PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

There were several questions that were answered correctly by a large proportion of the candidates and some of these were simple factual recall whilst others were fairly direct calculations. These included **Questions 1**, **6**, **13** and **16**. Candidates found **Questions 14**, **28** and **36** more challenging.

Comments on specific questions

Question 8

Many candidates realised that the correct answer was **A.** However, **B** was also chosen by many candidates. Since the two forces of magnitude 3.0 N and 4.0 N are added together, the total force (5.0 N) must start at the same point and end at the same point as the two other forces combined. In **B** the 5.0 N force is in the opposite direction to the combination and cannot equal the sum of the other two forces. The three arrows in **B** combine to produce a closed triangle with the arrows all anticlockwise which shows that the 5.0 N arrow is in fact equal to the negative value of the sum.

Question 10

All four options were chosen by a number of candidates but stronger candidates answered this correctly. Weaker candidates possibly struggled with the concept of inverse proportion which is important here and despite the diagram, there were many candidates who gave answers that suggested that the volume had doubled.

Question 14

As a liquid becomes a gas, thermal energy is supplied and the molecules gain potential energy as they overcome the intermolecular force of attraction and move apart. The average kinetic energy of the molecules does not change as the temperature remains constant. It is probably the need to supply thermal energy that made **A** the most popular choice here. However, stronger candidates answered this correctly

Question 20

Many candidates answered this correctly but **B** and **C** were chosen by a significant number of candidates. In this case, the correct option was the one that indicates less slowing down and less refraction and which repeated the term "less".

Question 21

Most candidates answered this correctly but the three incorrect options were each chosen by a significant number of candidates. **D** was possibly chosen by candidates who felt the number 10^8 was familiar in this context.

Question 23

Most candidates answered this correctly.

Question 28

The most commonly selected option was **C** although the correct option, **D** was the next most popular choice. The fact that **C** was so commonly given suggests that the principal source of inaccuracy was the incorrect belief that the resistance of the wire is directly proportional to its cross-sectional area rather than the correct relationship which is one of inverse proportionality.

Question 26

Many candidates answered correctly but both **B** and **C** were chosen by a small number of candidates. These two options suggest that a majority of candidates realised that the sphere would be negatively charged but some of these did not realise that removing the rod allows the negative charges to spread uniformly across the surface of the isolated sphere. There were a number of candidates who chose an answer consistent with the sphere being positively charged suggesting that the mechanism of electrostatic induction was poorly understood by these candidates.

Question 31

Only the strongest candidates answered this question correctly. Weaker candidates often selected **C** which ignores the effect of the time for which the heater is switched on. It is possible that some candidates confused the units given in this question.

Question 32

Stronger candidates answered correctly but many candidates gave **C** as their answer. There are perhaps candidates who mistakenly thought that there could still be a current in a lamp if an open switch is located in the neutral wire.

Question 36

Stronger candidates answered correctly but **B** was more commonly chosen than the correct answer. A smaller number of candidates chose **A** or **C**.

Question 37

Although the correct answer was chosen by more candidates than any other option, the three incorrect options were each selected by a significant number of candidates. The absence of any electrons from the diagram indicated that the first two options which refer to atoms were not correct and since these were chosen so frequently, it is possible that there are candidates who use the term atoms even in this context which concerns a nuclear reaction.

Question 38

This was answered correctly by stronger candidates. Many other candidates gave **B** as their answer.

PHYSICS

Paper 5054/12
Multiple Choice

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

General comments

The questions that many of the candidates answered well included **Questions 5**, **11**, **28** and **34**. Candidates found **Questions 14**, **19**, **27** and **31** more challenging.

Comments on specific questions

Question 14

The most commonly chosen answer was **A**. This answer represents the weight per unit volume of the block rather than any of the pressures that the block could exert when resting on the ground. The next most popular answer was the correct option but small number of candidates gave **D**.

Question 15

The correct answer, **B** was more commonly chosen than any other but **A** and **C** were chosen by a similar and significant proportion of candidates. These candidates possibly struggled with the concept of inverse proportion which is important here and despite the diagram, there were many candidates who gave answers that suggested that the volume had doubled.

Question 19

Few candidates gave the correct response here with both **B** and **D** more frequently selected than the correct answer, **C**. The time of 22 s was stated in the question but the appropriate time of 7.0 s had to be deduced from the graph.

Question 22

Only the strongest candidates answered this question correctly.

Question 24

Although the most popular answer was the correct option, both answers **B** and **C** were chosen by a significant number of candidates. In this case, the correct option was the one that indicated less slowing down and less refraction and which repeated the term 'less'.

Question 27

Both **A** and **C** were chosen more often than the correct response, **D**. The choice of **C** suggests that candidates did not take into account the fact that the sound has reflected off the sea bed and travelled a distance that is twice the depth given in the question. However, candidates who selected **A** ignored most of the context and simply divided the depth by the time for the return of five pulses.

Question 31

The most commonly selected option was **C** but the correct option, **D** was the next most popular choice. The fact that **C** was so commonly given, suggests that the principal source of inaccuracy was the incorrect belief that the resistance of the wire is directly proportional to its cross-sectional area rather than the correct relationship which is one of inverse proportionality.

Question 32

This question could be approached in two ways: either by calculating the power expended first or by calculating the charge that flows in the circuit first. The two methods are logically equivalent but were likely to lead to different incorrect answers if an error was made. In this question, the time was given in milliseconds and there was scope for a power-of-ten error for this reason. Stronger candidates answered this well. **B** was almost as commonly chosen and it was probably chosen by candidates who struggled to convert a time in milliseconds to seconds.

Question 33

Stronger candidates answered this question correctly. However, many candidates gave **C** as their answer. There are perhaps candidates who mistakenly thought that there could still be a current in a lamp if an open switch is located in the neutral wire.

Question 36

Only the strongest candidates answered this question correctly. All the options were chosen by a significant number of other candidates. **D** shows the usual state of an oscilloscope immediately after it is first switched on and it was the most commonly selected response.

Question 38

The most popular response to this question was **B**. The question was set in the context of a nuclear reactor and the correct answer, **C** may have appeared too simple to some candidates. There might have been candidates who felt that the correct option was not correct because it did not seem to be related to the context of nuclear physics.

Question 38

This was answered correctly by stronger candidates. Many other candidates gave **B** as their answer.

PHYSICS

Paper 5054/21
Theory

Key messages

- Candidates should always give units when giving the final answer to numerical questions. They should also give answers to an appropriate number of significant figures (usually at least two), and for this reason, 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 usually worth drawing it carefully and neatly and then labelling it, so that its intention is clear.
- The number of marks shown and the amount of space provided give a guide to the length of the answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail.

General comments

The majority of questions were accessible to all candidates. Calculations were generally performed well. Most candidates were able to quote a relevant formula, either in words or symbols and substitute correctly into it. A small number of candidates ignored the instructions for ***Section B*** and answered all three questions.

The standard of written English was high and there was no evidence of language problems. The quality of expression, even among the weaker candidates was good, even if the underlying physics was sometimes inaccurate.

Comments on specific questions

Section A

Question 1

(a) The majority of candidates were able to calculate the resultant force on the girl.

(b) (i) Most candidates gained partial credit by drawing a straight line from the origin to represent the initial stage of the motion where the acceleration of the cyclist was constant. Only a few candidates continued their graphs with a curve of gradually decreasing gradient to show that in this stage of the motion of the cyclist the acceleration was decreasing. Most graphs showed a decrease in speed, despite the fact that the cyclist was still accelerating.

(ii) This question was very well answered. Most candidates knew that the distance travelled by the cyclist could be found by determining the area under the line. Vague answers such as “the distance travelled is equal to the area of the graph” were not accepted.

Question 2

(a) (i) The pressure due to the oil at the level of the crack in the tank was usually calculated correctly. Those candidates who started by writing down the formula pressure = force/area were able to proceed no further with this question.

(ii) In this question candidates did not realise that since the atmospheric pressure acted on both sides of the crack then it would not affect the rate at which the oil would be pushed out from the crack. The rate is determined solely by the height of the oil above the crack.

(b) Most candidates calculated that as time passes, the height of the oil above the crack decreased so the pressure exerted at the crack would decrease and the oil would hit the floor closer to the base of the tank.

Question 3

(a) The extension-load graph for the spring was usually extrapolated correctly to show that after the limit of proportionality is reached, the extension for a given load would increase.

(b) (i) Many candidates did not subtract the initial length of the spring from the final length. Those who did the subtraction, usually used the graph correctly to calculate the weight of the wooden block. The error made by a significant number of candidates was to use the final extended length together with the graph to deduce the weight of the block.

(c) There were many correct and well-reasoned answers to this question. Many candidates realised that if two of the given springs were connected in parallel then the limit of proportionality would not be reached when a load of 9.0 N was added because the load would be shared equally between the two springs.

Question 4

(a) The formula for the kinetic energy of a moving body was well known. However, many candidates ignored the instruction given in the question and did not state what the terms in the equation they had written down represented.

(b) (i) The increase in thermal energy of the rock was usually calculated correctly. Occasionally no unit was given with the answer.

(ii) Many candidates did not realise that to calculate the minimum possible speed of the rock when it hit the earth, they needed to equate the increase in thermal energy of the rock to the kinetic energy formula – despite the instruction to do this being given in the question. There were many correct answers to this question, but the mathematics of the problem was challenging for many candidates.

(iii) Only stronger candidates realised that the speed they had calculated in **(ii)** would be less that the actual speed of the rock when it hit the Earth, because some of the internal energy produced upon collision would be transferred to the ground or the air, and not used to raise the temperature of the rock.

Question 5

(a) (i) The range of a thermometer was very often described as the distance between the fixed points instead of the difference between the maximum and minimum marked temperatures.

The sensitivity of a thermometer was only described correctly by a very small number of candidates as the distance moved by the thread per unit temperature rise. Most answers focused on the speed at which the thermometer reacted to a given change in temperature.

(ii) Many candidates were able to state one feature of the thermometer that would produce a high sensitivity, but far fewer candidates were able to explain why the feature they had chosen produced a high sensitivity. A common incorrect answer was that a small thermometer bulb would produce a high sensitivity.

(b) The purpose of the constriction in a clinical thermometer was well known.

(c) Despite the instruction being given to explain in terms of molecules, the word molecule was missing from many explanations. Many candidates stated that an increase in temperature would increase the energy of the molecules. Candidates needed to be more specific here and state that it was the kinetic energy of the molecules that increased. The important fact, that the molecules then pushed apart or that the intermolecular separation then increased, was missed by many candidates.

Question 6

(a) Only stronger candidates were unable to state that a compass needle is made from steel. The most popular choice of material was iron.

(b) Most candidates had some idea of how to use a plotting compass to plot the magnetic field around a magnet. Most candidates started with the compass near one pole of the magnet, marked the direction in which the needle pointed with a dot or cross and moved the compass on. Very few candidates explained that the dots needed to be joined up and the process repeated at different places around the magnet.

(c) Only the strongest candidates stated that the magnet induced poles on the iron bar as it was brought near to the bar and that the end of the bar nearest the magnet would have an induced North Pole. Many more candidates realised that the iron bar then moved towards the magnet due to the attraction of unlike poles. Candidates who talked about the attraction of unlike charges scored no credit here.

Question 7

(a) (i) This question was challenging for many candidates because they did not treat the parallel combination of resistors separately from the single series resistor. Those candidates who were successful, found the effective resistance of the parallel combination and then added this to the resistance of the series resistor. Many candidates either applied the parallel resistors formula to all three resistors at once, or just added the values of the three separate resistors together as they would for a series circuit.

(ii) Most candidates went on to calculate the reading on the ammeter correctly using the value of total resistance they had just obtained.

(b) (i) Only the strongest candidates defined “potential difference” in terms of work done or energy transferred. Most candidates stated that it was the current multiplied by the resistance, which although correct, did not define the term.

(ii) A number of candidates were unable to connect a voltmeter correctly across the 2.8 Ω resistor. The voltmeter was often connected in series into the circuit or across the wrong component in the circuit.

(iii) Only the strongest candidates answered this question correctly. These candidates realised that if the resistance of X is increased then the total circuit resistance would increase, leading to a decrease in current and therefore a decrease in the p.d. across the 2.8 Ω resistor.

Section B

Question 8

(a) Most candidates filled in the first missing word correctly to state that the mass of a body is the amount of substance or matter in a body, but far fewer knew that the mass of a body resists a change in the state of rest or motion of the body

(b) (i) Only a very small number of candidates gave a satisfactory explanation of what is meant by a gravitational field. Very few stated that a gravitational field is a region in which a mass experiences a force.

(ii) The mass of water in the bucket was usually calculated correctly. Fewer candidates were able to go one step further to calculate the weight of the water in the bucket. Even fewer candidates remembered to add on the weight of the bucket so that the total weight of the bucket and the water was found.

(c) (i) Most candidates gained partial credit for stating that the moment of the bucket and the water that acts upon the cylinder could be found by multiplying the force exerted by the perpendicular distance to the axis of the cylinder. Most candidates did not gain full credit because they did not realise that the correct distance was the radius of the cylinder and not the distance of the handle from the axis of the cylinder.

(ii) This was usually answered correctly.

(d) (i) Many candidates gained partial credit for stating that friction between the axle and cylinder was responsible for the fact that the force needed to raise the bucket of water would be greater than the value calculated in **(c)**. Few candidates gave a second acceptable reason. No candidate mentioned that the applied force was not perpendicular to the radius or that the rope wraps around itself, so that the moment changes.

(ii) Most candidates were unable to list the energy changes occurring as the bucket was lifted at constant speed. Answers consisted of a mixture of different energy forms with no real structure as to what was happening and with no links between them. Only the strongest candidates realised that since the bucket was raised at constant speed the chemical energy of the person raising the bucket would ultimately be converted to potential energy and thermal energy.

(e) Many candidates realised that if the bucket of water was travelling upwards at constant speed then there would be no resultant force. Other candidates incorrectly thought that if the bucket was moving upwards then there must be an upward resultant force.

Question 9

(a) Most attempts at explaining the difference between a longitudinal and a transverse wave failed because candidates made no reference to the vibration of the particles of the medium. Candidates who explained the difference in terms of crests and troughs and/or compressions and rarefactions answered well.

(b) (i) Most candidates applied the wave equation correctly and obtained the frequency of the water wave. A number of candidates incorrectly rounded up the answer to 9.0 Hz.

(ii) Few candidates knew that the frequency of the wave remained unchanged as it passed into the shallower water.

(iii) Only a minority of candidates used the diagram to deduce and state that the wavelength of the wave decreases, so the speed of the wave must therefore decrease to keep the frequency of the wave constant.

(c) (i) Only stronger candidates underlined two of the given options while other candidates underlined just one. The fact that light waves are both transverse and electromagnetic was not well known.

(ii) Most candidates calculated the angle of refraction in the glass correctly.

(iii) 1. The calculation of the critical angle for light in glass was well done.

2. Only stronger candidates were able to deduce from the geometry of the glass block, that total internal reflection would occur when the light struck side XY.

3. Few candidates drew the correct path of the ray after striking the face XY and finally emerging into the air again. Most attempts showed the ray of light emerging into the air at point P, instead of being totally internally reflected at P and then emerging from the vertical face of the glass block.

Question 10

(a) This question was well answered with most candidates giving one correct similarity and one correct difference between the different isotopes.

(b) (i) The equation for the decay of plutonium –239, was usually completed correctly.

(ii) Most candidates were unable to use the given data to calculate the number of half-lives that had elapsed since the start of the decay. Even when candidates deduced that 5 half-lives had elapsed during the decay, they were unable to calculate what the new count rate of the sample would be.

(iii) Only the strongest candidates answered this question correctly. Most diagrams showed the alpha-particle being deflected upwards rather than downwards. Of those candidates who chose the correct direction, many had the particle moving in a straight line rather than a circular arc. Only the strongest candidates went on to explain why the alpha-particle followed the path they had drawn. Fleming's left hand rule was rarely mentioned.

(c) (i) Few candidates stated that nuclear fission is the splitting of a nucleus. Most answers referred to the splitting of the atom.

(ii) Only a small number of candidates knew fission is caused in a nuclear reactor by firing neutrons at a polonium nucleus/by a plutonium nucleus absorbing a neutron.

(iii) Most candidates did not focus on the question asked, namely to state one advantage of generating electricity in a nuclear power station compared to an oil-fired power station or an array of wind turbines. It was often difficult to determine from what candidates wrote, which method of electricity production they were talking about. Correct comparisons were only given by stronger candidates.

PHYSICS

Paper 5054/22
Theory

Key messages

- Attention should be paid to the command word and instructions given in the question to ensure that answers address what is expected in the question. For example, if the question asks ‘Explain, in terms of molecules...’, answers that make no reference to molecules will not be awarded full credit.
- Candidates should be made fully familiar with the requirements of the paper as some candidates answered all ***Section B*** questions.
- Candidates should be advised to spend a few minutes looking through the questions in ***Section B*** to decide which they are going to answer. They should ensure they read all parts of the question to avoid realising they could have answered a different question more fully once they have started.

General comments

There were many strong performances from candidates but also some frequently seen errors or gaps in knowledge. There are several equations in the syllabus that candidates are expected to know of the form $x = yz$. These include: $V = IR$; $v = f\lambda$ and $m = \rho V$; as well as others. In calculations where such an incorrect rearrangement gives an equation such as $y = z/x$, the final answer is unlikely to be correct and when the only equation supplied is the incorrect rearrangement, then it is likely that no credit can be awarded.

This year there were also a number of issues with candidates recording answers to an incorrect number of significant figures. Answers should always be given to at least 2 significant figures, although an exception is made when a calculation produces an answer such as 0.4 exactly or where the answer is clearly an integer small than 10. Candidates should take care to round their answers correctly.

Comments on specific questions

Question 1

(a) Many candidates were able clearly to state the required difference. A few candidates stated that velocity is the rate of change of speed or something similar.

(b) (i) There was a wide range of answers here with a few candidates explaining that a change in the direction of the velocity is an acceleration. There were also others who gave answers relating to force or other ideas suggested by the satellite’s motion.

(ii) Stronger candidates answered correctly but a curved arrow drawn along the circumference was more common.

(c) Only a few candidates referred to the direction of the gravitational force on the satellite and the direction of its motion and many candidates made no mention of whether work was being done or not. More candidates stated that the energy of the satellite was not affected.

Question 2

(a) There were many good answers here but some candidates gave answers that were too vague.

(b) Most candidates gave one feature but the context of a sports car led to some candidates giving answers in terms of assumed features of the tyres or the engine rather than the more general features seen on the diagram that lead to stability.

(c) This question also produced a varied response with some candidates writing clearly and accurately about an experiment with which they were very familiar whilst others seemed unfamiliar with the experiment or gave answers that were brief and which were not always a description of what should be done. Although many candidates suggested that lines be drawn on the lamina, few indicated that the point of intersection was the centre of gravity.

Question 3

(a) Many candidates realised that the location of the heater ensured that a convection current was established in the water. Not all of these candidates explained why this is an advantage. Some candidates produced a rather standard explanation of how a convection current is formed without relating it to the electric kettle and without answering the question asked.

(b) (i) This was often well answered and both points were often made.

(ii) This question proved challenging for many candidates and the different expansion rates of liquids and solids was only mentioned occasionally. The idea that the expansion of the copper would lead to a reduced volume inside the kettle was a common misunderstanding. Many candidates explicitly referred to a reduction in the interior diameter whereas, of course, the capacity of the kettle increases as the diameter increases.

Question 4

(a) (i) This was generally well answered with frequent references to radiation or infrared waves.

(ii) Again, this was generally well answered. Some candidates stated that black surfaces are good absorbers and good emitters of radiation without being clear as to which of these properties is significant in this case.

(b) (i) This was generally well understood with many correct answers given. Errors seen included candidates using a time of 60 (minutes) rather than 3600 s and the expression VI being used to calculate the answer rather than VIt.

(ii) Most candidates were able to produce a discussion that dealt with this issue. The most common approach was to consider the effect of the production of CO_2 or other greenhouse gases. The destruction of the ozone layer is not related to the use of oil as a source of energy but many candidates suggested this as an answer here.

Question 5

(a) Although many answers were correct, substances such as wood and paper which are not true insulators were also given as examples of insulators. A wooden metre rule can be used to discharge a charged metal sphere.

(b) (i) Almost all candidates drew negative charges on the left of K and positive charges on the right of L and gained credit. However, many of these candidates also drew positive and negative charges either side of the point where the two spheres touch.

(ii) 1. Most candidates gave answers in terms of the charge being earthed or even reversed. Correct answers to this part were only seen from stronger candidates.

2. This was usually answered correctly. However, a common inaccurate answer was to state that the sphere becomes negative.

Question 6

(a) Almost all candidates calculated the numerical value correctly but many of these candidates did not supply a unit for the answer.

(b) (i) Some candidates ticked to correct boxes but there were also candidates who ticked almost any other combination of boxes.

(ii) There was a variety of answers supplied here with a common inaccuracy being to supply the proton number and neutron number of cobalt-60 rather than of the product X.

(c)(i) Almost all candidates stated that the half-life is a time for something to halve but the quantity that halves was often not well defined. Expressions such as the "time for the nucleus to halve" or "for the substance to halve" were not exact enough for full credit.

(ii) Only the strongest candidates answered this question correctly with few candidates making any reference to the values in the question. Many candidates did not seem to understand what the question was asking.

Question 7

(a) This was usually answered well. A common misunderstanding was to state that iron is a good conductor.

(b) (i) Many candidates gained partial credit for one difference but fewer candidates were awarded full credit for two distinct differences.

(ii) This question generated answers that were brief and fully correct from some candidates whilst other candidates were less sure of what was needed. References to the electrical conducting property of iron were common even from candidates who had answered **(a)** correctly.

Question 8

(a) (i)1. Many candidates answered this question correctly. A very small number of candidates gave answers such as "its weight" or "the space it occupies".

2. This was usually answered correctly.

(ii) Many candidates answered this well. A small number of candidates made errors such as omitting to square the speed when calculating the answer.

(b) (i)1. This was usually answered correctly.

2. This was answered well. A common error was to state that the graph had negative values on the axis or that the ball had a negative velocity.

(ii)1. Few candidate wrote down a time that was in the correct range. Many candidates gave incorrect answers between 1.80 and 1.84 s.

2. Many candidates attempted to use the area of a triangle or the area under the graph in a calculation but the correct area was not commonly used here.

(iii) There were some candidates who realised that this sudden decrease in velocity corresponded to the ball hitting the ground but there were a few other common misinterpretations of the graph.

(iv) There were some good answers and most candidates were awarded some credit. A common inaccurate answer was the suggestion that the final energy was a form of potential energy.

(c) Only the strongest candidates answered this question correctly.

Question 9

(a) Many candidates gave an acceptable answer and were awarded credit.

(b) (i) This question was not well answered. Few candidates made any reference to the transmission of energy by a wave or to the medium. When a longitudinal wave was referred to, it was rarely clear what it was that was parallel to the direction of propagation of the wave.

(ii)1. This question was usually answered carefully and most candidates labelled the diagram clearly and correctly. A few candidates labelled two compressions.

2. This was quite commonly correct although a few candidates gave arrows that were so poorly drawn that they were too long. The point where the arrow began and ended needed to be clear.

3. Many candidates obtained credit for a correct equation and many of these used it with appropriate values. A few candidates measured the distance in centimetres but then gave the answer in metres/second without converting the numerical value.

(c) (i) Many candidates answered this question correctly.

(ii) Many candidates showed that they knew what sort of answer was required here and full credit was awarded frequently. Weaker answers included a drawing of a set of contiguous parallel compressions which refracted the wrong way relative to their direction in the liquid.

(d) Only a small number of candidates showed any familiarity with this use of ultrasound. Many answers suggested that the ultrasound was used to detect the dirt rather than being used directly in the cleaning process. Such answers tended to borrow ideas from the use of ultrasound in prenatal scanning.

Question 10

(a) Many candidates stated that the charge carriers are electrons although a few also added protons or other positively charged particles. A smaller number of candidates gave the correct direction of motion and answers such as from positive to negative suggested that candidates were thinking of the direction of the conventional current rather than the charged particles.

(b) (i) Most candidates were able state the name of component X. A common answer that was not awarded credit was “variable resistor”.

(ii) Although a few candidates simply added the resistance values or omitted to add on the $1.3\,\Omega$ to the combined resistance of the parallel pair of resistors, there were many good answers that were awarded full credit.

(iii) This part was well answered and full credit was commonly awarded.

(iv) Some candidates produced the correct equation but a similar number did not. Given the wording of the question, an answer that was not an equation did not gain any credit.

(c) Although a few answers were awarded full credit because they were complete and followed a logical route to the correct answer, most answers contained one or two significant points without it being clear how this led to the answer given. Answers which referred to a change in a potential difference rarely made it clear which potential difference was being referred to; there are two important potential differences in the circuit and the total potential difference between the terminals of the battery.

(d) (i) This part was very often correct.

(ii) Only the strongest candidates answered this question correctly and a significant number of candidates left this blank.

PHYSICS

Paper 5054/31
Practical

Key messages

Working for calculations should always be shown, the units for quantities always stated and the final answers should be given to an appropriate precision (usually 2 or 3 significant figures).
Readings taken from an analogue instrument such as an ammeter or voltmeter should always be written down to the precision of that instrument. In the case of answers where the unit required was printed on the answer line candidates should ensure that their responses are given in that unit.

General comments

Many candidates were able to construct tables of results, perform calculations by substitution into equations, plot line graphs and make comments, predictions, or comparisons using their results and following the guidance in each part of a question. Some weaker candidates gave comparisons that were too vague. The terms "change" and "vary" are not considered precise enough whereas the terms "increases" and "decreases" or "stays the same" are more suitable for making comparisons.

In some cases, the plotting of graphs would benefit from further focus. A number of otherwise good responses used different scales in order to maximise the area occupied by the graph which was not successful. Candidates should choose scales which produce a graph of an adequate size (occupying over half the grid in both the *x* and *y* directions) and from which it is easier to obtain further numerical information. The best scales should be based on integers such as 2, 5, or 10 corresponding to 10 small grid lines. Scales based on 3, 6 or 7 should usually be avoided. The points should be accurately and clearly plotted and the best fit line drawn carefully using the Cartesian axis system with the orientation of axes as specified in the question.

A complete set of results for each set of apparatus should be provided with the Supervisor's report.

Comments on specific questions

Question 1

(b) Stronger responses listed several (two to four) measurements and averaged them.

(c) (ii) Stronger candidates gave 2 or 3 repeated measurements and averaged them.

(iii) The force applied was calculated by substituting the extension into the formula. The correct calculation and the correct unit (N, Newton) were required in order to be awarded credit.

(d) The time taken for 3 cm of the tape to be peeled off the paper was measured. The strongest candidates repeated and averaged measurements in the region of 2 to 50 s with a precision of at least 1 decimal place.

(e) The power developed was calculated by substitution of the candidates' values for the force and time into the given formula. Weaker candidates omitted the multiplication of the force by 0.03.

Question 2

(a) (i) Candidates were asked to measure the distance, *u*, between the filament of a lamp and the lens. The strongest candidates recorded 2 or 3 measurements in centimetres, given to the nearest millimetre and averaged them.

(ii) Candidates were then required to measure the distance, *v*, from the lens to the graph paper on the bench. The strongest responses recorded 2 or 3 measurements in centimetres, given to the nearest millimetre and averaged them.

(iii) Many candidates gave an explicit difficulty in obtaining these results such as keeping the ruler still or vertical whilst taking the measurement, knowing the exact position of the filament of the lamp or the centre of the lens, recognising that the glass envelope of the lamp could have a distorting, magnifying or diminishing effect on the viewing of the filament, or giving a good explanation of how a parallax error could occur in this specific situation. Weaker candidates gave vague statements or described how to overcome the difficulty rather than identifying the difficulty.

(b) The measured values of *u* and *v* were used to calculate the focal length of the lens using the formula provided.

Question 3

(a) Many candidates recorded repeat measurements for the mass of the measuring cylinder and calculated its average mass.

(b) Stronger candidates produced good, clear, labelled diagrams or written descriptions showing how the reading was viewed with the eye at right-angles to both the scale and the base of the meniscus of the liquid. Weaker candidates often confused “perpendicular” and “parallel” or wrote explanations that contradicted the diagram.

(c) Stronger candidates recorded several measurements of the mass of the oil-filled measuring cylinder, averaged them and then calculated the mass of the cooking oil.

(d) Stronger candidates correctly calculated the density of the oil with 2 or 3 significant figures and gave the correct unit.

Question 4

(a) The potential difference across the power supply was measured and stronger candidates recorded this to at least 1 decimal place. Weaker candidates using digital meters gave readings to a precision unjustified by the experiment.

(b) (i) The first recorded temperature should have been higher than 70 degrees Celsius, with a precision of either the nearest whole number or 1 decimal place.

(ii) There should have been at least seven sets of readings recorded as the temperature decreased. Repeating the experiment and averaging results was not necessary here.

(c) Stronger candidates showed the resistance increasing as the temperature decreased. Headings with units were required for the five columns.

(d) Stronger candidates drew neat, carefully plotted graphs with good best fit lines. Some responses indicated that the plotted points had been adjusted to fit the curve. It is expected that experimental data shows some scatter about the best line; the data should not be altered to fit the line. Some otherwise good responses showed some poor choices of scale used for the graph. Weak responses showed a line produced by joining one point to the next with a straight line (a dot-to-dot line) or with poor best fits.

(e) Stronger responses showed a well-judged tangent making contact with the curve at exactly the required point on the line and extending a good length either side of that point. Many candidates showed a large triangle, correctly placed with the triangle then used to calculate the gradient of the best line at the required point, with all working shown and the final answer given to 2 or 3 significant figures. Weaker candidates drew tangents which did not meet the curve at the required point or drew chords or used points from the table which were not on the best fit line, or used triangles that were too small. A few of the weaker candidates drew a triangle but used numbers corresponding to a different triangle.

PHYSICS

Paper 5054/32
Practical

Key messages

Working for calculations should always be shown, the units for quantities always stated and the final answers should be given to an appropriate precision (usually 2 or 3 significant figures).
Readings taken from an analogue instrument such as an ammeter or voltmeter should always be written down to the precision of that instrument. In the case of answers where the unit required was printed on the answer line candidates should ensure that their responses are given in that unit.

General comments

Many candidates were able to construct tables of results, perform calculations by substitution into equations, plot line graphs and make comments, predictions, or comparisons using their results and following the guidance in each part of a question. Some weaker candidates gave comparisons that were too vague. The terms “change” and “vary” are not considered precise enough whereas the terms “increases” and “decreases” or “stays the same” are more suitable for making comparisons.

In some cases, the plotting of graphs would benefit from further focus. A number of otherwise good responses used different scales in order to maximise the area occupied by the graph which was not successful. Candidates should choose scales which produce a graph of an adequate size (occupying over half the grid in both the *x* and *y* directions) and from which it is easier to obtain further numerical information. The best scales should be based on integers such as 2, 5, or 10 corresponding to 10 small grid lines. Scales based on 3, 6 or 7 should usually be avoided. The points should be accurately and clearly plotted and the best fit line drawn carefully using the Cartesian axis system with the orientation of axes as specified in the question.

A complete set of results for each set of apparatus should be provided with the Supervisor’s report.

Comments on specific questions

Question 1

(a) (i) Candidates were required to pull a weighted block of wood attached at one end to a spring using a loop of string until the block just began to slide along the bench and at this point measure the length of the spring. Stronger candidates recorded several values and averaged them.

(ii) Stronger responses showed repeated measurements and averaged them. The two measured lengths were used to calculate the extension in centimetres.

(iii) The force applied was calculated using the given equation. Stronger candidates used their value of the extension correctly to calculate the force and gave the correct unit (Newtons) for their answer. Weaker candidates often omitted the unit.

(b) The time taken for the block to be moved 20 cm was measured. The strongest candidates repeated and averaged measurements, showing the raw results and the working.

(c) The power developed was calculated by substitution of the candidate’s values for the Force, *F,* and the time, *t,* into the given formula. Weaker candidates did not multiply by the Force.

Question 2

(b) Stronger candidates gave values of potential difference and current, to appropriate levels of precision and with values consistent with the circuit used and demonstrating the correct trends. The answers from weaker candidates often indicated that the circuits had been set up incorrectly.

(c) Many candidates correctly calculated the resistance between the two points for each circuit.

(d) Very few candidates were able to explain why the current increases and then decreases very slightly to its constant value when the circuit is switched on. Stronger candidates stated that there was an increase in the resistance of the wire of the filament within the lamp as it became very hot very quickly when current flowed through it.

Question 3

(a) (i) Stronger candidates annotated **Figure 3.2** with an *X* in the region between the vertical line representing the filament and the position of the vertical midline of the lens.

(iii) Stronger candidates recorded a measured length of the image of the filament in the region of 1 cm to 3 cm. A number of weak responses provided values which demonstrated that the question had not been read correctly as the recorded value was far too large and corresponded to the distance between the lens and the screen.

(b) The length of the filament of the lamp was measured and recorded. Stronger candidates recorded several measurements and averaged them. A value between 0.1 cm and 1 cm was accepted. Candidates were then asked to suggest why the measurement may have been inaccurate. Many candidates suggested that it was not possible to get the ruler close enough to the filament because of the glass envelope of the bulb, or that the glass envelope could have a distorting, magnifying or diminishing effect on the viewing of the filament, or gave a good explanation of how a parallax error could have arisen in this specific situation. Weaker candidates made suggestions that were too vague or stated that the filament was too small to measure.

(c) The measured values of l_i and l_o were used to calculate the magnification produced by the lens using the formula provided. Stronger candidates divided l_i by l_o and gave a decimal number to 2 or 3 significant figures and with no unit. Weaker candidates often used fractions and recurring signs or added units which were not accepted.

(d) Stronger candidates showed working to indicate use of the value of *X* from **(a)(ii)** in the second formula for the magnification. They then compared this answer with the value of the magnification calculated in **(c)** to decide whether the results supported the theory or not. Weaker candidates omitted the calculation or gave insufficient comparison or explanation. Some weak responses showed an inability to use the concept of two numbers being the same within limits of experimental error or different because they were outside limits of experimental error. Some very good responses referring to percentage error were seen, but discussions in terms of being close enough to be regarded as the same, or too different to be the same were also sufficient to gain credit.

Question 4

(a) Candidates measured and recorded the distance required to balance the beam. Stronger responses included values in the region 5.0 to 25.0 cm, recorded to the nearest millimetre.

(b) Stronger candidates calculated the mass of the beaker by multiplying the length recorded in **(a)** by 5.

(c) When oil was added and the beam rebalanced many candidates recorded a new distance which was larger than the first, but less than 50 cm, given to the nearest millimetre.

(d) Weaker candidates often listed the symbol for the quantity instead of the unit. Stronger candidates often gave five sets of readings; repeating measurements and averaging them was not necessary here. These candidates showed the distance increasing by uniform amounts for equal increases in the volume of oil added, and the masses were calculated correctly. Weaker responses showed less uniform increments due to poor measuring of volumes or poor beam balancing.

(e) .A good set of results produced a well-judged best fit straight line. There were some weaker responses showing poor choices of scale. Some weaker candidates adjusted the plotted points to fit the line. It is expected that experimental data shows some scatter about the best line and this should have been shown rather than the data being altered to fit the line. Some weaker responses showed a line produced by joining one point to the next with a straight line (a dot-to-dot line).

(f) (i) Stronger candidates produced a large gradient triangle drawn using two points on the line (or at least correctly indicated with some appropriate marks) and then used the same triangle to calculate the gradient to 2 or 3 significant figures. A number of weaker candidates drew a triangle but used numbers corresponding to a different triangle, or used points from the table that were not on the best fit line, or drew small triangles or showed no indication of the coordinates used or other working.

(ii) Stronger candidates produced correct graphs and stated that the relationship between the gradient of the line and the density was that the gradient was equal to the density of the oil.

PHYSICS

Paper 5054/41
Alternative to Practical

Key messages

Candidates should ensure they report answers to a suitable number of significant figures.

General comments

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.

The level of ability shown by the candidates was good. However, some candidates approached this paper as they would a theory paper and not from a practical perspective. Candidates need to think about what they would do in a practical situation rather than try to answer the question from the point of view of a theory paper. Only a very small number of candidates failed to attempt all sections of each of the questions and there was no evidence of candidates being short of time. The stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately. Units were generally well known and usually included where needed.

Question 1

(a) In this question candidates were asked to explain why the water should be left to stand for a time before placing the purple crystal in the tube. Many incorrectly related this to allowing time for the temperature to reach room temperature. About half of the candidates realised that the reason was to allow time for the water to settle as moving water would spread the purple dye through the water for the wrong reason.

(b) In this question stronger candidates were able to explain that the colour change should not take place too quickly so that changes could be observed. Responses that the water should not boil were also credited but answers relating to breakage of the tube or other safety issues were not.

(c) The majority of candidates correctly drew an arrow in the tube to show the direction of water movement when the tube was heated. However, some candidates had arrows going in the wrong direction, all directions and even going out of the tube entirely.

(d) There were many different responses given but some were not related to safety.

Question 2

(a) (i) and (ii) Many candidates did not realise that they must ensure that they measure from the same point on the ball when indicating a distance moved by a ball. When showing distances on a diagram, stronger candidates showed precision and the arrows on the lines indicated the points being used for measurement. Many candidates did not appear to use a ruler in the examination.

(iii) Most candidates correctly chose a meter rule or a tape measure. A ruler would not have been suitable to measure the longer length so this was not accepted.

(iv) This question was answered well with the majority of candidates carrying out the calculation correctly.

(v) This was answered well. Most candidates calculated the correct value for E and gave the answer to 2 significant figures. However, a few did not give their answers to the correct number of significant figures.

(b) The graphs were drawn well by most candidates and the majority gained at least partial credit. The scales were mostly sensible and labelled and the points were plotted correctly. The drawing of the curve was less well done. A number of weaker candidates produced a straight line which was not credited.

(c) Stronger candidates suggested reducing the distance rolled by the ball (as it would go off the bench) and answers relating to increased friction or reducing the speed of the ball were also accepted. Many candidates thought it would reduce friction which was the total opposite of the answer required.

Question 3

(a) (i) This was answered well with the majority of candidates indicating that the eye must be in line with (bottom) of the meniscus. A few candidates mistakenly drew their eye facing the wrong way.

(ii) When asked to explain their answer to **(a)(i)**, most candidates talked about parallax error but this was insufficient for credit. Candidate needed to explain how parallax error is avoided i.e. the line of sight is perpendicular to the scale of the measuring cylinder.

(iii) The majority of candidates read the scale of the measuring cylinder correctly.

(b) (i) Most candidates correctly named a balance of some sort or said that scales were required to find the mass of the liquid.

(ii) The majority of candidates answered this question well although a significant number described finding the volume of an irregular solid rather than finding the mass of a liquid.

(c) Stronger candidates gave a sensible practical reason why the density value obtained may not match the recorded value. Many candidates gave incorrect calculations or an incorrect reading from the measuring cylinder. Practical errors were required e.g. liquid drops left in the beaker or a zero error on the balance. Only stronger candidates answered this question well.

Question 4

(a) This was usually answered correctly with the majority of candidates suggesting a micrometer or callipers.

(b) (i) Only stronger candidates answered this question correctly. Candidates were expected to understand that the wire would heat up once the circuit was switched on so it was important to take readings before this affected the readings.

(ii) This question was well answered. The majority of candidates correctly took the readings from the meters although some did not give units.

(c) (i) This question proved challenging for some although most candidates gained at least partial credit.

(ii) Candidates were required to use their results to suggest a relationship between the diameter of the wire and its resistance and most candidates did this well.

PHYSICS

Paper 5054/42
Alternative to Practical

Key messages

- Candidates should be reminded to include units when quoting the values of physical quantities. The unit they have provided should be appropriate for the calculated or measured quantity.
- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule should be given to the nearest millimetre. If a measured length is, for example, exactly 5 cm, the value should be quoted as 5.0 cm.
- Candidates should pay attention to detail when drawing or annotating diagrams. The accuracy of straight lines on diagrams could be greatly improved by using a sharp pencil and a ruler.
- Candidates should be advised to avoid using general 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 give detail on why the accuracy has improved or how parallax error was avoided.
- Candidates should be reminded that when plotting a graph using data obtained from practical work, there will almost always be some scatter about the line of best fit. Forcing the line through all points will often produce a curve that is not smooth, and candidates should be discouraged from doing this.

General comments

The level of competence shown by the candidates was good but some candidates approached this paper as they would a theory paper, and not from a practical perspective. Only a very small number of candidates failed to attempt all sections of each of the questions and there was no evidence of candidates being short 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 performed 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 was generally good.

Comments on specific questions

Question 1

(a) (i) The majority of candidates read the scale of the ammeter correctly and recorded it, as requested, in the table.

(ii) The reason for stirring the water before taking a temperature reading was less well understood. Many candidates did not realise that it was to ensure that the water is at a uniform temperature.

(b) The graph question was done well. The axes were usually labelled and sensible scales were chosen. There were few instances of scales on the axes that were multiples of 3, 7 etc. The use of such scales should be avoided.

Most candidates plotted the points accurately and drew a smooth curve of best-fit. The instruction to draw a smooth curve was sometimes ignored and a straight line of best-fit was drawn through the plotted points.

Candidates should be reminded that they need to plot to the nearest half square, so plotting all the points on grid intersections will sometimes mean an error in the plot. Some candidates forced their curve through the origin, when the downward trend of the plotted points clearly indicated that there should be an intercept on the y–axis.

(c) (i) A majority of candidates drew smooth extrapolations of their curve and extended it to give sensible estimates of the current in the circuit for a temperature of 0°C.

(ii) Only a small number of candidates were able to suggest that to obtain an estimate of the current flowing when the temperature of the thermistor was 0°C, (melting) ice should be added to the beaker.

(d) (i) Almost all candidates were able to use their graph to estimate the current flowing when the water temperature was 75°C.

(ii) Only the strongest candidates answered this question fully correctly. Most candidates gained partial credit for substituting into the given equation to calculate a value for the resistance of the thermistor. Only a very small proportion of candidates realised that because the current was in mA, and the unit of resistance given on the answer line was in Ω, the current had to be converted to A. Most answers were a factor of 1 000 out. A small number of candidates who realised that the current needed to be converted to A, divided the current by 10 or 100 instead of 1 000.

(e) (i) Most candidates gained partial credit for describing the relationship between current and temperature displayed by the graph, by stating that the current increased as the temperature increased. Fewer went on to say that the relationship was non-linear/not a straight line or that the current increased at a greater rate as the temperature increased.

Many candidates stated that the two quantities were directly proportional, despite the graph being a curve that did not pass through the origin. The concept of direct proportion was not well understood.

(ii) Most candidates also found it difficult to make the link between current and resistance i.e. if the current increased when the temperature increased, then the resistance of the thermistor would decrease as the temperature increased.

Question 2

(a) (i) Few candidates gained full credit on this question. Candidates were required to measure two lengths from the diagram to the nearest millimetre. A large number of candidates got at least one of the measurements wrong.

(ii) Stronger candidates realised that if the diagram they had just taken measurements from was drawn one-eighth full size, then to get the actual distances, their values in **(i)** would need to be multiplied by 8. Many candidates either divided their answers in **(i)** by eight or wrote down the same answers again.

(b) The substitution of the distances into the given equation was well done, and answers were generally correct. However, many candidates did not record their answers to two significant figures.

(c) The precautions that need to be taken whilst using an illuminated object to measure the focal length of a convex lens were not well known. Answers that gained credit included; carrying out the experiment in a dark room; repeating each reading and averaging; making sure that the object, lens and screen are perpendicular to the bench; taking the readings perpendicular to the scale of the ruler.

Question 3

(a) (i) The average value of the time between claps was usually calculated correctly. However, some candidates did not give their answer to two decimal places as instructed in the question.

(ii) Many candidates found it difficult to suggest why giving the average time to 2 decimal places was a sensible thing to do. As a general rule, since the data presented was given to 2 decimal places, the average value should be quoted to the same number of decimal places as the raw data.

(b) (i) Almost all candidates correctly suggested that a measuring tape or a trundle wheel would be suitable for measuring the distance from the candidate to the wall.

(ii) Most candidates found the calculation of the speed of sound straightforward. However, some confusion arose because the letter *s* appeared in the given equation. Although *s* had been defined as distance in the question, a minority of candidates thought that *s* represented seconds, the unit of time.

(iii) Only the strongest candidates answered this question correctly.

Question 4

(a) Most candidates gained partial credit for their descriptions of using a plotting compass to plot the pattern of the magnetic field between the two North poles of the magnets. Many answers lacked structure and missed out important details of the plotting process. Few candidates stated that when the dots were joined to complete the first magnetic field line then the same process of plotting would continue at different starting points so that the whole pattern of the magnetic field could be seen.

(b) Only stronger candidates were able to state that the direction or the strength of the magnetic field could also be deduced from the plotting exercise.