PHYSICS

Paper 0972/11
Multiple Choice (Core)

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

General comments

The new topic in the syllabus, space physics, was well understood and questions were mostly answered correctly. However, there were some misconceptions about mass and weight. It was evident that distance travelled from a speed–time graph, moments and energy stores were not well understood.

Comments on specific questions

Question 1

Only stronger candidates answered this correctly, with the majority confusing weight and mass and therefore choosing option **A.**

Question 2

Stronger candidates answered this correctly. However, a number of other candidates just tried to use distance = speed × time and therefore chose the incorrect option **D**.

Question 4

Candidates' understanding of mass and weight was better in this question, with the majority choosing the correct answer.

Question 6

Many candidates identified that a balance was also needed to measure the mass and therefore determine the density of the stone. However, some candidates thought that a metre ruler was needed, possibly confusing this with finding the volume of a regularly shaped object.

Question 8

There was some evidence that candidates guessed the answer rather than applying the principle of moments. Many candidates ignored the normal reaction force of the pivot on the ruler and therefore incorrectly chose option **B** by balancing the upwards force with the downwards force.

Question 9

Candidates should be familiar with an experiment to determine the position of the centre of gravity of an irregularly shaped object (syllabus statement 1.5.4). However, the majority of candidates did not recognise that suspending the object from just one point is not sufficient to determine the position of the centre of gravity, and instead chose option **C**.

Question 10

Many candidates had the misconception that air passing through a wind turbine speeds up and therefore its kinetic energy increases. The most popular answer was therefore option **D.**

Question 11

Although most candidates correctly calculated the change in gravitational potential energy (GPE) to be 350 J, many had the misconception that the GPE of the rock increases as it falls rather than decreases.

Question 12

Most candidates successfully made the link between the child having greatest power when work is done in the shortest time.

Question 14

The majority of candidates correctly identified the relative separation of the particles in gases, liquids and solids. Most incorrect answers were option **B**, highlighting the misconception that particles are far apart in liquids.

Question 15

Many candidates chose the correct option. However, other candidates confused boiling and evaporation and incorrectly chose option **D**.

Question 17

Nearly all candidates recognised that the wave with the largest amplitude had the biggest displacement on the graph. Candidates' understanding of frequency was not quite as strong, so the most common incorrect option was option **B**.

Question 19

Many candidates correctly identified that as the object moves closer to the lens, but remains outside the principal focus, the image will increase in size.

Question 20

Candidates found this question challenging. The main misconception was that the white light did not split when it entered the prism, so option **A** was often chosen as the answer.

Question 22

For numerical questions, candidates would benefit from writing down the relevant equation and their calculations to work out the answer before looking at the different options. Many candidates answered this correctly but the most common incorrect answer was option **D**, indicating that these candidates had not rearranged the equation correctly and instead they divided speed by distance.

Question 23

Candidates found this question on induced magnetism challenging and only stronger candidates answered correctly.

Question 24

Most candidates correctly identified that the final charge on the cloth would be positive and chose either option **A** or option **B**. However, some candidates had the misconception that the electrons would move from the negative rod to the positive cloth, possibly because they confused the charging of the rod with a situation where negative charges are attracted to positive charges.

Question 25

The majority of candidates answered this correctly.

Question 27

Candidates should be able to describe an experiment to determine the resistance of a component (syllabus statement 4.2.5). Some candidates found this question challenging and were not aware that the voltmeter should be placed in parallel with only that component and the ammeter placed in series with the component. Candidates would benefit from short activities where they analyse incorrectly drawn circuits and identify the errors.

Question 30

The majority of candidates had the misconception that a double-insulated appliance requires an earth wire.

Question 33

Although some candidates answered this correctly, others had the misconception that electricity is 'faster' when the voltage is higher.

Question 36

Candidates struggled to recall the necessary facts about the random nature of radioactive decay. Many candidates had the misconception that the probability of a nucleus decaying increases over time and therefore chose option **D**.

Question 37

Few candidates answered this correctly, with many choosing option **B**.

Question 40

This question on the new topic of space physics was answered correctly by the majority of candidates.

PHYSICS

Paper 0972/12
Multiple Choice (Core)

There were too few candidates for a meaningful report to be produced.

PHYSICS

Paper 0972/21
Multiple Choice (Extended)

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

General comments

Questions on apparatus used to determine density and evaporation were answered well. However, there were some misconceptions about transformers and the life cycle of stars. It was evident that questions involving a.c. generators, transformers and the direction of the force on an electron in a magnetic field were not well understood. The questions on the new syllabus topic, space physics, showed mixed levels of understanding.

Comments on specific questions

Question 1

Stronger candidates chose the correct response. Many other candidates chose option **C** while a significant, but smaller number, chose option **B**.

Question 3

While stronger candidates answered this correctly, others chose the incorrect option **D**, as they used distance = speed $\times$ time. Candidates should be aware that this equation can only be used when the speed is constant. To calculate the distance travelled from a speed–time graph, they should use the area under the graph.

Question 6

The vast majority of candidates answered this question correctly. Some weaker candidates thought that a metre ruler was needed and chose option **C**.

Question 7

Candidates found this question challenging. The question required candidates to realise that the frictional force is preventing the book moving to the left relative to the table because the table is accelerating to the right. Many candidates had the misconception that the train must be moving to the left, possibly because they thought that the movement of the train would be opposite to the frictional force.

Question 10

Few candidates answered this correctly. Many candidates had the misconception that air passing through a wind turbine speeds up and therefore its kinetic energy increases. The most popular incorrect answer was therefore option **D.**

Question 11

This question required candidates to rearrange the equation for kinetic energy in order to determine the speed. Weaker candidates chose the incorrect option **B** as they just divided the kinetic energy by the mass of the woman. For numerical questions, candidates would benefit from writing down the relevant equation and their calculations to work out the answer before looking at the different options.

Question 13

For this question, candidates had to use an equation to calculate the pressure at the bottom of a dam. Most stronger candidates chose the correct option. Weaker candidates chose the incorrect option **C**, as they used an incorrect equation and they did not multiply by the gravitational field strength.

Question 14

This question assessed candidates' knowledge of the movement of microscopic particles by collisions with molecules. Although most candidates knew that the pollen was moved by the water molecules, a large number did not make the correct distinction between particles and molecules and therefore chose option **D**.

Question 18

Some candidates answered this question about refraction correctly, but it was a challenging question for weaker candidates with many of these candidates choosing incorrect option **C**.

Question 21

This question required candidates to recall the speed of light (syllabus statement 3.3.6) and rearrange the equation for wave speed (syllabus statement 3.1.4) to calculate frequency. Stronger candidates were able to do this correctly.

Question 22

This question was answered correctly by stronger candidates. Other candidates' responses were evenly split between the correct option and the incorrect option **D**, where they had divided the speed by the distance.

Question 23

This question assessed candidates' knowledge of induced magnetism and the direction of the force on a magnetic material. Most candidates determined the correct polarity of end X, but others believed that the force on the soft iron was to the right rather than to the left, possibly because they confused it with the direction of the magnetic field at the N pole.

Question 25

This question assessed candidates' knowledge of the relationship between the resistance of a wire, its length and cross-sectional area. Most candidates knew that resistance is directly proportional to the length of the wire, but a few candidates incorrectly thought that the resistance is inversely proportional to the diameter of the wire.

Question 26

Some candidates could interpret the graph and deduced the correct relationship between the voltage across a wire and its resistance. However, other candidates had the misconception that as the voltage increases the resistance of the wire increases.

Question 27

This question required candidates to use equations to calculate the charge that passes and the e.m.f. of a battery. Stronger candidates correctly answered this question. The most common error was to forget to convert the time of 1 minute into seconds when using the equation $Q = It$.

Question 30

This was a very challenging question for many candidates. Responses were evenly distributed across the four options which therefore indicated that many candidates were guessing.

Question 31

Candidates found this question, where they had to use the left-hand rule to find the direction of an electron in a magnetic field, challenging. While stronger candidates chose the correct answer, incorrect answers were evenly distributed across the other three choices, suggesting much guess work.

Question 32

Stronger candidates answered this question about transformers correctly, but a number of candidates had the misconception that there is an alternating current in the iron core.

Question 35

In this question, candidates had to work out the corrected count rate for a radioactive source when given the number of counts in three minutes and the background count rate (syllabus statement 5.2.1.5). Many candidates either worked out the count rate but forgot to correct for background or worked out the count rate due to the source and forgot to subtract the background count from this.

Question 36

Only stronger candidates answered this correctly. Weaker candidates often forgot to subtract the background count rate and therefore chose incorrect option **B**.

Question 38

Many candidates found this question, where they had to use the equation: orbital speed = $2\pi r / T$ to calculate the speed of the space station, challenging. Many weaker candidates chose incorrect option **B** because they incorrectly used 7000 km for the distance travelled in one orbit by the space station.

Question 40

Candidates had to recall the stages in the life cycle of a star (syllabus statement 6.2.2.3) and many candidates gave the stages in the correct order. However, some candidates had the misconception that a stable star occurred before a protostar and chose option **A**.

PHYSICS

Paper 0972/22
Multiple Choice (Extended)

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

General comments

Questions on density and isotopes were answered well. There were some misconceptions about absolute zero, digital signals and the Solar System. It was evident that questions involving fission and fusion, beta emission and half-life were not well understood. The questions on the new syllabus topic, space physics, showed a mixed standard of recall and understanding.

Comments on specific questions

Question 1

Most stronger candidates chose the correct response **C**, but weaker candidates also chose options **B** or **D**.

Question 3

This question was answered correctly by many candidates. A higher proportion of weaker candidates chose incorrect option **D** because instead of calculating the area under the graph, they attempted to use distance = speed × time.

Question 6

The vast majority of candidates answered this question about density correctly.

Question 9

Candidates had to use two equations, force = mass × acceleration and acceleration = change in velocity / time, in order to calculate the change in velocity of the object. This question was answered correctly by most candidates. Some weaker candidates chose incorrect option **B**.

Question 13

In this question, candidates had to rearrange the equation for pressure in a fluid to calculate the depth of sea water when the total pressure (including atmospheric pressure) at that point was known and many answered this correctly. Many weaker candidates chose incorrect option **B** because they did not take atmospheric pressure into account.

Question 14

This question assessed candidates' knowledge of 'absolute zero'. Stronger candidates answered this correctly, but some weaker candidates had the misconception that absolute zero is when particles have the least gravitational potential energy.

Question 16

Candidates had to use their knowledge of thermal energy transfer in this question. Many candidates answered this correctly, with stronger candidates choosing the correct option **C**. However, many weaker candidates had the misconception that a black outside surface would keep the hot coffee warmer for longer.

Question 18

Candidates had to recall the description of a digital signal and the apply their knowledge of the speed of electromagnetic radiation in different states of matter. Many stronger candidates gave the correct response, but weaker candidates had the misconception that a digital signal consists of a continuous range of values.

Question 21

Candidates had to recall and rearrange the equation for wave speed as well as recall the speed of light. A large majority of stronger candidates chose the correct answer, but weaker responses were fairly evenly distributed across the four options, indicating errors with unit prefixes and using the speed of sound instead of the speed of light.

Question 26

This question assessed candidates' knowledge of the relationship between the resistance of a wire, its length and its cross-sectional area. Many candidates answered this correctly. Some weaker candidates chose option **B**, as they only took the effect of one change to the wire into account.

Question 27

This question required candidates to use an equation to firstly calculate the current in the fire and then use that value to calculate the charge passing in the fire in 1 hour. The most common error was to just multiply the voltage of the supply by the power in watts.

Question 29

Candidates were assessed on their knowledge of LDRs and relays in this question. Stronger candidates chose the correct option while the responses from weaker candidates were distributed across the four options.

Question 30

Many candidates correctly answered this question where they had to use an equation for a transformer. Some weaker candidates mixed up the values for the input voltage and output voltage and therefore chose option **A**.

Question 31

Candidates performed very well in this question about the direction and strength of the magnetic field around a current-carrying wire. Some weaker candidates knew that the strength of the magnetic field was greater at Q than at P, but thought that the magnetic field direction was anticlockwise and therefore chose option **C**.

Question 32

Many candidates were aware that the magnetic effect of a current is not used in a potential divider, but others had the misconception that the magnetic effect of a current is not used in a loudspeaker.

Question 33

Only stronger candidates were aware that the total mass of the fission products and the fusion products was less than the original nuclide (option **D**).

Question 35

Few candidates could recall what change occurred in a nucleus during beta emission.

Question 36

In this question, candidates had to work out the count rate due to the source after 8 days, given the initial count rate and the background count rate (syllabus statement 5.2.1.5). A common error was to add the background count rate at the end, but this was unnecessary as the question only asked for the count rate due to the source.

Question 37

This question was answered well but some weaker candidates had the misconception that there are many stars in the Solar System.

Question 38

In this question, candidates had to recall facts about comets. Although most candidates knew the shape of a comet's orbit as elliptical, many had the misconception that the Sun is positioned at the centre of a comet's orbit.

Question 40

Candidates had to recall the definition of the Hubble constant (syllabus statement 6.2.3.9) but only stronger candidates answered this correctly. Many others chose option **C**.

PHYSICS

Paper 0972/31
Core Theory

Key messages

Some candidates were unclear about what does or does not count as a significant figure. Candidates should be encouraged not to round to 1 significant figure and should practice exercises on this topic.

Some of the candidates' handwriting made it difficult to distinguish what they were writing. There were some issues differentiating between the number 1 and 7, 4 and 7, 6 and 0, 9 and 0 and sometimes 7 and 9. Candidates should be encouraged to ensure that working and answers to numerical questions are as clear as possible.

General comments

Most candidates were prepared for this exam. They were able to apply their knowledge and physics understanding to the questions set and to produce correct responses.

A high proportion of candidates displayed a good grasp of the English language, and almost all candidates had a sufficient understanding to be able to attempt the questions. However, in some cases answers were confused with unclear use of the pronouns, it and they. In addition, candidates frequently stated a property had changed but failed to state how it had changed i.e. whether it had increased/decreased.

Comments on specific questions

Question 1

(a) Most candidates understood the connection between distance travelled and the area under the speed–time graph. Almost all candidates knew that they needed to find either speed × time or the area of the triangle under the graph and arrived at the correct answer of 400 m. The most common incorrect answer was 800 m from calculating the area of a rectangle rather than a triangle. A very small number of candidates worked out the area under the entire graph line.

(b) The majority of candidates recognised the different parts of the speed–time graph. Acceleration and deceleration were recognised more often than constant speed, which was sometimes mistaken for being at rest. A few candidates gave "increasing, constant and decreasing" without saying what was changing. Some simply said that speed was changing without stating in which way. Large numbers of candidates recognised that the acceleration and deceleration were constant, but a small number invalidated their answer by stating that the cyclist was accelerating at a constant speed. Candidates should be encouraged to reread and check what they have written. Some candidates stated that the acceleration and deceleration were changing rather than the speed.

(c) Most candidates scored partial credit for 12 m / s but very few gained credit for direction. There were a few answers with incorrect units and others where candidates used the 12 that they had read from the graph to work out some other quantity that they presented as the speed. Very few candidates recognised that they needed to give north as part of their answer. Candidates should practice writing velocities with both magnitude and direction.

Question 2

(a) The majority of candidates gave the correct answer of 0.80(2) N / cm^2. The most common errors were to either invert the equation for pressure, or to simply multiply the force and the area. A few candidates failed to calculate the area correctly.

(b) The vast majority of candidates recalled the correct equation for the moment of a force and were able to evaluate the correct moment as 123 600 N cm. The most common error was to use an incorrect rearrangement of the equation. For example, some candidates divided the force by the distance or the distance by the force.

(c) From analysing the diagram, most candidates realised that there needed to be a greater distance between force and pivot. However, a significant number of candidates believed the exact reverse and claimed that a smaller distance was needed.

(d) Many candidates gave an incorrect response due to of a lack of precision in their answers. Large numbers felt that the surface area of the block was smaller in the figure. The surface area of the block is exactly the same regardless of which face it is lying on. Candidates needed to specify that the area of base in **Fig. 2.3** was less. A number of candidates showed their understanding of stability by pointing out that the centre of mass was higher.

Question 3

(a) This question was answered well by almost all candidates. Most candidates were able to work out that C had to be first, E was last and F came before B. Only a small number got the order wrong but most of these gained partial credit.

(b) The vast majority of candidates recalled a sensible disadvantage, but some were unable to express themselves well enough to gain credit. Some responses were too vague and answers such as being dependent on weather or causing pollution did not score. Weaker candidates gave responses not connected to wind turbines e.g. “will not work at night”.

Question 4

(a) (i) The majority of candidates were able to correctly recall the equation for work done and evaluate the work done on the load as 50 J. The most common error was to simply divide the force by the distance instead of multiplying them.

(ii) Many candidates found this item challenging. Only a few recognised that this was the same as the answer to **(i)**.

(iii) Candidates also found this item challenging. Very few were able to state that there was energy transferred to the surroundings. Candidates should be encouraged to practice questions about energy stores and energy transfers.

(b) The majority of candidates were able to correctly recall the equation for power and to evaluate the power output of the electric motor as 16 W. The most common error was to multiply the work by the distance to give an answer of 400.

Question 5

(a) The simple kinetic molecular model of matter was well understood, and most candidates gained full credit.

(b) This was generally answered well, with most candidates stating that the pressure increased as result of more collisions of particles with the walls. The most common error was to state that the pressure decreased.

Question 6

(a) Few candidates recognised that more than one wavelength should be measured. The most common errors were to either simply state "measure the distance between consecutive peaks or troughs" or to use $v = f\lambda$.

(b) The majority of candidates were able to correctly recall the equation $v = f\lambda$ and then to evaluate the wave speed as 24 cm / s. The most common error was to use an incorrect rearrangement of the equation, e.g. some candidates divided the frequency by the wavelength or the wavelength by the frequency.

(c) Most candidates correctly identified the process as refraction. The most common incorrect answer was diffraction, but a few candidates gave rarefaction as their answer. Very few candidates recalled that refraction was caused by a change in speed of the wavefronts.

Question 7

(a) Many candidates gained partial credit, with most going on to gain full credit but a lack of accuracy or understanding meant that many candidates did not draw both rays meeting at the principal focus. The most common mistake was to show only one ray converging, but showing neither ray converging was common and some candidates had both rays diverging.

(b) Many candidates gained credit with a suitable electromagnetic radiation but, many gave electromagnetic waves with a shorter wavelength than visible light.

(c) (i) (ii) This was answered well with most candidates giving a suitable use of gamma rays and a harmful effect of gamma rays. Where credit was not awarded, it was usually due to a lack of precision.

Question 8

(a) The majority of candidates were able to identify both poles of the magnets and placed N and S in the correct positions on the diagram. Some candidates placed N on one magnet and S on the other. A common mistake was to place S and S facing each other.

(b) Many candidates correctly described the method to plot the shape of the magnetic field using iron filings but then did not describe how to find the direction using a plotting compass. This limited the credit that could be awarded. There were many candidates who gave a clear description of a sensible method for plotting the magnetic field using a compass or compasses, giving sufficient detail for someone to be able to follow. However, other candidates just described the field pattern given in the question which scored no credit.

Question 9

(a) This question was answered well by most candidates. The most common mistake was to omit 'variable' from the variable resistor.

(b) The majority of candidates were able to correctly recall the equation power = $V \times I$ and then to evaluate the power as 2.4 W. The most common error was to calculate resistance, i.e. $V \div I$, and to give an answer of 15.

(c) This question was usually answered well. Very few candidates showed the lamps in series. A significant number of candidates wasted time in redrawing the circuit diagram in **Fig. 9.1**. Candidates should be reminded to draw on the printed image when instructed to do this in the question.

Question 10

(a) (i) Only stronger candidates answered this correctly. Many others showed little understanding of electromagnetic induction and failed to gain any credit. Some scored partial credit for "magnetic field" but failed to link this to induced current.

(ii) This was answered well by most candidates. A common error was to be too vague, e.g. “change the number of coils” or “change the magnet”, when they needed to state “increase the number of coils” or “use a stronger magnet”.

(b) Many candidates answered fully correctly. Candidates showed they could rearrange the equation and calculate V_s successfully. The most common error was to rearrange the equation incorrectly, but some candidates gained partial credit for the ratio calculation. Some candidates attempted a form of cross multiplication which was usually incorrect. Candidates should be encouraged to write down the transformer equation in symbols before attempting to rearrange the equation.

Question 11

(a) The majority of candidates gained at least partial credit. They demonstrated a good understanding of atomic structure. The most common error was to state that the number of neutrons was 14 or to interchange the charges on the electron and the neutron.

(b) Many candidates struggled with this calculation. The concept of half-life was not well understood by many candidates. Candidates should be encouraged to calculate and then clearly state the number of half-lives that are being used in this type of calculation.

Question 12

(a) Many candidates answered this question well, but in other responses there was confusion with the various rotations that were taking place. Many candidates had a clear understanding that the Earth spins on its axis, but fewer stated that this takes 24 hours. Weaker candidates simply described the passage of the Sun across the sky on a typical day. Others were convinced that the motion of the Sun around the Earth was the cause of day and night.

(b) Most candidates gained full credit here but others could not name three planets or thought that Jupiter, Saturn, Neptune and Uranus were closer to the Sun than the Earth is.

(c) This question was answered well by most candidates. However, some candidates did not realise that chemical elements were needed and incorrect answers included “rock”, “heat”, “energy” or “fire”.

(d) The vast majority of candidates answered this correctly. The most common error was to give the Universe as the answer.

PHYSICS

Paper 0972/32
Core Theory

There were too few candidates for a meaningful report to be produced.

PHYSICS

Paper 0972/41
Extended Theory

Key messages

- Candidates should take note of the command word and mark allocation of questions and should use these details to ensure they answer appropriately.
- Numerical answers should be given to the required number of significant figures, with the correct unit. Final answer (A) 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 will only be awarded for working shown by candidates.
- Working for calculations should be set out logically, showing the formulae used.
- This syllabus now requires that candidates take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m/s^2).

General comments

Many candidates had prepared well for this examination, demonstrating a good understanding across a range of topics within the syllabus. **Questions 2** and **4** were generally answered very well by most candidates while **Questions 6** and **10** proved more challenging for many candidates.

Candidates are expected to give numerical answers to two significant figures unless instructed otherwise in a specific question. On this paper, answers given to only one significant figure were sometimes seen in **Questions 2(a)(ii)**, **4(a)(ii)** and **6(a)**.

When asked to 'show that' a quantity has a particular value, candidates must demonstrate that they know the formula they are applying. They should be advised to write down the formula in words or symbols. Manipulation of numbers given in the question to achieve the correct numerical answer is insufficient to demonstrate understanding of the physics in the situation. This applied to **Questions 4(a)** and **5(c)**.

Candidates are expected to use the symbols for physical quantities given in the syllabus. Any alternative symbol will only gain credit if it is clearly (and correctly) defined by the candidate. This applied particularly in **Questions 4(a)** and **6(a)**.

Candidates using a scale diagram to determine a resultant vector should use a sharp pencil and a ruler and protractor to ensure that neat, accurate vectors are drawn to the required scale and at the correct angle.

When candidates wish to alter their answer, they should cross out the response they do not wish to be marked and write their new answer down (if necessary, using spare blank space in the answer booklet or a continuation sheet and identifying the question number they are answering).

Comments on specific questions

Question 1

(a) (i) Candidates were asked to determine the magnitude and direction of a swimmer's velocity relative to the river bank. They could do this by calculation or by use of a scale diagram. Most candidates calculated the magnitude of the velocity, using Pythagoras' theorem. It is important that candidates realise that the magnitude of a velocity vector includes a unit. Those candidates who used scale diagrams drawn with careful measurements of vector length generally found the correct magnitude of velocity. Candidates should be reminded that, having found the length of the resultant vector, they must convert it using their scale to determine the magnitude of the velocity.

To determine the direction of the resultant velocity, candidates were looking for the angle it made with the river bank, i.e. the horizontal or current vector. Many candidates knew how to use trigonometry to calculate the angle between two vectors. Those that successfully calculated the direction often made use of a sketch diagram (not drawn to scale) to ensure they identified the angle with the river bank. Candidates drawing scale diagrams should be taught that the resultant of two vectors at right angles to each other will be drawn from the tail of one vector to the tip of the other vector. Giving bearings or directions according to compass points (N, W etc.) were ignored as they were irrelevant when describing an angle to the river bank.

(ii) Stronger answers here used the magnitude of velocity from **(i)**, correctly recalled and rearranged the formula $v=s/t$ and converted 1.5 minutes to 90 s. Almost all candidates gained credit for correct recall of the formula. Candidates were expected to realise that point Q will lie somewhere along the resultant vector calculated in **(i)**. Weaker candidates often substituted the speed of the swimmer relative to the water into their equation. Almost all answers were given with the correct unit. Other common errors were incorrect (or no) conversion of time and incorrect rearrangement of the formula.

(b) In this question, candidates were asked to explain why the swimmer moves with constant speed when he produces a constant forward force. A comprehensive answer named the force that would oppose the forward force and recognised that there would be no resultant force or that the two forces would balance. Many candidates correctly stated that there would be friction or drag from the water opposing the forward force. Candidates who did not name a resistive force often gained credit for recognising that constant speed meant there was no resultant force. Candidates should be precise when naming a resistive force. In this question, air resistance was not relevant. Weaker candidates often stated that there was no acceleration, which is an alternative way of expressing constant speed and not an explanation for why speed is constant.

Question 2

(a) (i) Candidates were expected to select from the information supplied in the question for **(a)**. Many candidates recalled $a = \Delta v / \Delta t$ and rearranged it to calculate the speed correctly. Candidates should be reminded to include the unit with any calculated quantity. A common error was to give the unit for acceleration instead of speed. Weaker candidates often tried to use the formula $v = s / t$ here, substituting in the value for acceleration given in the question as the distance.

(ii) Candidates were expected to recall and use $F = ma$ to find the resultant force on the motorcyclist and many used the values of mass and acceleration from the question to calculate the force. Candidates were expected to give the unit N (newton) for force. Common mistakes included giving the force in kg m s^{-2} or using $F = mg$. A few candidates attempted to use (F =) (Δ)mv / (Δ)t along with their answer to **(i)** and, while this could have gained full credit, candidates using this approach generally did not obtain the correct answer.

(b) (i) Most candidates knew that the difference between a vector quantity and a scalar quantity is that the vector has a direction. There were several alternative ways of expressing this clearly. Weaker candidates sometimes wrote a contradictory statement following a correct answer, for example, stating that a vector has direction and magnitude, but a scalar only has direction.

(ii) This question expected candidates to apply the knowledge recalled in **(i)** to the specific situation of a motorcyclist travelling around a bend at constant speed. Stronger candidates stated clearly that the direction of the velocity was changing or that velocity changed due to a change in direction. Answers stating that velocity increased or decreased were insufficient to demonstrate understanding of what happens. Some weaker candidates contradicted a correct response by adding that the motorcyclist slowed down.

(iii) Many candidates stated that a resultant force was needed because there was a change in velocity or they stated that without a resultant force the motorcyclist would continue moving in a straight line. Either of these statements gained partial credit. Candidates should be encouraged to give additional knowledge of the relevant physics when a question asks them to explain something. Here they could do that by stating that the change in velocity meant that the motorcyclist is accelerating, or by stating that the resultant force would be towards the centre of the circular path, or simply by recognising that the resultant force is proportional to acceleration. Common mistakes included suggesting that the resultant force was an opposing force such as friction or air resistance. Candidates should avoid repeating phrases from the question. An answer that stated a resultant force is needed as she travels around the bend just restated the question, whereas the resultant force is needed to change the direction of motion demonstrated understanding of the physics relevant to the question.

Question 3

(a) Most candidates recognised that this question was about convection, and many gave clear answers explaining that heated air is less dense and so rises to the top of the room, displacing colder air. The question did not ask for an explanation in terms of particles. Candidates who chose to answer in terms of particles often gave incorrect statements about, for example, hot particles being less dense.

(b) (i) Helium particles move faster as the temperature of helium increases. Often this was expressed by candidates as the particles gaining kinetic energy. Candidates should give clear, precise answers to questions asking for a statement. Common answers that were too vague were that energy increases or that motion increases.

(ii) This question explicitly asked candidates to explain in terms of particles how the pressure inside a helium balloon stays constant when the temperature of the helium increases and the volume of the balloon increases. Stronger candidates explained the effect of temperature and volume separately, in terms of particles, and then clearly stated that if pressure is constant, one effect cancels out the other effect. Many candidates attempted explanations just in terms of the equation $p = F / A$ without any reference to particles. Weaker candidates often gave incomplete explanations or mentioned volume increasing without linking this to an increased area for collisions.

Question 4

(a) (i) When asked to show that something is true, it is essential that candidates include the relevant formula in either words or symbols before substituting in values from the question. Candidates who only manipulated numbers to arrive at the answer did not demonstrate understanding of the physics involved. Most candidates knew and quoted the formula $c = \Delta E / m\Delta\theta$. Almost all candidates calculated $\Delta\theta$. Candidates then had to change either the mass into kg or the specific heat capacity into J / (g °C). A fully correct answer concluded with ΔE as the subject of the formula and the numbers substituted giving the answer 6300 J.

(ii) This question gave candidates an opportunity to show a good understanding of efficiency, including recognition that it is the wasted energy that has been calculated in the experiment but the useful energy value that is needed for an efficiency calculation. Candidates unable to arrive at a fully correct final answer, to at least two significant figures, often gained partial credit by stating formulae in words or symbols before attempting to substitute in numbers. Common mistakes included mixing up which was the wasted energy and which was the useful energy in this experiment, and giving the answer to just one significant figure.

(b) The reason that the efficiency will be less than the value calculated in **(ii)** must be due to an increase in wasted energy. Candidates needed to give a specific example of additional wasted energy, recognising that the thermal energy transferred to the water has already been included in the efficiency calculated. The most common answer given was thermal energy lost to the air/surroundings. Some candidates mentioned thermal energy transferred to the glass beaker. A common incomplete answer was to state that energy is wasted without saying where it is lost from or dissipated to.

Question 5

(a) The syllabus defines monochromatic light as light of a single frequency. Candidates could also correctly express this as light of a single wavelength. Candidates should know that light of one colour can still have a range of frequencies and so is an inadequate definition of monochromatic light.

(b) Many candidates correctly stated that the ray of light enters the block along the normal or perpendicular to the curved side AB. Gaining further credit was more challenging and involved recognising that if the angle of incidence is 0, then the angle of refraction will be 0 or making a statement that there will be no refraction in this instance. Weaker candidates often followed a correct statement about the incident ray by restating the question saying that the light does not change direction. A few candidates attempted an explanation in terms of wavefronts and often these were imprecise, noting that all the wavefronts enter at the same time, rather than the statement that all parts of one wavefront enter the block at the same time. Some weaker candidates made a contradictory statement that the light ray enters perpendicular to the normal.

(c) The strongest candidates correctly recalled and wrote down the formula $n = 1 / \sin c$ before trying to substitute values. Candidates doing this were assured of some credit. Most candidates then rearranged the equation to make c the subject, substituted the value for n and evaluated c. Candidates who used calculators often did not write down a rearranged formula but could still gain credit by writing the more precise value of c (41.8°) as evidence that they had used the equation correctly. Weaker candidates often could not rearrange the equation to make c the subject. An alternative acceptable approach was to keep refractive index as the subject and substitute in c = 42°. To gain full credit with this method, it was necessary to state the full equation and give the more precise value of n as 1.49 as evidence that the equation had been used correctly.

(d) (i) Candidates needed to recognise that the angle of incidence was greater than the critical angle and so total internal reflection happens. Where candidates recognised that the angle of incidence is larger than the critical angle, answers were often fully correct. A common mistake was stating the light would reflect without making it clear that all the light reflects. Some candidates included contradictory statements with a correct answer, such as suggesting there would be some refraction. Other candidates only stated what would happen to the light without offering any explanation.

(ii) This question allowed the strongest candidates to demonstrate a good understanding of the physics involved since the answer to what happens was total internal reflection again. Several weaker candidates were less sure and often suggested that refraction happens as the ray of light hits CD.

Question 6

(a) Many candidates recalled the equation $v = f\lambda$ and were able to rearrange and substitute values to obtain the wavelength of the microwaves. Errors which led to some candidates scoring only partial credit included rounding the answer to 1 significant figure, incorrect rounding of the answer to 0.15 m, omitting the unit for wavelength or giving an incorrect unit, often λ. Weaker candidates were unable to manipulate indices correctly and a few candidates recalled an incorrect formula.

(b) The syllabus references two specific reasons why microwaves are used for mobile phone signals: microwaves can penetrate through walls and for transmission/reception only a short aerial is required. Other reasons why microwaves are better than other electromagnetic waves were also given credit. Candidates could state that microwaves are not ionising radiation and so not harmful. Some candidates just described the microwaves as having a long wavelength and low frequency. Many answers were too vague. Some candidates correctly described the properties of microwaves rather than giving a reason for using them in preference to other EM waves with the same properties. A few candidates confused the properties of analogue/digital signals with those of microwaves and gave answers appropriate to **(c)(ii)**.

(c) (i) Only the strongest candidates gained full credit here with accurate sketches and two short statements. Common mistakes were poorly drawn diagrams for digital signals that showed more than two states, or inadequate statements about analogue signals being continuous rather than continuously varying or varying over a range of values. Some candidates did not label the sketch graph and gave responses answering **(ii)**. Weaker candidates were unable to draw a suitable diagram of analogue or digital signals.

(ii) Stronger answers included clear advantages for digital signals such as faster data transmission rate, the ability to remove noise through regeneration of signals or the fact that regeneration allows digital signals to be transmitted over longer distances. Some candidates also gained credit for recognising that digital signals can be encrypted or for realising that error-checking is possible with digital signals. Common answers such as no noise, or faster signals could have gained credit with a little more precision and detail. Some candidates attempted this question in terms of the advantages of microwaves rather than the advantages of digital signals.

Question 7

(a) This question required a simple description of a potential divider as a device which splits the electromotive force (e.m.f.) across resistors in series in proportion to their resistances. Many candidates incorrectly stated that current would be divided, and some candidates tried to answer by describing the diagram given in the question.

(b) (i) This question proved to be challenging to all but the strongest candidates. They needed to look carefully at the circuit diagram and recognise that with the switch open the electromotive force is split equally between R_1 and R_2. Therefore, the reading on the voltmeter is half the value of the e.m.f. Many candidates gave the incorrect responses 7.5 V or 22.5 V. Candidates should read the questions carefully and use information in diagrams carefully when calculating quantities.

(ii) Many correct answers were seen in this question. Candidates demonstrated confidence in working out the combined resistance of a parallel combination of resistors and then using that to find the total resistance of the combination in **Fig. 7.1**. Almost all candidates gave the correct unit for resistance. A common mistake was to add R_1 and R_2 together first and then work out the combined resistance as though R_1 and R_2 combined were in parallel with R_3. Weaker candidates applied either the formula for a combination of resistors in series or a combination of resistors in parallel to all three resistors.

(c) Few candidates were able to calculate the correct value for the reading on the voltmeter. Candidates should be encouraged to inspect an answer once calculated to consider whether it is sensible as in many instances the value of V here was greater than the e.m.f. given in **(b)(i)**.

Question 8

(a) The strongest answers to this question set out how a simple transformer works clearly and logically. An alternating current in the primary coil causes a changing magnetic field which is strengthened, or transferred, by the iron core, and which cuts the secondary coils inducing an e.m.f. across the secondary coil. Where full credit was not gained, it was often for a lack of precision, for example, mentioning current in the primary coil without specifying that it must be a.c. Weaker candidates sometimes focused on describing step-up or step-down transformers rather than explaining how a transformer works.

(b) (i) Many candidates recalled the formula $N_p / N_s = V_p / V_s$ and rearranged and substituted values to obtain the correct answer. Candidates should be encouraged to check calculations carefully as a common error was misreading the answer by a factor of ten. Weaker candidates were not able to make N_p the subject of the equation. Candidates should be able to rearrange formulae so that they can make any quantity the subject.

(ii) Calculating the current in the primary coil required recall of $P = IV$, conversion of 77 MW into watts and then correct rearrangement and substitution into the power formula. Common mistakes included either incorrect conversion of MW or incorrect rearrangement of the formula with the weakest candidates struggling with both tasks.

Question 9

(a) Almost all candidates identified the electrons as the black circles orbiting the nucleus and then deduced that the number of protons = the number of electrons and so the white circles in the nucleus were protons leaving the grey circles as neutrons. This allowed them to gain full credit with the correct number and a variety of ways of expressing how to find it. The few incorrect responses either identified the wrong particle or miscounted the number of dots.

(b) (i) Candidates were expected to describe the difference between the nuclear composition of X1 and X2. Many candidates stated that X2 has more protons and fewer neutrons, without being specific that there was 1 more proton and 1 fewer neutron in X2 compared to X1. Candidates should be encouraged to read questions very carefully. This question asked about the composition of the nucleus and any reference to the number of electrons was therefore contradictory to a correct response.

(ii) Successful answers here identified that the nucleus of X2 has fewer (or no) excess neutrons or that X1 has more neutrons in its nucleus. Common incorrect answers referred to electrons and in particular the outer electron shell, demonstrating confusion between nuclear stability and atomic stability.

(c) (i) While most candidates identified the half-life as being an amount of time, few were able to express clearly what happened in this time. Candidates gaining full credit often mentioned the time for the count rate or activity to halve. The time for half the nuclei in a radioactive sample to decay was often expressed poorly with weaker candidates stating that it was the time for half the nucleus (or atom) to decay. Another common mistake was to state that it is the time for the substance to halve, without making clear that it is the mass of radioactive isotope that halves.

(ii) An isotope with a very short half-life is hazardous because it has a high decay rate, which means it emits a large amount of radiation in a short time. Candidates should be encouraged to state reasons clearly because emitting radiation quickly can mean at a fast rate but can also mean at a high speed. Ambiguous answers did not gain credit.

Question 10

(a) (i) In this question, candidates were asked to describe how the speed of Pluto varies as it moves from X to Y and then back to X. A full answer needed to state that speed decreases from X to Y and increases from Y to X. Common mistakes here were descriptions that were imprecise, such as stating the speed decreased at Y and increased at X or speed is slower from X to Y and faster from Y to X. Some weaker candidates only gave a partial answer stating that the speed decreases. Candidates should look carefully at the command word in a question as several candidates attempted explanations for variation in speed without describing how it changes.

(ii) Stronger answers to this question made three distinct statements about energy transfers to explain the change in Pluto’s speed as it orbits the Sun. GPE transferring to KE as Pluto gets closer to the Sun, and KE transferring to GPE as Pluto moves back to Y being were common answers. Many candidates linked an increase in KE to faster speed. A few candidates noted that total energy is conserved during the transfers between GPE and KE. Weaker candidates mentioned changes in GPE and KE without making it clear that the energy transfers were between these two stores. A common incorrect answer explained changes in speed as being a consequence of thermal energy transferring to kinetic energy.

(b) (i) Conversion of 43 K required use of the formula T (in K) = θ (in °C) + 273. There were few correct answers and many different incorrect responses. Candidates should be encouraged to check the sense of a numerical answer. 230 °C is obviously not a sensible value for the temperature on the surface of an object much further away from the Sun than Earth. Weaker candidates were not able to recall the conversion formula.

(ii) Many candidates gained credit either for recognising that white is a good reflector (or poor absorber/emitter) of radiation or that the dark surface is a good absorber (or emitter). A common mistake was omission of any reference to what is being absorbed, reflected or emitted. Some candidates added contradictory answers to a correct response, for example, correctly identifying the white surface as a good reflector but then wrongly stating that it is also a good emitter of radiation. The strongest candidates went on to explain that the white surface produced less variation in temperature as Pluto rotated. This could be done in several ways, for example stating that the temperature increased more when the dark side was facing the Sun or that the white side cooled down less than the dark side when facing away from the Sun.

PHYSICS

Paper 0972/42
Extended Theory

Key messages

- Candidates should take note of the command word and mark allocation of questions and should use these details to ensure they answer appropriately.
- Calculations should be set out carefully and logically and explanations should be shown clearly with each step clearly shown.
- Numerical answers should be given to the required number of significant figures, with the correct unit. Final answer (A) 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 will only be awarded for working shown by candidates.
- Candidates must use the symbols for physical quantities given in the syllabus and should ensure they include the correct unit and the required number of significant figures.
- This syllabus now requires that candidates take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m / s^2).
- Candidates should ensure they use a ruler and sharp pencil when drawing straight lines and ensure that their handwriting is legible.

General comments

The overall standard of answers on this paper was high.

When asked to ‘show that’ a quantity has a particular value, candidates must demonstrate that they know the formula they are applying. They should be advised to write down the formula in words or symbols.

Manipulation of numbers given in the question to achieve the numerical answer given in the question is insufficient to demonstrate understanding of the physics in the situation. This applied in **Question 5(a)(i)**.

Careful drawing of straight lines was required in **Questions 7(a)** and **8(a)**.

Candidates are expected to use symbols for physical quantities given in the syllabus. Any alternative symbol used will only gain credit if is clearly and correctly defined by the candidate, e.g. **Questions 3(a)** and **5(a)(ii)**.

Comments on specific questions

Question 1

(a) (i) Stronger candidates gave precise statements about the conditions required for equilibrium, i.e. that there should be no resultant/net force and no resultant/net moment. The condition of no resultant force was better known than the condition of no resultant moment. Incomplete statements relating to vertical forces being balanced (e.g. weight = lift) and anticlockwise moments = clockwise moments were insufficient. Some candidates confused momentum with moment and weaker candidates often made general statements trying to describe factors affecting the flight of a helicopter, e.g. wind speed, not flying too high or too low, mass of the helicopter.

(ii) Most candidates were able to recall the formula for the change in gravitational potential energy and usually quoted the formula in symbols before substituting numerical values. The most common error was to omit the unit or to give a wrong unit. The value for *g* which should now be used is 9.8 N / kg (as stated on the front of the question paper).

(b) (i) Most candidates were able to mark at least one of the points on the graph correctly and the strongest candidates could generally mark all three points correctly. Candidates should be advised that when asked to label a point, that the point should be clearly shown as a point with a dot or a cross. Weaker candidates often confused decreasing acceleration with negative acceleration or indicated that zero acceleration was at the origin.

(ii) Stronger candidates read the question carefully and gave well-structured answers describing the forces acting on the parachutist and their effect on the motion from when the parachutist left the hot-air balloon until point A. The weakest answers referred to changes in energy rather than forces or described what happened after the parachute was opened (at point A). References to gravity, instead of the force of gravity or weight, were insufficient for the first and fourth marking points. Few candidates stated that air resistance increases as velocity increases, and many linked the increase in air resistance with time. Many candidates were able to correctly describe the condition for terminal velocity/constant speed/zero acceleration. Weaker answers were confused and included statements about air resistance balancing acceleration. Weaker answers often included contradictions about increasing and decreasing speeds or acceleration.

Question 2

(a) Most candidates correctly stated the formula for kinetic energy in symbols. The most common errors were not squaring the numerical value of the velocity when substituted in the equation and not converting the mass in g into kg. Some candidates calculated a value for momentum instead of kinetic energy. Most answers included the correct unit. Weaker answers omitted the unit or gave an incorrect unit, usually N. The only acceptable derived unit for joules is N m.

(b) Answers using the change in momentum to calculate the average force were usually correct. Candidates who attempted to use $F = ma$ were often unable to calculate the acceleration correctly. There were many incorrect answers where candidates divided the kinetic energy they had calculated in **(a)** by time, often stating $F = E / t$.

(c) Many candidates knew that moving the hands backwards decreased the force and could state this effect. The question asked for an explanation, not just a statement, and only a few candidates were able to explain that the reduction in force was due to an increase in time taken to catch the ball.

Question 3

(a) Stronger answers to this question stated that the surface area in contact with the ice was greater when moving across the ice in the position shown in the diagram (a crawling position). These candidates then explained that this reduced the pressure on the ice because $p = F / A$ or pressure is inversely proportional to area (and force or weight is constant). The reverse argument about the effect on surface area and pressure was equally acceptable. Weaker candidates omitted the equation relating pressure and surface area or the statement about pressure being inversely proportional to area. A common error was to state that the force changed, and weaker answers were confused between force and pressure. The equation $p = F / S$ (instead of $p = F / A$) was only accepted if S was clearly defined as area.

The question asked for answers showing an understanding of pressure so references to friction being lower in the position shown and hence less likely to fall over or lower centre of gravity increasing stability were not acceptable.

(b) Many candidates gave the correct answer with the correct unit. These candidates had usually worked through the calculation of the pressure due to the water and the pressure due to the ice carefully and correctly found the sum of the two pressures. Weaker candidates only calculated the pressure due to the water or subtracted the two pressures or calculated the pressure due to the ice incorrectly by using the mass and not the weight of the ice. Some candidates wrote the equation as $p = m / A$. The value for g used in this question should be 9.8 N / kg.

Question 4

(a) Stronger candidates carefully explained that the speed or kinetic energy of the particles of the gas decreased resulting in a decrease in pressure and that this caused the frequency of the collisions and the force exerted by the particles to both decrease. Many otherwise good answers were not awarded full credit as they were not detailed enough. Some candidates only referred to fewer collisions instead of less frequent collisions. Others did not refer either to the difference in force exerted or that a smaller momentum change occurred. A significant number of candidates described the pressure change when the volume decreased, and others only described the pressure change when the temperature increased.

(b) (i) The value of absolute zero was not well known, especially by weaker candidates. There was a variety of incorrect answers with the most common being 0 and 273 (without the minus sign).

(ii) Candidates who answered this question correctly usually expressed their answer in terms of the particles not moving rather than giving the statement that they had the least kinetic energy. This was better known than the value of absolute zero. Stronger answers also referred to absolute zero being the lowest possible temperature. Common incorrect answers stated that water froze at this temperature, showing confusion between the scales of temperature. Some candidates, especially the very weakest ones, often made no attempt at this question.

(c) Most candidates correctly stated pV = constant in some form. Others tried to use proportionality between pressure and volume. Some candidates made the question more difficult than was necessary by attempting to convert cm^3 to m^3, with varying levels of success. Some were unable to correctly rearrange the equation. Candidates should be discouraged from drawing lines between numbers when trying to cross multiply, even when that is the correct method of calculation.

Question 5

(a) (i) This question required candidates to show that the mass of air in the room was 79 kg. Most candidates were awarded at least partial credit. Answers were only awarded the initial credit if the equation relating mass, volume and density was correctly stated in symbols or words in any form. This is a common requirement in 'show that' questions. Further credit was only given if candidates showed evidence of the use of the equation with the mass as its subject.

(ii) There were many correct answers to this complex calculation involving the use of both $E = mc\Delta\theta$ and $P = E/t$. Unless symbols were clearly defined, credit for equations in symbols was only awarded if symbols given in the syllabus were used. In this question, no credit was given for the use of Q instead of E or t instead of θ or T. Candidates should also use the symbol Δ when a change in a quantity is calculated. Some candidates did not realise that the mass of the air was the value that they had been given in **(i)**.

(iii) Stronger candidates stated that thermal energy was transferred to other objects in the room or outside the room and not just to the air in the room. Answers of heat loss to the surroundings or that the power of the heater was less than 100 per cent were insufficient. Some candidates did not attempt this question.

(b) This question asked for the main methods of thermal energy transfer to outside which are reduced by a double-glazed window with a narrow air gap. The expected answer to this question was conduction and convection. Some candidates stated radiation as their answer. This was another question where candidates needed to read the question carefully and answer the question asked. The transfer of thermal energy by radiation is unchanged by a double-glazed window. Some candidates gave explanations instead of naming the methods of heat transfer.

Question 6

(a) Most candidates knew that P and S waves were either longitudinal or transverse. Many seemed unsure of which was which and either named the same type of wave twice or gave answers that were the wrong way round. Either of these answers were awarded partial credit. Candidates who did not get any credit gave answers of electromagnetic waves or specific electromagnetic waves instead of transverse waves or sound for longitudinal waves. Some candidates did not attempt this question.

(b) All but the weakest candidates could correctly recall the equation $v = f\lambda$. Weaker candidates often stated the equation as $\lambda = fv$. Some candidates were unable to rearrange the equation correctly and others gave an incorrect unit or omitted a unit. The correct unit for wavelength is a unit of length, e.g. km. (λ is a variable used to represent wavelength).

Question 7

(a) Most candidates were able to draw the normal correctly. Candidates should use a ruler when asked to draw something that is a straight line. Incorrect answers included drawing the normal at right angles to the incident ray, only drawing a refracted ray or drawing a continuation of the incident ray. Although conventionally the normal has been drawn as a dotted line, drawing a solid line may lead to greater accuracy and may encourage candidates to use a ruler.

(b) Most candidates were able to recall the equation $n = \sin i / \sin r$. Only the strongest candidates realised that the drawing of the normal in **(a)** was intended to help them calculate the value of the angle of incidence. Most used the value of the angle with the surface of the oil and, if they did that correctly, they were awarded credit. Some weaker candidates subtracted 56° from 180°. Other incorrect answers resulted from candidates just multiplying or dividing 56° by 1.47 or being unable to find the inverse sine.

(c) Many candidates were able to recall the correct value for the speed of light in air and used correct units. Weaker candidates did not know the correct value and often gave the value of the speed of sound in air. Sometimes the unit was missing or incorrect.

(d) Many candidates were able to correctly select the formula relating the speed of light in oil to the speed of light in air and the refractive index of the oil. Some rearranged the equation incorrectly and others did not give their answer to 3 significant figures as required by the question. Many gave the answer to 1 or 2 significant figures and a few to 4 or more significant figures. The unit was sometimes omitted. Some candidates did not attempt this question.

Question 8

(a) (i) Many candidates were unable to state what is meant by a magnetic field. The correct answer was a region in which a force acts on a (magnetic) pole. Answers referring to a region or an area and a force on a magnet or magnetic material were awarded credit. A common omission was a reference to a region or area. Incorrect answers included the statement that the magnetic field was the area around a magnet, a region where an object (unqualified by the word magnetic) experiences a force or confusion between electric and magnetic fields.

(ii) Many candidates were able to state that the direction of a magnetic field was the direction of the force on a N pole, usually by stating that it was from N to S. The most common error was confusion between an electric and a magnetic field with candidates referring to the direction of the force on a positive charge or from positive to negative. Another common incorrect answer was that it was towards the N pole.

(b) Many candidates carefully drew four equally spaced radial lines with arrows from the outside to the edge of the sphere and towards the centre of the sphere. Candidates should use a ruler and a sharp pencil to draw straight lines and be precise with the end points of the lines. Some candidates had the wrong direction for the arrows and others tried drawing the shape of the magnetic field around the Earth or circles around the sphere.

(c) (i) Most candidates divided the e.m.f. of the three cells by 3 to get the correct answer. Common errors were confusing a cell with a battery, so giving the answer of 6.0 V or omitting the unit.

(ii) There were few correct answers to this question. The most common incorrect answers were 2:1 and 1:1.

(iii) 1 Stronger answers stated that the current would be zero as the diode was in the wrong direction to allow current to flow. Some candidates just stated that the current would be 0 without any adequate explanation. Common wrong answers were that the current increased or decreased or changed direction.

2 The most common incorrect answers here were 1:2 and 2:1. The answers 1 or $R_1 = R_2$ were insufficient. Candidates should be encouraged to use the format *x*:*y* when expressing ratios as in this question and **(i)**. Some candidates did not attempt this question.

Question 9

(a) There were not many completely correct answers for this question. Most candidates knew that an alpha particle contained 2 neutrons. Weaker candidates often gave answers of 0, –2, –1, 1, 1.2, 3 or 4 or did not answer this question. The most common incorrect answer was 4. The charge on the beta particle was often given as –1, ignoring the unit in the heading and the prompt of the value of the charge on an alpha particle given. A significant number of candidates indicated that lead was needed to stop gamma radiation. Lead on its own was insufficient. There needed to be an indication that it should be thick lead (i.e. at least 10 cm or many cm of lead). Concrete needed to be very thick or at least 1 m. Incorrect answers included the use of other materials, e.g. zinc, aluminium or steel.

(b) Most candidates gave insufficient answers here, and a significant number omitted the question completely. The answer needed to refer to both an increase of one proton and a decrease of one neutron. Answers referring to mass and proton numbers were insufficient. Some very weak answers suggested that there would be no change to the nucleus or described the charge of a beta particle.

(c) This question was answered well by many candidates. Stronger candidates subtracted the background count from the initial count rate, recognised that three half-lives would pass, correctly divided the corrected count rate by 8 and then added on the background count rate to calculate the final count rate. Common mistakes were forgetting to subtract and/or add on the background count rate. Some candidates made arithmetical errors and some weaker candidates multiplied the initial count rate by 3 or divided it by 25. Candidates should be encouraged to write down all the steps taken, including the number of half-lives, clearly in their working so that partial credit can be awarded for any correct stages. Some candidates made no attempt to answer this question.

(d) Most candidates were awarded at least partial credit. This was most often for the use of gloves or tongs (to prevent contact), the use of lead containers for storage or to keep a distance away. Answers such as wearing protective clothing or goggles were too vague.

Question 10

(a) Stronger candidates wrote down a complete equation, including v, an equals sign and $2\pi r / T$ and then defined r as the radius of the planet and T as the orbital period or time for planet to complete an orbit. Writing down only the right-hand side of the equation was insufficient for initial credit. Answers defining r as radius and T as time were insufficient and those defining r as the radius of the planet were incorrect. Some weaker candidates gave the general equation for v, i.e. $v = s / t$. This was insufficient. Others gave the equation defining the Hubble constant which did not answer the question. Some candidates did not attempt this question.

(b) Candidates who were awarded credit for this question were usually given it because they referred to the tilt of the Earth's axis. Few were able to express that the rays from the Sun strike the country at different angles during the year or that the country received rays from the Sun for a different number of hours per day. Some candidates did not attempt this question.

(c) Most candidates obtained at least partial credit for this question, usually for the formation of a black hole. Few candidates could correctly identify all the stages in the life cycle of a star more massive than the Sun. Common mistakes were omitting the 'super' from red supergiant, referring to a planetary nebula or omitting the 'star' from neutron star. Some candidates did not attempt this question.

(d) Candidates needed to know the equation $H_0 = v / d$ and how to convert a distance in km into light-years to gain full credit. The strongest candidates were able to do all of this. Some candidates did not know the formula or were unable to rearrange it correctly and few correctly converted km to light-years.

PHYSICS

Paper 0972/51
Practical Test

Key messages

- Candidates need to have 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 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 figures 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 showed evidence of regular experience of similar practical work. Some candidates appeared to have learned sections from the mark schemes of past papers and produced responses that were not appropriate to the questions in front of them. For example, some candidates calculated the gradient of the graph line in **Question 1(d)** and some candidates wrote about techniques involved in reading a measuring cylinder scale in **Question 2(e)**.

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

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 or a measurement carried out by the candidate.

Comments on specific questions

Question 1

(a) Most candidates recorded a realistic value for the distance *y* in cm.

(b) The majority of candidates successfully recorded the initial values of *P* and *x*. Most went on to record increasing values of *x* but some recorded values greater than 50 cm. All the *P* values were expected to be given to two significant figures and the *x* values to the nearest mm.

(c) Most candidates labelled the graph axes correctly and drew them the right way round. Some candidates chose a scale that resulted in the plots occupying too small a proportion of the graph 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 following a clear curve. However, many candidates drew a straight line that did not match the plots.

(d) Candidates were expected to show, on the graph, the method for finding the value of x. Many read the value accurately. Some candidates who had drawn a straight line, calculated the gradient instead of following the instructions.

Question 2

(a) Most candidates recorded a realistic room temperature.

(b) The majority of candidates successfully recorded realistic decreasing temperatures. However, some recorded room temperature at time t = 0. Many candidates completed the column headings correctly. Some gave wrong units (e.g. C in place of °C or sec in place of s). Others gave no units.

(c) Most candidates correctly calculated the decrease in temperature and average rate of cooling. Fewer successfully worked out that the unit was °C **/** s.

(d) Here candidates were expected to use their experience of similar experiments to suggest a change to the procedure such as continuing to take temperatures for a longer time or to use a higher or lower starting temperature. To display the results, many candidates sensibly suggested plotting a graph. Those who specified plotting temperature against time, or cooling rate against time, gained full credit.

(e) Many candidates correctly identified avoiding parallax error or explained the effect of not reading the scale at a right angle.

Question 3

(a) – (c) Most candidates produced a neat ray trace with a correctly positioned normal and incident ray. Candidates were expected to show the initial pin positions at least 5.0 cm apart. Most successfully placed the pins P_3 and P_4 in order to proceed to drawing in the refracted ray. Candidates were expected to measure the angle θ correctly to within ± 2°. Many achieved this in addition to correctly drawing the diagram so that the angle was greater than 30°.

(d) Here candidates were expected to state one technique that they used to obtain an accurate ray trace. For example, viewing the bases of the pins or drawing thin lines.

(e) (f) Many candidates viewed the images correctly and completed the ray trace well, obtaining a result for the angle θ that was within the tolerance allowed.

Question 4

Candidates who followed the guidance in the question were able to write concisely and addressed 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 was required. Candidates needed to 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. Many candidates drew a suitable circuit diagram with the lamp, ammeter and voltmeter correctly positioned. Some incorrectly placed the voltmeter in series with the other components. Candidates were expected to clearly state that the current and potential difference would be measured and then the resistance calculated. Candidates were also expected to write that the procedure would be repeated with different currents. A vague reference to repeats was not sufficient as it was not clear whether candidates were referring to using different currents or repeating the measurements with the same current.

Candidates were expected to specify a way to change the current, for example by using a variable resistor.

Many candidates drew a suitable table. They were expected to include columns for potential difference, current and resistance headed with quantities and appropriate units.

Candidates were expected to explain how to reach a conclusion by drawing a graph of resistance against current or by comparing values of resistance and current. The question did not ask for a prediction. Some candidates wrote a prediction but no explanation of how to reach a conclusion.

PHYSICS

Paper 0972/61
Alternative to Practical

Key messages

- Candidates need to have had thorough experience 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 figures 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 showed evidence of regular experience of similar practical work. Some candidates appeared to have learned sections from the mark schemes of past papers and written responses that were not appropriate to the questions in front of them.

The practical nature of the examination should be considered when explanations, justifications or suggested changes are required, for example in **Questions 1(e)**, **2(d)**, **2(f)** 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 recorded the correct value for the distance *y* in cm.

(b) Many candidates showed their familiarity with this type of experiment by commenting on the difficulty in obtaining balance.

(c) Most candidates labelled the graph axes correctly and drew them the right way round. Some candidates chose a scale that resulted in the plots occupying too small a proportion of the graph 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 following a clear curve. Nevertheless, many candidates drew a straight line that did not match the plots.

(d) Candidates were expected to show, on the graph, the method for finding the value of x. Many read the value accurately. Candidates who had plotted a good graph obtained a value for x within the permitted tolerance. Some candidates who had drawn a straight line, calculated the gradient instead of following the instructions.

(e) Candidates were expected to describe balancing the ruler on the pivot with no loads and state that the balance point shows the position of the centre of mass.

Question 2

(a) Most candidates recorded room temperature correctly.

(b) Many candidates completed the column headings correctly. Some gave incorrect units (e.g. C in place of °C or sec in place of s). Others gave no units. Most candidates recorded the times correctly.

(c) Most candidates correctly calculated the decrease in temperature and average rate of cooling. Fewer successfully worked out that the unit is °C **/** s.

(d) Here candidates were expected to use their experience of similar experiments to suggest a change to the procedure such as continuing to take temperatures for a longer time or to use a higher or lower starting temperature. To display the results, many candidates sensibly suggested plotting a graph. Those who specified plotting temperature against time, or cooling rate against time, gained full credit.

(e) Many candidates correctly identified avoiding parallax error or explained the effect of not reading the scale at a right angle.

(f) Candidates were expected to comment on taking the reading at the bottom of the meniscus or ensuring that the measuring cylinder is on a horizontal surface.

Question 3

(a) – (c) Most candidates produced a neat ray trace with a correctly positioned normal and incident ray. Candidates were expected to show the initial pin positions at least 5.0 cm apart. Most successfully placed the positions of pins P_3 and P_4 in order to proceed to drawing in the refracted ray. Candidates were expected to measure the angle α correctly to within ± 2°. Many achieved this.

(d) Here candidates were expected to state one technique that they used to obtain an accurate ray-trace. For example, viewing the bases of the pins or drawing thin lines.

(e) Most candidates measured the angle β to obtain a result that was within the tolerance allowed. Most went on to correctly calculate θ but a significant number of candidates did not show their working as asked for in the question.

(f) Here candidates were expected to observe that the two angles could not be regarded as equal as they were too different, or beyond the limits of experimental accuracy.

Question 4

Candidates who followed the guidance in the question were able to write concisely and addressed 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 was required. Candidates needed to 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. Many candidates drew a suitable circuit diagram with the lamp, ammeter and voltmeter correctly positioned. Some incorrectly placed the voltmeter in series with the other components. Candidates were expected to clearly state that the current and potential difference would be measured and then the resistance calculated. Candidates were also expected to write that the procedure would be repeated with different currents. A vague reference to repeats was not sufficient as it was not clear whether candidates were referring to using different currents or repeating the measurements with the same current.

Candidates were expected to specify a way to change the current, for example by using a variable resistor.

Many candidates drew a suitable table. They were expected to include columns for potential difference, current and resistance headed with quantities and appropriate units.

Candidates were expected to explain how to reach a conclusion by drawing a graph of resistance against current or by comparing values of resistance and current. The question did not ask for a prediction. Some candidates wrote a prediction but no explanation of how to reach a conclusion.

PHYSICS

Paper 0972/62
Alternative to Practical

Key messages

To perform well in this examination, candidates need to have a thorough grounding in practical work during the course. Candidates should have as much personal experience of carrying out experiments themselves as possible. The practical work should include reflection upon, and the discussion of the significance of results, precautions taken to improve reliability and control of variables.

Candidates should be advised to read the questions through very carefully to ensure that they are answering the question as written, and not simply recalling the answer to a different question.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques. These include:

- handling practical apparatus and making accurate measurements
- tabulating readings
- graph plotting and interpretation
- manipulating data to obtain results
- drawing conclusions
- understanding the concept of results being equal to within the limits of experimental accuracy
- dealing with possible sources of inaccuracy
- control of variables
- choosing the most effective way to use the equipment provided.

The majority of candidates were well prepared and the range of practical skills being tested proved to be accessible to the majority of the candidature. Most candidates demonstrated that they were able to draw upon their own personal practical experience to answer the questions. No parts of any question proved to be inaccessible to candidates and there was no evidence of candidates running short of time. The majority of candidates were able to follow instructions correctly, record measurements clearly and perform calculations accurately and correctly. Units were well known and were usually included. Writing was legible and ideas were expressed logically. However, candidates seemed less able to derive conclusions from given experimental data and justify them.

Some candidates showed an exemplary understanding of practical skills but equally, there were those who demonstrated a lack of graph skills, poor understanding of significant figures and a lack of comprehension of good practice in carrying out experiments.

Comments on specific questions

Question 1

(a) This question required candidates to draw a diagram of a spring, and to mark on it the unstretched length of the spring. Candidates often overcomplicated it by drawing in rulers and set squares. Many candidates were not careful enough with the position of the arrows at the ends of their lines used to mark the unstretched length. This produced marked distances which were greater than the lengths of the springs that they had drawn.

(b) The calculation of the extensions produced by the loads was done well, but a number of candidates calculated incremental, rather than total extensions. Some candidates rounded their correctly calculated extensions to the nearest whole number. This was presumably to make the graph plotting exercise which followed easier. This is bad practice and candidates should be discouraged from doing this.

Most candidates added correct units to the headers in the table. The incorrect 'N / mm' was often written at the head of the extension column.

(c) Graph-plotting skills were of a reasonable standard, but many responses failed to gain full credit. The most common sources of error were:

- awkward scales, such as 3 or 7; choosing such scales makes the points much harder to plot
- missing labels and/or units on the axes
- choosing scales so that the plotted points did not cover at least half of the given grid
- failure to plot the first point for which $L = 0$ and $e = 0$
- forcing the line of best fit to pass through the origin (whether plotted or not), resulting in an inappropriate line of best fit.

There were, however, still many excellent, carefully drawn, best-fit lines produced by candidates.

(d) Most candidates gained at least partial credit for this question. Credit for accuracy depended on the quality of the line of best fit they had drawn.

Candidates were asked to indicate on their graph how they obtained the information and in some cases this was missing.

Question 2

(a) Most candidates recorded the correct value for the room temperature. Occasionally, 20.3 °C was seen instead of 23 °C.

(b) The instruction to complete the column headings and the times in the table was very often not followed. The unit of temperature was often given incorrectly as C or C°. The list of times was usually recorded correctly, but a sizeable minority of candidates started with 30 s instead of 0 s at the start, with the result that the total time for the experiment became 210 s instead of 180 s.

(c) The calculation of the average rate of cooling of the water over the duration of the experiment was done well. There were occasional rounding errors and answers being left as fractions. However, some correctly calculated rates were rounded to just 1 significant figure.

(d) Most candidates were able to give at least one change to the experiment that would increase the rate of cooling of the hot water, without changing the starting temperature of the water. The most common correct answers were to remove the lid or to use a wider surface area. Occasionally, suggestions did just the opposite of what was required, e.g. using a thicker lid or wrapping the beaker in insulation.

(e) Candidates often misinterpreted what was required here, namely how accurate temperatures of the cooling water are obtained during the experiment. Creditworthy answers referred to perpendicular viewing of the thermometer scale, stirring the water before taking a reading, ensuring that the thermometer does not touch the sides of the beaker etc. Many responses were related to the accuracy of the final result or to improvements to the experiment. Answers such as repeat and average or keep the room temperature constant were common.

(f) Only stronger candidates answered this correctly. Very few candidates knew that the level of the liquid in the measuring cylinder is measured to the bottom of the meniscus and not the top because the volume of water between the bottom and the top is negligible. Credit was given to candidates who stated that reading at the top of the meniscus would give an overestimate of the volume.

Question 3

(a) Most candidates drew an acceptable normal at the centre of AB. The drawing of the incident ray caused problems as many candidates thought that the angle of incidence was measured to the surface of the block and not to the normal.

(b) Most candidates drew the path of the refracted ray correctly. In some cases, the end of the line was not labelled E, as asked for in the question. The angle of refraction was usually measured correctly, and provided with a unit. Occasionally the unit was missing or given incorrectly as °C.

(c) Only stronger candidates were able to identify a precaution that needed to be taken to produce an accurate ray trace. Common incorrect answers were "view the pins at right angles", "avoid parallax" and "keep one eye closed". Answers such as "view the bases of the pins", "ensure that the pins are vertical" and "draw thin lines" scored credit here.

(d) Angle α was usually measured correctly and was within the tolerance allowed.

Many candidates did not realise that angle β needed to be calculated and not measured.

Candidates' values of ($\alpha + \beta$) often did not add up to 90°.

(e) The idea of experimental tolerances, and whether two measured quantities are close enough to be considered equal, was not well understood by many candidates. Generally, if the values differ by 10% or less, the expected answer is "yes, they are the same". If the values differ by more than 10% the expected answer is "no, they are different". Candidates were expected to compare the two values and state yes or no qualified by a phrase, such as "yes, they are close enough to be considered to be equal" or "no, they are too far apart to be considered to be equal".

Question 4

Most candidates obtained at least partial credit for describing how they would carry out the investigation. A common omission here was that candidates neglected to mention that the distance between the electrodes must be measured.

In descriptions of the method, a number of candidates repeated the measurements of distance and current for at least four other distances. Many answers just stated that the procedure is repeated for different distances.

Most candidates were able to state one of the required two suitable variables they would need to keep constant. Creditworthy answers were volume of electrolyte, mass of electrodes, room temperature and depth of immersion of the electrodes. Only a few candidates realised the supply voltage/potential difference needed to be kept constant. Of those candidates who realised that a constant voltage was needed, many contradicted their answer by adding that the current should also be kept constant. The whole purpose of the investigation was to investigate the effect of changing the distance between the electrodes on the current in the liquid.

The table was usually drawn correctly. Common errors were the omission of units, or the inclusion of an incorrect unit, e.g. I instead of A for current.

Many candidates drew a valid conclusion from the measurements they had described.

The most popular method was to plot a graph of distance against current and to observe the trend. Other explanations were equally acceptable, e.g. use the results table to see if changing the distance between the electrodes has any effect on the current.