# PHYSICS

**Paper 0972/11**
**Multiple Choice (Core)**

| Question Number | Key |
|---|---|
| 1 | A |
| 2 | B |
| 3 | A |
| 4 | A |
| 5 | B |
| 6 | B |
| 7 | A |
| 8 | A |
| 9 | D |
| 10 | A |

| Question Number | Key |
|---|---|
| 11 | D |
| 12 | C |
| 13 | B |
| 14 | D |
| 15 | D |
| 16 | B |
| 17 | A |
| 18 | D |
| 19 | D |
| 20 | C |

| Question Number | Key |
|---|---|
| 21 | A |
| 22 | B |
| 23 | C |
| 24 | A |
| 25 | C |
| 26 | C |
| 27 | D |
| 28 | C |
| 29 | D |
| 30 | D |

| Question Number | Key |
|---|---|
| 31 | D |
| 32 | B |
| 33 | C |
| 34 | B |
| 35 | D |
| 36 | C |
| 37 | C |
| 38 | C |
| 39 | C |
| 40 | D |

## General comments

Candidates demonstrated very good knowledge of the behaviour of gas particles when the temperature of the gas increased, and the process of melting. However, there were some misconceptions about current in a series circuit and the acceleration of a falling object.

It was evident that calculations involving echoes and energy transferred were not well understood.

## Comments on specific questions

### Question 3

This question assessed candidates' knowledge of acceleration due to gravity. The majority of candidates had the misconception that the acceleration of an object falling to the Earth decreases as the object falls.

### Question 4

Most candidates found this question challenging. Many candidates incorrectly thought that gravitational force was equal to the weight per unit mass.**Question 8**

Most candidates struggled with this question with the majority of candidates failing to recognise that the steel sphere becomes warmer.

### Question 13

The majority of candidates demonstrated very good knowledge about the behaviour of gas particles when the temperature of the gas increased.

**Question 22**

Although most candidates recalled that microwaves are used for satellite television, many candidates had the misconception that infrared was used for security marking, and so chose option **A**.

**Question 23**

The most common incorrect answer was option **D**, indicating that candidates had forgotten to halve the time given in the question. This is a typical error that candidates make when attempting questions involving echoes so candidates would benefit from practice of this type of question.

**Question 27**

Candidates struggled with this question where they had to use the equation relating energy, power and time. The majority of candidates did not convert the time from minutes into seconds and therefore incorrectly chose option **C**. Many weaker candidates also did not use the correct equation for energy. For numerical questions, candidates would benefit from writing down the relevant equation and their calculations to check that the units are correct, before looking at the different options.

**Question 29**

Only stronger candidates answered this correctly. Most candidates identified that this was a series circuit, but most candidates had the misconception that current decreases in the circuit as you go further away from the battery, and therefore chose option **C**.

**Question 30**

In this question, candidates had to calculate current by converting power from kW into W and rearranging the equation power = current × potential difference, and then choose an appropriate fuse size. Only stronger candidates answered this correctly. Other candidates' responses were evenly distributed across the four possible options, indicating that many had guessed the answer.

**Question 35**

Stronger candidates performed well on this question. Most weaker candidates demonstrated poor knowledge about the random nature of radioactive decay and tried to spot a pattern, resulting in option **C** being chosen.

**Question 39**

Most candidates demonstrated excellent knowledge about the Sun and the Milky Way.

# PHYSICS

**Paper 0972/21**
**Multiple Choice (Extended)**

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

## General comments

Candidates demonstrated very good knowledge about evaporation and changes of state. However, there were some misconceptions about the acceleration of free fall and how the Sun is powered.

All candidates struggled to compare the resistances of wires with different dimensions and weaker candidates struggled with numerical questions involving unit conversions.

## Comments on specific questions

### Question 1

Most stronger candidates identified the measurement that was recorded to the nearest millimetre. However, weaker candidates struggled to do this, with a significant number choosing option **D**.

### Question 2

The vast majority of stronger candidates were able to calculate the distance correctly. Although most weaker candidates recalled the correct equation, many of them did not notice that they had to convert minutes into seconds and therefore chose option **A**. Candidates would benefit from short activities in lessons where they practice converting between different units and using unit prefixes.

**Question 4**

Candidates demonstrated a poor understanding of the acceleration of free fall of an object, with many candidates having the misconception that the acceleration of free fall increases as the object falls.

**Question 7**

This question required candidates to recall an equation which gave the momentum change of an object. The majority of stronger candidates were able to identify the correct equation, but most weaker candidates thought that momentum change depends on distance.

**Question 11**

Nearly all candidates used the correct equation relating pressure, force and area in this question. However, most weaker candidates did not read the question carefully enough and did not notice that the question asked for the area of each foot. Candidates would benefit from highlighting key words and phrases in questions to reduce the chance of them missing out important information.

**Question 15**

This question assessed candidates' understanding of the definition of specific heat capacity. Nearly all stronger candidates answered this correctly, but many weaker candidates thought that 1 kg of aluminium required more energy to raise its temperature by 1 °C than the same mass of copper because aluminium was a poorer conductor of thermal energy than copper.

**Question 25**

This question required candidates to recall the equation relating charge, current and time and convert minutes into seconds. The vast majority of stronger candidates were able to calculate the charge correctly. Although most weaker candidates recalled the correct equation, many of them again did not notice that they had to convert minutes into seconds and therefore chose option **B**.

**Question 27**

In this question, candidates needed to compare the resistances of wires with different lengths and different diameters. All candidates found this question extremely challenging, especially when applying the relationship between resistance and diameter. It appeared that most stronger candidates were aware that as the length doubled, the resistance doubled. However, the most common error was thinking that if the diameter was a quarter of the initial value, the resistance was 1/4 of the initial value instead of 1/16, resulting in a ratio of 1 : 8 instead of 1 : 32.

**Question 28**

Most stronger candidates identified the circuit symbols for a fixed resistor and a diode. Some weaker candidates confused the symbol for the fixed resistor with that of the variable resistor.

**Question 31**

This question required candidates to determine the direction in which a rod was moved across a magnetic field so that there was an induced current from end X to end Y. The majority of stronger candidates were able to work out in which plane the rod was moved but about the same number of candidates chose into the paper (option **C**) as out of the paper (option **D**). Weaker candidates' responses were more evenly distributed across the four possible options, indicating that many had guessed the answer.

**Question 33**

Candidates found this question on transformers very difficult with most candidates choosing options **B** or **C**.

**Question 39**

The majority of stronger candidates recalled that the Sun is powered by fusion reactions but many weaker candidates had the misconception that the Sun is powered by fission reactions.

# PHYSICS

**Paper 0972/31**
**Theory (Core)**

## Key messages

Apart from basic matters of learning, there were three further aspects where candidates could have improved their performance.

- In calculations, candidates must set out and explain their working correctly. If poor or no working is shown by the candidate and it leads to the correct answer, the examiner may be able to give credit due to the merit of the work. However, when a candidate gives a wrong final answer and no working is shown, it is often impossible for the examiner to give due reward for those parts that are correct.
- Greater clarity and precision when answering questions requiring a description or explanation.
- It is important that candidates read the questions carefully in order to understand exactly what is being asked.
- In order to improve their performance candidates should practise applying their knowledge to new situations by attempting questions in support materials or exam papers from previous sessions.

## General comments

A high proportion of candidates were well prepared for this paper. Equations were generally well known by better and by slightly below average candidates, but a significant number struggled to recall the equations for wavespeed i.e., $v = f\lambda$ and electrical energy $E = IVt$.

Often candidates had been well taught how to apply their knowledge and understanding to fairly standard situations. On occasions, when asked to apply their knowledge to a new situation, they could become confused and display a lack of breadth of understanding. More successful candidates were willing to think through the possibilities and apply their knowledge when the question asked for suggestions to explain new situations. Less successful candidates found difficulty in applying their knowledge to new situations and did not show the stages in their working and did not think through their answers before writing.

The English language ability of most of the candidates was adequate for the demands of this paper. There were a very small number of candidates, who struggled to express themselves adequately. One point was raised by a few examiners – the numeral 4. Candidates can make this look like 9, 7, 5, 3 and 1. If a candidate is doing a calculation where marks are awarded for a correct numerical answer, it is in their interest to ensure that the correct numeral is being marked.

## Comments on specific questions

### Question 1

**(a)** The majority of candidates correctly identified the speed of the cyclist as 8 m / s.

A common error was to divide 8 by 15 to give an answer of 0.533.

**(b)** This item was well answered by most candidates. Common errors included incorrectly writing increasing acceleration for part 1 and increasing/decreasing deceleration for part 3. However, the most common error was failing to describe region 2 correctly. Many candidates simply wrote ‘constant’ instead of ‘constant speed’.

**(c)** The majority of candidates derived the correct answer of distance travelled as 40 m by determining the area under the graph. A few tried using distance divided by time with the attendant risk of not using the average speed. The most common error however was to use an incorrect equation i.e., distance = speed/time to give 0.8. This did not score any marks.

**Question 2**

**(a)** The vast majority of candidates correctly gave the resultant force as 20 N to the left/forwards. Weaker candidates added the forces instead of subtracting 10 from 30. Many stated a direction on a compass i.e., East or West. Candidates must be made aware that this does not score unless the compass directions are added to the diagram by the candidate.

**(b) (i)** The majority of candidates correctly determined the work done as 2000 J. The most common error was to state that work done = force/distance and use this to give 0.8 J. This does not score any marks.

**(ii)** The majority of candidates scored one mark for either kinetic energy store or thermal energy store. Common errors included friction, chemical energy store and potential energy store.

**(c)** The majority of candidates correctly determined the pressure as 6.3 $N / cm^2$. The most common error was to use an incorrect rearrangement of the equation $P = F \div A$ such as $P = F \times A$ to give an answer of 9120 $N / cm^2$.

**Question 3**

**(a)** The majority of candidates gave very clear descriptions of how to use the measuring cylinder to find the volume of the piece of metal using a displacement method. Some candidates did not score full marks because their answers lacked detail or clarity.

E.g., many candidates failed to state that once the water was added to the measuring cylinder that its 'volume' should be read from the scale on the measuring cylinder. Similarly, after the metal was submerged.

Many candidates simply stated 'After adding the water to the measuring cylinder take a reading.'

**(b)** The majority of candidates correctly determined the density of the metal as 19.4 $g / cm^3$. The most common error was to use an incorrect arrangement of the equation $D = M \div V$, usually $D = M \times V$ to give an answer of 6300.

**Question 4**

**(a) (i)** The vast majority of candidates correctly determined the wasted output energy as 12 J.

**(ii)** Most candidates correctly identified the energy store as the thermal energy store.

**(b)** Candidates found this item surprisingly difficult. Only more able candidates scored full marks for an answer of 4500 J. The most common error was failing to convert the time to seconds. These candidates usually scored 3 marks for an answer of 75.

Many candidates could not recall the equation electrical work done = power x time Centres are advised that candidates should practise writing out all the equations on the syllabus to assist with recall.

**(c)** Candidates found this item surprisingly difficult. Centres are advised that candidates should practise using flow diagrams to represent the energy transfers involved in common devices and in electricity generating systems.

**Question 5**

**(a)** The majority of candidates scored well on this item. This is a part of the syllabus that is obviously well understood. Vague answers such as ‘fixed shape/no fixed shape’; ‘move in any direction/freely’; ‘not too far from each other’ or ‘loosely packed’ were the usual reason for marks to be withheld. A common error was to describe particles in a solid rather than in a gas.

**(b)** Many candidates scored marks for descriptions including: ‘speed decreases’ ‘(because) kinetic energy **or** (internal) energy decreases’ ‘(and so) collision rate decreases.’ Common errors included stating that the particles will stop moving or that the speed increases as the temperature decreases.

**Question 6**

**(a)** Most candidates were able to state that the second sound was caused by the sound waves reflecting off the rocky cliff face to give an echo.

**(b)** The majority of candidates scored full marks by determining the distance as 440 m. Common errors included: halving the distance as they mistakenly treated the sound from the fireworks as an echo and much more common was an incorrect rearrangement of the equation speed = distance ÷ time. Many candidates used distance = speed ÷ time.

**Question 7**

**(a) (i) (ii)(iii)** The majority of candidates identified the correct process for one or two effects but only the more able correctly identified all three. Centres should ensure that candidates have seen diagrams of these effects in ripple tanks.

**(iv)** Most candidates struggled with this item. Only the more able candidates stated that the change in direction was due to a change in the speed of the wavefronts as they moved from deep water to shallow water.

**(b)** Most candidates struggled with this item. Only more able candidates seemed able to give a precise description of the direction of vibration of the particles in a transverse wave. The most common error was in failing to link the vibrations as being perpendicular to the direction of propagation of the wave. Vague references about the direction of the wave were insufficient.

**(c)** Candidates found this item surprisingly difficult. Only a minority correctly identified radio waves and light waves as examples of transverse waves.

**(d)** The majority of candidates successfully calculated the wavelength as 6.0 m. The most common error was to give an incorrect rearrangement of the equation for wavespeed, i.e., $v = f \times \lambda$. The most common of these was $\lambda = v \times f$

**Question 8**

**(a) (i)(ii)** Candidates found these items surprisingly difficult with only a minority giving the image distance as 0.11 m and even fewer identified the focal length as 0.08 m.

**(iii)** Candidates found this item surprisingly difficult. Only a minority gave the properties of the image in Fig. 8.1 as (any two from;) real, inverted or diminished.

**(b) (i)** Many candidates did not recognise the electromagnetic spectrum in order of increasing wavelength and consequently gave microwaves and radio waves instead of X-rays and gamma rays. Centres should ensure that candidates are familiar with the electromagnetic spectrum in order of increasing frequency and increasing wavelength.

**(ii)** The vast majority of candidates were able to give a use for ultraviolet radiation.

**(iii)** The vast majority of candidates were able to give one danger of excessive exposure to ultraviolet radiation.

**Question 9**

**(a)** Most candidates gave a correct description such as: close the switch and then see if the lamp lights **or** there is a reading on ammeter. The most common error was to omit the detail from the description i.e., 'see if there is a current in the circuit' 'look at the lamp' did not score the second mark.

**(b)** This is a difficult concept and only the more able candidates scored full marks. Common errors were omitting to mention 'free electrons' and the idea that an e.m.f. was needed to move the free electrons around a circuit.

**Question 10**

**(a)** Many candidates could not recall the equation $E = I \times t \times V$, with many using $E = (V \times t) \div I$, possibly from a mistaken idea linked to resistance.

**(b)** A surprising number of candidates could not recall the three wires in a mains cable as earth, live and neutral. Most candidates could name one or two. Weaker candidates tended to give the names of three metals.

**(c)** The transformer calculation was very well done by many candidates.

The most common error was an incorrect equation as the starting point.

A number who did start with the correct equation made errors in rearranging the equation.

**Question 11**

**(a)** The vast majority of candidates correctly identified the four planets. A common error was to interchange Mercury and Mars or to interchange Jupiter and Saturn.

**(b)** This item proved to be a good discriminator with more successful candidates giving clear and detailed descriptions. Less successful candidates often gave some detail about the Big Bang or the formation of a star.

# PHYSICS

**Paper 0972/41**
**Theory (Extended)**

## Key messages

Candidates should be reminded to:

- read each question carefully and answer the question that is being asked
- show their working clearly in calculations
- write formulae using the symbols for variables stated in the syllabus
- describe and explain phenomena with clear statements.

Final answer marks for calculations are only awarded for correct numerical answers with the correct unit. Where either the numerical value is incorrect or the unit is missing or incorrect, marks are only awarded for working shown.

## General comments

Candidates generally demonstrated good quantitative skills in performing calculations. Some candidates found working with numbers in standard form was challenging, as seen in **Question 9**.

Many candidates demonstrated a good understanding across the range of topics within the physics syllabus including continued improvement in the new topic of space physics. Candidates had some difficulty in answering parts of **Question 6** suggesting a weakness in understanding of potential dividers.

Candidates are expected to give numerical answers to two significant figures unless instructed otherwise. Evidence of answers being rounded to one significant figure was seen in **Question 1(c)(i)**.

The syllabus specifies acceptable units for different quantities. Candidates should ensure that they give the correct unit with any numerical value. Missing or incorrect units were noticeable in **Question 1(b)**, **Question 1(c)(i)**, **Question 5(b)** and **Question 9(b)**. In **Question 2(a)(iii)** acceleration was often given the incorrect unit N/kg.

## Comments on specific questions

### Question 1

**(a) (i)** Most candidates correctly recorded both readings on the meter ruler and included the unit. Common errors included misreading the scale on the *y*-axis as 42.5 cm and 62.5 cm or omitting the unit in the answer.

**(ii)** Many candidates correctly calculated the extension of the spring from their values in **(i)**. Some weaker candidates incorrectly tried to use the formula $k = F \div x$.

**(b)** Most candidates correctly recalled the formula $k = F \div x$ and many went on to calculate the spring constant correctly. Weaker candidates made errors when rearranging the formula and some candidates omitted the unit or gave an incorrect unit with their answer.

**(c) (i)** Candidates recalled the formula $W = m \times g$ and used it correctly to calculate the weight of the object. Some candidates rounded their answer to one significant figure. Weaker candidates sometimes gave an incorrect unit, confusing weight with mass.

**(ii)** The strongest candidates calculated the resultant force correctly and gained full credit by using it to calculate acceleration. Weaker candidates were able to recall and use $F = m \times a$ to calculate an acceleration. They were more likely to use either the tension in the spring or the weight as the force rather than determining the resultant force. Some candidates incorrectly gave the unit of acceleration as m / s and, a few gave the unit as N / kg.

**Question 2**

**(a) (i)** Many candidates recorded the correct value for maximum momentum, together with a correct unit and gained full credit. Partial credit was awarded to candidates who recalled $p = m \times v$. Weaker candidates attempted to calculate a change in momentum rather than the maximum momentum. Some candidates omitted the unit in their answer.

**(ii)** Most candidates knew that the area under the line graph in **Fig. 2.2** represented the distance travelled by the car. A common error was to say that distance equalled the gradient of the line. Some weaker candidates gave a vague statement such as the distance travelled was the shape of the graph.

**(iii)** Many candidates correctly calculated the distance travelled by the car in the first 6.5 s by calculating the area of the triangle in **Fig. 2.2**. Weaker candidates used $v = s \div t$ without realising that they needed to work out the average velocity over time. Some candidates gave an incorrect unit or omitted the unit in their answer.

**(b) (i)** Most candidates stated either that **Fig. 2.2** showed speed decreasing or that there was a negative gradient. Vague answers, such as that the slope decreases, did not gain credit. Weaker candidates sometimes confused the feature here with the feature required in **(b)(ii)**.

**(ii)** Stating that the line was curved or that it was not straight were the most common ways of gaining credit here. Stronger candidates sometimes gave the more precise answer that the gradient was decreasing. Stating more generally that the gradient was changing was sufficient to gain credit but the incorrect statement that the gradient increased was not given credit.

**(c)** Stronger candidates gave a clear statement that energy was transferred from the kinetic store to the thermal (or internal) store. Common errors included stating that the transfer was to the gravitational potential store, introducing an intermediate store or stating that energy was transferred from some other initial store into the kinetic store.

**Question 3**

**(a)** Only the strongest candidates gained full credit for stating that the moment of a force is the force × the perpendicular distance of the force from the pivot, and that the moment is a measure of the turning effect of a force. A common error was the omission of reference to the perpendicular distance. Weaker candidates sometimes described balancing of anticlockwise and clockwise moments which is not the same as defining the moment.

**(b) (i)** Stronger candidates stated clearly that the centre of gravity is the point where all the weight of an object appears to act. A common error was suggesting it was a region, or area, or just stating that it was where the weight appears to act. Weaker candidates referred to gravity acting, rather than the force due to gravity or weight. Candidates who qualified their answer by stating that it is the point where most of the weight acts did not gain credit.

**(ii)** Only the strongest candidates gained full credit here for a correct calculation of the moment with the correct unit. Many candidates did not realise that the perpendicular distance was found by halving the distance given in **Fig. 3.1**. Some candidates gave an incorrect unit or omitted the unit in their answer.

**(c)** Candidates who made clear statements that the resultant force was zero and the resultant moment was zero were most likely to gain full credit. Some candidates stated that the sum of anticlockwise moments equals the sum of clockwise moments which gained credit. Many candidates gave the answer that the upward force will be equal to the downward force, which could not be credited. Some weaker candidates referred to momentum instead of moments in their answer.

**Question 4**

**(a)** Most candidates gained at least partial credit by correctly suggesting the necessary measurements required to calculate specific heat capacity or by stating the equation $c = \Delta E / (m \times \Delta\theta)$. Where other variables were given in an equation and not defined, credit was not given. For full credit, candidates needed to describe a method for transferring a measurable amount of energy and for stating how to calculate $\Delta E$. Only the strongest candidates used clear diagrams or described the use of an electric heater and thermometer inserted into an aluminium block. Full credit then required recall of $E = P \times t$ to calculate the energy transferred to the aluminium block. Weaker candidates often used gas burners to transfer energy to the block. Credit was available for candidates who poured hot water into an insulated calorimeter with appropriate calculations, but no credit was available for using an uninsulated aluminium dish such as that shown in **Fig. 4.1**.

**(b) (i)** Many candidates gained partial credit by correctly stating that thermal energy was transferred from the water to the dish by conduction. Full credit required either completion of the explanation by saying that net transfer of energy stopped once the temperatures became equal or an explanation that after a short time the temperatures equalise at a value between the initial temperature of the water and the initial temperature of the dish.

**(ii)** Most candidates gained partial credit for stating that aluminium particles gained energy in the kinetic store. Stronger candidates gained full credit for adding that this led to increased separation of the particles. Weaker candidates often described particles expanding instead of particle separation increasing or tried to give an explanation in terms of gas pressure by referring to more frequent collisions.

**(iii)** Stronger candidates were able to clearly state that evaporation is the escape of the most energetic molecules at the surface of the water. Common errors included neglecting to specify the escape is from the surface or stating that there is a change of state from liquid to gas, rather than describing the escape of molecules from the liquid.

**Question 5**

**(a)** Only the strongest candidates recognised that the distance from the centre of a compression to the centre of the neighbouring rarefaction is half a wavelength. Weaker candidates tried to use $v = f\lambda$ or simply repeated the distance given in the question.

**(b)** Some candidates correctly recalled a value for the speed of sound in the range 330 – 350 m/s. Many gave the incorrect answer that is the speed of electromagnetic radiation in a vacuum and a few answers consistent with the speed of sound in a liquid were also seen. A few candidates omitted the unit in their answer.

**(c) (i)** Most candidates recalled and used $v = f \times \lambda$ to calculate the frequency of the sound using their answers to **(a)** and **(b)** and included the unit. Partial credit was given for recall of the formula even if candidates were unable to complete a calculation.

**(ii)** Many candidates compared their answer to **(i)** with the normal range of human hearing to explain whether the sound from the loudspeaker could be heard. Weaker candidates made no statement about whether the sound could be heard or not, or gave an incorrect range for normal hearing, or omitted any explanation.

**(d)** This question required a reference to diffraction for any credit. The strongest candidates gained full credit by stating that there was only a little diffraction since the gap width was much larger than the wavelength and that this explained why sound was heard at K but not at J. Some candidates contradicted a correct reference to diffraction with an incorrect reference to refraction taking place.

**Question 6**

**(a)** Only the strongest candidates gave a precise definition of potential difference (p.d.) as the work done by a unit charge passing through a component. Some candidates confused the definition with the definition of electromotive force. Weaker candidates often simply stated that potential difference is a voltage or omitted a reference to unit charge. Some candidates gained partial credit for answers that referenced the work done in moving charge.

**(b)** The strongest candidates, who understood the relationship between electromotive force and the potential difference (p.d.) across components in a series circuit, gained credit for stating that the p.d. across the thermistor = e.m.f – the reading on the voltmeter. Weaker candidates suggested the use of $V = I \times R$ which was not relevant here or suggested connecting the voltmeter across the LDR which did not answer the question.

**(c) (i)** To gain credit here, candidates needed to know that the resistance of an LDR decreases when light intensity increases, and that the resistance of a thermistor increases when temperature decreases. The correct combination of changes was seen as often as a range of incorrect responses from candidates of all abilities.

**(ii)** In this question candidates needed to apply their knowledge of how e.m.f. is shared across components in a series circuit in proportion to their resistance. Some candidates correctly stated that the reading on the voltmeter decreases. Only the strongest candidates were able to explain this in terms of the ratio of resistances and the ratio of voltages across the LDR and thermistor. Weaker candidates often simply stated that voltage is proportional to resistance or stated $V = I \times R$.

**Question 7**

**(a)** Most candidates correctly identified iron as a suitable material for the bar, with many giving the more precise answer of soft iron. The most common incorrect response was steel and other incorrect responses included copper or just the general term 'metal'.

**(b) (i)** Many candidates drew good diagrams showing the magnetic field around the bar. They included at least one complete loop from north to south pole above and below the bar. Additional loops and/or field lines emerging from north or entering south pole were shown. Common errors included arrows going from south to north or patterns which were unbalanced with many more field lines on one side of the bar than the other. Candidates are advised to take special care when adding arrows to diagrams as sometimes correct arrows were contradicted with incorrect arrows.

**(ii)** The strongest candidates stated clearly that when resistance increases the current in the solenoid decreases. They then linked this to a reduction in field strength and either a greater space between field lines or a decrease in the number of lines (in same space). Weaker candidates often made unclear statements about the magnetic field decreasing which did not gain credit. Some candidates did not state clearly how the current changed. This was necessary to explain the changes in the magnetic field strength and pattern.

**(c)** Some candidates recognised that altering resistance of the variable resistor would alter the current in the solenoid. Few candidates linked this to the production of a changing magnetic field which was cut by the square coil. Many answers lacked clarity in expression, and it was often difficult to work out whether candidates were talking about the current in the solenoid or a current in the square coil. Partial credit was most often gained for recognising that a current or e.m.f. was being induced in the square coil. There were many misunderstandings with this question with some candidates thinking that the square coil was connected to the solenoid circuit and others thinking that the square coil rotated, i.e. an application of the motor effect.

**Question 8**

**(a)** Most candidates drew clear diagrams, using the symbols in the key, showing 6 protons and 8 neutrons in a central nucleus and 6 electrons orbiting around that nucleus and so gained full credit. Weaker candidates who mixed up the number of electrons or neutrons still usually showed the arrangement of particles correctly. Candidates should be advised to use all the space provided for a diagram and to clearly distinguish between solid, black circles and open circles as answers where the protons and neutrons were indistinct were not given credit.

**(b)** Full credit was gained here for a precise answer stating that an atom of carbon-14 had one more neutron and one less proton than an atom of nitrogen-14. Partial credit was given to candidates who stated carbon-14 has more neutrons and fewer protons than nitrogen-14. Credit was not given to candidates who just stated that carbon-14 and nitrogen-14 contained different numbers of protons and neutrons. When candidates are asked to describe the difference in composition, they should always try to quantify any difference.

**(c) (i)** Most candidates correct recalled that an electron is identical to a beta-particle. Common incorrect responses included alpha-particle, hydrogen and gamma.

**(ii)** Only the strongest candidates described a neutron changing into a proton as a beta-particle is emitted from carbon-14. Credit was also given for stating that one neutron was lost, and one proton was gained. Weaker candidates often only gave one half of this alternative answer or simply repeated a comparison of the two atoms already covered in **(b)**.

**(d)** Many candidates gained at least partial credit here for working out that $1.2 \times 10^{11}$ is $9.6 \times 10^{11} \div 2^3$. For full credit, candidates needed to realise that this meant 3 half-lives had elapsed and then to calculate 3 × 5700 years. Common errors included multiplying 5700 × 8 or subtracting the final number of C-14 atoms from the original number of C-14 atoms.

**Question 9**

**(a)** Most candidates correctly stated the key point that a galaxy is made up of a (large) number of stars. Some candidates added extra detail beyond that which is required of the syllabus. Weaker candidates often confused a galaxy with the Universe. Unclear answers such as that a galaxy is made up of many solar systems did not gain credit.

**(b)** Stronger candidates correctly recalled 1 light-year = $9.5 \times 10^{15}$ m and used this to convert the diameter of the Milky Way. Some candidates who could not recall this value tried to work it out from first principles with varying success. Other candidates made errors in the conversion of m to km resulting in a power-of-ten error in their final answer.

**(c) (i)** Many candidates stated that the amount of redshift or the increase in wavelength allowed the speed at which a galaxy is moving away to be determined. A common insufficient answer was mention of the wavelength without stating that it is the change in wavelength that needed to be noted. Other incorrect answers included the distance from Earth, velocity, the Hubble constant and the speed of light.

**(ii)** The brightness of a supernova is one different observation that is used to determine the distance to a far galaxy. Candidates who did not gain credit in **(i)** were given credit here if they suggested amount of redshift or increase in wavelength. A common incorrect response here was CMBR.

**(iii)** Many candidates described the relationship as the further away the galaxies are from Earth, the faster they are moving away. Stronger candidates expressed the relationship as speed being directly proportional to distance from Earth or by stating the two quantities are related by Hubble's Law. An answer that simply stated Hubble constant was insufficient to gain credit. Weaker candidates sometimes described the relationship as inversely proportional or stated that the further away a galaxy is, the slower its speed.

**(iv)** Most candidates recalled that the age of the Universe = $1 / H_0$ with many using this to calculate the correct value in seconds. Some incorrect answers demonstrated weakness in working with numbers in standard form. Stating the approximate age of the Universe in years did not gain credit, since the question asked candidates to use the Hubble constant provided and the unit was included on the answer line.

# PHYSICS

**Paper 0972/61**
**Alternative to Practical**

**Key messages**

- Candidates will need to have had a thorough grounding in practical work during the course, including reflection and discussion on the techniques used to improve reliability and control of variables.
- Candidates should be aware that, as this paper tests an understanding of experimental work, explanations and justifications will need to be based on practical rather than theoretical considerations.
- Numerical answers should be expressed clearly, to the appropriate number of significant figures and with a correct unit, where applicable. Candidates should know that sensible use of significant and correct units will be tested at some point in the paper.
- Candidates should be ready to apply their practical knowledge to different situations. Questions should be read carefully to ensure that they are answered appropriately.

**General comments**

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques, including the following:
- plotting graphs
- tabulating readings
- manipulating data to obtain results
- drawing conclusions
- dealing with possible sources of error
- controlling variables
- handling practical apparatus and making accurate measurements
- choosing the most suitable apparatus

It is assumed that, as far as possible, the IGCSE course will be taught so that candidates undertake regular practical work as an integral part of their study of physics.

Questions on experimental techniques were answered much more effectively by candidates who clearly had regular experience of similar practical work and much less successfully by those who, apparently, had not. Some candidates appear to have learned sections from the mark schemes of past papers and written responses that are not appropriate to the questions in front of them.

The practical nature of the examination should be borne in mind when explanations, justifications or suggested changes are required, for example in Questions **1(e)**, **1(f)**, **2(e)**, **2(f)**, **3(b)** and **3(f)**.

It is expected that numerical answers will be expressed to a number of significant figures which is appropriate to the data given in the question.

**Comments on specific questions**

**Question 1**

**(a)** Most candidates calculated the period $T$ correctly and successfully obtained $T^2$.

**(b)** Most candidates recorded the additional values correctly. It was expected that both values of $T^2$ should be given to the same number of significant figures. Three or four significant figures were acceptable.

**(c)** Most candidates gave the unit s for the period $T$ but many gave s instead of $s^2$ for $T^2$.

**(d)** Candidates were expected to explain that when measuring the total time for 10 oscillations, the possible timing error becomes less significant. This should not be confused with taking 10 separate measurements of one oscillation and then taking an average.

**(e)** Candidates were expected to show understanding of the use of a set square as a horizontal aid or using the meter ruler close to the pendulum bob.

**(f)** Candidates were expected to explain use of a fiducial aid or counting as the pendulum passes the vertical.

**(g)** Although many candidates gave a realistic value for $x$, a significant minority gave an answer that could have been the distance from the bottom of the support to the bench or the distance from the pendulum bob to the bench or a measurement from the diagram.

**(h)** Candidates were expected to suggest at least three additional values for $d$. The second mark was awarded to those candidates stating all their values between 25cm and their value of $x$.

**Question 2**

**(a)** Most candidates showed the value for room temperature successfully.

**(b)** A minority of candidates correctly used the unit minutes for the time column. Most used seconds (s). Candidates should be advised to read the question with care and not to assume that a similar response to that in a past paper is required.

**(c)** Most candidates labelled the graph axes correctly and drew them the right way round. Some candidates started the temperature axis at the origin (0, 0) which resulted in plots that used only the top part of the grid. Plotting was generally accurate. Candidates should use neat crosses (×) for the plots, or neatly circled dots (⦿) so that the accuracy of the plotting can be assessed. Most candidates obtained a realistic set of readings that resulted in plots producing a clear curve. Nevertheless, some candidates drew a straight line that did not match the plots or a series of straight lines joining each plot to the next.

**(d)** Candidates were expected to write a statement that matched the shape of their graph line. The explanation needed match both the statement and the line. Candidates who obtained the expected curve were able to comment that the slope of the curve was decreasing.

**(e)** Candidates were expected to know that the scale is read at right angles to avoid a parallax error. Candidates unfamiliar with that term were given credit for an explanation that explained a parallax error.

**(f)** Candidates were expected to draw a recognisable measuring cylinder with the water level shown. Some drew a beaker whereas others drew a careless diagram that showed a test-tube with graduations. Candidates were expected to show clearly that the line of sight is at right angles to the measuring cylinder and lined up correctly with the water level.

**Question 3**

**(a)** Most candidates obtained the correct value for $h_O$ and the majority of those included the appropriate unit (cm or mm).

**(b)** Candidates were expected to explain how to find the best position by moving the screen slowly back and forth and to have a darkened room (or bright object).

**(c)** The calculation of focal length was completed successfully by many candidates. An answer to two or three significant figures was expected with the appropriate unit.

**(d)** In this part, many candidates correctly stated that the image is inverted and magnified.

**(e)** Many candidates calculated the focal length correctly.

**(f)** Candidates were expected to write a statement that matched the results with an explanation of why they could or could not be regarded as equal within the limits of experimental accuracy. For example, if the results were similar (the result obtained from correct working), the candidate could comment that they were within 10 per cent of each other, or very close to each other.

**Question 4**

Candidates who followed the guidance in the question were able to write concisely and address all the necessary points. Some candidates copied the list of apparatus and other information given in the question. This was unnecessary and often introduced a vague explanation of the investigation.

A concise explanation of the method is required. Candidates should concentrate on the readings that must be taken and the essentials of the investigation. It may benefit candidates to plan their table of readings before writing the method to help them to think through the measurements that must be taken in order to address the subject of the investigation.

Candidates were required to complete the circuit diagram using the correct symbols for an ammeter and a variable resistor, both in series with the rest of the circuit.

Candidates needed to identify the variable to be tested. The question stated that the fuse wires all had the same length. Therefore, the two possible variables are the diameter of the fuse wire and the metal of the fuse wire. Candidates needed to choose one of these to test and the other to keep constant. Unfortunately, some candidates chose to investigate the resistance of the variable resistor.

For the method the candidates needed to adjust the current (using the variable resistor) and take the current reading at the moment when the fuse melted. The procedure should then be repeated with different diameters or different wire materials (but not both) depending on which variable was chosen to be investigated. A vague reference to repeating is not sufficient as it is not clear whether the test variable has been changed.

Many candidates drew a suitable table. They were expected to include columns for their chosen variable and current with the appropriate unit.

Candidates were expected to explain how to reach a conclusion by drawing a graph of the diameter variable against current. or a bar chart of current against metal. or by comparing values from the table. The question did not ask for a prediction. Some candidates wrote a prediction but no explanation of how to reach a conclusion.