Questions matter

GCSE

Combined Science: Trilogy

8464/P/2H Combined Science: Trilogy Physics Paper 2H

Report on the exam

Published: August 2025

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Overview

This paper is one of the six examined components for Combined Science: Trilogy. All of these papers follow a similar structure and test the same assessment objectives.

This paper has 70 marks available to students and is made up of six questions.

- Approximately 40% of marks assess AO1; 40% of marks assess AO2; and 20% of marks assess AO3.
- Approximately 40% of marks target Standard demand, 40% of marks target Standard/high demand and 20% of marks target High demand.

Questions 1 and 2 on this paper and questions 6 and 7 on the Foundation Tier paper are common. These questions are identical and are targeted at standard demand.

Questions are set at three levels of demand for this paper:

- **Standard demand** questions are designed to broadly target grades 4–5.
- **Standard/high demand** questions are designed to broadly target grades 6–7.
- **High demand** questions are designed to broadly target grades 8–9.

A student's final grade is based on their attainment across all six papers.

Summary of overall performance

Students were provided with a Physics Equations Sheet that included all equations needed. This considerably eased the demand of some calculation questions, although some of these did still cause problems. A large proportion of students did not appear to understand how deceleration is linked with acceleration in question **02.1**, for example, and only a small proportion were able to do appropriate unit conversions in calculations where these were needed.

When explaining why light refracts in question **03.5**, there were many students who referred to density or optical density. It may be that students are using large language A.I. models to help with their revision, and the term 'optical density' cropped up there. Certainly, when an A.I. model is asked to explain refraction, the reply referred to the density of materials. The use of these models to aid revision is largely very helpful, but it may be worth teachers being aware of common misconceptions that these models can propagate. Optical density is not a term used in the specification, and references to density or optical density were ignored.

Many of the topics covered by this paper are conceptually very demanding, and many students struggled with questions that required explanations. Even on question **02.2**, a common question with the Foundation tier, and set at standard demand, students had a tendency to use appropriate terminology, with many not even referring to thinking distance or stopping distance as directed in the question, and instead using terms that are perhaps more colloquial language such as 'braking faster' which did not gain credit.

Overall, students found this paper to be accessible, with the vast majority attempting to answer all questions.

Question 1 (Standard demand)

01.1 Almost all students selected the correct equation.

01.2 Almost all students were able to calculate the answer using the relevant equation. Of those who did not, it was surprisingly common to see answers where the student had attempted to round their answer to two significant figures and decided that 2.23 should be rounded to 2.3. This led to an incorrect final answer.

0 1 . 2 The longest dog-sled race in the world covers a distance of 1 500 000 m.

One team finished the race in a time of 670 000 s.

Calculate the average speed of this team during the race.

[3 marks]

speed = distance ÷ time

= 1500000 ÷ 670000

= 2.23880597

= 2.34

Average speed = 2.34 m/s

This student's response shows incorrect rounding after calculating their answer. A small but significant proportion of students made errors such as this.

If this student had left their answer as 2.23880597 they would have scored all three marks, but the incorrect rounding meant that their final answer was incorrect and so only two marks were awarded.

01.3 Slightly more than 60% of students answered this question correctly, with another fifth scoring 1 mark. The instruction to 'Calculate the resultant force…' had many students attempting to use $F = ma$ which was not possible given the information provided. Some students drew sketch diagrams to help them answer, which tended to lead them along the right lines.

0 1 . 3 At the start of the race, 6 dogs pulled on the rope.

The average forward force on the sled from **each** dog was 370 N.

The backwards force on the sled from friction was 520 N.

Calculate the resultant force on the sled.

[2 marks]

resultant force = mass x acceleration

= (370 x 6) x -520

2220 x -520 = -1,154,400

Resultant force = -1,154,400 N

0 1 . 3 At the start of the race, 6 dogs pulled on the rope.

The average forward force on the sled from **each** dog was 370 N.

The backwards force on the sled from friction was 520 N.

Calculate the resultant force on the sled.

[2 marks]

520 ← ▭ → (370x6) = 2220

2220 - 520 = 1700

Resultant force = 1700 N

Two different approaches to answering the question.
The first response above tried to use Newton's second law which was incorrect physics and gained no credit.
The second response illustrates how useful a diagram can be in some situations.
This student arrived at the correct answer using correct physics and scored both marks.

01.4 Fewer than half the students were able to recall that the gradient of a distance-time graph represents speed. Many responses gave descriptions of the distance increasing with time, or the steepness of the line. A description of the trend shown in the graph is not the same as what the gradient represents, so these answers did not gain any credit. Other common incorrect answers included suggestions that the gradient shows the average speed of the sled.

01.5 Just under three quarters recalled that at a constant speed the resultant force is zero and therefore selected the correct option.

01.6 Only about four in ten students were able to identify the Newton's third law pair to the force of the rope on the sled.

Question 2 (Standard demand)

02.1 Slightly more than half the students answered this question correctly, with the vast majority of those who managed a correct substitution going on to score all 3 marks.

There seemed to be a lack of understanding from some students that deceleration and acceleration are effectively referring to the same quantity. This led to many students correctly selecting the equation $v^2 - u^2 = 2as$ to calculate a deceleration but thinking that they needed to calculate an acceleration using $a = \frac{\Delta v}{t}$ before substituting into that equation. This approach tended to lead to a mark of zero, because the substitution into $v^2 - u^2 = 2as$ was not correct.

0 2 . 1 The driver applies the brakes when the car is 24 m away from the roadworks.

The velocity of the car changes from 18 m/s to 0 m/s.

Calculate the constant deceleration needed to stop the car in a distance of 24 m.

Use the Physics Equations Sheet.

[3 marks]

(final velocity)^2 − (initial velocity)^2 = 2 × acceleration × distance

time = $\frac{\text{distance}}{\text{speed}}$

$(0)^2 - (18)^2 = 2 \times 13.8461 \times 24$

time = $\frac{24}{18} = \frac{4}{3} = 1.3$

$= 664.6128$

$\sqrt{664.6128} = 25.78$

Deceleration = 25.78 m/s^2

acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$

acceleration = $\frac{18}{1.3} = 13.8461$

On the left side of this student's response, they have used incorrect physics to calculate an acceleration of 13.8 m/s^2.

The student then substituted this value into $v^2 - u^2 = 2as$, along with the other values given in the question and then tried to work out the deceleration from this. This substitution is based on incorrect physics, so no marks could be awarded.

02.2 Only a small proportion of students managed to give a Level 3 response, with slightly more than a third of students giving answers above Level 1.

When discussing the conditions of the tyres, some students mentioned that slick tyres have more friction, whereas some described worn tyres as having less friction with the road. The level of physics knowledge expected of the students did not go to this level, so if students linked the idea of friction (either increasing or decreasing) with the condition of the tyres, they gained credit.

Part of the issue was with students describing the situation using more colloquial terms. Mentions of good or bad braking distance were insufficient to gain credit, because it was not clear whether students thought that a greater braking distance was better or worse. It was also common to see students describing braking time instead of braking distance, or using expressions such as ‘slows down faster’, neither of which were sufficient.

Some students expressed the misconception that at lower speeds, drivers had more time to react so the thinking distance would increase. The thinking distance is the distance travelled as the driver is reacting, and driver reaction time is not affected by speed.

A significant minority of students argued that a lower speed limit is more dangerous, giving reasons such as:

- driving at a lower speed can lead to drivers in the car behind becoming impatient
- driving at lower speeds means cars can be closer together
- driving at lower speeds means there are more cars on the road at any given time.

It was relatively common for students to list as many factors as they could which would affect the braking distance or thinking distance.

Students who referred to any of these ideas could still go on to score marks.

0 2 . 2 As a safety measure, the speed limit on the road was reduced.

Explain how the safety of road users is affected by:

- the condition of the brakes and tyres
- reduced speed.

You should refer to thinking distance and braking distance.

[6 marks]

Thinking distance is the distance travelled in the time taken for someone to react to a hazard and braking distance is the distance travelled after the brakes are pushed. If brake pads are worn, braking distance will increase, howeve it would not affect thinking distance. ~~as~~ Similarly to worn tyres. If the tread is not ~~thick~~ deep enough the braking distance increases. Reduced speed affects both thinking and braking distance as if you react at the same time going 40mph or 10mph you would've travelled further going 40mph in the same amount of time. Also braking distance ~~increases~~ decreases ~~also as it takes lon~~ with reduced speed as it

Extra space takes less time (therefore distance) to reduce speed at a lower starting speed than a higher one.

This student gave a strong Level 2 response, but gave no reference to safety which prevented them from accessing Level 3.

02.3 About two thirds were able to score some credit on this question.

Many had the idea of braking causing heating, but this was given in the question, so students needed to give more detail. The answer needed to be comparative, with a faster car having greater kinetic energy, or needing more friction.

Some students described the brakes ‘working harder’ which was taken as a description of the effort put into braking, rather than using the physics terminology of doing more work. A fair number of students included incorrect descriptions such as ‘friction becomes thermal energy’ or ‘heat is produced’, and some included statements that were insufficient, such as ‘more energy is needed to stop the car’.

Less than half referred to the increased risk at a greater speed, with students far more likely to just state that braking from a greater speed will cause the brakes to overheat, which was not enough to gain the third marking point.

Question 3 (Standard, standard/high and high demand)

03.1 About a quarter of students were able to give a complete and correct definition of a transverse wave, with just under a fifth giving a definition that gained partial credit.

03.2 Nearly two thirds were able to give another risk caused by exposure to ultraviolet.

03.3 Just over 60% identified that ultraviolet has a shorter wavelength than visible light.

03.4 Giving an answer in nm proved to be very challenging, with just under 10% managing to work out the correct final answer.

A surprisingly large proportion of students struggled to calculate the correct power of ten to their answer, with working such as $\frac{3\times10^{8}\ \mathrm{m/s}}{6.25\times10^{14}\ \mathrm{Hz}} = 4.8\times10^{21}\ \mathrm{m}$ being relatively common. Students who did this could then go on to convert their calculated value into nm and gain the final mark, but it was very common for students to multiply their answer by 10^{-9} instead of dividing by 10^{-9}, so the final mark was not often gained. Many students who attempted the conversion to nm thought that nano referred to 10^{-3} or 10^{-6}.

0 3 . 4 A wave of visible light has a frequency of 6.25×10^{14} Hz.

speed of light = 3.00×10^{8} m/s

Calculate the wavelength of this light.

Use the Physics Equations Sheet.

Give your answer in nanometres (nm).

[4 marks]

wave speed = frequency × wavelength.

wave speed / frequency = wavelength.

$3.00\times10^{8} / 6.25\times10^{14} = 4.8\times10^{21}$ m

$4.8\times10^{21} / 1000 = 4.8\times10^{18}$ nm

Wavelength = 4.8×10^{18} nm

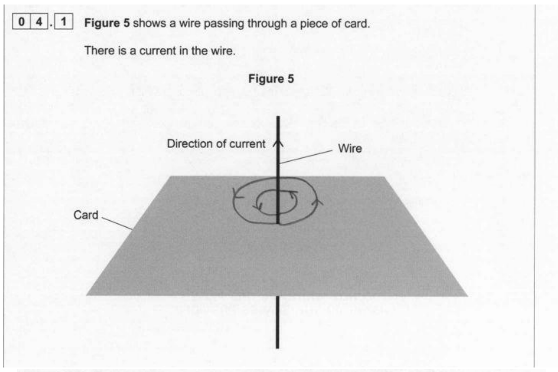
This student correctly substituted into and rearranged the equation but made errors when calculating the wavelength in metres. This answer also illustrates the difficulties many students had in converting a value from metres to nanometres.

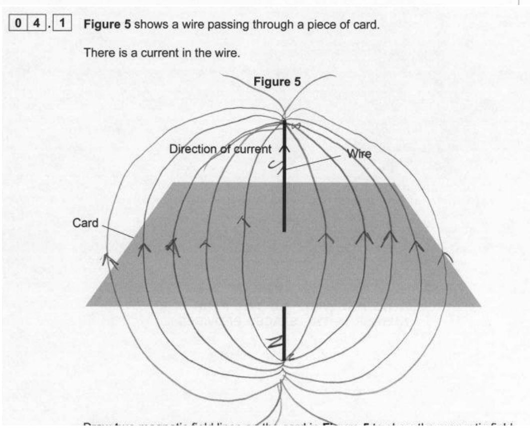
03.5 Students struggled to explain why refraction occurs using the idea of wavefronts. It was very common for students to refer to the density of the glass, and sometimes to optical density. All of these references were ignored. Some students recalled that the wave speed changes but did not make it clear whether they thought the waves were increasing or decreasing in speed, so did not score any marks. Only about a fifth of students gained any credit in this question.

03.6 About four in ten students gained at least one mark, with approximately 20% giving a fully correct answer. The refracted rays drawn were in many different directions, but those who were able to draw the ray in the correct direction usually did so with accuracy and gained the second mark, and those that did not score the second mark tended to draw their refracted rays in completely the wrong direction. Some students gained the mark for drawing the refracted ray without having drawn a normal.

Question 4 (Standard, standard/high and high demand)

04.1 Surprisingly few students were able to draw the magnetic field pattern around a current-carrying wire, with only about 40% of students scoring any marks, and only about half of these gaining both marks. The marks were independent, and some students gained credit for giving the correct direction of the magnetic field without drawing 2 concentric rings. Students needed to draw both rings on the card, so that the bottom of each ring was between the lower edge of the drawing of the card and the point in the centre of the card where the wire emerged. Some students drew rings around the very top of the wire and the very bottom of the wire, which did not gain any credit. Common incorrect answers included drawing field lines connecting the wire below the card to the wire above the card, and drawing the field pattern for a bar magnet, with the top of the wire representing a north pole and the bottom of the wire representing a south pole.





Neither of these responses gained any credit. The top response shows a circular field pattern on the card behind the wire, with the field pointing to the right immediately behind the wire, which is incorrect.
The second response suggests that this student knows the field pattern for a bar magnet but is unfamiliar with the field pattern around a current-carrying wire.

04.2 Very few students were able to recall the unit of magnetic flux density. Many used the equation $F = BIl$ to derive an equivalent unit in terms of newtons, metres and amps, but this was insufficient for the mark. It was relatively common for students to either make no attempt to convert mN to N, or to convert incorrectly. Almost 90% gained some credit on this question, with over 80% gaining at least 3 marks.

04.3 Students found it very difficult to explain how the loop begins to rotate. There were many misconceptions communicated, as well as many students who included in their answers explanations of why the loop continued to rotate once the plane of the coil became vertical. References to the commutator were ignored, as the question only asked for an explanation of why the rotation begins.

Misconceptions included ideas that:

- current is attracted or repelled by the north or south pole
- the current is in the axle
- the axle becomes a magnet
- side A has more current than side B, because the current comes from the positive side of the battery and reaches side A first
- side A is positively charged, and positive charge is attracted to the north pole of the magnet, and negative is repelled by the south pole
- the wires become induced magnets.

About a third of students managed to gain some credit on this question, but it was rare to see a full explanation given.

When the switch is closed, magnetic forces on the loop make the loop begin to rotate.

Explain how.

You should refer to side **A** and side **B** of the loop of wire in **Figure 6**.

[5 marks]

When the switch is closed, a magnetic field is made around the wire carrying a current and it would be in the magnetic field of magnets which would create a force. Side A would experience a downward force while side B would experience an upward force as ~~they are~~ the current runs the opposite direction. ~~then~~ The split ring commutator spins around and is split so that the positive charge always flows in the same direction. This ~~then~~ causes

Extra space the loop to ~~spin~~ rotate on the axle as the force is being generated in the same direction each time – this is called the motor effect. This ensures the circuit is closed and that the motor keeps rotating in the one direction.

This answer gives a very clear explanation and gained all 5 marks.

Question 5 (Standard, standard/high and high demand)

05.1 Only about 15% of students were able to correctly identify the random error in the results. This perhaps illustrates a misconception that many students perceive that digital devices give a definitive value for what they are measuring, and therefore cannot possibly show random errors.

05.2 This question was not well answered, with fewer that one in five students gaining any credit. Many students correctly calculated that the sum or mean of the numbers is zero, but this gained no credit. It was also common to see students calculate the size of the range, but to state that this was equal to the uncertainty, so gained no marks.

> **0 5 . 2** Determine the uncertainty in the measurements. **[2 marks]**
>
> −0.5 −> 0.5 = 1
>
> Uncertainty = ± 1 °C

> **0 5 . 2** Determine the uncertainty in the measurements. **[2 marks]**
>
> range = −0.5 to ·5 = 1 °C
>
> Uncertainty = ± 1 °C

By giving an answer of 1 on the answer line, the top answer above shows that the student thinks that the uncertainty is 1 and does not identify that the value determined is the range. This response scored no marks.
The second answer clearly demonstrates that the student knows that the range is 1°C, and so scored the first mark, but did not then halve this value to determine the uncertainty.

05.3 Almost all students gained at least 3 marks, but the line of best fit, ignoring the anomaly, proved to be challenging to many. Approximately 40% gained full marks for plotting this graph.

05.4 Nearly two thirds of students gained full marks, with many others gaining some credit. Some of those arriving at an incorrect answer appeared to be using strange numbers – perhaps they had read values from their line of best fit describing the white cube, rather than using the values for the black cube given in the question. These students could still score one mark for converting 2 minutes into seconds.

05.5 About a third scored two marks, most commonly for identifying that black surfaces are good absorbers of infrared while white surfaces are not. Explaining the idea of a thermal equilibrium in terms of absorbing and emitting infrared radiation at the same rate was a far more challenging idea, and very few students were able to express this with sufficient detail.

It was relatively common for students to express that the cubes were absorbing heat, but this was not given any credit. Heat was taken to be a reference to the internal energy of the cubes, but answers should have been referring to the cube absorbing and emitting infrared radiation, which would then affect the internal energy of the cube.

When attempting to explain why the black cube initially increased in temperature at a greater rate, common misconceptions shown in answers included the idea that white surfaces are the best emitters and, less commonly, that black surfaces attract heat. Some stated that black surfaces conduct heat better or are better at absorbing temperature. It was also quite common for students to write about Leslie's cube.

When attempting to explain why both cubes stopped changing temperatures, it was common for students to think that the cubes had reached room temperature, or to illustrate another misconception that the cubes had reached their specific heat capacity and so could not get any hotter.

0 5 . 5 The student made two observations:

1. The rate of change of temperature was initially greater for the black cube than for the white cube.
2. After a few minutes, both cubes stopped changing temperature.

Explain the student's observations.

You should refer to the absorption and emission of radiation from the surfaces of the cubes.

[4 marks]

Matte black surface of the cube is a better absorber and emitter of IR radiation, than white or shiny surfaces. It's because if to fill Leslie cube with hot water from freshly-boiled kettle and use IR detector/ thermometer at fixed distance from each surface - black ~~cub~~ side will emit more IR radiation. Both cubes stopped changing

Extra space temperature, because they emitted all IR radiation. Hotter objects emit more IR radiation too.

outside the box

14

Despite giving an answer about Leslie's cube, this answer explains why the black cube increased in temperature at a greater rate than the white cube and goes on to state that hotter objects emit more infrared (IR) than cooler objects, gaining 3 marks in total.

Question 6 (Standard, standard/high and high demand)

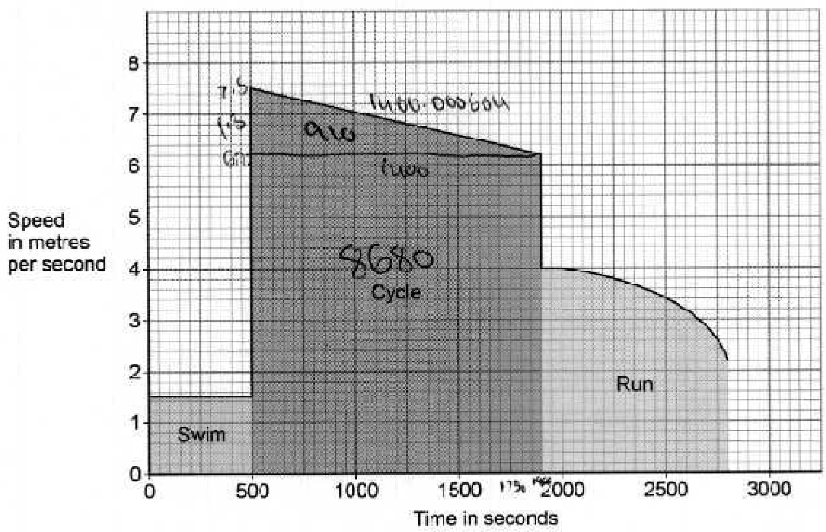
06.1 Less than half of the students correctly identified that the swimming speed of the triathlete was equal to a typical walking speed.

06.2 There were several different approaches that students could take to determine the distance moved by the bicycle. Most students struggled to do this correctly but did demonstrate that they were attempting to determine an appropriate distance and so went on score the last three marks.

Common errors, no matter which approach was taken, included misreading the initial or final values of the speed of the cycling section, or using a time of 1900 s instead of 1400 s.

Figure 8 shows a speed–time graph for the athlete for the whole triathlon.

Figure 8



Annotations to the graph were common and could gain credit.
This student went on to score all 6 marks, using the area under the graph to determine the distance moved by the cyclist before using the equation for work done by a force.

06.3 About a quarter of students gained at least one mark, usually for identifying that the speed of the runner was constant. It was very common for students to state that the velocity was constant, which prevented them from scoring the first mark. Only a small proportion scored both marks. Some students did not read the question correctly and described how the speed changed during the entire 'run' section of the graph.

0 6 . 3 The first part of the **run** was on a circular track.

The time taken for the athlete to run round the track was 100 s.

Describe the velocity of the athlete during the first 100 s of the **run**.

Use **Figure 8**.

[2 marks]

Velocity is a vector quantity, the run was on a circular track, therefore the direction keep changing which mean the velocity will keep changing.

This answer scored the second mark, for identifying that direction constantly changes when moving in a circle.

0 6 . 3 The first part of the **run** was on a circular track.

The time taken for the athlete to run round the track was 100 s.

Describe the velocity of the athlete during the first 100 s of the **run**.

Use **Figure 8**.

[2 marks]

~~decelerating~~ running at a constant speed of 4 m/s but at changing directions (in a circular track)

This student clearly understands how velocity changes when moving at a constant speed on a circular path and gained both marks.

06.4 Just over 10% of students gained at least one mark, with very few giving a full explanation and scoring both marks. It was quite common for students to suggest reasons why the athlete slowed down, with statements such as the runner becoming tired. Those who did try to explain using the graph often did not use precise enough language and did not refer to the gradient of the graph. Descriptions of the trend shown in the graph, such as 'it is a downwards curved line' or 'slowed down as time increased' did not answer the question but did not prevent marks from being scored.

0 6 . 4 After running round the track once, the rest of the run was on a straight, horizontal road.

Explain how **Figure 8** shows that the magnitude of the deceleration of the athlete increased.

[2 marks]

Shows the athlete began to decrease in speed as the athlete became more tired towards the end of the run.

The above example is an answer suggesting why the speed may have decreased, but not explaining how the graph shows the acceleration, or how the graph shows that the deceleration increased.

0 6 . 4 After running round the track once, the rest of the run was on a straight, horizontal road.

Explain how **Figure 8** shows that the magnitude of the deceleration of the athlete increased.

[2 marks]

the gradient represent acceleration or deceleration, it is getting steeper toward 0, so deceleration increased

The second example is from a student who scored both marks, clearly using the graph to explain how the deceleration changed.

Contact us

Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

Tel: 01483 477756
Email: gcsescience@aqa.org.uk

aqa.org.uk