

(b) Only the strongest candidates calculated the thermal energies successfully. The following errors were seen from other candidates:

- A mass of 1 g for both the hot and cold water was used, presumably because candidates had seen g in the units of specific heat capacity.
- A combined mass of 150 g for both hot and cold water was used.
- Masses were used the wrong way round, i.e. 50 g for the hot water and 100 g for the cold water.
- The wrong temperature change for the cold water was used, typically $\theta_2 - \theta_1$.

(c) The mark in **(c)** was dependent on the correct calculations in **(b)**. The statement had to be sensible: for example, if the candidate's results indicated that the hot water lost less heat than the cold water gained, then this could not be attributed to heat lost to the surroundings. In this case it is likely that the cold water gained heat from the hot beaker as well as from the hot water.

Question 3

(a) Because of the variation in the lamps used, it was not possible to supply a range for the expected values of the potential difference across the lamp or the current in the lamp. However, it was expected that the potential difference across the lamp plus the potential difference across the resistor should be equal to the voltage of the power supply. This was expected to be 3 V, although a number of Centres reported using smaller supply voltages, and the Examiners took account of this. Sensible results were thus judged against $3\,\text{V} \approx V + 3.3\,I$. The following errors led to the loss of marks:

- Units were omitted from the voltage or current measurements.
- The units of current were given as A rather than mA.
- Values were out by a factor of, say, 2, because the wrong scale of the meter was read.

(b) The resistance was usually calculated correctly. The most common errors were the omission of units or the lack of conversion from mA to A.

(c) A number of candidates seemed to have connected the voltmeter between points A and C, because the potential differences in **(a)** and **(c)** were identical. Examiners expected V_2 to be less than V_1. As in **(a)**, it was expected that $3\,\text{V} \approx V + 33\,I$ (note the use of 33 because the resistor had been changed to one of value $33\,\Omega$).

(d) The resistance was generally calculated correctly. It was expected that this resistance would be less than the first value because the filament would have been at a lower temperature.

(e) Candidates did not generally refer to the change in temperature. A very small number of candidates said that Ohm's law was not obeyed because the physical conditions had changed.

Section B

Question 4

(a) A significant number of candidates incorrectly thought that the angle of incidence is the angle between the incident ray and the surface of the block.

(d) Ray construction was better than usual this year. Many candidates correctly placed a pin at the point where the ray left the block, and the pins on the incident ray had a large separation, indicated by one of the pins being close to the edge of the page. Strong candidates obtained a correct value for the angle of refraction.

(e) The results table produced good discrimination between candidates. Weak candidates had a small number of results, over a narrow range with values that were not particularly accurate. Stronger candidates had a large number of accurate results over a wide range. Typical errors that led to the loss of marks were:

- Units for sin *i* and sin *r* in the headings of the table.
- Values of the sines only being quoted to 1 significant figure.
- A narrow range of angles being used in the experiment.
- Measured values not being in the expected range, i.e. they were inaccurate.

(f) The most common error in the graph plotting was that the plotted data occupied less than half the page in either the *y*-axis direction or the *x*-axis direction. Candidates should be encouraged to choose scales such that the data occupies more than 12 cm vertically and more than 8 cm horizontally.

(g) Strong candidates accurately read a triangle that used more than half the drawn line and produced an accurate value for the refractive index of glass. Typical mistakes made by the weaker candidates were:

- Using a small triangle.
- Misreading the sides of the triangle.
- Finding an inaccurate value for the gradient because their results were inaccurate.

PHYSICS

Paper 5054/41
Alternative to Practical

Key Messages

- 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 the points will often produce a curve that is not smooth, and candidates should be discouraged from attempting to do this.

- Credit is often lost for lack of care and attention to detail when drawing or annotating diagrams. Many candidates would benefit from further practice at drawing diagrams. The accuracy of straight lines on diagrams could be improved by using a sharp pencil and a ruler.

- Candidates should avoid using learnt phrases such as “to make it more accurate” or “to avoid parallax error”. These comments alone will not usually be credited, because the responses need to be linked to the practical situation, e.g. “avoid parallax error in reading the voltage on the voltmeter”.

General Comments

The Alternative to Practical paper requires candidates to have a good background in practical physics. Candidates who have not used or assembled equipment will find the questions much more challenging than those who have regularly participated in practical work during their physics lessons. It is important to ensure that learners have the opportunity to develop practical skills by the discussion of practical techniques during demonstrations as well as by handling equipment themselves.

The level of competence shown by the candidates was sound, although, as in previous years, some candidates approach this paper as they would a theory paper, and not from a practical perspective. Only a very small number of candidates did not attempt all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Many candidates dealt well with the range of practical skills being tested. The stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were generally 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) The majority of candidates marked the height of the sphere above the bench correctly. A vertical line from the top of the bench to somewhere within the sphere was expected, but some candidates did not gain this mark because of careless drawing. Occasionally, the distance from the sphere to the top of the plastic channel was marked.

(ii) Most candidates realised that a mark should be made or a pointer placed at the point of release to ensure that the sphere was released from the same point each time.

(b) (i) Candidates found difficulty in drawing the path taken by the sphere after it had left the channel. What was expected was an initial horizontal section followed by a curved (parabolic) path. There were some serious misconceptions about the path followed by the sphere – a sizeable minority of candidates thought that the sphere would fall vertically, and many candidates thought that the path taken would be a diagonal straight line.

(ii) The horizontal distance travelled by the sphere was usually marked correctly on the diagram, although many candidates lost this mark by drawing untidy freehand diagrams which usually did not span the complete distance. Candidates should be advised to use rulers and to attempt to mark the distance as precisely as they can.

(c) This was done well. The most common correct answers were to paint the sphere so that it would leave a mark on the floor, or to let it land in a tray of sand.

(d) Although the average value of *d* was usually calculated correctly, the majority of candidates ignored the instruction to give their answer to a suitable number of significant figures. The other values of *d* given in the table below should have given candidates a clue as to how many significant figures were required.

(e) (i) Only a very small number of the most able candidates were able to answer this question correctly. Most candidates tried to use the data in the table to extrapolate a value of *d* when $h = 0$, and were unsuccessful. What was required here was the understanding that, when $h = 0$, the ball would have no horizontal velocity and would thus fall vertically downwards and travel no distance horizontally.

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

(iii) Most candidates correctly stated that the given suggestion was incorrect and were able to justify this by stating that the line was not straight or did not pass through the origin.

Question 2

(a) (i) Many candidates realised that if candidate B was not concentrating, the card would fall further before he caught it or that he might miss it altogether.

(ii) This part was well done, with the majority of candidates realising that the candidate with the fastest reaction time would catch the card at a lower number on the marked scale.

(b) (i) Most candidates correctly calculated that the distance fallen by the card in 0.1 s was 5 cm, but many of these candidates lost credit because they omitted to give the unit.

(ii) The calculation of the reaction time proved to be difficult, and only the most able candidates were able to calculate the correct time.

(iii) Candidates found great difficulty in conveying the meaning of the word *calibrate*, even though the question text describes the process involved. In the context of this question, all that was required was to state that it meant to mark *time* on the card. Only a very small number of the most able candidates had any idea of how to mark the calibrated card. Many attempts consisted of a series of equidistant lines marked of the card, but some of the strongest candidates correctly showed the separation of the lines increasing and had a correct time marked.

Question 3

(a) The normal at the point of incidence was usually drawn correctly and the correct angle of incidence was marked and measured. Common mistakes were drawing the normal at the point of incidence vertically and measuring the angle of incidence to the block rather than to the normal.

(b) (i) This was done well, with most candidates realising that the purpose of the board was to allow the pin to stand up.

(ii) The need to have a reasonable distance between the optics pins was appreciated by a minority of candidates. Acceptable answers were to place the pin at the end of line L or to place them more than 5 cm apart. A very common incorrect response was to place the second pin at the point where the incident ray hits the glass block.

(iii) The need for both optics pins to be vertical was not understood. Very few correct answers were seen, which suggests that few candidates had actually performed an experiment with optics pins. Candidates will be able to score more highly on this paper if they have practice of carrying out this type of practical work as part of their study of physics.

(c) Very few candidates were able to produce a sensible reason as to why the student would find it difficult to mark the emergent ray, with the apparatus set up as it was. It was evident reading the responses of candidates that many were unaware of where the emergent ray would be. The more able candidates realised that the block was too near the edge of the paper and, consequently, there would be no room to place pins on it.

Question 4

(a) Despite the highly structured nature of this question, which was designed to help candidates plan their answers, many candidates did not read the instructions carefully and consequently lost credit. The question was a straightforward determination of resistance using an ammeter and a voltmeter, but only a very small minority of candidates gained full marks. Several marks were awarded for a correct circuit diagram, but only a very small number of candidates gained these marks.

The most common errors were ammeters connected in parallel and voltmeters connected in series. There was often an absence of any means of varying the current so that a range of readings could be taken, despite the fact that candidates had been told to do so.

(b) Many candidates met with more success here and were able to describe one way of improving the accuracy of their experimental result.

PHYSICS

Paper 5054/42
Alternative to Practical

Key Messages

- 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 the points will often produce a curve that is not smooth, and candidates should be discouraged from attempting to do this.

- Credit is often lost for lack of care and attention to detail when drawing or annotating diagrams. Many candidates would benefit from further practice at drawing diagrams. The accuracy of straight lines on diagrams could be improved by using a sharp pencil and a ruler.

- Candidates should avoid using learnt phrases such as “to make it more accurate” or “to avoid parallax error”. These comments alone will not usually be credited, because the responses need to be linked to the practical situation, e.g. “avoid parallax error in reading the voltage on the voltmeter”.

General Comments

The Alternative to Practical paper requires candidates to have a good background in practical physics. Candidates who have not used or assembled equipment will find the questions much more challenging than those who have regularly participated in practical work during their physics lessons. It is important to ensure that learners have the opportunity to develop practical skills by the discussion of practical techniques during demonstrations as well as by handling equipment themselves.

The practical situations described in this paper were familiar to very few candidates, so the majority had to read the question carefully to appreciate the physics involved. This was evident in **Question 1** where the some candidates suggested replacing the iron base of the clamp stand used to attract the magnet with a non-magnetic material. Also, in **Question 4**, the candidates were asked to find the average diameter of a group of ten marbles using a 30 cm ruler. Many candidates ignored the instructions and used a micrometer or vernier calipers instead of the ruler.

Another instance of not following instructions occurred in **Question 1**. The candidates were asked to take the reading on the newton meter and then add their value into a table. A significant number of candidates left the table blank. This was a surprising failure to follow a simple instruction which often resulted in a loss of a mark when plotting the graph. Other candidates added a different value to the one they had measured in **(b)**.

The graph plotting skills were generally good, but few were able to draw a smooth curved line. Many attempted to make the line go through all the points. In this case, the readings from the meter were to the nearest 0.5 N, so the line will definitely not pass through all the points.

Comments on Specific Questions

Question 1

(a) (i) Although there were many good candidates who recognised the difficulty in taking the reading on the newton meter at the same time as pulling the meter upwards, a large number were unable to appreciate the practical situation. A number of candidates clearly explained that the reading on the meter would change quickly at the moment the reading was to be taken and others gained the mark by simply saying that the reading on the meter was not constant.

Credit was given to those who said the stand might move and then went on in **(ii)** to describe using a clamp to attach the base to the bench.

(ii) The most common correct response here was to describe how two people can work together, one pulling the newton meter and the other taking the reading. Many gained the mark by saying they would repeat the reading. A few suggested the use of a video with play-back on slow motion, which was an acceptable response. Those who did not understand the purpose of the experiment suggested using a wooden clamp stand.

Some candidates had thought carefully about the problem and described attaching the meter to another clamp stand and pulling down on the iron base, thus enabling the meter to be viewed from in front and avoiding parallax error.

(b) Most candidates could read the value on the newton meter correctly. The most common reason why candidates lost credit here was omitting or giving an incorrect unit. Candidates should be aware that the correct abbreviation for newtons is N. A few candidates read the scale incorrectly as 6.5 N rather than 5.5 N.

(c) (i) Although there was no mark for entering the value of F from **(b)** in the table, candidates lost credit if they did not use their value obtained in **(b)** when plotting the graph.

The graph was well plotted with almost all candidates labelling the axes, choosing suitable scales and plotting the points correctly, thus gaining three out of the four marks available. Very many candidates, however, simply joined the points rather than draw a smooth curve of best fit.

(ii) The relationship between F and n is an inverse relationship. Some candidates believe that all inverse relationships are inversely proportional. This is not the case here.

Most candidates gained the mark by simply stating that increasing n decreases F.

(d) Many candidates struggled to express their ideas clearly here. The statement that it was "not accurate" was insufficient. Those who attempted to explain the fact that the reading was too small to be measured on the scale of this newton meter usually gained the mark. There was often confusion between accuracy, sensitivity and precision of the scale. Credit was given if the candidate explained that the meter could only be read to the nearest 0.5 N.

Some candidates who did not understand the experiment suggested here that the force would be too large for the meter to read.

(e) (i) This question tested the candidates' understanding of the inverse relationship and was well answered by most. The question asked candidates for a reason, and no credit was available for those who simply stated "the second paper" without any explanation. Some candidates who gained the mark for **(c)(ii)** stated that the paper with the 3.5 N force was thicker.

(ii) Many candidates were able to explain that thinner papers allowed more values of n before F became too small to measure. Others stated that the force would be larger and this was taken to mean "for the same number of papers" and credited, even though the initial force with $n = 0$ would be unchanged.

(f) Many candidates did not gain this mark because they omitted the "state" part of the question. Simply explaining that aluminium is non-magnetic was insufficient; the candidate should also say that, as a consequence, it is suitable for the experiment. Some candidates thought aluminium was a magnetic material and would therefore not be suitable as it would affect the experiment.

Question 2

(a) This question was well answered by those candidates who had clearly performed the experiment for themselves. Candidates need to be aware that, if they are given an apparatus list, then they should use that apparatus in their experiment. Many candidates used a ray box or laser rather than using the pins to locate the reflected ray. This reduced the number of marks available for their answer. If the question asks for a diagram, then candidates will not gain full credit if they do not include a diagram.

Candidates always find it difficult to describe how the image of the pins is located in the mirror. They need to ensure they include practical detail when describing an experiment of this type, e.g. "measure the angles" not just state that $i = r$.

Some candidates lost marks by describing refraction rather than reflection of light.

(b) There are always many ways to obtain a mark for describing how an experiment is made accurate. A variety of good answers were seen, including use of a sharp pencil and viewing the base of the pins. Most candidates were able to gain this mark.

Question 3

(a) (i) Most candidates were able to read the correct value from the voltmeter. The most common reason for not gaining the mark was a missing or incorrect unit. Some candidates read the scale incorrectly as 1.1 V and others rounded to 1 V. The sign of the answer was ignored.

(ii) Few candidates gave the expected answer of crocodile clips. Credit was given for any type of clip or for winding the wire round the electrode.

(iii) Most candidates were able to describe that the needle deflected to the opposite side of the scale. This was often described as a negative value of *V* if **(a)(i)** was positive and vice versa. The most common incorrect response was 0 V.

(b) The majority of responses here concerned the size of the lemon or the e.m.f./voltage produced being too small. Some responses did not seem to be related to physics.

(c) Many candidates knew the rules for cells in series and parallel, gaining marks for 2.7 V and 0.9 V respectively. Some reversed the answers and others attempted difficult calculations involving reciprocals. The sign of the numerical answers was ignored.

Very few candidates gained the marks for connecting the cells. Many did not attempt to answer the question. Those who did attempt the question had a variety of ways of joining the lemons, but did not show connections to the electrodes. The question text above **(a)** describes making connections to the copper strip and iron nail, and this is reinforced by the question **(a)(ii)**. Careful reading should have given candidates the information they needed to answer this question even if they were not familiar with this type of cell.

Question 4

(a) Although there were many good answers here with candidates scoring all three marks, some candidates did not follow instructions and used different apparatus from that given. Some reproduced the diagram in Fig. 4.1 and stated that they would use a micrometer. Others used vernier calipers.

The practical detail required here was how to keep the marbles in a tight straight line and how to measure to the ends accurately. Further detail for the third mark was to use all ten marbles together to obtain an average value. Most candidates gained at least one and usually two marks for the detail.

(b) (i) Many candidates found this part difficult, suggesting that they did not know how to read a micrometer.

(ii) Many candidates found it difficult to describe clearly what they would do. There were many excellent answers seen, but some just described what it means to be spherical rather than the practical detail of how they would check it.