

Examiners' Report

June 2023

GCSE Combined Science 1SC0 1PH

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Introduction

Questions were set to test students' knowledge, application and understanding from the six Physics topics in the Paper 5 section of Combined Science specification:

- Topic 1 – Key concepts of physics
- Topic 2 – Motion and Forces
- Topic 3 – Conservation of energy
- Topic 4 – Waves
- Topic 5 – Light and the electromagnetic spectrum
- Topic 6 – Radioactivity

It was intended that the examination paper would allow every candidate to show what they knew, understood and were able to do. Within the question paper, a variety of question types were included, such as objective questions, short answer questions worth one or two marks each and longer questions worth three or four marks each. Some questions were designed to target candidates' knowledge and understanding of practical work. This included assessing their fundamental knowledge of practicals specified in the specification, together with further application, especially where they were asked to propose improvements to a procedure. There was also one extended open response question, worth six marks.

Although the specification required candidates to recall certain equations, a full list of all relevant Physics equations was also provided in a separate booklet as an appendix to the examination paper. Therefore, the assessment of students' mathematical skills involved selection of the relevant equations and became more demanding as the paper progressed with some requiring two or more steps to arrive at a correct answer.

Successful candidates:

- were well-acquainted with the content of the specification
- had been engaged with practical work during their course
- were competent in quantitative work, especially in being able to recall and rearrange equations and use numbers in standard form
- recognised key command words such as "describe" and "explain" and constructed their responses accordingly.
- were willing to apply physics principles to the novel situations presented to them
- Less successful candidates:
- had gaps in their knowledge of the topics of this paper
- had gaps in their procedural knowledge, relating to their practical work
- failed to set out calculations in a logical way that could be easily followed by the examiner
- did not focus sufficiently on what the question was asking

This report will provide exemplification of candidates' work, together with tips and/or comments, for a selection of questions. The exemplification will come from responses which highlight successes and misconceptions, with the aim of aiding future teaching of these topics.

Question 1 (b)(i)

Candidates were required to devise an experimental procedure. Acceptable descriptions usually included timing a cupcake case as it fell through a measured distance and then repeating the measurement with a different number of cases in a stack. This would score 3 marks. Some candidates mentioned how to calculate velocity from the measurements for an additional mark. There was frequent mention of taking repeat measurements and averaging but it was often not clear whether the averaging was (correctly) for several trials with the same number of cases or (incorrectly) the average of measurements over different numbers of cases.

(i) The student also has a stop clock and a metre rule.

Describe an investigation to show how the speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack.

(4)

use your meter rule to measure the height at which you are dropping the ~~cupcake~~ cupcake cases from. Start with one case, start the timer when you drop it and stop the timer when ~~you~~ it hits the floor. (you may want to repeat this a few times and ~~avg~~ average the time to avoid human error affecting your results) repeat these steps each time adding more cases to the stack, just be sure to keep the height the same.



ResultsPlus
Examiner Comments

Very good answers such as this were often seen.

The method is clearly described. In addition, the candidate has made it clear that the same trial (i.e. keeping the number of cup cases constant) is repeated and an average time for that number of cup cases is found.

It scored the full 4 marks.



"Repeat and average" will only score a mark if it is clearly described.

Many candidates included unnecessary explanation of what the investigation might show rather than focusing on a description of the investigation.

The speed of the falling stack of cupcake cases depends on the number of cupcake cases in the stack because of the weight that the gravitational force pulls down on. Resulting in a faster ~~speed~~ speed with ~~more cu~~ with more cupcake cases. You would set up a ruler using a clamp, get a stop clock, drop the cupcake cases from the top of the ruler, and when it reaches the bottom you stop the stop clock.



The actual description does not start until the last two lines. There is no mention of how to calculate the speed of the cup cases from the measurements, nor a clear statement that the investigation should be repeated with different numbers of cup cases in the stack.

This scored 2 marks out of a possible 4.



If the question asks you to describe a procedure then make sure you focus on describing all the steps that should be followed.

Question 1 (b)(ii)

The calculation of weight was confidently and correctly completed by most candidates.

Question 1 (b)(iii)

Most candidates correctly drew an upwards pointing arrow to show the force due to air resistance.

Question 1 (b)(iv)

Better candidates recognised that at a constant velocity the acceleration is zero. A large number gave an incorrect answer of 10 m/s^2 which only applies to objects freely falling, and therefore accelerating, due to gravity.

Question 2 (a)(i)

Candidates had to substitute the given values into the equation supplied and rearrange the expression in order to calculate the height. Substitution and rearrangement could be done in either order. It was quite common to see a correct rearrangement and then values incorrectly substituted into that equation.

2 (a) Figure 4 shows a football kicked against a wall.

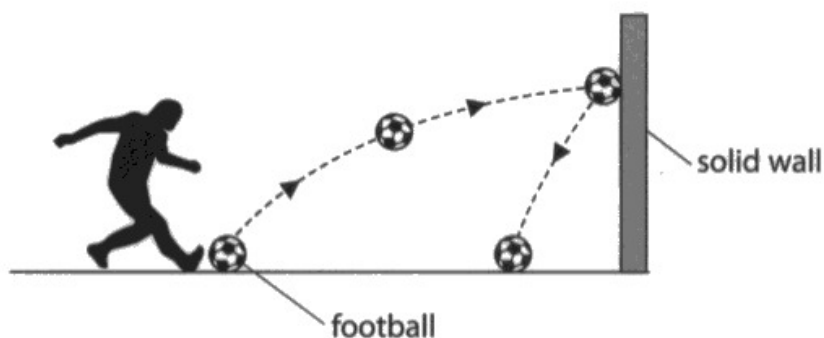


Figure 4

The football has a mass of 0.42 kg.

- (i) The football gains 11 J of gravitational potential energy as it moves from the ground to the wall.

Calculate the height at which the ball hits the wall.

(3)

Gravitational field strength = 10 N/kg

Use the equation

$$\Delta GPE = m \times g \times \Delta h$$

$$11 = 0.42 \times 10 \times \Delta h$$

$$\Delta h = \frac{0.42 \times 10}{11}$$

$$\text{height} = 0.382 \text{ m}$$



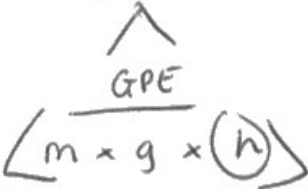
The candidate has clearly substituted the correct values into the equation given and therefore scores one mark.

The rearrangement is incorrect however and therefore the final answer is wrong.

Score 1 out of 2.



You can often score at least one mark if you show that you can substitute the correct values into an equation.



$$\Delta GPE = m \times g \times \Delta h$$
$$h = \frac{GPE}{m \times g} = \frac{10}{0.42 \times 11} = 2.1645$$
$$= 2.2$$
$$= 2$$

height = ~~2.2~~ 2 m



The candidate has rearranged the equation correctly and so scores the first mark. However the values for GPE and g have been substituted incorrectly.

Score 1 out of 2



Although a triangle may be useful way to remember how to rearrange an equation, it will not score a mark. The mark was given here for the rearranged equation underneath the triangle.

Question 2 (a)(ii)

Most candidates were able to calculate the kinetic energy using the values supplied and the equation given on the paper.

- (ii) Calculate the kinetic energy of the football when it is moving at a velocity of 12 m/s.

(2)

Use the equation

$$KE = \frac{1}{2} \times m \times v^2$$

$$\frac{1}{2} \times 0.42 \times 12^2 = 30.24$$

kinetic energy = 30.24 J



ResultsPlus
Examiner Comments

A clear and fully correct answer that scored 2 marks out of 2.

The mass of the football was given as 0.42 kg and the velocity was given as 12 m/s. Therefore the calculated value will be in joules (J).

Use the equation

$$KE = \frac{1}{2} \times \overset{\text{mass (m)}}{m} \times v^2$$

$$\frac{1}{2} \times 420 \times 12^2 = 30240$$

kinetic energy = 30240 J



ResultsPlus
Examiner Comments

There was no need to convert 0.42 kg into 420 g.

Examiners could give partial credit only.

Score 1 out of 2.



ResultsPlus
Examiner Tip

Remember that the standard unit for mass is kg. It does not need to be converted into g.

Question 2 (a)(iii)

Candidates were clearly familiar with transfers between kinetic energy and gravitational potential energy as a moving object changes its height above the ground and very many attempted to use that knowledge in this question. However, examiners were looking for energy transfers when the ball hits the wall rather than travelling to or from the wall. Acceptable responses described a (mechanical) transfer of kinetic energy to elastic potential energy or thermal energy.

(iii) Describe the energy transfers that happen when the ball hits the wall.

(2)

when the ball hits the wall, the kinetic energy will be turned into elastic potential energy and sound energy.



A short and correct answer that scored 2 out of 2 marks.

(iii) Describe the energy transfers that happen when the ball hits the wall.

(2)

when the ball hits the wall, the kinetic energy used to move it is transferred into gravitational potential energy as it falls towards the ground.



Answers such as this were very common. Although there is often a transfer between kinetic energy and gravitational potential energy when an object is moving, it will only be when the height above the ground is changing. That does not apply in this case.



Make sure you understand the situation involved in the question.

Question 2 (b)

Candidates had to first select a suitable equation from the booklet supplied. It was common to see an attempt to use distance = speed x time; presumably because both velocity and distance were mentioned in the question. They were then faced with two unknown values: distance and time. This made solution of this equation impossible from the data given. Better candidates correctly selected $v^2 - u^2 = 2ax$. Most of those went on to substitute the values for velocity given in the question but many were less certain about what to use as a value for the acceleration (a). Successful candidates either recalled that acceleration due to gravity was 10 m/s^2 or looked back to the previous part of the question where this was clearly stated. These candidates were then often able to correctly rearrange the equation and evaluate the distance.

(b) A stone is held at rest above the ground.

The stone is released and falls until its velocity is 17 m/s .

Calculate the distance the stone has fallen when its velocity has reached 17 m/s .

(2)

distance travelled = average speed x time

$dt = 17 \times \text{time}$

$= 17 \times 1$

$dt = 17$

$17 \text{ m} = 1 \text{ second}$

distance = 17 m

Handwritten notes: "Meters per second / time = ?"



ResultsPlus
Examiner Comments

The candidate has selected an equation that included (average) speed and time. However, the average speed is not the same value as the final speed and the value for time is not known.

No marks could be scored here.



ResultsPlus
Examiner Tip

There may be more than one equation that includes the quantity that you are being asked to calculate. Make sure that you select an equation where the values of all the other quantities are already known or can be calculated.

$$\begin{aligned}
 u &= 0 & a &= 10 \text{ m/s}^2 \\
 v &= 17 \text{ m/s} & v^2 - u^2 &= 2 \times a \times x \\
 17^2 - 0^2 &= 2 \times 10 \times x \\
 \frac{17^2 - 0^2}{2 \times 10} &= x \\
 x &= 14.45 \text{ m}
 \end{aligned}$$

distance = 14.45 m



ResultsPlus
Examiner Comments

A fully correct answer that scored 2 marks out of 2.

$$\begin{aligned}
 v^2 - u^2 &= 2 \times a \times x \\
 v^2 &= 17 & v^2 - u^2 &= 2 \times 17 \times x \\
 u^2 &= 0 & 289 - 0 &= 34 \times x \\
 a &= & 289 &= 34 \times x \\
 x &= ? & \div 34 & \div 34 \\
 & & 8.5 &= x
 \end{aligned}$$

distance = 8.5 m



ResultsPlus
Examiner Comments

The candidate selected the appropriate equation but substituted the value of the velocity for acceleration due to gravity instead of using the value of 10 m/s^2 given earlier.

No marks could be scored here.



ResultsPlus
Examiner Tip

The values that you need to use in an equation may sometimes be given in an earlier question.

An alternative method is to use energy transfers.

~~$KE = \frac{1}{2}mv^2$~~

$$KE = \frac{1}{2}mv^2$$

$$GPE = mgh$$

$$KE = GPE$$

$$\frac{1}{2}mv^2 = mgh$$

$$\frac{1}{2}v^2 = gh$$

$$\frac{1}{2} \times 17^2 = 10 \times h$$

$$\frac{1}{2} \times 289 = 10 \times h$$

$$144.5 = 10 \times h$$

$$14.45 = h$$

$$h = 14.45 \text{ m} \quad (2)$$

$$\text{distance} = \underline{\hspace{2cm} 14.45 \hspace{2cm}} \text{ m}$$

(Total for Question 2 = 9 marks)



ResultsPlus
Examiner Comments

The candidate has, quite correctly, reasoned that GPE lost by the stone = KE gained by the stone. Then using the equations for GPE and KE, arrived at the correct answer.

This approach was rarely seen but scored full marks.

Although this is mathematically equivalent to using $v^2 - u^2 = 2 \times a \times x$, it demonstrates an excellent understanding of the underlying principles.

Question 3 (c)

Question 3 concerned interpretation of a velocity-time graph.

In part c, the acceleration is found by calculating the gradient of the graph. Very many candidates successfully read the graph and divided 4 m/s by 1.4 s. It was common, however, to see candidates incorrectly attempting to calculate the area under the graph.

- (c) Use the graph in Figure 5 to determine the acceleration of the lift during the first 1.4s.

(3)

$$A = \frac{\text{change in velocity}}{\text{time}}$$

$$A = \frac{4}{1.4}$$

$$A = 2.86$$

acceleration = 2.86 m/s²



ResultsPlus
Examiner Comments

A fully correct answer that scored full marks.

Many candidates attempted to find the area under the graph (which gives the total distance travelled) rather than the gradient of the graph to find the acceleration.

$$1.4 \times 4 = 5.6 \div 2 = 2.8$$



base $\times$ height $\div 2$
 $\div \frac{1}{2}$

acceleration = 2.8 m/s²



ResultsPlus
Examiner Comments

The candidate has incorrectly tried to find the area under the graph.

The examiner did give partial credit however for obtaining the correct values of velocity and time.

Score 1 mark out of 3



ResultsPlus
Examiner Tip

Make sure you know how to use a velocity-time graph to find acceleration and to find distance travelled.

Question 3 (d)

The distance travelled is found by calculating the area under the graph for the first 6.0 s.

The area under the graph can be found by using the formula for the area of a trapezium. Many candidates divided up the relevant section and calculated the sum of the areas of the two triangles and the rectangle. This frequently resulted in an error in one of the calculations, although examiners would give partial credit where the working could be seen.

- (d) Use the graph in Figure 5 to determine the distance that the lift travelled during the first 6.0 s.

$$\begin{aligned} \text{Area of trapezium} &= \frac{(a+b) \times h}{2} \\ \frac{(6+3.6) \times 4}{2} &= 19.2 \end{aligned} \quad (3)$$

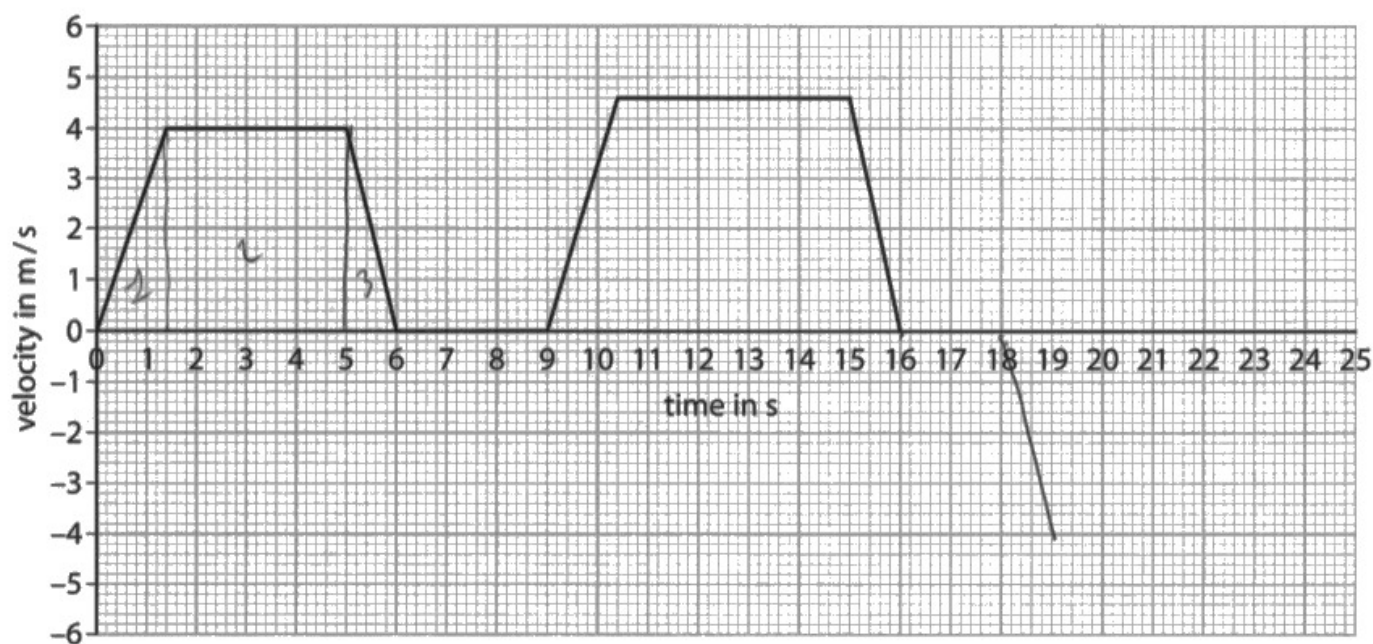
distance = 19.2 m



ResultsPlus
Examiner Comments

The candidate has used the trapezium rule to arrive at the correct answer in one mathematical step and scored full marks.

3 Figure 5 is a velocity/time graph for a lift moving upwards in a tall building.



(d) Use the graph in Figure 5 to determine the distance that the lift travelled during the first 6.0s.

$$\begin{aligned}
 \text{first triangle} &= \frac{1.4 \times 4}{2} = 2.8 & (3) \\
 \text{rect square (rectangle)} &= 3.6 \times 4 = 14.4 & 14.4 + 2.8 \\
 & & + 2 = 19.2 \\
 \text{2nd triangle} &= \frac{1 \times 4}{2} = 2 \\
 \text{distance} &= 19.2 \text{ m}
 \end{aligned}$$



ResultsPlus
Examiner Comments

Here, the area has been found by adding up the area of two triangles and the rectangle and scored full marks.

The candidate has also correctly extended the graph at 18s to score the marks for part (e).

Question 4 (a)(i)

Candidates had to first calculate the time taken for the sound to travel from L to M before using this value to find the reaction time as a percentage of the sound travel time.

A correct answer of 63% illustrates why this method is an unreliable way of measuring the speed of sound since the time recorded on the stopwatch is likely to be much less than the actual time taken for the sound to travel.

This should lead candidates to suggest that (in part ii) increasing the distance between L and M would result in a longer time for the sound to travel and therefore reaction time would be less significant.

- (i) Calculate M's reaction time as a percentage of the time sound takes to travel from L to M.

$$s = \frac{d}{t}$$

$$330 = \frac{120}{t}$$

$$330t = 120$$

$$t = \frac{120}{330}$$

$$t = 0.3636$$

$$\frac{0.23}{0.3636} \times 100 = 63.25\%$$
$$= \underline{63.3\%}$$

63.3 %



ResultsPlus
Examiner Comments

A clearly presented response that scored full marks.

Marks could still be scored if an incorrect calculation of the time taken for the sound to travel was used to find the percentage.

~~distance = velocity × time~~
~~120 = 330 × 0.23~~
~~120 = 330 × 2.75~~

$330 \div 120 = 2.75$
~~120 =~~

$\frac{0.23}{2.75} \times 100 = 8.36\%$
 8.4%
 $330 \div 120 = 2.75$

(3)

8.4 %



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Examiner Comments

The calculation of time is incorrect, but the value 2.75 s was correctly used in an attempt to find the percentage. The examiner would award two marks out of a possible 3.



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Examiner Tip

Always show your working. You may still score marks if part of your answer is wrong.

Question 4 (b)

Candidates were unlikely to have seen refraction of sound as it travels from air to water in the way shown in the diagrams. Nevertheless they should be familiar with the refraction of light diagram and be able to apply their understanding of why refraction occurs to explain both situations presented.

The most able candidates could describe how a decrease in velocity of light when it enters a more dense medium causes the ray to refract towards the normal and to reason that the velocity of sound must change in the opposite way (i.e. increase) to cause refraction in the opposite direction (away from the normal).

Many candidates unsuccessfully attempted to either apply their knowledge that the velocity of sound is less than the velocity of light or that sound waves were longitudinal and light waves were transverse. Although both are true, they do not explain refraction.

(b) Figure 7 shows the difference in refraction of sound waves and light waves when these waves travel from air into water.

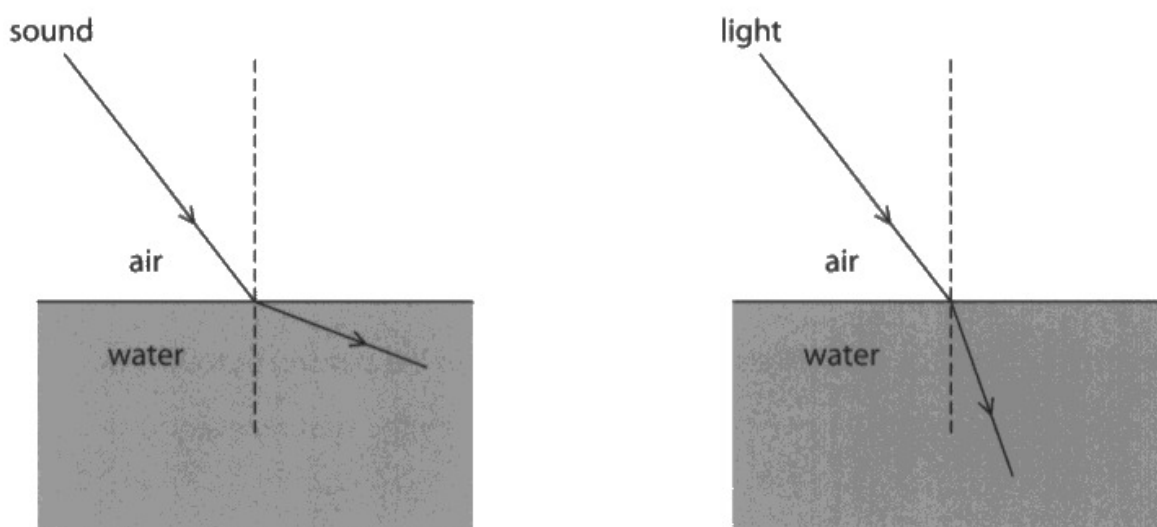


Figure 7

Explain why the refraction of the sound wave is different from the refraction of the light wave in Figure 7.

(3)

The particles in light waves are able to pass/travel through water easier and quicker which means their refraction is not too different from their normal line of travel. The particles in sound waves travel slower through water so their refraction is changed more easily through denser states.



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Examiner Comments

This response shows that the candidate knows that refraction is caused by a change in speed when a wave goes from one medium to another. This scores one mark; even though the actual change in speed is not correct.

- Sound travels faster through more dense materials and environments
- This is because sound is passed through oscillations and therefore more dense materials with more molecules would mean sound travels faster.
- Light travels fastest in vacuums. This is because it does not collide with other particles.
- However in water, light ~~collides~~ collides with many particles, therefore slowing down, towards the normal.



ResultsPlus
Examiner Comments

This response gives a good explanation in terms of sound speeding up as it enters water and light slowing down as it enters water.

Question 4 (c)

Examiners were looking for two examples of energy transfer by electromagnetic waves.

The answers did not need to be as detailed as the example given in the stem of the question but did need to refer to the effects of the wave(s).

Acceptable responses included the descriptions of uses of EM waves given in the specification.

1 Gamma - releases the highest amount of energy as it has the highest frequency and is the most ionising

2 X-ray - x-rays are used in hospitals to see inside the human body. Too much exposure to x-ray can lead to chemical reactions within the body.



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Examiner Comments

The description of the effects of X-rays is clear and scores 2 marks. Although gamma radiation is mentioned and so scores a mark, the rest of the response describes the properties of gamma radiation rather than how it is used: 3 marks total out of a possible 4.

1 Gamma rays In microwaves energy is transferred to the food causing it to heat up

2 In ultraviolet rays energy is transferred from the sun to our planet Earth



ResultsPlus
Examiner Comments

Although energy transfer by microwaves is described, the description for ultraviolet was incomplete. 3 marks scored out of 4.

1 Microwaves transfer energy from the microwave to the object (food).

2 Infrared waves transfers energy from one heat source to another object that isn't as hot, causing temperature changes.



ResultsPlus
Examiner Comments

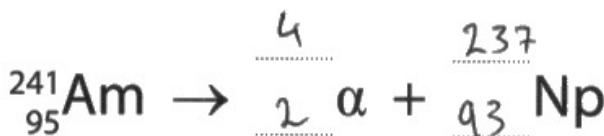
A clear description of infrared for 2 marks. Although identifying microwaves as an example of an electromagnetic wave scores a mark, the description is not sufficient to score the last mark.

Question 5 (a)(iii)

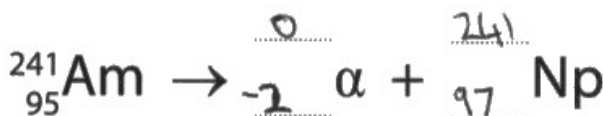
Very many candidates could correctly complete the nuclear equation. The most common error was an incorrect value(s) for the alpha particle; however credit could still be given for values for neptunium that still gave a total of 241 nucleons and 95 protons.

(iii) Complete the equation in Figure 9 for americium-241 decaying into neptunium (Np).

(3)



A clear and correct answer for all 3 marks.



Although the values for alpha are incorrect, the total for the top and bottom lines both add up to the values given for americium. 2 marks out of a possible 3.



Nuclear equations are a good way to score marks. Make sure you know how alpha and beta (both plus and minus) particles are represented.

Question 5 (b)

Very many candidates were able to deduce the activity at three different times; usually 64 Bq at 17s, 32 Bq at 34 s and 16 Bq at 51s, and then plot these accurately on the graph. The most common error was in the plotting of activity where the minor gridlines on the vertical axis were 4 Bq apart. Candidates who were unable to plot any points correctly could still gain some credit by demonstrating knowledge that activity halved every 17s.

(b) The activity of a radioactive source is measured as 128 Bq.

This is shown as a point on the graph in Figure 10.

(3)

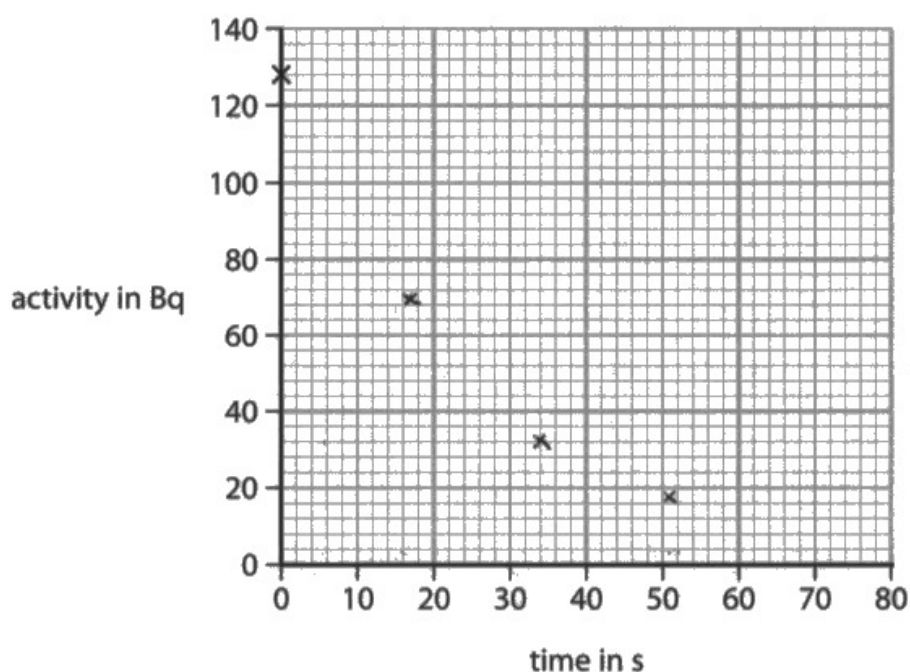


Figure 10

The half-life of this radioactive source is 17 s.

Use this information to plot three more points on the graph grid in Figure 10 to show how the activity of the source changes with time.



The points plotted at 34 s (32Bq) and 51 s (16Bq) are correct to within one small square. However the point plotted at 17 s is actually for 70Bq and not 64Bq.

This scored 2 out of 3 marks

Note that the question did not ask for a line to be drawn through the points.



Look carefully at the numbers on the axes. Make sure that you know what each small square represents. It may not always be 1, 2 or 5 units.

Question 5 (c)

There was considerable uncertainty about the process of positron emission. Very many candidates wrote about the nucleus becoming unstable when a positron is emitted.

Examiners were looking for knowledge that a proton was involved in the process, for one mark.

A second mark was awarded for a correct description of a proton decaying into a neutron. Partial credit was also given to candidates who correctly described changes in the mass number or atomic number or overall charge of the nucleus or release of gamma radiation without being able to correctly describe proton decay.

(c) Describe what happens in the nucleus of an atom when a positron is emitted.

(2)

In the nucleus of an atom, a
proton converts into a neutron,
releasing a positron.



ResultsPlus
Examiner Comments

This is a clear answer. The examiner awarded the full 2 marks.

the nucleus undergoes nuclear rearrangement with
the loss of energy as gamma radiation.



ResultsPlus
Examiner Comments

A mark could be scored by correct reference to the release of gamma radiation as given in this answer.

Question 6 (a)

The calculation of momentum was usually correctly carried out with the answer being written in the correct standard form.

Question 6 (b)

Although many candidates realised that the change in momentum was calculated from the difference of the two values given, very few appreciated that momentum is a vector quantity and therefore the momentum after the collision is a negative value with respect to the momentum before the collision. Consequently the total momentum change is the **sum** of the two magnitudes, i.e. 1.4 kg m/s rather than the difference of 0.2 kg m/s .

The calculation also required a conversion from 70ms to 0.07 s .

This question was very near the end of the paper and it was expected that the more able candidates would be those more likely to score full marks.

(b) Figure 11 shows a ball before and after it collides with a wall.

The arrows show the direction of movement of the ball.

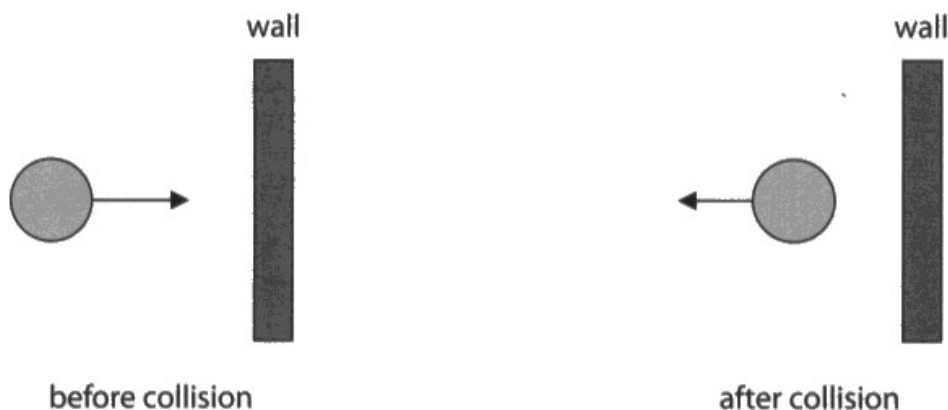


Figure 11

Before the collision, the momentum of the ball is 0.80 kg m/s .

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

The ball is in contact with the wall for a time of 70 ms during the collision.

Calculate the force exerted on the ball by the wall.

(3)

Use an equation selected from the list of equations at the end of the paper.

$$F = \left(\frac{mv - mu}{t} \right) = \frac{0.80 - -0.60}{0.07} = \frac{1.40}{0.07} = 20$$

force = 20 N



ResultsPlus
Examiner Comments

The candidate has correctly converted time from ms into s. The change in momentum has been correctly calculated by treating the "after" momentum as negative with respect to "before". The examiner awarded the full 3 marks.

(b) Figure 11 shows a ball before and after it collides with a wall.

The arrows show the direction of movement of the ball.

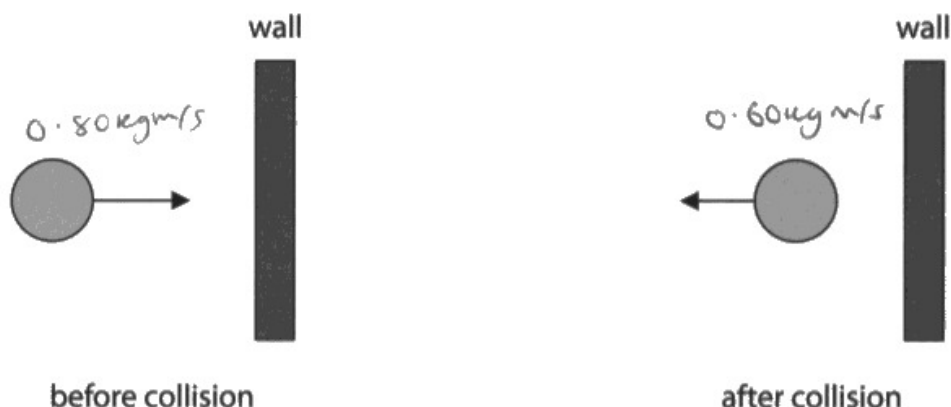


Figure 11

Before the collision, the momentum of the ball is 0.80 kg m/s.

After the collision, the momentum of the ball is 0.60 kg m/s in the opposite direction.

The ball is in contact with the wall for a time of 70 ms ^{milli seconds} during the collision.

Calculate the force exerted on the ball by the wall.

(3)

Use an equation selected from the list of equations at the end of the paper.

70 ms $\rightarrow$ s = 0.075 *momentum
force
speed*

$\text{Force} = \frac{mv - mu}{t}$

$0.80 - 0.60 = \frac{0.20}{0.07} = (\text{force}) 2.857$

force = 2.857 N



ResultsPlus
Examiner Comments

This was a creditable attempt. The time has been correctly converted from ms to s. The change in momentum has been calculated as the difference in magnitude between "before" and "after" without taking into account that momentum is vector quantity which has a direction. Although not scoring full marks, it did score 2 out of 3.

Question 6 (c)

The question asked candidates to describe a core practical and many candidates were able to do so. A good answer often included equipment added to the diagram such as light gates next to the runway and an interrupter card on the trolley. It would also show weights on a string passing over a pulley and attached to the trolley. This put the candidate well on the way to scoring several marks and indeed, Level 1 could be reached by simply stating some of these items or showing them on the diagram. To reach level 2, there needed to be some detail of the procedure. This could be, for example, how the light gate(s) are used or how the runway can be slightly sloped to compensate for friction. Level 3 answers would continue to describe at least one other procedure together with mention of some additional facts about the equipment to be used or how the results could be processed. Although some very good answers were often seen, many candidates were unclear about how the acceleration was measured; vague statements such as “use a stopwatch to find the acceleration” were common. There was also considerable uncertainty about where to place additional weights and their purpose. Lastly, it was often not clear about how a steady force can be applied and suggestions involving pulling the trolley by hand were not uncommon.

*(c) Newton's second law can be stated as

$$\text{force} = \text{mass} \times \text{acceleration}$$

A student is provided with a trolley and a runway on a bench, as shown in Figure 12, and access to other equipment.

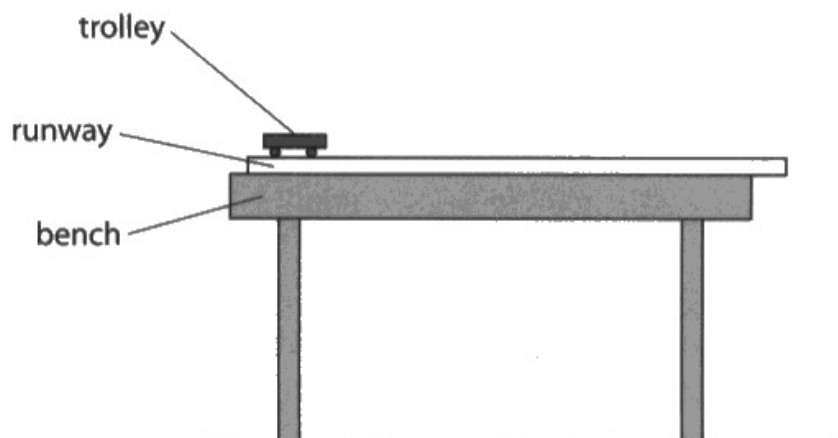


Figure 12

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

You may add to the diagram in Figure 12 to help your answer.

(6)

- Attach a string to the trolley at one end and some weights.
- Place some weights on the trolley.
- Place two light gates at a distance.
- Use a stopwatch ~~let the weights~~ to measure time.
- Use the formula $F = ma$
- Repeat the procedure.



Here the candidate has stated some of the items of equipment needed but it is not clear what the weights are for. Light gates are mentioned but not how they are to be used.

The stopwatch can measure time, but what time is being measured?

Lastly, the purpose of the experiment is to show that $F = ma$. The formula cannot be used to show that the formula is true.

This is a Level 1 response and scored 2 marks.

*(c) Newton's second law can be stated as

$$\text{force} = \text{mass} \times \text{acceleration}$$

A student is provided with a trolley and a runway on a bench, as shown in Figure 12, and access to other equipment.

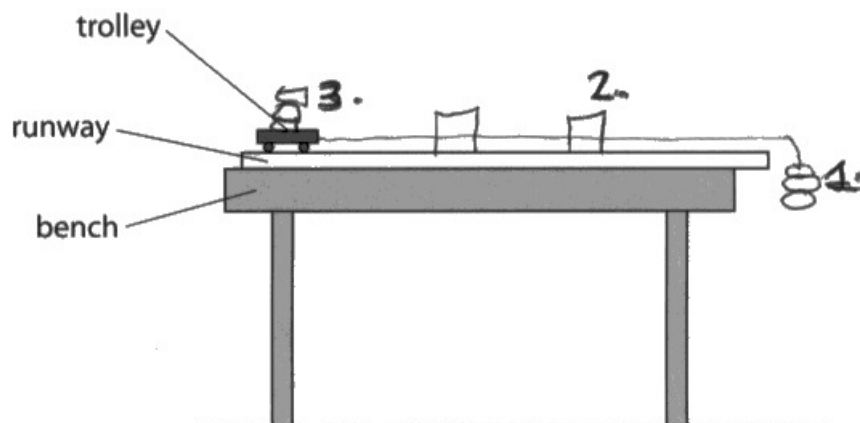


Figure 12

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

You may add to the diagram in Figure 12 to help your answer.

(6)

1. the student should first attach a weight to the end of the trolley and runway.
2. this will help measure ^{mass} ~~force~~ on the trolley.
2. the student should add light gates in the middle of the ramp. This will help them to measure the acceleration of the trolley.
3. they could also add weights to the trolley to help measure mass and force on the trolley.
4. the student can show how acceleration of trolley depends on force applied by using $\text{force} = \text{mass} \times \text{acceleration}$.

(Total for Question 6 = 12 marks)



At least three items of equipment are mentioned; weights on trolley, light gates and weight on a string. This is enough for Level 1.

There is a description of the use of the light gates to measure acceleration of the trolley. Although this is not very detailed, it is sufficient to bring the response to Level 2.

The candidate mentions adding weights to the trolley but it is not clear what happens next. If the candidate had gone on to write "and measure the acceleration again" then this would have just made it to Level 3. As it stands, however, the description would not investigate how the acceleration depends on the force applied. Although the equation $\text{force} = \text{mass} \times \text{acceleration}$ (which was given in the question) was written, you cannot "use the equation" itself to show that the equation is true.

4 marks

*(c) Newton's second law can be stated as

force = mass $\times$ acceleration

$$F = m a \quad a = \frac{F}{m}$$

A student is provided with a trolley and a runway on a bench, as shown in Figure 12, and access to other equipment.

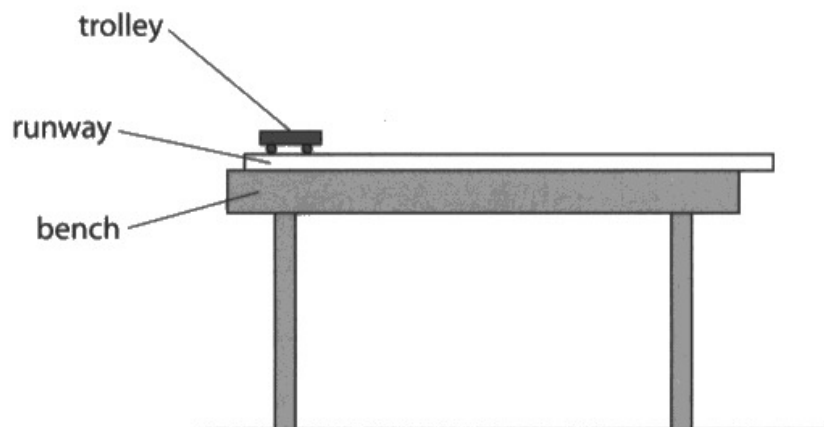


Figure 12

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

You may add to the diagram in Figure 12 to help your answer.

(6)

The student could use a string which attaches to the trolley and at the end of the string could use different weights. The heavier / the more weights there are will exert more force on the trolley as the trolley is being pulled by these weights. The students can use a series of different weights and use light gates between the start and end of the runway to calculate the trolley velocity between the two points. They can then use the formula $a = \frac{(V - U)}{t}$ to calculate the acceleration and how much it is affected by the different forces. The student can also calculate acceleration in this experiment by rearranging Newton second law of $F = ma$ to equal acceleration by dividing the force applied by the weights by the mass of the trolley.



A very good answer. Although the candidate did not add to the diagram, the description makes it clear what equipment is being used and the purpose of the weights and the light gates. The description of how to determine acceleration is very clear. In addition it describes how the force can be varied by using different weights. The examiner awarded the full 6 marks.

An answer did not have to be long to reach Level 3.

*(c) Newton's second law can be stated as

$$\text{force} = \text{mass} \times \text{acceleration}$$

A student is provided with a trolley and a runway on a bench, as shown in Figure 12, and access to other equipment.

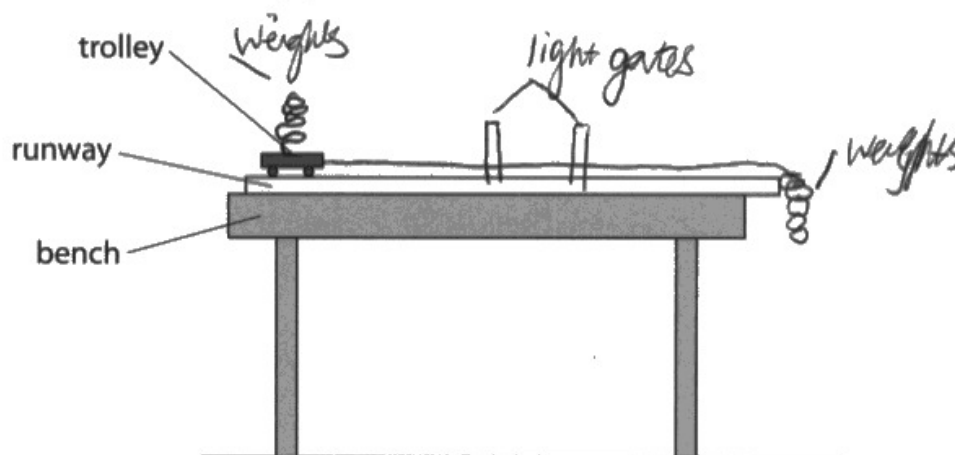


Figure 12

Describe a procedure the student could use to investigate how the acceleration of the trolley depends on the force applied to the trolley.

You may add to the diagram in Figure 12 to help your answer.

(6)

The student could undertake an experiment in which an increasing number of weights are added to the trolley, some on the trolley itself, some at the end of a string. The weights at the end of the string, hanging off the table will use their GPE to apply force to the trolley, pulling it through the light gates. The light gates, which, will be placed in the same location in each subsequent experiment can measure the speed, and thus, acceleration, helping the student investigate how force, mass and acceleration are linked.



The diagram shows the equipment needed and this reaches Level 1 straight away.

The candidate then describes how the weights apply a force and how this force can be changed. This description of a procedure brings the answer to level 2.

There is a short description of how the light gates are used to determine the acceleration. This brings the answer to Level 3.

Paper Summary

Overall this exam gave ample opportunity for candidates to display their knowledge and understanding at grades 4-9. Candidates have continued to do well with most calculation questions, although many didn't cope well with the units involved, which included the prefixes kilo, and Mega. The standard of answers on practical questions was variable with some candidates showing good procedural knowledge, whilst for others there was a clear lack of familiarity shown, especially in question 6c which concerned the core practical investigating the acceleration of a trolley. Based on their performance on this paper, candidates should make the most of opportunities afforded in school laboratories where they can become acquainted with practical work from the specification. This concerns both core practicals and the suggested practicals. It would benefit candidates to always question 'What is the purpose of this experiment?' making sure they are clear in their minds about it.

Based on their performance on this paper, candidates are offered the following advice:

- make sure that they have a sound knowledge of the fundamental ideas in all the topics
- get used to the idea of applying their knowledge to new situations by attempting questions in support materials or previous examination papers
- when describing a practical procedure, make sure they are clear about what is to be measured and how the measurements will be taken.
- when suggesting improvements or extensions to a practical procedure, make sure they are relevant to the context of the question and not just 'repeat readings'.
- where a question involves a calculation, make sure they understand the physics of the situation before recalling or selecting an equation to use calculation.
- make sure that they recognise SI prefixes such as m and k and M and how to handle these in calculations.
- use the marks at the side of a question as a guide to the form and content of their answer.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

<https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html>

