PHYSICS

Paper 5054/11
Multiple Choice

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

General comments

Questions 16 and **40** were answered correctly by a high proportion of the candidates.

Comments on specific questions

Question 3

The most common choice was the correct option, **A**. The question was about the effect of air resistance on an object falling due to gravity in the Earth's atmosphere before terminal velocity is reached. The other options were chosen by some candidates but very few chose option **D** which described the velocities of the objects.

Question 5

Only stronger candidates answered this correctly. The principal source of inaccuracy was reflected in candidates' choosing option **D** which suggested that in a magnetic field, a stationary electron would experience a force. This showed a widespread confusion between electric and magnetic fields.

Question 14

The correct option, **B** was selected by fewer candidates than option **D**. It is likely that some of these candidates divided by the melting point of the wax, although this would not on its own lead to the value given in option **D**.

Question 17

This was only answered correctly by stronger candidates. The incorrect option **B** was more commonly chosen that the correct answer, **A**. Only the first two options show a change that is subsequently reversed and perhaps candidates who chose one of the last two options were under the impression that once the wavelength changed, it did not revert to its original value. It is not clear why option **B** was more popular than option **A** as a reduction in speed would not produce an increase in wavelength. It is possible that some candidates confused the wavelength with the amplitude.

Question 23

A noticeable minority of candidates incorrectly selected option **A** or **B**. A knowledge of the dispersion of visible light was needed to obtain the correct option, **D**, and this was selected by many candidates.

Question 25

The correct answer here was **D** and this was the most frequently chosen answer. A small minority of candidates chose an answer that omitted the factor of two that relates to the sound reflecting from the wall and thus travelling a distance $2x$. More candidates chose the incorrect option **B**. In this option, the N is misplaced in the fraction. It is likely that this error arose from rearranging a fractional expression incorrectly but candidates might have somehow deduced that the total time was N times greater than the time measured.

Question 27

The increase in the reading when object Y is moved towards object X reveals the fact that they are repelling and that the repulsion increases as the distance between them decreases. This one deduction led directly to the answer and only two magnets repel. An unmagnetised iron object is attracted to a magnet and cannot be repelled. Magnets are made of steel as iron cannot be permanently magnetised. The correct option, **B**, was the most commonly selected one.

Question 32

Most candidates answered correctly. However, a significant minority of candidates chose option **B** which is the energy supplied to just one of the resistors. Candidates who did not convert the time of 36 minutes to hours obtained option **D**.

Question 33

This question required the rearrangement of the expression that is needed when calculating the cost of using electrical energy. The correct answer was often given but different errors in rearranging the expression led some candidates to select one of the other options.

Question 34

The most frequently chosen option was option **B**. Some candidates possibly assumed that the power supplied to the transformer was magnified in some way by the transformer or perhaps these candidates did not calculate the current and then the power in the secondary circuit using the information given.

Question 36

More candidates chose the incorrect option **B,** than the correct option **C**. The other two incorrect options were rarely selected. Candidates who made the assumption that the diagram consisted of four complete periods (rather than two) might have selected option **D**. Perhaps a power-of-ten error was made or perhaps the numerical value 330 was chosen as it seemed familiar in the context of question on sound.

Question 39

Although nuclear power stations are sophisticated and expensive to construct, the generation of electricity is carried out in a very conventional manner. The nuclear energy is harnessed to boil water and to produce steam. The steam is then used in exactly the same manner as in a fossil fuel power station. Candidates who were aware of this usually selected the correct option, **C**. However, many candidates chose option **B**.

PHYSICS

Paper 5054/12
Multiple Choice

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

General comments

Question 7 was correctly answered by almost all candidates and **Questions 3**, **8** and **39** were also answered well by most candidates. **Question 3** involved calculation and a topic that was more challenging for many candidates.

One source of inaccuracy arises when an equation needs to be rearranged and some candidates found this difficult. There are various techniques that can be used to do this accurately and it is probable that some candidates would benefit from practising this process.

Comments on specific questions

Question 4

Many candidates gave the correct response, **D** for this question. The question relied on determining the directions of the forces that are acting. Candidates who selected option **C** might have thought that the tension in the thread *T* produced a downward force on the object. Downward force could be produced by a solid rod in compression but this is not a possibility for threads.

Question 10

The correct option, **D** was selected only by stronger candidates. Pressure is transmitted unchanged through a liquid and so the pressure produced next to piston X is the same as the pressure next to the other two pistons, Y and Z. The most commonly selected option, **B**, was in terms of the width of the pistons and so represented the order of the forces. Option **A** was also frequently chosen.

Question 11

The correct answer for this question was **B**. To obtain the correct answer, candidates needed to notice that the volume of the trapped air increases by a factor of three rather than two. Many candidates realised this and most then chose the correct option. However, some other candidates assumed that the volume doubled and these were divided more or less equally between those who selected 2*p* and those who selected *p* / 2.

Question 12

Here, the kinetic energy of the skater is completely exhausted as work is done against the braking force. Many candidates selected the correct option with option **B** being the next most frequently chosen. This answer is half the correct one and it is perhaps due to the $\frac{1}{2}$ in the expression for kinetic energy which was used incorrectly.

Question 18

Although the question relied on the definition of specific heat capacity, candidates needed to pay attention to the details to obtain the answer. The power output was given for 1.0 m^2 but the area of the panel is greater than this. In the same way, the power was given in W (which is equivalent to J / s) but the time was given in hours. Despite this, the correct option was selected by more candidates than any other.

Question 19

The correct option, **B**, was selected by fewer candidates than option **D**. It is likely that some candidates divided by the melting point of the wax, although this would not on its own lead to the value given in option **D**.

Question 24

The question tested the production of images by lenses. Diverging lenses only produce virtual images and virtual images produced by a single lens cannot be upside down. This immediately led to the correct option, **D**. Stronger candidates answered correctly but other candidates chose one of the other options.

Question 26

Candidates could immediately eliminate options **A** and **B**, as the colour labels on the *x*-axes are not in the correct order in terms of frequency. However, a number candidates did not do this and selected one of these options. A knowledge of the dispersion of visible light could then be used to obtain the correct option **D**.

Question 30

Almost all candidates selected either option **A** or **B**. Both of these show the compass needle parallel to the magnetic field. The correct option can be determined in one of two ways. The magnetic field of a bar magnet is directed from the N pole to the S pole and as the compass needle aligns with the magnetic field, option **A** is correct. However, in this case a more direct approach was to notice that in the correct orientation, the S pole of the compass was pointing towards the N pole of the bar magnet.

Question 34

The two most frequently chosen options were option **B** and the correct option, **C**. Perhaps there were candidates who assumed that the power supplied to the transformer was magnified in some way by the transformer or perhaps these candidates did not calculate the current and then the power in the secondary circuit using the information given.

Question 37

Although nuclear power stations are sophisticated and expensive to construct, the generation of electricity is carried out in a very conventional manner. The nuclear energy is harnessed to boil water and to produce steam. The steam is then used in the exactly the same manner as in a fossil fuel power station. Candidates who were aware of this usually selected the correct option, **C**. However, this was only a minority of candidates and the most popular of the other options was option **B**.

Question 38

The term “half-life” was not always fully understood by candidates. Half-life itself is one of these quantities. In this question, candidates who fully understood the quantity, selected the correct option, **B**. This was the most commonly chosen option. However, all of the other options were also chosen by a significant number of candidates.

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 candidates intend to convey much more accurately than just words. Whenever a diagram is asked for or suggested, candidates should include one and then label 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 giving unnecessary or irrelevant detail.

General comments

The majority of questions were accessible to all candidates. The quality of expression, even among weaker candidates was good, even if the underlying physics was sometimes inaccurate.

Calculations were generally performed well. Most candidates were able to quote a relevant formula, either in words or symbols and substitute correctly into it. Occasionally candidates who had performed a correct calculation did not give a unit or gave an incorrect unit.

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

Comments on specific questions

Section A

Question 1

(a) Most candidates used the correct formula to calculate the pressure exerted on the ground due to the bench. The main source of error was not realising that as there were two supports. The area of contact with the ground by the bench was twice the given area of contact of one support.

(b) (i) Many candidates did not realise from the information given in the question that the position of the centre of mass of the bench was exactly in the middle of the bench. Few candidates commented about the symmetry of the shape of the bench, but many gained partial credit by supplying an appropriate definition of the term “centre of mass”.

(ii) The principle of moments was used by most candidates in their attempts to solve the problem. In many cases the distances of the forces from the fulcrum were computed incorrectly. Correct answers for the magnitude of the maximum force that could be exerted downwards on the bench without it rotating about point Q were rare. A minority of candidates incorrectly attempted to use pressure considerations to attempt to calculate the force.

Question 2

(a) The weight of the man was almost always calculated correctly.

(b)(i) Most candidates applied the equation F = ma correctly to calculate the resultant upward force on the man as the lift accelerated.

(ii) Few candidates were able to deduce the force exerted on the man by the floor of the lift. Most candidates subtracted the value of the resultant upward force on the man from the weight of the man instead of adding it to the weight of the man.

(c) Candidates found this part of the question very demanding. Only the strongest candidates were able to sketch the distance-time graph for the journey of the lift. Most candidates were unable to sketch the distance-time graph for an object which was accelerating/decelerating.

Question 3

(a) Many candidates were able to state that fusion was the type of nuclear reaction occurring in the Sun which is responsible its release of thermal energy. Common incorrect answers were fission and chemical.

(b) (i) Candidates found this question part challenging. Few candidates stated that the thermal energy emitted from the surface of the Sun was infra-red radiation. Even fewer went on to say that this was in the form of electromagnetic waves.

(ii) Stronger candidates gave a correct value for the speed of infra-red radiation in a vacuum. Many candidates quoted an answer in the form of 3×10^n but the value of n was usually not 8. Occasionally, candidates who had the correct magnitude for the velocity omitted the unit.

(iii) Many candidates answered fully correctly.

(c) Only stronger candidates gained full credit here. Most candidates knew that wearing white clothes on sunny days kept the wearer cooler. Very few candidates went on to explain that white surfaces are good reflectors/poor absorbers of (infra-red) radiation.

Question 4

(a) Some candidates knew that the form of energy in coal that is transferred to electrical energy in a coal-fired power station is chemical energy. The most popular incorrect answer was thermal energy.

(b) (i) The statement of the principle of conservation of energy was well known. Occasionally candidates stated that energy cannot be created but did not follow up with the fact that energy cannot be destroyed.

(ii) Only stronger candidates were able to explain why the quantity of electrical energy produced by the power station was much less than the energy contained in the coal burnt to produce it. Candidates did not realise that most of the energy is converted to thermal energy, which is lost to the surroundings.

(c) Stronger candidates gave an acceptable environmental consequence of energy generation by coal-fired power stations. A common answer that was considered too vague was "causes pollution".

Question 5

(a) (i) Few candidates were able to explain why rubbing a plastic rod with a woollen cloth made the rod positively charged and then referred to the transfer of electrons from the rod to the cloth during the rubbing process.

(ii) Most candidates correctly stated that the woollen cloth would acquire a negative charge.

(b) (i) Many candidates showed that there were more negative than positive charges on the side of the sphere closest to the rod on the diagram and received credit for this. Far fewer showed equal numbers of positive and negative charges on the opposite sides of the sphere.

(ii) The reason for the sphere being attracted to the rod was understood by stronger candidates. These candidates were aware that the electrons on the sphere were attracted by the positive charges on the rod. Only a very small minority of these stronger candidates went on to say that the force of attraction of the rod on the electrons on the sphere is greater than the force of repulsion of the rod on the positive charges on the sphere.

Question 6

(a) Many candidates deduced the e.m.f. of one of the cells in the battery from the information that the battery consisted of three identical cells and had an e.m.f of 4.5 V. Many candidates attempted to apply the formula for Ohm's law to the circuit to deduce the answer.

(b) (i) Only stronger candidates were able to define the term "potential difference" in terms of the work done or energy transferred per coulomb of charge passing through a circuit component. Most candidates stated that it was equal to the current multiplied by the resistance.

(ii) Few candidates were aware of how to deduce the value of the resistance of the variable resistor from the information given in the circuit diagram. Only the strongest candidates knew that the potential difference across the variable resistor was (4.5 – 2.5) V. Most candidates assumed that the potential difference across the variable resistor was 4.5 V, despite the fact that there was another fixed resistor in series with the variable resistor.

Question 7 (EITHER)

(a) Electromagnetic induction was not well-understood. The idea that the magnetic field lines of the magnet are cut by the turns in the solenoid was rarely expressed. Many candidates incorrectly stated that the magnet cut the magnetic field lines of the solenoid as it moved into it. The idea that an electromotive force was produced was better understood, but few candidates went on to say that it was this induced e.m.f. that was responsible for producing the induced current in the solenoid.

(b) Many candidates knew that the induced current would flow in the opposite direction when the magnet was removed from the solenoid. Fewer candidates provided a correct explanation.

Question 7 (OR)

(a) Most candidates identified the NOR gate correctly.

(b) (i) Many candidates were able to explain why terminal Y in the given logic gate combination had a logic level of 0.

(ii) The effect on the output terminals X and Y of connecting terminal P to a supply of logic level 1 was deduced correctly by many candidates.

(iii) Few candidates were able to deduce the effect on the output terminals X and Y of returning terminal P to a logic level 0. Only the strongest candidates realised that the logic levels at X and Y would not change.

(iv) This question was very challenging for almost all candidates.

Section B

Question 8

(a) Many candidates correctly stated that the extra piece of apparatus needed to make the coil of the loudspeaker experience a force was a magnet.

(b) (i) Only the strongest candidates were able to use the graph of the alternating electromotive force (e.m.f.) applied to the loudspeaker coil to explain why the coil of the loudspeaker vibrates. Very few candidates mentioned that the current in the coil continually reverses, and because of this the force on the coil reverses.

(ii) The instruction to explain in terms of molecules how a sound wave is produced by the cone was often not followed. The fact that the backwards and forwards motion of the cone continually compressed and rarefied the air molecules in contact with the cone of the loudspeaker was seldom mentioned. Partial credit was given to candidates who stated that the air molecules were made to vibrate or that compressions and rarefactions travelled through the air.

(iii) The difference between a longitudinal wave and a transverse wave was not well understood. Candidates should be advised that when comparing the two types of wave motion, they should compare the direction of the vibrations of the particles of the medium with the direction of the energy transfer through the medium. Although the words parallel and perpendicular often appeared in candidates' answers, it was often unclear what was parallel or perpendicular to what.

(iv) There were some good attempts at using the graph of the e.m.f. supplied to the cone against time to calculate the number of times that the cone of the loudspeaker reverses its motion per second. Not realising that the direction reversed twice in each time period of the alternating e.m.f. was the most common error. Most incorrect answers were out by a factor of two.

(v) Candidates often used the wave equation to calculate the wavelength of the sound produced by the loudspeaker well.

(c) (i) Most candidates knew that if the maximum voltage of the e.m.f. applied to the loudspeaker was reduced, the loudness of the sound produced would decrease. The instruction to explain the effect on the loudness of the sound was often not followed. Few candidates went on to state that this was because the amplitude of the sound had decreased.

(ii) Many candidates realised that the pitch of the sound would be unchanged but did not support their answer by stating that this was because the frequency of the sound was unchanged.

Question 9

(a) (i) Many candidates completed the diagram to show how the molecular structure of a liquid compared to the supplied diagrams of a solid and a gas. Correct answers showed a similar packing density to the given diagram of the solid with most molecules touching, and a random arrangement of molecules.

(ii) Most candidates stated that it is easier to compress a gas than to compress a solid because the molecules in a gas are further apart. Far fewer candidates made any reference to the fact that forces between the gas molecules are much smaller than those between the molecules of a solid.

(iii) The fact that the molecules of the liquid in a thermometer move faster when the temperature of the thermometer increases was well known by most candidates. Fewer candidates stated that the molecules would also move further apart. A common incorrect response was that the molecules of the liquid would also expand. Candidates should be reminded that the molecules of a liquid do not expand on heating, they get further apart. It is this increase in molecular separation that causes the expansion of the liquid.

(b) (i) Few candidates were able to state what is meant by the ice point and the steam point. The melting point/temperature of ice and the boiling point/temperature of water were rarely mentioned.

(ii) Although some candidates realised that the ice point and the steam point are used to calibrate a liquid-in glass thermometer, only a small minority of stronger candidates knew how this is done. Of those who realised that the interval between the fixed points is divided up, few stated that it was divided into 100 divisions.

(c) (i)(ii) There were no fully correct answers to this part of the question which was concerned with the factors affecting the range of a liquid-in-glass thermometer. Candidates were asked to explain how the range of the thermometer is affected by increasing the mass of liquid in the bulb and by increasing the diameter of the tube. Occasionally, candidates correctly stated that increasing the mass of the liquid decreases the range and increasing the diameter increases the range. Explanations given were almost always incorrect. This section of the syllabus was not well-known.

Question 10

(a) The majority of candidates were able to state one feature common to all isotopes of yttrium.

(b) The description of the differences between a neutral atom of yttrium-90 and Q, its daughter product by beta-particle emission, was very poor. Candidates were expected to compare the numbers of protons, neutrons and electrons in neutral atoms of these two nuclides. To score full credit, candidates needed to state that a neutral atom of Q had one more proton, one less neutron and one more electron than a neutral atom of yttrium-90.

(c) (i) Few candidates were able to deduce the average background radiation count rate from the decay graph of count rate against time for the sample of yttrium.

(ii) The possible origins of the background count were well known and most candidates were able to list at least one, with many candidates able to give two different origins.

(iii) This more challenging problem involved the determination of the half-life of yttrium-90 from the given decay curve. Only the strongest candidates realised that the average background count needed to be subtracted from the initial count rate before any halving of the count rate took place. The average background count then needed to be added back on to resulting count rate before the graph was used to read off the half-life. Most candidates who were able to make any progress at all with this problem, ignored the fact that there was a background count, halved the initial count rate of the yttrium-90, and read off the corresponding time from the graph. These candidates were awarded partial credit for their answers.

(iv) Candidates who answered 'experimental error' did not receive credit. The process of radioactive emission is random, and any one measurement may deviate from the average represented by the best-fit line because of this randomness and not because of experimental error.

(d) Most candidates knew that the beta-particles would travel in a curved path between the charged plates and scored full credit for their diagrams. Occasionally, the curvature of the beam of beta-particles was incorrectly directed towards the negatively charged plate.

PHYSICS

Paper 5054/22
Theory

Key messages`

- Candidates should take note of the mark allocation for each question as this gives an indication of the amount required in answers.
- Candidates should read questions carefully and should ensure their answers fully fulfil the demands.
- Where there is a choice of question, such as in **Question 5** or **Section B** of this paper, candidates should follow the instruction and should not spend time answering more than the required number of questions.

General comments

There were some good performances on this paper but some candidates would have benefitted from writing in simpler terms to make sure their answers were clear. Simple sentences or bullet point phrases are usually adequate to convey what is required.

Similarly, when setting out calculations, candidates should be advised to start with the standard equation that defines the quantity or to apply the equation in the circumstances set out in the question then to rearrange it, substitute numbers and complete the calculation. In some cases, units were not given with otherwise correct calculations. Some candidates found the use of a calculator challenging and particularly so where numbers in standard form were used. Candidates found dividing by numbers with a negative exponent more difficult and power-of-ten errors in such calculations were common.

Comments on specific questions

Question 1

(a) Most candidates were able to supply two differences between mass and weight but there were often errors with units. It should be noted that an answer such as "weight depends on the gravitational field strength whereas mass does not" give only one difference even if it is written in the two separate answer sections.

(b) Many candidates were able to gain full or partial credit for their answers to this question. Where errors were made, it was often because the need to subtract the mass of the measuring cylinder or to tare the scale was not referred to.

(c) In order for the correct answer to be obtained, it was necessary to rearrange the usual definition of density to obtain $V = m / \rho$. A significant number of candidates simply multiplied the mass by the density. There were also candidates whose answers included an incorrect power of ten or who converted to cm^3 incorrectly.

Question 2

(a) This question was answered well by most candidates.

(b) (i) Many candidates were awarded at least partial credit for their answers but full credit was much less common. The statement "to every action there is an equal and opposite reaction" did not gain any credit unless it was made clear that the terms action and reaction are opposite forces.

(ii) Some candidates realised that the question was about how the swimmer reaches a terminal velocity. However, some candidates confused the forces involved and the swimmer's weight was commonly used as a force that opposed the resistive force due to the water.

Question 3

(a) (i) Only stronger candidates answered this fully but many others correctly commented on the refraction being in some way due to a change in speed. In general, answers were lacking sufficient detail for full credit.

(ii) Many candidates gave full answers here but others only referred correctly to the reduction in the wavelength. There were also some answers that suggested that the changes had been selected with little consideration of the exact circumstances of the question asked.

(b) (i) There were many candidates who wrote down an expression in terms of the sine function but whose answer was derived from 45 / 1.6 rather than from sin (45°) / 1.6. A common error was to give the final answer as 26° rather than its complement.

(ii) The answer here was not always correct and not always consistent with the answer given in **(i)**. Very often, the answer just stated what happens rather than explaining it. There were only a few comments concerning the critical angle.

Question 4

(a) These two parts were rarely both correct. Many candidates stated that there was no current in the neutral wire and a current of 13 A in the earth wire.

(b) (i) Answers to this part were usually awarded some credit but many answers were not detailed enough for full credit. Most candidates recognised that the fuse would melt.

(ii) This was not answered well. Most answers were in terms of the current whereas it is the potential difference of the live wire that is the significant consideration.

Question 5 EITHER

(a) Many candidates understood how to answer this question and obtained at least partial credit. A common error was the use of a current of 1.0 A rather than 1.0 mA as given in the question.

(b) (i) Very few candidates recognised that the increase in the resistance of the LDR in one branch of this circuit would not affect the current in the parallel branch.

(ii) Both the effect of the change in the brightness of the light on the resistance and the effect of the change in the resistance on the time taken for the charge to pass were often misunderstood. Many candidates stated that because the current decreases, the time taken for the given charge to flow decreases.

Question 5 OR

(a) Only a small number of candidates gave the correct name here. Common misidentifications included LDR and rheostat.

(b) (i) Of the few candidates that attempted this part of this optional question, only stronger candidates answered correctly.

(ii) Only a few candidates answered this part and of these very few answers were in terms of the operation of a transistor. Where credit was awarded, it was for other relevant comments.

Question 6

(a) There were some good answers here but some candidates confused nucleons and neutrons.

(b) (i) Many candidates mentioned the background count.

(ii) Many candidates gave answers that either repeated or merely rephrased the question. An explanation was required here.

(c) (i) (ii) Few candidates drew an arrow that was directed towards the centre of the circular path. Vertical arrows and arrowheads drawn along the curved path were more frequently seen.

(iii) Only stronger candidates answered this correctly.

Section B

Question 7

(a) (i) Stronger candidates recognised what was required and answered this question well.

(ii) The force between molecules was rarely mentioned but a few candidates gained credit for answers in terms of the proximity of molecules to each other.

(b) The reduction in friction caused by using oil for a hydraulic system was a focus for some candidates but a more popular answer was in terms of the density of the oil or occasionally, its boiling point.

(c) (i) This question that applied the definition of pressure to a calculation was very often correct. Some candidates used the correct substitutions but subsequently made a calculation error.

(ii) This part was also well answered but again some candidates made calculation errors. There were a few candidates who wrote down an addition sign but who multiplied the two pressures to obtain the correct answer.

(iii) There were many correct answers here but some candidates struggled to manipulate numbers in standard form.

(d) (i) Only a small minority of candidates related the increase in pressure to the increase in the depth of the oil. Many answers referred to the difference in the surface area of the two ends of piston 2.

(ii) This was started well and most candidates reached an answer of 4500 (Pa). There were some candidates who stopped at that stage and did not calculate the increase in force that was required.

(e) Most candidates understood what was required and were awarded at least partial credit. Only a few candidates gave answers that were sufficiently detailed for full credit. When the molecular collisions are discussed, it is important to state that the frequency of the collisions increases rather than simply stating that there are more collisions.

Question 8

(a) When defining the distance that is used in the definition of moment of force, many candidates did not use the term “perpendicular to the force” or anything equivalent. A few candidates used the term “parallel to the direction of the force” or an equivalent phrase. Only a few of the candidates who gave a correct verbal definition could indicate the perpendicular distance on the diagram.

(b) (i) Some candidates simply defined what is meant by moment. Of those that gave answers in terms of the clockwise and anticlockwise moment, the most common error was to make no reference to equilibrium.

(ii) Although many candidates recognised what was required here, only a few candidates gained full credit. Many stated what had to be done and just gave an example of a balanced ruler. A case where equal masses were placed equal distances from a central fulcrum did not prove anything as any erroneous definition of moment would produce equal values for the two sides.

(c) (i) This was very often correct. A few candidates used the mass from the question either with or without a change of unit.

(ii) There were some good answers to this question. An answer such as “where all the mass is concentrated” was not accepted; An expression such as “seems to be concentrated” was needed.

(iii) There were some good answers but some candidates repeated the comment that the ladder is wider at one end than the other. On its own, this did not gain any credit.

(iv) The were some correctly calculated answers here but there were some common errors such as dividing the weight and the perpendicular distance or using the mass instead of the weight.

(v) Only stronger candidates answered this correctly. The moment due to the weight of the ladder was frequently ignored.

Question 9

(a) There were some good answers and candidates often drew the a.c. graph correctly. The d.c. graph was less well drawn. Occasionally two correct graphs were drawn but were left unlabelled.

(b) (i) This was answered well and a correct value for the current was often given.

(ii) This question was answered well.

(iii) Most candidates could supply one advantage of a parallel connection and some of these went on to give a second advantage.

(iv) The number of days in a year was often taken to be 360. Only stronger candidates reached the correct final answer. Some candidates did not include the fact that there were five lamps and others did not include the number of hours in a day.

(c) (i) Many candidates drew a completely correct circuit. The most common error was to put the voltmeter in series in the circuit.

(ii) Several candidates realised that the resistance would be smaller in the circuit powered by 1.5 V cell but very few related this to a lower temperature of the filament.

PHYSICS

Paper 5054/31
Practical

Key messages

Candidates should aim to make careful, accurate observations, to take repeat measurements whenever possible and make accurate records of their work as they obtained their results.

Calculations should always be shown, whether or not they are asked for.

The units for quantities should always be stated and measurements and final answers given to an appropriate level of precision. 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.

Readings from analogue instruments such as some ammeters and voltmeters should always be written down to the precision of that instrument.

General comments

Candidates were able to perform the tasks requested by following the instructions accurately. Most made accurate observations and took 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, in parts of **Question 1** where ray diagrams are drawn. 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, judgements or make other comments about their results.

Some weaker candidates gave comparisons that were too vague; for example, by using the terms “change”, “are different” or “vary”, Stronger candidates used more exact phrases.

It would be useful for candidates to refer to the advice on plotting graphs issued by Cambridge. A number of otherwise good responses to questions involving the plotting of graphs used impractical scales which led to errors. The plotted points on graphs should be marked with small, fine, but visible crosses and placed accurately. The Cartesian axis system should be used, with increasing positive values from left to right along the x-axis and upwards along the y-axis. The best fit straight line or curve should be a carefully drawn, suitably placed, thin line.

Comments on specific questions

Section A

Question 1

(a) Most candidates answered this well. The most common incorrect responses were 30° or 120°.

(b) (i) The pair of hinged mirrors should have been placed so that the corner where they were hinged was at point **C** on **Fig 1.1**. The mirror labelled *2* was then rotated until the light ray reflected from it passed through point **x** on the centre line and a line drawn along the face of the rotated mirror. The angle between the mirrors was measured. The construction lines needed to be present and the value of angle b_x written in the space provided and have a value less than 90°. There were few correct responses and many weaker candidates had diagrams with incorrectly placed construction lines. Ray diagrams and constructions like the one in this question should be neatly drawn using fine pencil lines and small points in order to produce good results.

(ii) The trend in angle from b_x to b_y to b_z should have been a decrease and with 50° the minimum acceptable value for b_z.

(c) Stronger candidates identified the trend of angle *b* decreasing as the reflected ray from mirror *2* was used to rotate the ray so that it passed from point **X** to point **Z**. Weaker candidates identified no trend or an increase in angle due to poor practical use of the equipment or due to not following the instructions.

(d) Weaker candidates often described situations where there was poor experimental technique as a cause of inaccurate results. Stronger candidates described reasons attributable to lighting, the precision to which the angle could be measured, or factors due to the reflecting surface.

Question 2

(a) Given the assembled circuit and a list of symbols, the task of drawing a correct circuit diagram should have been straightforward for many candidates. Stronger candidates had perfect diagrams with two lamps and an ammeter in series with the power supply (3 cells) and in the parallel branch, a LDR in series with a fixed resistor. The voltmeter should have been drawn with connections across the fixed resistor only. There were a few perfect diagrams but many weaker candidates gained at least partial credit.

(b) When the correct equipment was used candidates should have found the current to be 0.16+/–0.05 A and the potential difference, 0.7 +/–0.3 volts.

(c) Stronger candidates referred to a change in the voltmeter reading if there was a change in the lighting level (intensity). Weaker candidates often referred to matters such as checking the circuit connections, or how to obtain an average reading.

Question 3

(a) (i) The question asked for an accurate time, so there should have been evidence of at least two timings and the calculation of the average of those timings. For this measurement of the time to travel from the top of the track to the 50 cm mark stronger candidates gave values of 3.0+/– 1.0 s. Weaker candidates had values outside the accepted range or lacked evidence of multiple timings or calculation of the average. Some candidates were not able to translate digital stop clock displays into times in seconds in the correct decimal notation.

(ii) The ball again should have been released from the top of the track, but timings should have been made for the ball as it travelled from the middle of the track (50 cm mark) to the end of the track. In this case there were two reaction time errors and the time should have been close to, but greater than, the value found in **(i)**. Stronger candidates demonstrated this and the strongest used the average of repeat measurements again even though evidence of this was not demanded. Weaker candidates gave values outside the accepted range.

(b) Stronger candidates were able to calculate the average speeds of the ball in the two halves of the track from the formulae.

(c) This question was answered well by stronger candidates. These candidates provided evidence of at least one timing of the ball for its travel along the entire 100 cm length of the track and calculated the average speed (distance travelled/time taken, i.e., a practical measure of v_3). They took repeat measurements and averaged them and then calculated the average speed. The given formula was used with the candidates' values for v_1 and v_2 to calculate v_3. This value for v_3 should have been compared with the experimentally obtained value for the run down the entire track (practical v_3). Some stronger candidates used the formula to calculate v_3, then a time t_3 for the run down the whole track and then compared this value to their measured time. Many weaker candidates incorrectly obtained two identical values simply by adding their two timings from the earlier parts of the question, calculating the speed and then comparing the value with that calculated from the formula.

Section B

Question 4

(a) Many good responses identified at least one feature that prevented the apparatus from falling over, namely that there was a heavy weight on the base of each clamp stand or that the bases of the clamp stands themselves were wide and very heavy. In addition, stronger candidates also noted that the bosses attaching the spring to the stand were placed as low as possible (yet still permitting the free movement of the weighted rod), or the clamp stands were not placed too far apart (so that the spring was not stretched so much that the stands risked being pulled towards each other).

(b) Stronger candidates followed the instructions correctly and measured the distance from the centre of the spring to the centre of the small piece of putty attached near to the lower end of the spring.

(c) (i) A description of one complete oscillation of the system was given in the question. Stronger candidates described the correct method for producing an accurate time for one oscillation, *T*, namely, timing between 10 and 20 complete oscillations and dividing that time by the number of complete oscillations.

(ii) Some candidates gave good answers in **(i)** and then proceeded to use poor experimental technique, writing down times demonstrating that they counted individual oscillations in **(ii)**. Some weaker candidates showed that half-oscillations were incorrectly treated as complete oscillations. Stronger candidates obtained values for *T* in the range 1.15s +/– 0.15s using times for between 5 and 20 oscillations.

(d) Values for $L^2/100$ and T^2 were calculated and the data entered into the first row of the body of the table and the missing headers, with units added to the table. Stronger candidates listed the columns in a sensible order, *L*, cm, $L^2/100$, cm^2, *T*, s, and T^2, s^2. In some responses the column for *T* also listed the working for n oscillations divided by n. Weaker candidates often omitted the unit for T^2 or gave the unit of s. Stronger candidates provided a full set of 8 measurements covering a wide range of lengths, *L* (at least 25 cm) with correct calculations and columns with consistent precision (same number of decimal places, or significant figures).

(e) Stronger candidates plotted the line graph with T^2, s^2 on the y-axis and $L^2/100$, cm^2 on the x-axis, as instructed in the question, with scales that were sensible, easy to use and which produced plots occupying at least half of the grid. These candidates plotted the points accurately, to within half a small square of their intended position, using small dots or fine crosses. The best straight line should have been drawn with a ruler as a fine continuous line. Plots which are to be ignored because they are lying too far from the expected line should be annotated in some way (e.g., circled, or labelled as outliers) and there should only be one or two at the most.

(f) Only stronger candidates answered this well with a valid judgement from their data and a valid reason. These candidates made decisions (curve or straight line) consistent with their data and explanations consistent with that decision. Some weaker candidates showed a poor understanding by giving inconsistent explanations. It should be noted that s-shaped curves should not be considered.

Answers such as "the increase in T^2 becomes smaller as $L^2/100$ increases", or "the plots at each end of the line are below the best fit straight line and the middle plots are above it" sufficiently supported the decision that a curved line would be a better fit. Answers such as "the plots are evenly spread either side of the best fit straight line" or "T^2 increases by about the same amount for equal increases in $L^2/100$" sufficiently supported the decision that a straight line would be the best fitting line.

(g) Few strong responses were seen to this part of the question. Candidates agreeing with the suggestion could have stated that the reaction time was a smaller proportion of the total time when *L* was larger and oscillations took more time to complete, or that when the oscillation took longer it was easier to judge the beginning and end of oscillations, or that plots at larger values of $L^2/100$ were closer to the best fit line than for smaller values. Similarly, candidates disagreeing with the suggestion could have stated that the reaction time error was the same each time or the plots for smaller values of $L^2/100$ were closer to the best fit straight line. Weaker candidates referred to human error which was too vague for credit.

PHYSICS

Paper 5054/41
Alternative to Practical

Key messages

- Candidates should take care to give their answers to a suitable number of significant figures.
- Care should be taken in rounding numerical answers correctly.

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 did not attempt all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Stronger candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly.

Comments on specific questions

Question 1

(a) Well prepared candidates answered this question well. Weaker candidates did not use a ruler to measure correctly. Even then, they could have gained partial credit, but some divided by eight instead of multiplying.

(b) Most candidates answered **(i)** well but some did not give their value to 2sf as asked for in the question. In **(ii)** they needed to add their value to a table of results and calculate the value of T, the time for one oscillation, and T^2. This was generally done well but several candidates did not round their value for T^2 correctly and so could not be awarded credit. In **(iii)**) candidates usually related the reason for timing 10 oscillations rather than just one to accuracy. Some correctly said that the time for one oscillation was too quick to measure. Stronger candidates combined these two possible responses and explained that reaction time errors were reduced when measuring 10 oscillations.

In answers to **(iv)**, the graph was usually drawn well. Most candidates used a sensible scale, labelled the axes and plotted points precisely although some candidates used large circular blobs to plot their points. Candidates should be encouraged to use a sharp pencil when plotting points and drawing best fit lines. There was a mixed response to **(v)**, where candidates were asked to find the gradient of their line. Candidates need to show their working when they do this on the graph, to gain credit. They should use values on the graph that cover at least half of the data and preferably more, to get an accurate gradient. Many candidates did this well and had a value within the expected range. Others did not show the points used on the graph itself, sometimes had the gradient upside down and some did not attempt the question.

Most candidates gained credit in **(vi)** if they had a gradient in the previous question, sometimes with error carried forward. The final part of the question asked candidates to compare the value of *g* calculated in **(b)(vi)** with the accepted value of 10 N/kg. The margin of error should be about 10 per cent of an accepted value and good responses stated whether their value was within this range and went on to state yes or no depending on their values.

Question 2

(a) Most candidates were able to record the required value to one decimal place but there were some unusual incorrect answers.

(b) Generally, candidates were able to record the volume of water as required. However, some candidates made errors in measurement. The answer was 46 cm^3 but 40.6 cm^3 was seen often.

(c) Stronger candidates had no problem in calculating the value correctly in this question but very few gave a correct unit for their answer. Weaker candidates had difficulty in using the equation and rarely gained credit.

(d) Most candidates could correctly relate the method used to energy lost from the beaker or from the copper during the transfer from the boiling water to the cooler water but others either left this blank or talked about reading errors. Parallax errors are unlikely to be relevant in this sort of question.

Question 3

(a) Most candidates had no difficulty in correctly drawing how a voltmeter should be positioned across a thermistor on the diagram provided in **(i)**. It was rare to see incorrect symbols used and very few candidates drew a line through their voltmeter symbol. In **(ii)**, most candidates could correctly read the scales on the ammeter and voltmeter.

(b) In **(i)**, candidates were usually able to explain why the water should be stirred. In **(ii)**, stronger candidates answered well but this part was often omitted by weaker candidates. Candidates should have been able to note that the current had increased in **Fig. 3.3**, but the voltmeter reading had not changed so the resistance must have decreased. Some candidates went on to calculate the two resistances and compared them which was also given credit, but no calculation was necessary to gain full credit.

Question 4

(a) Candidates were given what should have been a familiar scenario of a cardboard lamina with three small holes punched along its edge and a small mass on a string to use as a plumb line. It was expected that this would be a familiar experiment for them to describe. While a few excellent descriptions were seen, many candidates found this very challenging. Some candidates managed to gain partial credit by describing how the intersection of the lines indicated the position of the centre of mass of the lamina but full credit was rarely given.

(b) The question asked how the position of the centre of mass found in **(a)** could be confirmed using the sharp pin only. It was clear that many candidates had never done this but there were some very good answers. It was expected that the point of the pin would be placed at the point of intersection of the lines and if the lamina balanced on the top of the pin head, the centre of mass would be correct.

PHYSICS

Paper 5054/42
Alternative to Practical

Key messages

- 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.
- It is important to record measurements to the correct precision. In particular, measurements made with a rule marked with a millimetre scale should be given to the nearest millimetre.
- 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 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.

General comments

The level of 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 suffering from a shortage 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) Candidates who understood that the voltmeter must be connected in parallel with the heater found this relatively straightforward. Sometimes the connections were not clearly shown. Many candidates drew a series connection.

(b) The reading on the meters were almost always correct. The voltmeter reading was sometimes given to an unrealistic precision e.g., 13.45 V.

(c) (i) The missing value in the table was usually deduced correctly from the information provided.

(ii) Many candidates gained full credit for the graph-plotting exercise. The axes were usually labelled, and sensible scales were chosen. There was little evidence of scales on the axes that were multiples of 3, 7 etc. The use of such scales makes it difficult for candidates to plot their points accurately and clearly. Most candidates plotted the points accurately. Candidates should be reminded that if dots are used to indicate the position of a plotted point, then these dots should be small, certainly no bigger in diameter than one-half the size of a small grid square. Candidates should also 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.

Attempts at drawing a line of best fit were good. Candidates should attempt to draw a line which passes through the middle of the data, with any plotted points that do not lie on the line equally scattered about the best-fit line. Some candidates forced their line through the origin.

Occasionally the question was misread, and candidates plotted the wrong variables. When this occurred, partial credit for plotting the graph could still be gained.

(d) Although most candidates understood what the term "gradient" meant, there were many incorrect gradient calculations. Candidates often used data points from the table that did not lie on their best-fit line or chose points which were too close together.

The instruction to indicate on the graph the values chosen to calculate the gradient, was frequently not followed.

(e) The calculations were done well, with most candidate answering fully correctly. Where errors were made, it was usually due to incorrect rounding of the final answer.

(f) Many candidates did not read the question carefully enough, and their answers referred to evaporation losses and the consequent loss in mass of the water in the beaker after boiling had commenced. The question asked about the loss in mass of the water as it was being heated, before it had reached its boiling point.

(g) (i) Only stronger candidates answered this correctly and were able to explain why the loss of thermal energy from the sides of the beaker during the experiment produced a value for the specific latent heat of vaporisation which was greater than the accepted value. Few candidates realised that the gradient of their graph was smaller than it would have been if no thermal energy losses occurred. Use of the equation given in **(e)(ii)** then gave the answer.

(ii) Most candidates realised that the loss of thermal energy in the experiment could be reduced by insulating the beaker or by using a lid.

Question 2

(a) Some candidates had difficulty in interpreting the information given in the question and divided the thickness of the folded sheet of paper by numbers other than 32. Any correct answer expressed to more than one significant figure was accepted.

(b) (i) Although most candidates were able to calculate the mean of the three thickness values given, many did not follow the instruction to give their answer to two significant figures.

(ii) Many candidates who had calculated the mean thickness of the pack of paper correctly, did not understand what they needed to do next. Instead of dividing the thickness of the pack by 500 (or 499), many divided the thickness by 32. This implied that they had not fully understood the two methods explained in the question or had failed to read the question carefully enough.

(c) Most candidates realised that method 2 was more accurate but had difficulty in explaining exactly why. Stronger candidates stated that the (percentage) error is less in Method 2 because a larger sample of paper was used.

Question 3

(a) (i) Most candidates followed the given instructions and drew the rays correctly. Occasionally, the instruction to label the points where the rays met the mirror with the letters A and B was not followed.

(ii) The instruction to draw the two incident rays was usually carried out correctly. Many rays drawn, were very thick and lacked accuracy.

(iii) A number of candidates measured the wrong angle. Candidates needed to be able to identify the angle of incidence from unfamiliar ray diagrams.

(b) The position of the image was usually determined correctly. Occasionally, the instruction to label the image with the letter I was not followed.

(c) (i) Candidates who had not used a ruler or who had drawn thick pencil lines to represent the rays of light were often unable to gain credit here.

(ii) Candidates were asked to compare their measured values of object distance and image distance and to state whether they agreed with the statement given in the question, namely that they were equal. If the measured distances were the same, then it was sufficient to state just this. If the distances were different, a comparison of the two distances was needed, and a simple statement that the two calculated values were close enough to be considered equal, or that they were too far apart to be considered equal.

Question 4

(a) Most candidates were able to convert the written description of the circuit into a circuit diagram. Common errors were using incorrect symbols for the lamps, the inclusion of extra components or not labelling the circuit so that the lamps P, Q and R could be identified.

(b) Despite being told that only two of the five possible explanations given were correct, a sizeable minority of candidates ticked three or more of the five boxes.

Most candidates correctly ticked the second box and a few candidates ticked the first box. Common incorrect suggestions were that the filaments of the lamps or the connecting leads were broken.