AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.5.4.3.2

Reaction time

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**5**
Available paper years	**2018–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

6.5.4.3.2 Reaction time

Answer 01 · Mark scheme June 2018 | 8464/P/2H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	either: 7.5 (m) **and** 12.3 (m) from the graph **or** 15 (m/s) × 0.32 (s) using speed extra distance = 4.8 (m)	an answer between 4.7 (m) and 4.9 (m) scores **2** marks allow 7.5 (m) and between 12.2 (m) and 12.4 (m)	1 1	AO2 6.5.4.3
06.2	there is a decrease in kinetic energy of the car so this (causes) the internal / thermal energy store of the brakes to increase	allow work is done by friction (on the brakes)	1 1	AO1 6.1.1.1 6.5.4.3.4
06.3	$19^2 - u^2 = 2 \times 2 \times 84$ $u^2 = 19^2 - (2 \times 2 \times 84)$ u = 5 (m/s)	an answer of 5 (m/s) scores **3** marks $u = \sqrt{19^2 - (2 \times 2 \times 84)}$	1 1 1	AO2 6.5.4.1.5

6.5.4.3.2 Reaction time

Answer 01 · Mark scheme

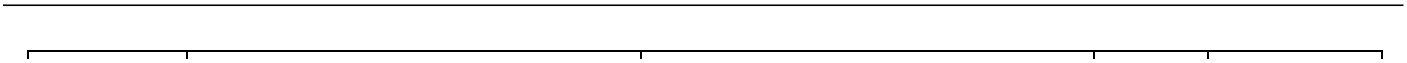
June 2018 | 8464/P/2H | Original Q6

Question	Answers	Mark	AO / Spec. Ref.
06.4	**Level 3:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	5–6	AO3
	Level 2: Scientifically relevant facts, events or processes are identified and their relevance is clear. The account is not fully accurate.	3-4	AO1 AO3
	Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.	1–2	AO1
	No relevant content	0	
	Indicative content • use of drugs, alcohol, tiredness and distractions would increase the thinking distance • thinking distance increases with speed • thinking distance is directly proportional to speed • use of drugs, alcohol, tiredness and distractions would increase the gradient of thinking distance • poor brakes, poor tyres, wet / icy roads and mass would increase the braking distance • braking distance increases with speed • braking distance increases at an increasing (accept greater) rate (with speed) • poor brakes, poor tyres, wet/icy roads and mass would increase the gradient of braking distance • braking distance is directly proportional to speed squared • stopping distance = thinking distance + braking distance • factors that increase thinking and / or braking distance would increase the gradient of stopping distance • stopping distance increases at an increasing (accept greater) rate (with speed)		6.5.4.3.1
Total			**13**

6.5.4.3.2 Reaction time

Answer 01 · Mark scheme

June 2018 | 8464/P/2H | Original Q6



6.5.4.3.2 Reaction time

Answer 02 · Mark scheme

June 2022 | 8464/P/2H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	$21 = 30 \times t$ $t = \frac{21}{30}$ $t = 0.7$ (s)	allow use of any correct pair of values from the graph allow 0.70 (s)	1 1 1	AO2 6.5.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	one square represents 5 (m) number of squares = 9 braking distance = 9 × 5 = 45 (m)	 allow number of squares in the range 8.5 to 10 allow an answer in the range 42.5 (m) to 50 (m)	1 1 1	AO2 6.5.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	gradient is equal to acceleration gradient / acceleration is not constant so resultant force is not constant because resultant force is directly proportional to acceleration (for constant mass)	 allow resultant force is not constant because F = ma	1 1 1	AO1 AO3 AO3 6.5.4.2.2

Total Question 6		9

6.5.4.3.2 Reaction time

Answer 03 · Mark scheme

June 2023 | 8464/P/2H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	$a = \frac{26 - 0}{5.25 - 2.0}$	allow any pair of correct points substituted allow ± half a small square for reading of time	1	AO2 6.5.4.1.5
	$a = 8$	allow 8.0 allow a correct calculation using their acceptable values from the graph ignore any minus sign	1	
	m/s^2		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2		allow ecf for acceleration and initial velocity from question **07.1**		
	thinking distance			
	$s = 26 \times 0.75$	to award MP1 and MP2 a time of 0.75 must have been used	1	AO3
	$s = 19.5$ (m)		1	AO2
	braking distance			
	$s = \frac{(5.25 - 2.0) \times 26}{2}$ **or** $s = \frac{26^2 - 0^2}{2 \times 8.0}$	allow a range of 5.2 to 5.3 for final time	1	AO3
	$s = 42.25$ (m)		1	AO2
		marks for thinking distance and braking distance may be awarded independently		
	stopping distance			
	$s = 19.5 + 42.25 = 61.75$ (m)	for this mark to be awarded both the thinking distance and braking distance must have been calculated using correct equations allow an answer correctly rounded to 2 or 3 sig figs	1	AO2 6.5.4.1.5

6.5.4.3.2 Reaction time

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	the brakes can overheat (so) the brakes will not work properly **OR** can lead to loss of control (1) (because) the tyres lose traction / grip (1) **OR** the greater the deceleration the greater the force (1) (and) large forces can cause injury (1)	 dependent on MP1 allow the car may skid dependent on MP1 dependent on MP1 ignore accidents and crashes throughout	1 1	AO1 6.5.4.3.4

Total Question 7	10

6.5.4.3.2 Reaction time

Answer 04 · Mark scheme

June 2024 | 8464/P/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	$5.8 = \frac{\Delta v}{2.5}$ $\Delta v = 5.8 \times 2.5$ $\Delta v = 14.5$ $v = (20 - 14.5) = 5.5$ (m/s)	 allow use of an incorrectly calculated Δv if the correct equation has been used	1 1 1 1	AO2 6.5.4.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	multiply the speed of the car by the reaction time		1	AO3 6.5.4.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	braking distance $\propto$ speed^2		1	AO3 6.5.4.3.4

6.5.4.3.2 Reaction time

Answer 04 · Mark scheme

June 2024 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	6250 = m × 5.0		1	AO2 6.5.4.2.2
	$m = \frac{6250}{5.0}$		1	6.5.5.1
	m = 1250 (kg)		1	
	v = 12 (m/s)		1	
	p = 1250 × 12	allow a substitution using a value of v in the range 11.8 to 12.2 allow a correct substitution using their incorrectly calculated value for m using the correct equation	1	
	p = 15 000 (kgm/s)	allow a calculation using a value of v in the range 11.8 to 12.2 allow a correct calculation using their incorrectly calculated value for m using the correct equation	1	

Total Question 5	12

6.5.4.3.2 Reaction time

Answer 05 · Mark scheme

June 2025 | 8464/P/2H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	$(0^2-)\ 18^2 = 2 \times a \times 24$	allow $18^2 = 2 \times a \times 24$	1	AO2 6.5.4.1.5
	$a = \dfrac{(-)18^2}{2 \times 24}$		1	
	$a = (-)\ 6.75\ (m/s^2)$	allow $(-)\ 6.8\ (m/s^2)$	1	

6.5.4.3.2 Reaction time

Question	Answers	Mark	AO / Spec. Ref.
02.2	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO2
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO1
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1
	No relevant content	0	6.5.4.2.2 6.5.4.3.1 6.5.4.3.3 6.5.4.3.4
	Indicative Content **Thinking distance** • condition of brakes and tyres does not affect thinking distance • speed does not affect thinking / reaction time • decreased speed decreases thinking distance **Braking distance** • condition of tyres affects friction between tyres and road • poor condition of tyres and brakes increases braking distance • decreased speed decreases braking distance **safety** • stopping distance = thinking distance + braking distance • poor condition of brakes and tyres increases stopping distance • decreased speed decreases stopping distance • decreased speed decreases the chance of the driver losing control of the vehicle • decreased speed decreases the chance of a collision • decreased speed decreases the risk of injury during a collision for **Level 3,** answers must include references to brakes / tyres, speed, thinking distance, braking distance, and safety.		

6.5.4.3.2 Reaction time

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	frictional / braking force is greater (for the faster car) **or** the faster car has more kinetic energy		1	AO1
	(so) more work done (by the brakes to stop the faster car)	allow so more energy is transferred (by the brakes to stop the faster car) ignore more heating	1	AO3
	(so) the risk of the brakes overheating is greater (for the fast car)	allow (at greater speed) there is a risk of overheating MP3 dependent on MP1 or MP2	1	AO3 6.5.4.3.4

Total Question 2	12

6.5.4.3.2 Reaction time

Answer 01 · Examiner comments

June 2018 | 8464/P/2H | Original Q6

Question 6 (standard / high & high demand)

06.1 About 30% gained both marks, with fewer than 1% gaining just one mark. There was widespread misreading of the graph, in some cases misreading the scale but in a very large proportion there was little attempt to read between the grid lines.

Those who were successful adopted one of three routes: reading the distance off the graph between the given times; finding the time interval from the data given and reading that off the graph from the origin; using the data from the graph along with distance = speed x time to find the extra distance.

06.2 This was not answered well, with many students simply talking about heat energy, and many of those who referred to kinetic energy talking about kinetic energy in the brakes.

Many students overcomplicated their responses to this question. Over three quarters of students gained no marks.

06.3 This calculation was fairly well done with just over 42% gaining full marks. There were not many able to score compensation marks and so 40% scored zero.

The major problem was the inability to rearrange the equation, and substitution marks were rare as students were trying to substitute into an incorrect equation. A significant minority divided rather than subtracted when moving v^2 from one side of the equation to the other.

06.4 Many students did not grasp that a specific requirement of the question was to include factors that would affect the gradient and only a minority talked about the gradient being altered by factors rather than simply describing the graphs presented.

Lower attaining students described the graphs, often saying that “everyone has stopped by 112 km/h” as this was seen as an end point. Many mentioned factors that would affect each of the distances but the factors were not always attributed to the correct distance. A significant number of students cited factors that affected the stopping distance in their own right.

Fewer than 6% of responses achieved level three.

6.5.4.3.2 Reaction time

Answer 02 · Examiner comments

June 2022 | 8464/P/2H | Original Q6

Question 6 (Standard/high and high demand)

06.1 As students were provided with the equations, this question proved to be more straight-forward than originally expected. Students had to interpret the graph to determine the reaction time. As they were given the equation over 70% were able to read two values off the graph, and correctly determine the reaction time. Nearly all students that did read two correct values scored full marks. Those that did not usually rearranged the equation incorrectly.

06.2 Only a small percentage of students appreciated that they had to determine the area under the graph. Of those that did, only about 1% failed to go on and score all the marks. About 6% of students scored on this question. Most incorrect answers gave two values from the graph and multiplied them together.

06.3 This was a high demand question, and approximately 30% of students gained some marks. Nearly all answers that did not gain any marks did not mention the gradient at all. Only about 3% of students went on to say that the gradient represents the acceleration, and very few stated that acceleration was proportional to force or that force is equal to mass times acceleration.

6.5.4.3.2 Reaction time

Answer 03 · Examiner comments

June 2023 | 8464/P/2H | Original Q7

Question 7 (high demand)

07.1 25% of students gained three marks on this question. 20% of students correctly determined the gradient but could not recall the unit for acceleration. A significant number of students knew to calculate the gradient but mis-read the graph and used an initial velocity of 25 m/s.

07.2 5% of students gained full marks on this question. 20% of students gained two marks for correctly calculating the thinking distance. Of the 65% of students that scored zero marks the majority neither attempted to determine the area under the graph or used a correct equation.

07.3 15% of students scored a mark on this question. Most of those that did score a mark wrote that large decelerations could lead to a loss of control.

6.5.4.3.2 Reaction time

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

6.5.4.3.2 Reaction time

Answer 04 · Examiner comments

Question 5 (standard/high & high demand)

05.1 This calculation was the most demanding on the paper, with 80% of students not gaining any marks. Most students used an incorrect equation and substituted the value of acceleration as the displacement. Of the approximately 20% of students that did use the correct equation, the vast majority gained full marks.

05.2 This question was not well answered, with less than 10% of students gaining the mark. It is common for students when answering questions on this topic to not make the distinction that reaction time is a time and thinking distance is a distance.

05.3 Approximately 33% of students identified the correct relationship between speed and braking distance. Inversely proportional was a more popular response.

05.4 Nearly 50% of students were able to calculate the mass of the car and achieve the first 3 marks. Of the 20% of students that did not gain any further marks, most did not use the graph to determine the speed from the given braking distance, despite being instructed to use it in the question, and so could not go on to calculate the momentum.

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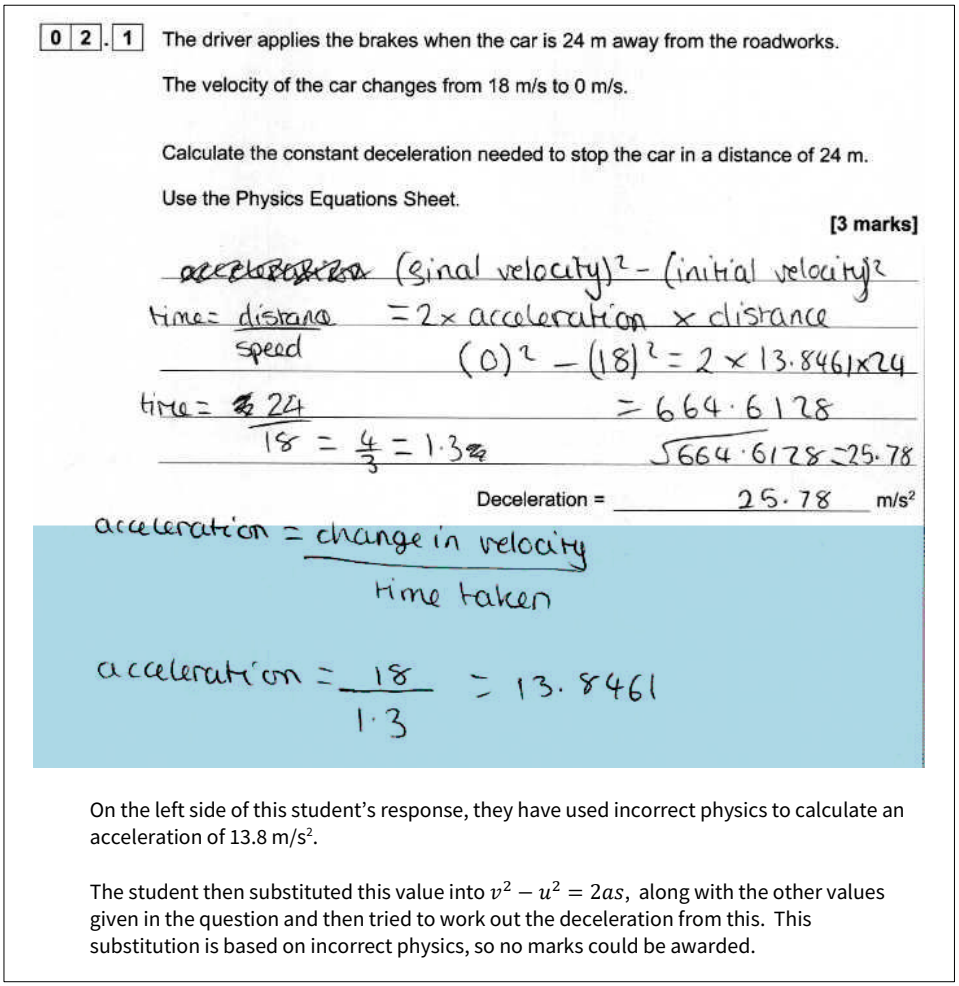
6.5.4.3.2 Reaction time

Answer 05 · Examiner comments June 2025 | 8464/P/2H | Original Q2

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]

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

time = distance / speed

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

time = 24 / 18 = 4/3 = 1.3

$= 664.6128$

$\sqrt{664.6128} = 25.78$

Deceleration = 25.78 m/s^2

acceleration = change in velocity / time taken

acceleration = 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.

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6.5.4.3.2 Reaction time

Answer 05 · Examiner comments

June 2025 | 8464/P/2H | Original Q2

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.

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6.5.4.3.2 Reaction time

Answer 05 · Examiner comments June 2025 | 8464/P/2H | Original Q2

02.2 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, however 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~~ on with reduced speed as it takes less time (therefore distance) to reduce speed at a lower starting speed than a higher one.

Extra space

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

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6.5.4.3.2 Reaction time

Answer 05 · Examiner comments

June 2025 | 8464/P/2H | Original Q2

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.

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