AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.5.2

Work done and energy transfer

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**5**
Available paper years	**2021–2025**

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.

6.5.2 Work done and energy transfer

Answer 01 · Mark scheme November 2021 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	different temperatures emit different intensities of infrared which are represented (on the infrared camera) as different shades / colours	 allow wavelength / frequency / amount for intensity throughout	1 1	AO1 AO3 6.6.2.4
05.2	visible light		1	AO3 6.6.2.1
05.3	both ionising radiation so some risk of cancer the whole body is irradiated by gamma rays when an X-ray is taken only part of the body is exposed exposure time for gamma rays is longer		1 1 1 1	AO1 AO3 AO3 AO3 6.6.2.3
05.4	$1.2 \times 10^{-13} = F \times 0.015$ $F = \frac{1.2 \times 10^{-13}}{0.015}$ $F = 8.0 \times 10^{-12}$ N	 allow a correct rearrangement using an incorrectly / not converted value of s allow 8×10^{-12} allow a correct calculation using an incorrectly / not converted value of s	1 1 1	AO2 6.5.2

6.5.2 Work done and energy transfer

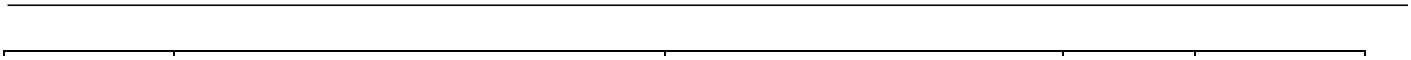
Answer 01 · Mark scheme

05.5	some of the energy of the electrons causes heating (therefore) increasing the temperature (so using tungsten) allows more electrons to be collided per second than using any other metal	 allow (so using tungsten) enables more energy per second to be transferred than using any other metal	1 1 1	AO1 AO3 AO3 6.5.2
Total			**13**	

6.5.2 Work done and energy transfer

Answer 01 · Mark scheme

November 2021 | 8464/P/2H | Original Q5



6.5.2 Work done and energy transfer

Answer 02 · Mark scheme

June 2022 | 8464/P/1H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	**Child** gravitational potential energy decreases kinetic energy increases **and** then decreases (to zero) **Springs** elastic potential energy increases **Surroundings** internal / thermal store of energy increases	ignore descriptions of energy transfers before the child reaches position A ignore references to kinetic energy of the springs allow energy is dissipated allow (average) kinetic energy of the particles increases	1 1 1 1	AO1 6.1.1.1 6.1.2.1

Answer 02 · Mark scheme

June 2022 | 8464/P/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	**At position A** $4.9 = 0.5 \times k \times 0.056^2$		1	AO2 6.1.1.2
	$k = \frac{2 \times 4.9}{0.056^2} = 3125$ (N/m)		1	
	At position B $8.1 = 0.5 \times 3125 \times e^2$	allow a correct substitution of an incorrectly calculated value of k using 0.056 m **and** 4.9 J	1	
	$e = \sqrt{\left(\frac{2 \times 8.1}{3125}\right)}$	allow $e^2 = 0.005184$ allow a correct re-arrangement using an incorrectly calculated value of k	1	
	$e = 0.072$ (m)	allow an answer consistent with their calculated value of k	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	the total energy transferred by the child		1	AO1 6.1.1.4

Total Question 3		10

6.5.2 Work done and energy transfer

Answer 03 · Mark scheme

June 2022 | 8464/P/2H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	work done = force × distance (along the line of action of the force) **or** $W = F\ s$		1	AO1 6.5.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	3 360 000 = F × 42 000 $F = \frac{3\ 360\ 000}{42\ 000}$ F = 80 (N)		1 1 1	AO2 6.5.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	distance travelled = speed × time		1	AO1 6.5.4.1.5

6.5.2 Work done and energy transfer

Answer 03 · Mark scheme

June 2022 | 8464/P/2H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	42 000 = v × 5600 $v = \frac{42\,000}{5600}$ v = 7.5 (m/s)		1 1 1	AO2 6.5.4.1.2

Question	Answers	Mark	AO / Spec. Ref.
02.5	**Level 2:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	3–4	AO3 6.5.4.1.2
	Level 1: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	1–2	
	No relevant content	0	
	Indicative content the effect on speed must be consistent with the cause of the change • competitors accelerate at the start • so speed increases • the road is not flat • so speed increases going downhill and / or speed decreases going uphill • the competitor goes round a bend • so speed decreases • competitors may tire towards the end (so the force they exert decreases) • so they slow down • competitors may sprint during the race • causing speed to increase • may get a puncture • so speed would decrease or they would stop • resistive forces on competitors may increase/decrease • so speed would decrease/increase		

Total Question 2		**12**

6.5.2 Work done and energy transfer

Answer 04 · Mark scheme June 2024 | 8464/P/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	kinetic energy (of the beater / food) internal / thermal energy (of the surroundings / whisk / food)	ignore sound	1 1	AO1 6.2.4.2 6.1.2.1 6.1.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	power = $\frac{\text{work done}}{\text{time}}$ or $P = \frac{W}{t}$		1	AO1 6.1.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	$92 = \frac{23\,000}{\text{time}}$ $\text{time} = \frac{23\,000}{92}$ 250 (s)		1 1 1	AO2 6.1.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	$P = I^2 R$		1	AO1 6.2.4.1

6.5.2 Work done and energy transfer

Answer 04 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	I = 0.500 A		1	AO2 6.2.4.1
	$P = 0.500^2 \times 640$	allow a correct substitution of an incorrectly / not converted current	1	
	P = 160 (W)	allow a correct calculation using an incorrectly / not converted current	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6	230 (V)		1	AO1 6.2.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.7	decreases		1	AO1 6.2.4.1

Total Question 1	**12**

Answer 05 · Mark scheme

June 2025 | 8464/P/2H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	athlete's swimming speed = typical walking speed		1	AO1 6.5.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	time taken = 1400	subsequent marks may be awarded if time taken is determined from the graph	1	AO3 6.5.2 6.5.4.1.5
	mean speed = $\frac{7.5 + 6.2}{2}$ (= 6.85 m/s)	allow mean speed calculated using a maximum speed between 7.4 m/s and 7.6 m/s	1	
	distance (= 6.85 × 1400) = 9590 (m)	allow a distance consistent with their calculated mean speed subsequent marks may only be awarded if values of speed and time from the graph have been used to determine a distance subsequent marks may be awarded using their value of total distance	1	
	110 000 = F × 9590		1	
	$F = \frac{110\,000}{9590}$		1	
	F = 11(.470…) (N)		1	

06.2 cont.	**OR**			
	time taken = 1400 (1) area of triangle (1) = 0.5 × 1400 × (7.5 - 6.2) (= 910) **and** area of rectangle = 1400 × 6.2 (= 8680) distance (1) (= 910 + 8680) = 9590 (m) 110 000 = F × 9590 (1) $F = \frac{110\,000}{9590}$ (1) F = 11(.470…) (N) (1)	subsequent marks may be awarded if time taken is determined from the graph allow area calculated using a maximum speed between 7.4 m/s and 7.6 m/s allow a distance consistent with their calculated areas subsequent marks may only be awarded if values of speed and time from the graph have been used to determine a distance subsequent marks may be awarded using their value of total distance		

06.2 cont.	**OR**			
	time taken = 1400 (1)	subsequent marks may be awarded if time taken is determined from the graph		
	acceleration $= \frac{6.2 - 7.5}{1400}$ (1) (= (-)0.00092857…)	allow acceleration calculated using a maximum speed between 7.4 m/s and 7.6 m/s subsequent marks may be awarded if their calculated value for acceleration is rounded		
	distance $\left(= \frac{6.2^2 - 7.5^2}{(-)2 \times 0.00092857 \ldots}\right)$ (1) = 9590 (m)	allow a distance consistent with their calculated acceleration subsequent marks may only be awarded if values of speed and time from the graph have been used to determine a distance subsequent marks may be awarded using their value of total distance		
	110 000 = F × 9590 (1)			
	$F = \frac{110\ 000}{9590}$ (1)			
	F = 11(.470…) (N) (1)			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	constant magnitude (of velocity)	allow speed was constant allow speed was 4 m/s allow (magnitude of) velocity was 4 m/s do **not** accept constant velocity	1	AO2
	direction (of velocity) kept changing		1	AO1
		if no other mark awarded allow **1** mark for the velocity is constantly changing		6.5.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	the gradient is equal to the deceleration / acceleration		1	AO3 6.5.4.1.5
	(and) the (magnitude of the) gradient increased		1	

Total Question 6	**11**

6.5.2 Work done and energy transfer

Answer 01 · Examiner comments November 2021 | 8464/P/2H | Original Q5

Question 5 (standard/high demand and high demand)

05.1 Only 10% of students scored marks on this question. At high demand it is expected that where a question follows a figure, students should use information from the figure. Very few students linked the amount of infra-red radiation to temperature, or stated that different temperatures are displayed at different colours, despite that information being given in Figure 8.

05.2 This was a demanding question - students had to compare wavelengths given in nm and mm and in standard form. They then had to use their understanding of the electromagnetic spectrum. Less than 30% of students answered this question correctly.

05.3 The vast majority of the 40% of students that scored marks on this question only scored 1 mark, and that was mostly for saying that there is some risk of cancer with both.

05.4 This question performed as expected with 30% of students scoring 2 marks. Only 8% of students included the conversion to gain full marks.

Answer 01 · Examiner comments November 2021 | 8464/P/2H | Original Q5

05.5 20% of students gained at least 1 mark. Most of those stated that the energy from the electrons would cause heating and increase the temperature. Some went on to say that tungsten could be heated to a higher temperature than any other metal. No student scored full marks for explaining this meant that more electrons could be collided.

Answer 02 · Examiner comments

June 2022 | 8464/P/1H | Original Q3

Question 03 (Standard and standard/high demand)

03.1 Many students struggled with this question, which revealed a number of misconceptions held by students. Around 70% of students gained at least one mark, but very few managed to score all 4 marks.

Many students began by describing energy changes as the child moved from the trampoline to the maximum height. This was ignored, and most of these responses went on to describe what happened as the child then fell downwards.

A lot of students described the forces acting on the child, which did not answer the question, and it was reasonably common to see descriptions of gravitational potential energy being a force which acts on the child. The concept of energy stores continues to be widely misunderstood by students, with some students making statements suggesting that there is a gravitational potential energy store when the child is in the air, for example. Lots of responses to the question described a transfer of gravitational potential energy to kinetic energy as the child descended, which gained the first marking point. Very few students realised that the kinetic energy of the child would decrease after landing on the trampoline.

For the springs, it was common to read descriptions of the springs stretching, rather than descriptions of changes to energy stores. Some students identified that the elastic potential energy of the springs would increase, but added that the chemical energy of the springs would decrease, and therefore did not gain the mark. A fair number of students made statements that elastic energy was used to stretch the springs, which was not credit-worthy.

For the surroundings, a lot of students stated that there was no change to the energy stores, and a lot of students described an increase in sound energy. This is not a store of energy, and was ignored. A fair proportion of students did identify that energy would be dissipated to the surroundings, thus gaining the mark.

6.5.2 Work done and energy transfer

Answer 02 · Examiner comments June 2022 | 8464/P/1H | Original Q3

03.2 This calculation proved to be very challenging, with nearly three quarters of all students failing to gain any marks.

A lot of students calculated the difference between the energies at positions A and B, which is incorrect physics so was unable to gain credit. A lot of students substituted 0.056 m in for the spring constant in position A, and some students forgot to square the extension when using the elastic energy equation.

Students who realised that they needed to use the value of elastic potential energy at position A to calculate the spring constant, tended to do very well in this question, with nearly two thirds of those who gained any credit scoring all 5 marks. A few students arrived at the correct final answer, but then subtracted the original extension to find the change in extension, an approach which scored a maximum of 4 marks.

03.3 Over 60% of students selected the correct definition of work done.

Answer 03 · Examiner comments June 2022 | 8464/P/2H | Original Q2

Question 2 (Standard demand)

02.1 Over 99% of students were able to select the correct equation.

02.2 This was a relatively straight forward calculation, with nearly 90% of students gaining full marks.

02.3 Over 99% of students were able to select the correct equation.

02.4 Over 95% of students gained full marks on this speed calculation.

02.5 30% of students were able write a response that contained logically linked statements. The most common creditworthy responses described competitors getting tired. Of the students that did not get into level 2, most just gave reasons why the speed may change, but did not link this to an increase or decrease in speed.

Answer 04 · Examiner comments

June 2024 | 8464/P/1H | Original Q1

Question 1 (standard demand)

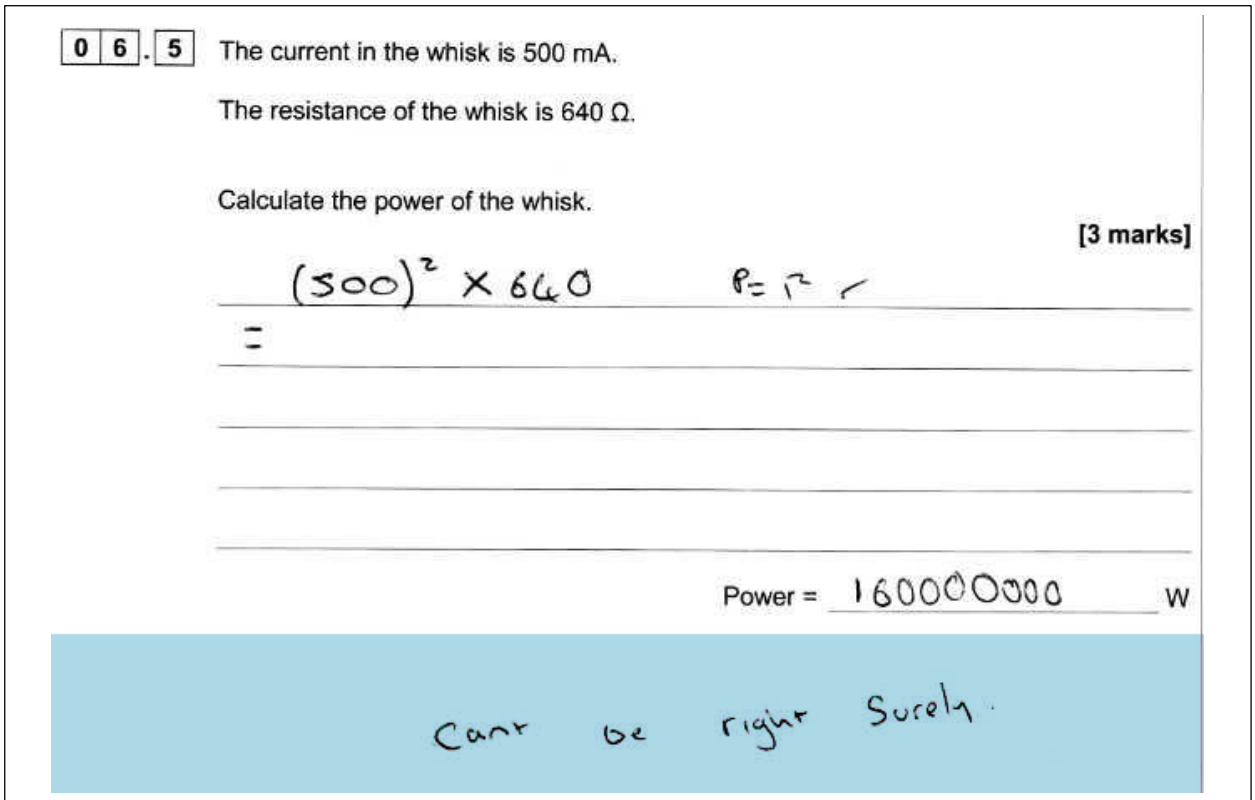
01.1 Almost all students scored at least 1 mark on this question, with nearly two-thirds scoring both marks. The most common incorrect answers were an increase in electrical energy and an increase in chemical energy.

01.2 A very low proportion of students answered this incorrectly.

01.3 Nearly 90% of students arrived at the correct final answer for this calculation, gaining 3 marks.

01.4 Most students selected the correct equation, with about 1% of students not gaining this mark.

01.5 For this calculation, many students did not correctly convert the current into amps. Some students forgot to show that the current should be squared in their substitution. Others showed a valid substitution but forgot to square the current when they entered it in their calculator. About 40% scored all 3 marks, but about 50% gained 2 marks, and over 95% scored at least 1 mark.



This student did not realise that the current was given in milliamps, so only scored marking points 2 and 3. However, the comment 'Can't be right, surely' indicates that they realise that the power of an electric whisk ought to be a lot lower. Students who think about how realistic their answer is may give themselves a much better chance of spotting their mistakes and doing something to rectify them.

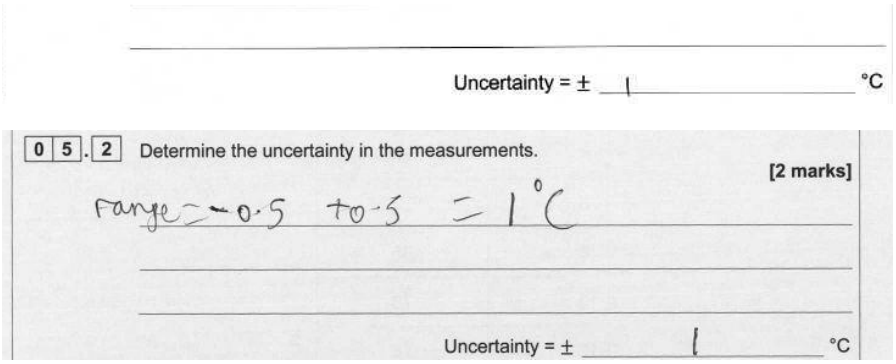
01.6 Slightly more than one in two students could recall the potential difference between the live and neutral wires.

01.7 Over 80% of students identified that an increase in current would be caused by a decrease in resistance.

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6.5.2 Work done and energy transfer

Answer 05 · Examiner comments



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.

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6.5.2 Work done and energy transfer

Answer 05 · Examiner comments

June 2025 | 8464/P/2H | Original Q6

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 ~~tub~~ side will emit more IR radiation. Both cubes stopped changing temperature, because they emitted all IR radiation. Hotter objects emit more IR radiation too.

Extra space

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.

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Answer 05 · Examiner comments

June 2025 | 8464/P/2H | Original Q6

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

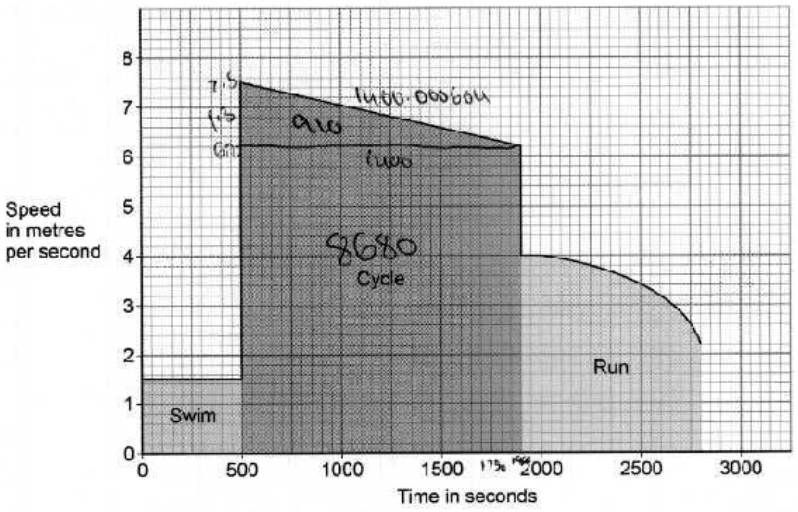
06.1 Less than half of the students correctly identified that the swimming speed of the triathlete was equal to a typical walking speed.

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.

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6.5.2 Work done and energy transfer

Answer 05 · Examiner comments

June 2025 | 8464/P/2H | Original Q6

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 ~~by~~ 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.

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6.5.2 Work done and energy transfer

Answer 05 · Examiner comments

June 2025 | 8464/P/2H | Original Q6

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.

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Contact us

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