PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

Many candidates performed well on this paper. However, many needed to read the questions more carefully as they sometimes selected an answer that might have looked familiar or plausible but did not answer the question as it had been set.

Candidates need to be aware that in numerical calculations, the wrong options are derived from the incorrect manipulation of the numbers supplied. It therefore follows that combining the numbers in the question until one of the options is found is more likely to lead to an incorrect choice that a correct one

On this paper, **Question 21** was correctly answered by almost all the candidates, and **Questions 7** and **37** were also very frequently answered correctly.

Comments on specific questions

Question 12

This question supplies no information about the structure of the object except to describe it as non-uniform. The location of its centre of mass, therefore, can only be deduced from its behaviour. This must be at **D** so that the weight of the object produces a clockwise moment about the pivot that cancels the moment of the added weight. Option **C** was more commonly chosen than **D**, indicating some confusion amongst candidates over what is needed for balance.

Question 13

In the second situation, the tension is no longer shared between two springs and each spring supports the full weight of the load; the two springs are joined end to end and so the total extension is the sum of the two individual extensions. Both effects double the extension and so the correct option is **D**. Option **C** was more popular than **D**.

Question 15

This question concerned the total pressure at the bottom of a lake. In terms of the symbols in the question, the total pressure is given by $P + hrg$. This corresponds to option **A**. This was chosen by a significantly smaller number of candidates than option **D** which was hrg.

Question 17

Option **B** proved to be an attractive though incorrect choice. More candidates chose **B** than chose the correct **A**. The direction of W is, in this case, vertically downwards and so the appropriate distance moved is x. The definition of work done includes the expression *distance moved in the direction of the force*. This wording is significant here.

Question 19

Although the correct option **C** was chosen by more candidates than any other, both option **B** and **D** attracted a not insignificant number of candidates. The range, of course, is the difference between the lowest reading and the highest and, provided that everything else is kept constant, the range is inversely related to the sensitivity. Option **D** would increase the sensitivity and reduce the range.

Question 20

The scale on this thermometer has been misplaced and all readings are 1°C too great. The question is about a temperature increase, however, and since both the initial and final temperature readings are too great, the difference between them is correct. Option **C** proved popular with all candidates; the correct option **B** was more popular with candidates who scored the most highly on the rest of the paper.

Question 27

The light does not undergo total internal reflection as it enters either prism but, in both cases, it then strikes a glass-air interface at 45° and does undergo total internal refection. The correct option A was the most commonly selected but the other options all attracted some candidates.

Question 29

This relatively straightforward question was made more challenging by the used of different units in the options. This produced numerical values in options **C** and **D** which were familiar as numbers but incorrect when coupled with the unit given. This is a question where several candidates might well have chosen a familiar number rather than thinking carefully about the speed of sound. In fact, each of the options was chosen by a significant number of candidates and the most frequently selected option **D** contained the familiar power of ten: $\times 10^8$. Candidates need to be clear that the option selected corresponds to the question that has been asked.

Question 33

Few candidates selected either option **B** or **D** but the correct option **A** and the erroneous **C** turned out to be equally popular. A single diode prevents only allows a current in the forward direction. It blocks but does not reverse a current in the opposite direction. This was not widely understood.

Question 36

This is a question that solely assesses factual knowledge. Both the correct option **A** and the incorrect **C** proved popular. In fact, **C** was chosen by more candidates than **A**. It is clear that most candidates know that the fuse is fitted into the live wire but perhaps those who were uncertain about the location of the switch were more likely to chose an option where the answers in the two columns of the answer table differ. This is no more likely to be correct than an option where the answers in the two columns of the answer table are the same. This is the case here.

Question 39

The most widely chosen option **A** was not correct and, in fact, all the options were chosen by a noticeable number of candidates. This is not an alternating current (a.c.) supply but a direct current (d.c.) supply that is being switched on and off. Perhaps there candidates who interpreted the 4.0 V difference shown on the screen as being double the amplitude of an a.c. Similarly, f is the number of times the supply is switched on every second. The supply is switched off f times per second as well but the question does not concern itself with this.

PHYSICS

Paper 5054/12
Multiple Choice

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

General comments

Many candidates performed well on this paper. However, many needed to read the questions more carefully as they sometimes selected an answer that might have looked familiar or plausible but did not answer the question as it had been set.

Candidates need to be aware that in numerical calculations, the wrong options are derived from the incorrect manipulation of the numbers supplied. It therefore follows that combining the numbers in the question until one of the options is found is more likely to lead to an incorrect choice that a correct one.

On this paper, **Question 1** was correctly answered by many candidates, and **Question 25**, **29** and **32** were also quite frequently answered correctly.

Comments on specific questions

Question 8

Many candidates answered this question correctly but option **A**, which would have been the direction of the frictional force, was often chosen. This could have been because the word *frictionless* was overlooked by candidates.

Question 10

This question gave no information about the structure of the object except to describe it as non-uniform. Therefore, the location of its centre of mass could only be deduced from its behaviour. Stronger candidates gave the correct answer of **D** recognising that the weight of the object produces a clockwise moment about the pivot that cancels the moment of the added weight. However, **C** was more commonly chosen than **D**.

Question 11

Option **C** was a more popular answer than the correct option: **D**. The question required a certain amount of work before the correct option could be chosen. In the second situation, the tension is no longer shared between two springs but each spring supports the full weight of the load. Furthermore, the two springs are joined end to end and so the total extension is the sum of the two individual extensions. Both effects double the extension and so the correct option is **D**.

Question 13

There is an inverse proportionality between the pressure of a gas and its volume at constant temperature. Hence, the correct option was **C** and this was the most commonly selected option. However, a number of candidates chose option **A**, possibly because a graph with a straight line through the origin was familiar.

Question 14

This question assessed familiarity with the equation for kinetic energy in terms of the value of a ratio. Option **A** was rarely chosen and the correct option **D** was the most popular choice, but both **B** and **C** were selected by a number of candidates. Some candidates had possibly not considered the increase in the mass and others might not have considered that the effect of the speed depends on the square of its value.

Question 17

Stronger candidates generally answered this well but a number of other candidates selected **C**. The scale on this thermometer had been misplaced and all readings were 1°C too great. However, as the question was about a temperature increase, and since both the initial and final temperature readings were too great, the difference between them was correct.

Question 23

Although none of the incorrect options was chosen by more candidates than the correct option **D**, each of the options was chosen by a significant number of the candidates. In general, there appeared to be a great deal of uncertainty concerning wavefronts.

Question 28

Either option **C** or **D** was chosen by the majority of the candidates. Option **C** is a factor of two too small. This might have been chosen by candidates who did not realise that the return journey is double the distance of 80 m given in the question. Some candidates may have used the time in the question (one second) as the time for the return journey, when a more careful reading of the question indicated that the relevant time is half of this value.

Question 31

The correct option, **C**, was chosen by more candidates than any other option but other options were all popular choices. Only stronger candidates were able to show understanding of the problem caused by lightning.

Question 35

This question was essentially concerned with resistance and current. The correct option was the most frequently chosen, but option **D** was nearly as popular. Clearly the greatest power is developed when the current is greatest which, in turn, is when the resistance is the least. It is then only necessary to arrange the resistor combinations in order of decreasing resistance.

Question 37

A large number of candidates selected the correct option which stated that the transformer decreases the current in the transmission cable and increases the potential difference. However, both option **A** and **D** were commonly chosen. Some candidates did not fully understand what was happening when a step-up transformer was used at the beginning of a transmission cable. Some candidates did not apply the equation $V = IR$ correctly and believed that since the current decreases, the potential difference must too. Another misunderstanding was the belief that the current must increase in order to force its way more effectively through to the far end.

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 reminded to 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 a 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

Many candidates answered this paper well and calculations were generally performed accurately. Most candidates were able to quote a relevant formula, either in words or symbols and substitute correctly into it.

The standard of written English was high and there was no evidence of a language problem, even for the weaker candidates. However, a minority of candidates ignored the instructions for ***Section B*** and answered all three questions.

Comments on specific questions

Section A

Question 1

(a) (i) Only the strongest candidates gave an adequate explanation of why the mercury level in the tube falls when the glass plate is removed. Few candidates attempted to compare the downward pressure in the tube to the atmospheric pressure acting on the surface of the mercury in the dish.

(ii) Many candidates knew that there would be a vacuum at point X in the tube once the mercury had fallen, but a sizeable minority thought that there would be air remaining in the tube.

(b) Most candidates only gained partial credit for this question. Many were able to state that a value for the atmospheric pressure could be determined by measuring the height of the mercury column in the tube. Far fewer candidates specified that it was the height of the mercury column above the level in the dish that should be measured. Of the few candidates who realised that to determine a value for the atmospheric pressure in pascals, the equation $p = h\rho g$ needed to be used, no candidate stated that the height h needed to be expressed in metres.

Question 2

(a) The expressions mgh and $\frac{1}{2}mv^2$ for gravitational potential energy and kinetic energy were well known.

(b) Despite the obvious clue given in **(a)**, only stronger candidates were able to determine the speed of the coin as it hits the ground by applying the conservation of energy to the situation. A small number of correct solutions were also seen from candidates who applied the relevant equation of motion. Most candidates wrote down a mixture of equations with no explanation and proceeded no further.

(c) (i) Only a very small number of candidates were able to state that if air resistance is ignored when released from rest at the same height, the heavy and the light coin would hit the ground with the same speed because they have the same acceleration.

(ii) Only the strongest candidates answered this question correctly and stated that if air resistance acts, then the air resistance force is a smaller proportion of the weight of the heavier coin and so the heavier coin would have the greater acceleration and reach the ground first.

Question 3

(a) Most candidates made some progress with the difference in molecular behaviour of the molecules in a liquid and a gas. Most candidates could describe one or two differences, but only stronger candidates identified a third difference.

(b) Many candidates stated that intermolecular bonds/forces needed to be broken in order to turn a liquid at its boiling point into a gas. Very few candidates related this to the work that needed to be done to cause this separation. Candidates who linked this process to latent heat being supplied gained partial credit.

Question 4

(a) The names of the missing components of the electromagnetic spectrum were well known by candidates, but they were not always listed in their correct order in the spectrum.

(b) Stronger candidates realised that the component of the electromagnetic spectrum that has the greatest frequency also has the smallest wavelength, and gave gamma rays for both their answers.

(c) The explanation of the use of X-rays to produce an image of a broken bone was not well known. Most candidates had no idea of this application, and of those who did, the extent of their knowledge was to state that X-rays can pass through flesh but not bone. Few candidates mentioned the fact that they are detected photographically or by a detector behind the bone.

Question 5

Fully correct answers to this problem on the determination of the density of oil were rare, but most candidates gained partial credit. Many candidates failed to subtract the weight of the measuring cylinder from that of the cylinder and the oil, and others had problems with the conversion of the weight of the oil into a mass so the density equation could be applied. In addition, the graph was often not read correctly which resulted in the weights of incorrect volumes of oil being used by candidates.

Question 6

(a) (i) The majority of candidates calculated the current in the lamp correctly.

(ii) The resistance of the lamp was usually calculated correctly.

(b) (i) Most candidates knew that a combination of two 1.5 V cells connected in series would give a voltmeter reading of 3V. However, some candidates thought that the voltmeter would read 1.5 V.

(ii) Most candidates gained at least partial credit here. They realised that at the lower voltage the resistance of the lamp would be smaller, but only a very small number of candidates related this to the fact that the filament of the lamp was now at a lower temperature.

(iii) Many candidates made the sensible suggestion that when a filament lamp blows, it does so immediately after being switched on as there is a surge of current due to the fact that the resistance of the lamp is lower when cold.

Question 7

(a) (i) Most candidates identified atom Q as the ionised atom.

(ii) Only the very strongest candidates stated the size and the sign of the charge on the ionised atom. Of those candidates who answered correctly that the charge was 1.6×10^{-19} C, most did not show or state that the sign of the charge is positive as requested.

(b) Most candidates identified atoms Q and S as being isotopes of the same element.

(c) (i) Only the strongest candidates were able to deduce that atom R is the isotope that decays to produce one of the other atoms.

(ii) Only a small number of candidates identified which atom was the product of the decay of atom R.

(iii) Many candidates deduced that the decay was by β-emission.

(iv) Most candidates obtained partial credit for the half-life calculation by realising that 3 half-lives elapsed in 99 years.

Of those who correctly determined that one-eighth of the original particles remained after 3 half-lives, only a very small number went on to deduce that seven-eighths of the atoms will therefore have decayed.

Section B

Question 8

(a) The principle of magnetic shielding was not well understood. Very few candidates realised that the component to be screened should be surrounded by a box and that the box should be made from iron.

(b) (i) Stronger candidates who attempted this question were able to draw a diagram of a simple electromagnet. The core of the electromagnet was frequently missing, and if present was often not labelled. When the core was labelled, the label was often steel and not iron. Few candidates realised that a switch should be included in the circuit diagram so the electromagnet could be switched on and off.

(ii) Most candidates gained partial credit for stating one use of an electromagnet, but very few were able to describe the named use in detail.

(c) (i) The concept of electromagnetic induction was not well understood. Although most candidates stated that the ammeter would show a deflection when the bar magnet is inserted slowly into the coil, far fewer candidates gave the reason for this deflection, namely that the magnetic field lines of the magnet were being cut by the solenoid. It was rare to see the terms *induced voltage* or *current* used in the description.

(ii) Most candidates incorrectly thought that the ammeter would give a reading when the magnet is held stationary in the coil

(iii) The importance of the word *quickly* in the question was not recognised by most candidates. Although stronger candidates stated that on withdrawing the magnet from the solenoid, the ammeter deflection will be in the opposite direction, very few stated that the deflection would be larger than before.

Question 9

(a) Few candidates stated that the warmer water in the plastic container did not mix with the cooler water below because it is lighter/less dense and so would not sink.

(b) (i) Only stronger candidates suggested that the pipe in the tank was made from copper because copper is a good conductor of thermal energy. A number of candidates suggested that the reason was that copper is a good conductor of electricity.

(ii) The mechanism of the conduction of thermal energy in metals by the movement of free electrons was not well understood, and most candidates were unable to offer an explanation for the process. Most candidates did not take note of the instruction to explain in terms of free electrons and talked about molecular collisions transferring the thermal energy through the copper. There were some good explanations of the process from stronger candidates who discussed the movement of mobile free electrons transferring energy by moving through the metal and transferring energy to the atoms of the copper.

(iii) The description of the mechanism of convection in the water was much better understood. Many candidates stated that the cooler water sinks to the bottom and the warmer water rises to the top of the reservoir, but few mentioned that this was due to the change in density of the water as its temperature changed.

(c) Most candidates managed the calculation and correctly calculated the thermal energy that needed to be removed to cool the water. The most common error was a failure to convert the mass of the water from grams to kilograms before substituting into the equation.

(d) (i) Only the strongest candidates answered this question correctly by describing how the molecules in a liquid at a constant temperature move. Where credit was awarded it was usually for the statement that the molecules slide over one another. Very few candidates stated that the molecules move in clusters or that they move throughout the liquid.

(ii) Most candidates stated that as the temperature of a liquid decreases, the average speed of the molecules decreases. If candidates talked about the energy of the molecules decreasing, the word *kinetic* needed to appear in the answer.

Question 10

(a) Few candidates wrote down a correct value for the speed of light in a vacuum. Answers ranged from 3 m/s to $3 \cdot 10^{20}$ m/s. Many candidates confused the speed of light with the speed of sound and quoted answers of either 300 or 330 m/s.

(b) Most candidates stated the colours of the visible spectrum correctly, but a sizeable minority of candidates either had colours missing, or added colours such as yellow and brown to their list.

(c) (i) Most candidates used the scale of the diagram to correctly deduce that the focal length of the lens was 6.0 cm. A common incorrect answer was 12.0 cm, where candidates measured the distance between the two principal foci.

(ii) Very few candidates produced a correct ray diagram to show the formation of the image by the diverging lens. The majority of candidates ignored the diverging lens in the diagram and attempted to draw a ray diagram for a converging lens.

(iii) The height of the image was usually measured correctly when one was present. Candidates who had drawn an incorrect ray diagram could still get full credit here if the image they had drawn had been measured correctly

(iv) Many candidates were able to determine the magnification of the image. Many found the reciprocal of the correct ratio by dividing the height of the object by the height of the image.

(v) The differences between a real image and a virtual image were not well known, with most candidates managing to give only one difference instead of the two asked for.

(vi) The only correct use for a diverging lens seen from candidates was for correction of short-sight. Most other answers referred to telescopes, cameras and binoculars.

(d) Stronger candidates were able to make progress in explaining why wavefronts of light change direction as light passes from air into glass. Partial credit was often awarded for stating that light travels more slowly in glass. The idea of one side of the wavefront slowing down before the other was seldom seen, nor was the fact that the wavelength of the wave decreases in the glass.

PHYSICS

Paper 5054/22
Theory

Key messages

In order to perform well on this paper, a candidate must understand all the rest of the syllabus thoroughly and to expect questions from any part to appear.

Candidates should pay attention to the exact question that is asked and ensure that it is answered in the way demanded. When a question includes a phrase such as *in terms of molecules*, answer which make no reference to molecules are unlikely to be awarded full credit. Similarly, where a question includes two commands such as *state and explain*, it is important that the second command is not ignored. There are occasions when the second command word appears in a second sentence.

The context of a question must always be considered when it is answered. Candidates sometimes produced lists of facts or properties that had been learnt by them even though some of the items were not relevant to the question that had been asked.

General comments

Candidates should take care not to contradict themselves when writing an answer. If a candidate makes two opposing statements within one answer space, credit cannot be given for that point.

Candidates should take care to present their answers as clearly as possible so that they are legible and well set out.

Comments on specific questions

Section A

Question 1

(a) Only a very few candidates answered this question directly and full credit was rarely awarded. However, a larger number of candidates made some relevant comments and obtained some credit. Many candidates stated or implied that the absence of an atmosphere on the Moon resulted in the absence of any gravity but most of these candidates made further references to the downward acceleration of the hammer and feather.

(b) (i) Many candidates obtained the correct answer by the correct method and were awarded full credit. However, a noticeable minority of candidates tried other approaches and did not gain any credit. These approaches varied from simply dividing the acceleration by the time, to rather more complex calculations involving v^2. Acceleration was not always thoroughly understood.

(ii) Many candidates drew a straight line of positive gradient from the origin but an appropriate value was not always marked on the *y*-axis at the correct position. Lines and curves of other shapes were also seen. The most common of these was a straight line of negative slope that intersected the *x*-axis at a time of 1.5 s.

(iii) Although many candidates obtained a fully correct answer or an answer that was obtained correctly using a previous erroneous value, the most common approach was to multiply the final speed by the time taken. Therefore, an answer that was double the correct value was quite common.

Question 2

(a) (i) This part was well answered and full credit was often awarded. A very small number of candidates rearranged a known equation incorrectly to obtain an expression such as the incorrect $F = p/A$. This led to an incorrect answer.

(ii) Only stronger candidates realised that air on the other side of the piston also exerted a force.

(b) This part was well answered with almost all candidates receiving full or nearly full credit. When full credit was not awarded, it was often because the answer given was too vague. Some candidates made no reference to collisions with the walls, whilst others referred to more collisions rather than to more frequent collisions. The only significant misunderstanding made by a small number of candidates was to refer to the increased speed of the molecules, despite the gas remaining at a constant temperature.

Question 3

(a) (i) This was often quite well answered although the rather ambiguous term *fusion* was used by some candidates. Candidates who were aware that the Sun is powered by a nuclear fusion reaction did not always describe the reaction in terms of small nuclei combining to produce larger nuclei. Other explanations offered included nuclear fission, chemical reaction and the transfer of gravitational potential energy to thermal energy.

(ii) Most candidates were able to supply an acceptable component of the electromagnetic spectrum or to simply state *radiation*.

(b) This part was well answered and most candidates were aware that black surfaces are good absorbers of infrared radiation. The fact that black surfaces are also good emitters was not relevant in this context.

Question 4

(a) Many candidates were awarded full credit here and most candidates produced at least one acceptable difference.

(b) There were many good answers and full credit was commonly awarded. There were a few candidates who, despite the wording of the question, made no reference to molecules in their answers.

(c) (i) This part was well answered although some answers made no reference to physics. The answer "to produce more salt" was not on its own sufficient.

(ii) This part was also well answered by many candidates although answers such as "it is too cold" were not sufficiently direct.

Question 5

(a) This was rarely well answered and a variety of misunderstandings and omissions was presented. Many candidates made no reference to vibration or to the particles of the medium. Other candidates supplied descriptions of transverse waves. A common incorrect answer stated that the waves move parallel to the wave direction. Of course, this is inevitably true for all waves.

(b) (i) The answer to this part was very commonly correct with the correct working included. Some candidates rearranged the equation $v = fl$ incorrectly and gave a variety of incorrect answers. There were also some answers that were too large or small by factors of ten.

(ii) This was generally well understood although some explanations lacked sufficient detail.

Question 6

(a) (i) Candidates who realised that the potential difference (p.d.) required could be obtained from the position of the trace on the screen of the oscilloscope usually gave the correct answer. However, candidates who tried to calculate the answer from other information obtained answers that ranged enormously from 0.017 V to 8400 V. The second value is greater than the electromotive force (e.m.f.) of the supply. Other common values included 12 V and 8.0 V.

(ii) The answer to this part was quite commonly correct or obtained by the correct use of an incorrect answer from **(i)**. Candidates who did not get as far as the answer often obtained some credit for the working shown. This question was omitted more often than others.

(b) A few candidates were awarded full credit and others gained some credit for making appropriate comments concerning the circuit. This was a part where unlikely answers were supplied by candidates who probably had no real understanding of the situation. Such attempts included the suggestion that trace on the screen became a sine wave or simply oscillated vertically.

Question 7

(a) (i) Only a minority of candidates were awarded full credit for this part. The presence of a current in a magnetic field was rarely mentioned.

(ii) Many candidates answered this question in an appropriate manner with full credit being awarded fairly often. An unfortunate source of uncertainty was the description of the current direction. The obvious indication, *B to A*, was rare and many other terms were unclear or inaccurate. References to the left-hand rule were often given although the right-hand rule was stated by some candidates.

(b) Only the strongest candidates answered this question correctly but many candidates clearly understood what was needed to some extent. Often candidates only supplied the moment due to one side of the coil. Candidates who realised that both sides contributed to the total moment often ignored the need to convert the distance from cm to m.

(c) (i) Some candidates are confused as to the difference between a *slip ring* and a *split ring*.

(ii) This was well answered with many candidates stating an appropriate change.

Section B

Question 8

(a) A very common error here was to answer in terms of the point beyond which the deformation becomes permanent. This point is the *elastic limit*, which despite not being a syllabus term, was used by many candidates in answers.

(b) (i) There were many good answers. A few candidates answered in terms of weight; e.g. $m = W/g$.

(ii) Most answers made some reference to gravity although fewer made it explicitly clear that weight is a force. There were many answers that were awarded full credit.

(c) (i) This was very commonly correct.

(ii) This part was rarely awarded credit. Although the calculation was often correct, the answer was very often supplied without a unit.

(d) (i) There were some candidates who made little progress here and obtained no credit. Others made some progress and the answer 3.7 kg was not uncommon. However, few candidates were awarded full credit.

(ii) This part was rarely awarded full credit. The overwhelming majority of answers included a straight line that passed through the origin rather than beginning above it. Some lines beyond the limit of proportionality began to curve back on themselves, which in these circumstances is not possible.

(e) There were many good answers to this question with most answers being awarded some credit and full credit was awarded quite often. Some answers did not make clear the direction in which the energy change was being made. Since both elastic energy and gravitational energy are forms of potential energy, the answer *potential energy* needed further qualification but this was quite commonly not supplied.

Question 9

(a) This was well answered. The most frequent reason for full credit not being obtained was that it was not clear that the boiling point is a temperature. A second common omission was to use the term *boiling* without any description of the phase change to which it refers.

(b) Many candidates referred, in some way, to the intermolecular forces and the need to overcome them. Only occasionally was work done, increased potential energy or latent heat mentioned. A few candidates supplied answers that were essentially a description of evaporation rather than boiling.

(c) Full credit was often awarded here and nearly all candidates placed the symbol for an ammeter in an appropriate position. A few voltmeters were shown connected into the series circuit or where connected in parallel with the ammeter.

(d) (i) Full credit was commonly awarded but occasionally candidates divided the potential difference (p.d.) by the current or supplying the joule (J) as the unit for power.

(ii) This part was also well answered although there were candidates who did not convert 1.0 minute to seconds and who calculated an answer that was sixty times too small.

(iii) This part was also well answered but there were candidates who calculated the reciprocal of the correct answer as a consequence of either rearranging a known equation incorrectly or because of a confusion between latent heat and specific latent heat. The latter confusion was often made when an equation was quoted in the form $L = ml$.

(e) The opinions of the candidates were fairly evenly divided as to whether the upward force on the piston changed as it moved upwards. Those who correctly stated that he force did not change very commonly gave a suitable explanation in terms of the constant speed of the piston.

Question 10

(a) This was well answered and full credit was very commonly awarded.

(b) (i) Although the effect of alpha-particle emission was well understood, some candidates determined the number of neutrons in a radon –222 nucleus.

(ii) The fact that the question asked about the original nucleus rather than the product challenged some candidates and whilst many answers were correct, there were many others that were incorrect.

(iii) This part was not well answered. A commonly given incorrect answer was that alpha-particles are radioactive.

(c) (i) This part was very well answered indeed. Even though the question was only concerned with interpreting a graph, the scale was expressed in standard form and this added some complication.

(ii) Full credit was often awarded here and many candidates had some idea about what was being asked. Whilst many candidates realised that this sort of question is likely to involve halving something a few times, there were candidates who halved the number 222 or even 7.6.

(d) Most candidates gained credit here and this part was well answered.

(e) Almost all candidates mentioned a particular, hazardous consequence of radiation on the lungs. A somewhat smaller number of candidates related this to the strong ionising effect of alpha-particles.

PHYSICS

Paper 5054/31
Practical

Key messages

In order to produce good responses, candidates needed to make accurate observations with repeated measurements whenever possible and also to make accurate records of their work as they obtained their results. It is important to take repeated measurements and calculate the average whenever possible.

Working for calculations should always be shown, the units for quantities always stated and measurements and final answers given to an appropriate level of precision. Readings from analogue instruments such as some ammeters and voltmeters should always be written down to the precision of that instrument. In the case of answers where the unit required is printed on the answer line on the question paper, candidates should ensure that their response is given in that unit.

General comments

Many candidates read the questions and performed the tasks requested by following the instructions accurately, making accurate observations and taking measurements carefully to an appropriate degree of precision using the equipment provided. Measurements should be repeated and averaged whenever possible. There were some situations where it was not appropriate to take repeat measurements, for example, **Question 4(d)**. Stronger candidates were able to construct tables of results with appropriate headings, with the name of the quantity and the unit, for each column. The results obtained were used, according to the guidance provided in each part of a question to perform calculations by substituting values into equations and plot line graphs or make valid, accurate comparisons, predictions or other comments about their results. Some weaker candidates gave comparisons that were too vague; for example, the terms "change", "are different", "vary" are too vague but stronger candidates used phrases such as "as A increases, B decreases" or "the values of X are close enough to say that they are the same" which were much more specific.

It is important (and beneficial to the candidates) that each set of equipment used conforms as closely as possible to the equipment specified in the Confidential Instructions which are sent to centres. It is in the interest of candidates that a complete set of results for each set of apparatus is provided with the Supervisor's report.

Candidates would benefit from further practice in the plotting of graphs. Some responses to questions involving the plotting of graphs used impractical scales based on the difference between the first and last values in the results table and comparing this with the number of squares on the grid. This led to graphs which were challenging to read and some candidates made errors in plotting and interpretation. Scales which occupy over half the grid in the x and y directions and are based on a scale of 2, 5, or 10 units corresponding to 10 small grid lines are recommended. Scales based on 3,6,7 and non-integers should be avoided. The plotted points on graphs should be marked with small, fine, but visible crosses and placed accurately. The Cartesian axis system should be used. The best fit straight line or curve should be a carefully drawn, suitably placed, thin line.

Comments on specific questions

Question 1

(a) (i) Candidates were required to find an accurate time (in seconds) for 30 oscillations of a mass suspended from a spring system. 30 complete oscillations should have been timed, repeated at least once, the results written down and their average calculated. Weaker candidates often omitted to show that times had been repeated and averaged. Many of these candidates recorded times in stopwatch notation: essentially just copying the digital display of the stopwatch. This should be avoided. A number of weaker candidates also misinterpreted the display of hundredths of seconds as milliseconds. The correct use and taking of readings from the display of a stopwatch is a very important and useful skill, worth revising thoroughly, as this will frequently be required by candidates in practical physics tests (as well as in practical tests in some other science subjects).

(ii) Stronger candidates noted that the amplitude of the oscillation decreased with increasing time (or from the first to the last oscillation).

(b) (i) The spring system then had a piece of card attached to its lower end and the time for 30 oscillations measured. The time should have been larger and stronger candidates showed the average time to be approximately 1 or 2 seconds longer for the 30 oscillations with the card present.

(ii) Stronger responses described how the amplitude changed when the card was added and gained credit for stating that the amplitude decreased more quickly with the card or that the time taken for the amplitude to reach zero was less, or shorter. Weaker candidates often incorrectly described the amplitude decreasing in a faster time.

(iii) Stronger candidates explained that the differences in the times and change in amplitude occurred because the card added extra air resistance. Mentioning drag or air friction in the correct context were also accepted. Some candidates observed that the system developed a lateral oscillation, so phrases describing this, for example, “it started moving like a pendulum” or “it started moving from side to side” were accepted as alternative responses and were credited. Weaker responses that just used the term “resistance” or “damping” without further clarification were not accepted.

Question 2

(a) Stronger candidates described the two essential points: what to measure and the condition that meets the criterion for the rule to be horizontal. Candidates should have stated that the height of the rule above the bench was measured in two places (preferably at each end of the rule or at least well-separated points along the rule) and those two heights were found to be equal if the rule was horizontal. Weaker candidates frequently referred to checking that the rule was perpendicular to the upright part of a clamp stand, but this was an unreliable method as the uprights of many clamp stands are out of alignment. Many other weak responses suggested measuring the height of the rule in two places but did not complete their response with the second part, the comparison of the heights and finding them equal. The use of a spirit level was not accepted as these devices are not often available in physics laboratories and are not on the basic list of laboratory equipment.

(b) (i) A large range, 30° to 60°, was accepted for the angle between the L-shaped beam and the end of the metre rule. This large range of accepted angles was because of variations in the materials, construction and performance of the apparatus. Stronger candidates took repeated measurements and averaged them, but evidence of this being done was rarely seen. Precision higher than the nearest degree was unrealistic.

(ii) Stronger candidates described how the mass attached to hole A would be changed several times whilst keeping the mass at B constant. Only the very strongest candidates mentioned the need to keep the load at B a constant value.

(c) The sketch graph should have commenced at the origin but a small intercept on the y-axis was allowed. A curve or straight line, with the angle increasing as the mass increased, was accepted providing it ended or levelled off horizontally for the angle of 90°. The graph should have been a curve but very few curves were seen.

Question 3

(a) Many candidates gained full credit here by marking point *U* on the edge of the block and correctly identifying the angle of refraction as the ray between the normal and the refracted ray on the left side of the centre line. Weaker candidates often marked the incorrect angle as the angle of refraction. The ray should have been drawn carefully, using a sharp pencil so that the angles of incidence and refraction could be measured accurately for **(b)**.

(b) The angles of incidence and refraction should have been measured carefully and have values within the tolerances, +/–1° for the angle of incidence and +/–3° for the angle of refraction. The tolerance for *r* was unusually large on account of the large size of the dots used to identify points *s* and *t*. Many candidates gained at least partial credit for this question.

(c) The refractive index of the block was calculated. It was essential for the working to be shown and this should have included writing the formula with the values for the angles correctly replacing *i* and *r*, writing down the unrounded value and then the final, rounded value (to a suitable precision of 2 or 3 significant figures.

Question 4

(a) (i) The resistance of a heated thermistor was investigated in this question. The potential difference across points A and C in the circuit was measured and should have been close to the supply p.d. and been in the range of 3.5 V to 4.5 V.

(ii) Strong candidates gave descriptions of one or more valid points which would have contributed to making the measured p.d. as accurate as possible. The most common points mentioned in these responses were to repeat the measurement and take the average, to ensure all connections were good and tight, to make allowance for zero error on the voltmeter and to ensure that when the switch was closed that it made a good electrical contact. The importance of selecting the correct range on a digital meter was also an acceptable response but was rarely seen. If the response concerned parallax error then a detailed explanation was required of how that error arose and was avoided but such explanations were hardly ever seen. The phrase “parallax error was avoided” was inadequate as a response but was frequently seen in many weaker responses. Many weaker candidates also suggested repeating the measurement to see if they were the same but this was inadequate. “Leaving the switch on until the readings stopped changing” was also a weaker response that could not be credited.

(b) (i) The potential difference across the 100 Ohm resistor was measured. Stronger candidates reported a value in the range of 0.65 +/– 0.2 V. Weaker candidates often reported very low values or values close to the first potential difference measured due to connecting the terminals across the wrong position(s).

(ii) Stronger candidates calculated the current by making correct substitution into the given equation and performing the calculation correctly. Some candidates gave the answer in milliamps and this was acceptable as long as the unit mA was then given.

(iii) The resistance of the thermistor was calculated by substitution into the given formula. There were many correct answers but weaker candidates often had difficulty with the calculation. There was a wide variation in values reported. The resistance using the specified equipment should have been in the region of 590 Ohms. Answers with precision of up to 4 significant figures were accepted.

(c) Stronger responses showed that the values obtained had been transferred to the table and included the correct unit for each quantity.

(d) (i) and (ii) The circuit was then switched on again and voltmeter readings taken every minute for 5 minutes, the calculations repeated and new values added until the table had been fully completed. Stronger candidates used consistent and sensible precision down each column. They showed the correct trends down each column with no breaks in the trend, showing that the potential difference increased, the current increased and the resistance of the thermistor decreased with a decreasing rate as the time increased.

(e) (i) A graph of resistance (along the y-axis) against time (along the x-axis) should have been plotted as a line graph and the best fit curve drawn. It should be noted that as this was a practical test and the candidates had obtained their own data to use for plotting the graph, it was not expected that the graph produced would be a perfect straight line or perfect curve. Stronger candidates had plots scattered either side and close to the best curve. These candidates labelled the axes carefully with the quantity and the correct unit, used a sensible scale for each axis, plotted the points accurately and neatly and then drew in pencil a neat fine curved line of best fit. Weaker candidates often omitted units or chose poor scales. Some plotting was very inaccurate or candidates used thick pen or pencil marks. Weaker candidates showed, for example, thick plots placed inaccurately, ‘dot-to dot' lines drawn so smooth curves were not produced or poor choices for the position of the 'best' line. The best line should have been a curve with no discontinuities.

(ii) Candidates should remember that the graph in their response is there to make it easier to convey, or obtain information about the relationship between two quantities and the use of scales based on the integers 2, 5, or 10, usually make it easier to plot the graph and to derive information from it. Weaker responses with poor scales often had plotting errors or errors in getting information from the graph. The graph was used to find the value of the thermistor's resistance at a given time (2.5 minutes). Responses were expected to have marks on the graph indicating the position of that time and preferably a 'tie-line' drawn from that point vertically up to the curve and then a line drawn horizontally across to the corresponding resistance value. There were some good responses, but some weaker candidates had only a faint indication on the graph and others had no visible indication at all. Weaker candidates placed the 'tie-line', (or indicating marks on the graph) in the wrong place so that it did not correspond to the time of 2.5 minutes, or misread the values.

PHYSICS

Paper 5054/32
Practical

Key messages

In order to produce good responses, candidates needed to make accurate observations with repeated measurements whenever possible and also to make accurate records of their work as they obtained their results. It is important to take repeated measurements and calculate the average whenever possible.

Working for calculations should always be shown, the units for quantities always stated and measurements and final answers given to an appropriate level of precision. Readings from analogue instruments such as some ammeters and voltmeters should always be written down to the precision of that instrument. In the case of answers where the unit required is printed on the answer line on the question paper, candidates should ensure that their response is given in that unit.

General comments

Many candidates read the questions and performed the tasks requested by following the instructions accurately, making accurate observations and taking measurements carefully to an appropriate degree of precision using the equipment provided. Measurements should be repeated and averaged whenever possible. There were some situations where it was not appropriate to take repeat measurements, for example, **Question 3**. Stronger candidates were able to construct tables of results with appropriate headings, with the name of the quantity and the unit, for each column. The results obtained were used, according to the guidance provided in each part of a question to perform calculations by substituting values into equations and plot line graphs or make valid, accurate comparisons, predictions or other comments about their results. Some weaker candidates gave comparisons that were too vague; for example, the terms “change”, “are different”, “vary” are too vague but stronger candidates used phrases such as “as A increases, B decreases” or “the values of X are close enough to say that they are the same” which were much more specific.

It is important (and beneficial to the candidates) that each set of equipment used conforms as closely as possible to the equipment specified in the Confidential Instructions which are sent to centres. It is in the interest of the candidates that a complete set of results for each set of apparatus is provided with the Supervisor’s report.

Candidates would benefit from further practice in the plotting of graphs. Some responses to questions involving the plotting of graphs used impractical scales based on the difference between the first and last values in the results table and comparing this with the number of squares on the grid. This led to graphs which were challenging to read and some candidates made errors in plotting and interpretation. Scales which occupy over half the grid in the x and y directions and are based on a scale of 2, 5, or 10 units corresponding to 10 small grid lines are recommended. Scales based on 3,6,7 and non-integers should be avoided. The plotted points on graphs should be marked with small, fine, but visible crosses and placed accurately. The Cartesian axis system should be used. The best fit straight line or curve should be a carefully drawn, suitably placed, thin line.

Comments on specific questions

Question 1

(a) Stronger candidates described the two essential points: what to measure and the condition that meets the criterion for the rule to be horizontal. Candidates should have stated that the height of the rule above the bench was measured in two places (preferably at each end of the rule or at least well-separated points along the rule) and those two heights were found to be equal if the rule was horizontal. Weaker candidates frequently referred to checking that the rule was perpendicular to the upright part of a clamp stand, but this was an unreliable method as the uprights of many clamp stands are out of alignment. Many other weaker responses suggested measuring the height of the rule in two places but did not complete their response with the second part, the comparison of the heights and finding them equal. The use of a spirit level was not accepted as these devices are not often available in physics laboratories and are not on the basic list of laboratory equipment.

(b) The card was rotated and released so that the system started oscillating. Candidates were asked to find the accurate time for one oscillation (5.5s to 8.5s). The majority of candidates counted single oscillations several times and then calculated the average of them. This was accepted, but a more accurate method would have been to count numerous oscillations several times, divide by the number of oscillations and then take the average. The sets of results collected by many weaker candidates indicated that half-oscillations had been counted. These candidates often omitted to show that times had been repeated and averaged. Many of these candidates recorded times in stopwatch notation: essentially just copying the digital display of the stopwatch. This should be avoided. A number of weaker candidates also misinterpreted the display of hundredths of seconds as milliseconds. The correct use and taking of readings from the display of a stopwatch is a very important and useful skill, worth revising thoroughly, as this will frequently be required by candidates in practical physics tests (as well as in practical tests in some other science subjects).

(c) As the masses were moved closer together, the time for one oscillation was reduced. Some weaker responses were not specific enough; to write only "as the masses moved closer" was ambiguous and required clarification by qualifying the term "closer".

Question 2

(a) An inclined track (composed of two metre rules, joined together with narrowing separation and inclined) was set up for the candidates and they were required to measure the height at the top end and the width at each end. There were many good responses, but a few were out of the tolerance and some weak responses used incorrect units for the values they recorded.

(b) A glass ball was released from the top of the track and the time taken for it to roll from one end of the track to the other was recorded. The strongest candidates took repeated measurements and averaged them, although this was not an essential requirement for credit to be awarded. It was necessary for the correct notation to be used for the times and the time should have been in the range 3.7s to 4.6s. There were many good responses.

(c) The time taken for the glass ball to roll down the track when the top end was the widest was then measured. Stronger candidates showed times were reduced by 0.2s or more and again recorded repeat measurements and averaged them, although this was not an essential requirement. Candidates would have gained the most consistent results by releasing the ball from exactly the same distance from, and as close to, the start of the track as possible.

(d) Only the strongest candidates answered this question well. Most on the responses discussed friction or the surface area of contact at the start, but these effects are negligible for a glass sphere on an inclined track set up as for this question. The conversion of potential energy into kinetic energy was a far more important factor in reducing the time taken for the sphere to roll down the track. The diagrams in **Fig. 2.3** and **Fig. 2.4** should have guided candidates to consider the two track arrangements, the height above the bench of the centre of mass of the sphere and the amount of potential energy converted into kinetic energy as the sphere moved down the track.

Question 3

(a) (i) This part of the question was generally well answered but some weaker candidates failed to label the rays and a few rays were incorrectly placed.

(ii) The slit plate was removed and the paths of the rays should have been extended back to point *s* where they should have intersected. The ray paths should not have been allowed to extend behind point *s* unless they were marked as dotted (or dashed) lines (because the area behind point *s* would be behind the light source), although a very short extension (<5 mm), to aid the construction of the diagram, was ignored. The angle between the rays was labelled Θ and measured and should have been between 40° and 50°. One of the most common errors in weaker responses was to label the angle between one ray and the centre line as *Θ*.

(iii) The angle between the rays, *Θ,* and should have been between 40° and 50°.

(b) Candidates were asked to predict what would happen to the angle *Θ* if the distance, *d*, from the point *s* to the slit plate were increased to 5 times its original value. Many candidates gained partial credit by predicting that as *d* increased *Θ* would decrease, but there were very few responses that gained further credit for suggesting that as *d* increased, *Θ* would decrease by smaller and smaller amounts.

Question 4

(a) (i) The potential difference, V_{AC}, across the LDR and the 10 kΩ resistor in series with it was measured. Many candidates made repeated measurements and averaged them and obtained values in the range 1.0 V to 4.0 V, given to a precision of 2 or 3 sig. figs.

(ii) Stronger candidates gave descriptions of one or more valid points which would have contributed to making the measured potential difference as accurate as possible. The most common points mentioned were to repeat the measurement and take the average to ensure all connections were good and tight, to make allowance for zero error on the voltmeter and to ensure that when the switch was closed it made a good electrical contact. The importance of selecting the correct range on a digital meter was also an acceptable response but was rarely seen. If the response concerned parallax error then a detailed explanation was required of how that error arose and was avoided but these were hardly ever seen. The phrase “parallax error was avoided” was inadequate as a response but was frequently seen in many weaker responses. Many weaker candidates also suggested repeating the measurement to see if they were the same but this was inadequate. “Leaving the switch on until the readings stopped changing” or “click on hold” were also weaker responses that could not be credited.

(b) (i) The potential difference, V_{AB}, across the 10 kΩ resistor was measured. Stronger candidates obtained values that were less than was measured in **a(i)**. Values of zero were not accepted.

(ii) Many candidates used the given formula and divided the p.d. measured in **(i)** by 10 000 to obtain the current that was passing through the resistor. Any correctly calculated value was accepted provided any unit given was a unit for current.

(iii) The resistance of the LDR was calculated using the given formula. Values in the range 0.1 kΩ to 4.5 kΩ were accepted. Few candidates answered this correctly and many candidates had difficulty either in manipulating quantities in units with the prefix k (kilo) or managing numbers involving powers of ten. Some responses indicated that candidates had ignored, or not noticed, the unit specified at the end of the answer line for this part of the question.

(c) Stronger candidates put headings in the table for each quantity accompanied by the appropriate unit. Other candidates often missed one or more units or used the wrong symbol for the current.

(d) (i) and (ii) One sheet of paper was placed between the lamp and the LDR, the potential difference was measured and the current and resistance were calculated and the values written in the table.

Further sheets of paper should have been added, one by one, and after each additional piece of paper the potential difference, current and resistance recorded in the table with each column with a consistent and appropriate level of precision. Stronger candidates showed a decrease in the values of V_{AB}, a decrease in the current and an increase in the resistance passing down the column as the number of sheets of paper was increased. The value of V_{AB} should have decreased by larger and larger amounts as the number of sheets of paper increased. The value of V_{AC} should have remained constant throughout the experiment but a few weaker candidates recorded a decrease.

(e) (i) A graph of resistance (along the y-axis) against ‘number of sheets of paper’ (along the x-axis) should have been plotted as a line graph and the best fit curve drawn. It should be noted that as this was a practical test and candidates had obtained their own data to use for plotting the graph, it was not expected that the graph produced would be a perfect straight line or perfect curve. Many candidates had plots scattered either side and close to the best curve. Circles should have been drawn around points which were clearly anomalous and therefore were not being included for consideration when choosing the best curve. Stronger candidates showed the axes labelled carefully with the quantity and the correct unit on the y -axis, and 'number of sheets of paper' (with no unit) on the x-axis using a sensible scale for each axis. They plotted the points accurately and neatly and then drew in pencil a neat fine curved line of best fit. Weaker candidates often omitted the unit for the resistance or chose poor scales. Some plotting was very inaccurate or used thick pen or pencil marks. Weaker candidates showed, for example, thick plots placed inaccurately, 'dot-to dot' lines drawn so smooth curves were not produced or poor choices for the position of the 'best' line. The best line should have been a curve with increasing gradient with no discontinuities. There were some excellent responses but also some very weak ones.

(ii) The strongest candidates sketched a curve under their graph, with the line for the half-thickness paper intercepting their graph at the value for which the number of sheets of paper was zero, and with a more shallow gradient. The new line was usually labelled correctly. Weaker candidates often had a line drawn under the original graph but which was drawn equidistant from it along its length.

PHYSICS

Paper 5054/41
Alternative to Practical

Key messages

- Candidates need to think about what they would do in a practical situation rather than try to answer the questions from the point of view of a theory paper.
- Candidates should take care to read the questions carefully and to answer exactly as the questions have been set.

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
- suggesting practical methods.

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. Stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly although a few were unable to give an answer to the correct number of significant figures. Units were generally well known and usually included where needed.

Comments on specific questions

Question 1

(a) The question required candidates to suggest how an illuminated object could be focused on to a screen. The question clearly stated that the lens was fixed in position so suggestions of moving the lens back and forth could not be credited. Stronger responses suggested moving the screen back and forth until a clear image was obtained. There were many other suggestions made but none of them would have resulted in a better focused image.

(b) In **(i)**, candidates were required to measure two lengths on the paper which were clearly marked. This was generally done well with the majority of candidates gaining credit for this. Answers needed be given to at least 2 significant figures but one significant figure was allowed here for 6.0 cm as it was an exact integer. In **(ii)**, candidates were expected to use their values from **(i)** in a simple calculation and this was also done well by the majority of candidates.

Candidates were asked in **(iii)** to suggest how it could be ensured that the value of f (the result of the previous calculation) was accurate. A large number of candidates immediately suggested the 'no parallax' argument which was not suitable in this case. The accuracy of the value for the focal length could be ensured by repeating the measurements. However, stronger candidates gained credit here.

Question 2

(a) In **(i)1**, candidates were asked to find the diameter of a ring and this was done well. In **(i)2**, candidates were asked to draw the ring onto a ruler so that it was centrally placed at the 5.0 cm position. Only stronger candidates did this well. There were many different sizes and shapes of ring drawn but candidates were expected to draw it to the correct size and with the centre on the 5.0 cm mark. In **(ii)**, candidates were asked to explain why the rings needed to be added carefully and this was generally answered well with candidates realising that the ruler might easily topple and that it was important to get the exact balance point.

(b) The graph in **(i)** was a straightforward one to plot and this was mostly done well. A few candidates did not start their axes from (0,0) as instructed and so could not be credited. Some candidates plotted points with large blobs rather than neat crosses. The curve was mostly drawn well. In **(ii)**, candidates were asked to find the number of rings to balance the ruler when the length was 18.0 cm. They were also asked to show their working on the graph. Many did not show their working or found the value of N at 16.0 cm rather than 18.0 cm as they misread their own scale. Only stronger candidates gained the credit available for accuracy. Those candidates who had taken care with their graph often gained full credit. In **(iii)**, candidates were given an equation to use to calculate the mass of the meter rule using their data from **(ii)**. Most candidates gained some credit here by using their previous value correctly but many did not give their answer to 2 significant figures as instructed. In **(iv)**, candidates were asked to name a piece of apparatus to use to check their result and most candidates knew that a balance was required here. Some suggested a scale which was not given credit as most apparatus used has a scale of some sort.

(c) The question asked for a way of improving the method used in the experiment. This was a challenging question and only stronger candidates realised that this method was limited by the mass of the individual rings. Using rings of smaller mass or a combination of heavier and smaller rings to balance the metre rule would have meant a better result could have been obtained.

Question 3

(a) Candidates were expected to draw an ammeter and voltmeter on to a circuit diagram to show how the current through a filament lamp and the potential difference across it could be measured. Many candidates gained full credit but errors included having the meters the wrong way round, incorrect circuit symbols used and placing the voltmeter across the variable resistor or power pack instead of across the filament lamp.

(b) In **(i)**, candidates were asked how the circuit could be adjusted to get different sets of values. The obvious method was to adjust the variable resistor but this was completely missed by most candidates. Some candidates gained credit for suggesting using different numbers of cells. Parts **(ii)** and **(iii)** were generally answered well although some candidates left out the units of resistance.

(c) This was answered well. Most candidates realised that the lamp would be brighter and many also followed this through to suggest that it would also get hotter.

Question 4

(a) Candidates were asked how they could mark the length of an uncalibrated thermometer at 0 °C. They were expected to suggest the apparatus used and the method. However, few candidates realised that they needed to use melting ice to find this value. Many just thought it could be done with a ruler.

(b) Here candidates were expected to explain how it could be calibrated at 100 °C but only stronger candidates answered this correctly.

(c) Finally, candidates were asked how the thermometer could then be used to find room temperature. They were expected to use the values on their thermometer and to equally divide the intervening length into 100 equal divisions. Final credit was available for indicating leaving their thermometer in a room and noting the temperature on their thermometer. Some candidates overcomplicated this by leaving their thermometer in water until it reached room temperature.

PHYSICS

Paper 5054/42
Alternative to Practical

Key messages

- Candidates should be reminded to include units when quoting the values of physical quantities. They should be encouraged to check that the unit they have provided is appropriate for the calculated or measured quantity.
- Candidates should be made aware that it is important to record measurements to the correct precision. In particular, measurements made with a rule should be given to the nearest millimetre. If a measured length is, for example, exactly 5 cm, the value should be quoted as 5.0 cm.
- Candidates should take care and 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 vague phrases, such as, "to make it more accurate" or "to avoid parallax error". These comments need to be linked to the practical situation being considered, and candidates should state why the accuracy has improved or how parallax error was avoided.

General comments

The level of competence shown by the candidates was good although 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. Stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were well known and usually included where needed. Writing was legible and ideas were expressed logically.

Comments on specific questions

Question 1

(a) (i) The majority of candidates measured the length of the spring and recorded answers that were within the tolerance allowed. Some candidates ignored the instruction that the loops at the end of the spring were not to be included in their measurement.

(ii) The position of the ruler was usually drawn close to the spring, but often it was not carefully drawn and very obviously not vertical. Occasionally the ruler drawn was much shorter than the spring itself.

(iii) Most candidates marked the position of the candidate's eye correctly, level with the bottom of the spring.

(b) (i) Many candidates found this to be difficult and correct answers were not common. The load values in the table were deliberately recorded in a random sequence, so the obvious way to improve the table of results was to list the readings in order of increasing or decreasing load. The most common incorrect answer was that the readings should be repeated but this in itself would not improve the table of results.

(ii) The graph question was done well. The axes were usually labelled and sensible scales were chosen. There was some evidence this year of scales on the axes that were multiples of 3, 7 etc. The use of such scales makes it difficult for the candidates to plot their points accurately, and difficult for the accuracy of these plots to be seen.

The instruction that the scale of both axes started form the origin was frequently ignored and this caused problems in the next part of the question.

Most candidates plotted the points accurately and drew a good line of best fit, as requested. 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 did not gain credit for best-fit line because they forced their line through the origin, when clearly the trend of the plotted points made it obvious that there should be an intercept on the l–axis.

(iii) This was only answered well by stronger candidates. The concept of direct proportion was not well understood. Most candidates stated that $l \text{ and } L$ were directly proportional because the graph was a straight line, and as one quantity increased, so did the other. Only the strongest candidates realised that the quantities were not proportional to each other because although the graph was a straight line, it did not pass though the origin.

(iv) Most candidates extrapolated their graph and obtained a sensible value for the length of the unstretched string. Credit was available here for the accuracy of point plotting and the positioning of the line of best fit. This was only awarded for answers within the range 34 ± 2 (mm)

(c) (i) Most candidates only gained partial credit for this calculation. The graph was usually read correctly to determine the spring length for a load of 3.6 N, and most candidates gave this as the answer. The question asked candidates to determine the extension of the spring for this load, and only stronger candidates realised that the unstretched length of the spring needed to be subtracted from their graph reading.

(ii) The graph of *L* against *e* was well known, and most candidates drew a straight line passing through the origin.

(d) This more difficult final part was done well. A majority of candidates deduced that a spring of the same length but with a greater force constant, would have the same initial value of l but would have a greater gradient. The sketch graphs they drew reflected this.

Despite the instruction to draw their lines on **Fig. 1.2** on the axes provided, a large number of candidates drew their sketch graphs on **Fig. 1.3**.

Question 2

(a) The majority of candidates correctly recorded the reading on the top-pan balance to three significant figures. Common errors were the incorrect rounding of the truncated value and using a colon instead of a decimal point.

(b) (i) The reading of the new water level in the measuring cylinder caused many candidates problems, perhaps because the water level was between two consecutive scale graduations. Common incorrect answers were 81 and 69.5.

(ii) The increase in the volume reading on lowering the test-tube into the water was nearly always found correctly.

(iii) Many candidates misread the question and explained how to read the scale of the measuring cylinder accurately. However, the question was different to this, and asked for a source of experimental inaccuracy, so answers needed to give examples of how not to read the scale of the measuring cylinder accurately.

(c) Most candidates divided their values of mass and volume correctly to determine the density of water. Where errors occurred, it was usually in the incorrect rounding of a truncated value. Some candidates did not know the unit of density or omitted this.

Question 3

(a) (i) The scale reading of the voltmeter was usually correct. Occasionally it was recorded as 0.22 (V).

(ii) Most candidates substituted correctly into the given equation and obtained the correct answer for the resistance of a 10.0 cm length of the wire.

(b) Although most candidates gained partial credit here, the reasoning behind their answers was usually incorrect. Candidates were expected to deduce that the length of the wire and its resistance were directly proportional to each other. Although many candidates stated this, they went on to say that they were directly proportional because as one increased, so did the other. This was an insufficient explanation and did not, in isolation, necessarily mean that the quantities were directly proportional. Stronger candidates showed that the ratio of resistance to length was constant for the values in the table, or that doubling one quantity, doubled the other etc.

(c) Most candidates described a sensible precaution to prevent the overheating of the resistance wire in an investigation of this type. The most common correct answers referred to using smaller currents/voltages or switching off the circuit between readings. The use of a fan to cool the wire was also accepted but immersing the apparatus in water gained no credit.

Question 4

(a) (i) Most candidates drew a normal to the prism at point Z. The normal was expected to extend on both sides of the air-glass interface.

(ii) Although there was a clue given in the diagram because of the positioning of the pins P_3 and P_4, many candidates had difficulty in drawing the path of the ray of light until after it emerged from the prism. Many candidates refracted the ray back out into the air at point Z or had the ray from Z missing side XY altogether and reflecting downwards to emerge from WY. What was expected, was two total internal reflections of the ray from WX and then from XY with the ray then emerging normally through WY and passing through pins P_3 and P_4.

(b) Only the strongest candidates answered this question correctly. Candidates were asked to describe the overall effect of the prism on the ray of light. Most candidates were preoccupied with the ray being totally internally reflected, when all that was required was to state that the direction of the ray had been reversed, or that the ray had been turned through 180°.