AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.5.3

Forces and elasticity

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**9**
Available paper years	**2018–2024**

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.

6.5.3 Forces and elasticity

Answer 01 · Mark scheme June 2018 | 8464/P/2H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	D needs the greatest force to extend the spring the same amount	allow 20 (N) allow fourth (newtonmeter) reason only scores if correct newtonmeter selected	1 1	AO1 6.5.3
04.2	zero (error) any **one** from: • record the value and subtract from readings taken • adjust the newtonmeter to zero	allow systematic (error) allow subtract 1 from all readings	1 1	AO3 6.5.3

6.5.3 Forces and elasticity

Answer 01 · Mark scheme

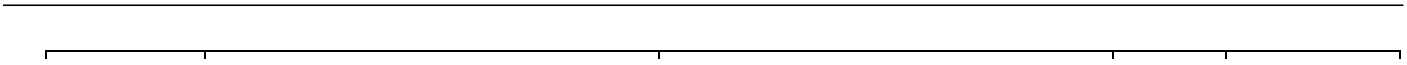
June 2018 | 8464/P/2H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3		an answer of 0.02 (m) gains **6** marks		AO2 6.5.3
	$4.5 \times 10^{-2} = 0.5 \times 400 \times e^2$	this mark may be awarded if the standard form value is incorrectly converted	1	
	$e = \sqrt{\frac{4.5 \times 10^{-2}}{0.5 \times 400}}$	this mark may be awarded if the standard form value is incorrectly converted allow $e^2 = \frac{4.5 \times 10^{-2}}{0.5 \times 400}$	1	
	e = 0.015 (m)	this answer only	1	
	2.0 = 400 × e		1	
	e = 0.005 (m)	this answer only	1	
	0.015 + 0.005 = 0.02 (m)	allow their initial extension + their additional extension correctly calculated	1	
	or			
	$4.5 \times 10^{-2} = 0.5 \times 400 \times e^2$ (1)	this mark may be awarded if the standard form value is incorrectly converted		
	$e = \sqrt{\frac{4.5 \times 10^{-2}}{0.5 \times 400}}$ (1)	this mark may be awarded if the standard form value is incorrectly converted allow $e^2 = \frac{4.5 \times 10^{-2}}{0.5 \times 400}$		
	e = 0.015 (m) (1)	this answer only		
	F = 400 × 0.015 F = 6 (N) (1)	allow an answer of 400 × their calculated value of e		
	total force = 6 + 2 8 = 400 × e (1)	allow an answer that is consistent with their calculated value of e		
	e = 0.02 (m) (1)			
Total			**10**	

6.5.3 Forces and elasticity

Answer 01 · Mark scheme

June 2018 | 8464/P/2H | Original Q4



6.5.3 Forces and elasticity

Answer 02 · Mark scheme

June 2019 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
05.1	force ∝ extension		1	AO1 6.5.3	A
05.2	F = 0.49 × 1 200 **or** F = 588 (N) 588 = m × 9.8 $m = \frac{588}{9.8}$ m = 60 (kg) **OR** 0.49 = mean mass per spring × 9.8 (1) mean mass per spring = $\frac{0.49}{9.8}$ (1) mean mass per spring = 0.050 (1) m = 0.050 × 1200 = 60 (kg) (1)	an answer of 60 (kg) scores **4** marks allow a correct substitution using an incorrectly calculated value of F allow a correct rearrangement using an incorrectly calculated value of F allow a correct calculation using an incorrectly calculated value of F	1 1 1 1	AO2 6.5.1.3	E
05.3	$0.49 = k \times 3.5 \times 10^{-3}$ $k = \frac{0.49}{3.5 \times 10^{-3}}$ 140 N/m	an answer of 140 scores **3** calculation marks	1 1 1 1	3 x AO2 1 x AO1 6.5.3	E

6.5.3 Forces and elasticity

Answer 02 · Mark scheme

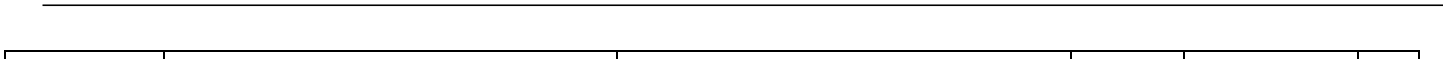
June 2019 | 8464/P/2H | Original Q5

05.4	springs with a low spring constant because they can compress by a larger amount (for a given force)	 allow they can compress by the same amount for a smaller force allow low stiffness	1 1	AO3 6.5.3	E
Total			**11**		

6.5.3 Forces and elasticity

Answer 02 · Mark scheme

June 2019 | 8464/P/2H | Original Q5



6.5.3 Forces and elasticity

Answer 03 · Mark scheme

November 2020 | 8464/P/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	the (maximum tendon) extension increases (as speed increases)	allow the tendons stretch more (as speed increases)	1	AO3 6.1.2.2
	so the elastic potential energy increases	allow so the (elastic) force increases	1	
	which is transferred to gravitational potential energy		1	
07.2	E = 770 × 0.14	allow E = 107.8 (J)	1	AO2 6.1.1.2
	extension = 0.070m		1	
	$107.8 = 0.5 \times k \times 0.070^2$	this mark may be awarded if extension is incorrectly/not converted and/or if the efficiency equation has not been applied	1	
	$k = 2 \times \frac{107.8}{0.070^2}$	this mark may be awarded if extension is incorrectly/not converted and/or if the efficiency equation has not been applied	1	
	k = 44 000 (N/m)	this mark may be awarded if extension is incorrectly/not converted this mark may not be awarded if the efficiency equation has not been applied	1	
Total			8	

6.5.3 Forces and elasticity

Answer 04 · Mark scheme

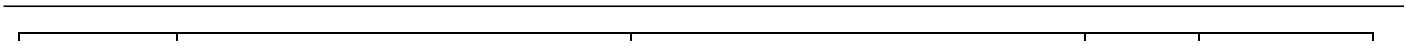
November 2020 | 8464/P/2H | Original Q3

question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	the spring will return to its original length when the force is removed		1	AO1 6.5.3
03.2	Any **two** from: • spring constant • (original) length • diameter		2	AO3 6.5.3
03.3	0.80 = k × 0.0040 $k = \frac{0.80}{0.0040}$ k = 200 (N/m)		1 1 1	AO2 6.5.3
03.4	the upward force on the spring is equal to the downward force the spring is inelastically deformed		1 1	AO3 6.5.3
Total			**8**	

6.5.3 Forces and elasticity

Answer 04 · Mark scheme

November 2020 | 8464/P/2H | Original Q3



6.5.3 Forces and elasticity

Answer 05 · Mark scheme

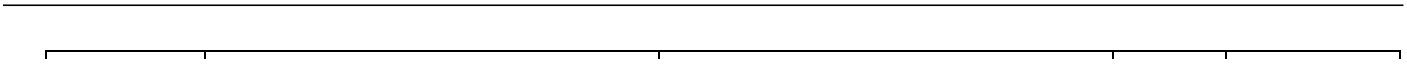
November 2021 | 8464/P/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	the spring will return to its original length when the force is removed		1	6.5.3 AO1
01.2	measure the original length of the spring **and** the extended length of the spring (with the metre rule) extension = extended length – original length		1 1	6.5.3 AO1
01.3	e = 0.080 m $E_e = 0.5 \times 40 \times (0.080)^2$ $E_e = 0.128$ (J)	 allow a correct substitution using an incorrectly / not converted value of e allow a correct calculation using an incorrectly / not converted value of e	1 1 1	6.5.3 AO2
01.4	force = spring constant × extension **or** F = k e		1	6.5.3 AO1
01.5	$300 = k \times 0.40$ $k = \frac{300}{0.40}$ k = 750 (N/m)		1 1 1	6.5.3 AO2
Total			**10**	

6.5.3 Forces and elasticity

Answer 05 · Mark scheme

November 2021 | 8464/P/2H | Original Q1



6.5.3 Forces and elasticity

Answer 06 · 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 06 · Mark scheme

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

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

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

Answer 07 · Mark scheme

June 2023 | 8464/P/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	the measurement will be more accurate	allow parallax error is reduced	1	AO3
	because (in position B) the eye is level with (the maximum height of) the toy		1	AO1 6.1.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	64 cm = 0.64 m		1	AO2 6.1.1.2
	$0.049 = m \times 9.8 \times 0.64$	allow a correct substitution using an incorrectly / not converted height	1	
	$m = \frac{0.049}{9.8 \times 0.64}$	allow a correct rearrangement using their incorrectly / not converted height	1	
	$m = 0.0078125$ (kg)	allow an answer consistent with their incorrectly / not converted height	1	
	$m = 0.0078$ (kg)	this mark can only be scored if the equation $E_p = m\ g\ h$ has been used	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	energy from the toy is dissipated (to the surroundings / air)	allow energy from the toy is transferred to the surroundings / air	1	AO1 6.1.2.1 6.1.1.1
	(but) in a closed system the total energy remains constant		1	

Total Question 5	9

Answer 08 · Mark scheme

June 2023 | 8464/P/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	$W \propto e$		1	AO1 6.5.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	750 = k × 0.060		1	AO2 6.5.3
	$k = \frac{750}{0.060}$	allow a correct rearrangement using an incorrectly / not converted value of *e*	1	
	k = 12 500 N/m	allow a correct calculation using incorrectly / not converted value of *e*	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	(an object that is inelastically deformed) will not go back to its original length	allow shape for length	1	AO1 6.5.3
	when the force is removed		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	$1800 = ½ \times 225 \times e^2$		1	AO2 6.5.3
	$e = \sqrt{\frac{2\times1800}{225}}$	allow $e^2 = \frac{2\times1800}{225}$	1	
	e = 4 (m)	allow *e* = 4.0 (m)	1	

Answer 08 · Mark scheme

June 2023 | 8464/P/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	$e = \frac{750}{225}$ e = 3.3… (m) the extension will be too great so not suitable for use in the chair **OR** F = 225 x 0.3 (1) F = 67.5 (N) (1) the weight of a person will be too great so (spring is) not suitable for use in the chair (1)	 allow a conclusion consistent with their calculated extension allow the chair would rest on the ground allow the spring will not stretch beyond its elastic limit	1 1 1	AO3 6.5.3

Total Question 5	12

6.5.3 Forces and elasticity

Answer 09 · Mark scheme

June 2024 | 8464/P/2H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	(as a spring decompresses) the elastic potential energy of the spring decreases (as the gymnast leaves the floor) the kinetic energy of the gymnast increases **or** the gravitational potential energy of the gymnast increases **OR** (as a spring decompresses) the spring exerts a force on the gymnast (1) (so) work is done on the gymnast (1)		1 1	AO1 6.5.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	e = 0.012 m		1	AO2
	E_e= 0.5 × 8500 × 0.012^2	allow a correct substitution using an incorrectly / not converted value of e	1	AO2
	E_e = 0.612	allow 0.61 allow a correct calculation using an incorrectly / not converted value of e	1	AO2
	J **or** joule		1	AO1 6.5.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	measure the original length of the spring **and** the compressed length of the spring (using a metre rule) compression = original length − compressed length **OR** calculate / measure the weight of the mass on the spring (1) use the equation $e = \frac{F}{k}$ (1)		1 1	AO3 6.5.3 RPA18

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	masses could fall (off the spring) (so) less likely to cause injury / damage (if done on the floor)	 allow less hazardous allow lower risk (of injury) allow specific cause of injury eg landing on foot	1 1	AO1 6.5.3 RPA18

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	Δy = (330 – 80 =) 250 (N)		1	AO3 6.5.3 RPA18

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	Δx = (0.052 – 0.010) = 0.042 (m)		1	AO3 6.5.3 RPA18

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.7		allow ecf from question **02.5 and** question **02.6**		AO3 6.5.3 RPA18
	$k = \frac{250}{0.042}$	allow k = 5952.38	1	
	5950 (N/m)	allow their calculated gradient to 3 significant figures	1	

Total Question 2	14

6.5.3 Forces and elasticity

Answer 01 · Examiner comments

June 2018 | 8464/P/2H | Original Q4

Question 4 (standard / high & high demand)

04.1 Nearly 70% identified the correct newtonmeter but very few stated that it was the extension being the same for all of the newtonmeters that was the key factor.

04.2 Fewer than 10% could correctly identify the type of error, with many giving descriptions rather than stating zero error or systematic error. Terms used incorrectly with some frequency included human error.

Over 50% were then able to say how the error could be corrected. Some suggested that the newtonmeter might just be 'sticky' and need to be pulled down and released which, whilst showing practical experience, would not be a solution in all cases.

04.3 Whilst only just over 5% gained all 6 marks, correct solutions, when seen, were clear and well set out. A significant number, nearly 17%, calculated the initial extension, but did not complete the calculation to determine the total extension.

Those managing to do the second part of the question opted in about equal numbers for each of the two expected methods.

Typical errors in the first part included not finding the square root of the answer for the extension and in dividing by 2 twice.

A few candidates realised there were two parts but worked out incorrect values. They were able to gain the final mark by adding the two incorrect extensions correctly.

6.5.3 Forces and elasticity

Answer 05 · Examiner comments November 2021 | 8464/P/2H | Original Q1

Question 1 (Standard demand)

01.1 30% of students correctly selected the meaning of elastically deformed.

01.2 Approximately 25% of students scored at least 1 mark on this question for suggesting that the length of the spring should be measured with a ruler. Nearly 15% correct suggested that the initial and final length should be measured, then subtracted.

01.3 85% of students were able to select the correct equation from the physics equations sheet, and substitute the values into the equation. Nearly all these students correctly evaluated the answer and were awarded 2 marks. Around 15% of these students converted 80 mm to metres and scored full marks.

01.4 Approximately 65% of students correctly recalled the equation.

01.5 Approximately 65% of students were able to substitute the numbers into the correctly rearranged equation and evaluate the answer to score full marks.

6.5.3 Forces and elasticity

Answer 06 · 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.

6.5.3 Forces and elasticity

Answer 06 · 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 07 · Examiner comments June 2023 | 8464/P/1H | Original Q5

Question 05 (Standard/high and high demand)

05.1 Around half of students gained at least 1 mark on this question. There were many acceptable ways to describe the toy being at eye level in position B. A fair number of students suggested that in position B the student could push down harder on the toy so that it would reach a greater height, which missed the point of the question and tended to score no marks.

05.2 About 85% of students gained at least 1 mark for this calculation, with about 20% scoring full marks, about 25% on 4 marks and about 15% on 3 marks. Most students did not attempt to convert the height into metres. Many students struggled to give the answer to 2 significant figures, perhaps caused by students not understanding how their calculators were giving the answer in standard form. So, for example, 7.8125×10^{-3} as an answer might have been rounded to 7.8 without any power of 10 shown.

Answer 07 · Examiner comments June 2023 | 8464/P/1H | Original Q5

05.3 Approximately a quarter of students scored at least 1 mark, with many not knowing how the specification defines a closed system.

6.5.3 Forces and elasticity

Answer 08 · Examiner comments

June 2023 | 8464/P/2H | Original Q5

Question 5 (standard/high demand and high demand)

05.1 Approximately 70% of students selected the correct relationship.

05.2 90% of students correctly substituted and calculated a spring constant. However, only 35% of students converted the extension to metres and scored three marks. 55% of students did not do the conversion or did it incorrectly and scored two marks.

05.3 Approximately 60% of students knew that an object that is inelastically deformed will not go back to its original length but did not refer to when the force is removed. Only 2% of students were awarded both marks for this question. Many students who scored zero marks wrote vague statements such as the object will not go back to its original form.

05.4 50% of students scored full marks. Many students who scored zero used an incorrect equation despite having the equation sheet. Many students tried to substitute into the correct equation but omitted the squared symbol.

05.5 Many students find evaluate questions challenging, particularly when they have to do a calculation. 30% of students did score at least two marks for a calculation, and 12% went on to draw a sensible conclusion and were awarded all three marks.

Answer 09 · Examiner comments

Question 2 (standard demand)

02.1 This question was more demanding than expected, with 40% of students able to gain any marks, although half of these students scored 2 marks. Students find the idea of energy stores very confusing. As in previous series, the mark scheme allows students to be awarded marks for answering in terms of transfers or transformations: this is the only way students were able to score marks on this question.

02.2 Nearly 90% of students did the calculation correctly and gained 2 of the 4 marks. Most of the students that scored 3 marks got the unit correct but missed the conversion of centimetres to metres. Less than 50% of students gave the correct unit, some clearly under the impression that elastic potential energy has a different unit from energy.

02.3 A little under 50% of students were able to gain a mark for suggesting that the length of the spring should be measured before and after it is compressed. Of those that did, approximately half suggested subtracting the two measured values for the second mark.

02.4 Approximately 30% of students identified that the large masses meant that the experiment should be done on the laboratory floor rather than on the table for safety reasons. Most students gained no marks as they wrote that the table would not be level or that as it was higher that would affect the readings.

02.5 Just under 80% of students correctly used the values from the graph to determine the value for Δy. Most incorrect answers gave it as either 300 or 330.

02.6 About three-quarters of students correctly determined Δx. The most common incorrect answer was 0.52.

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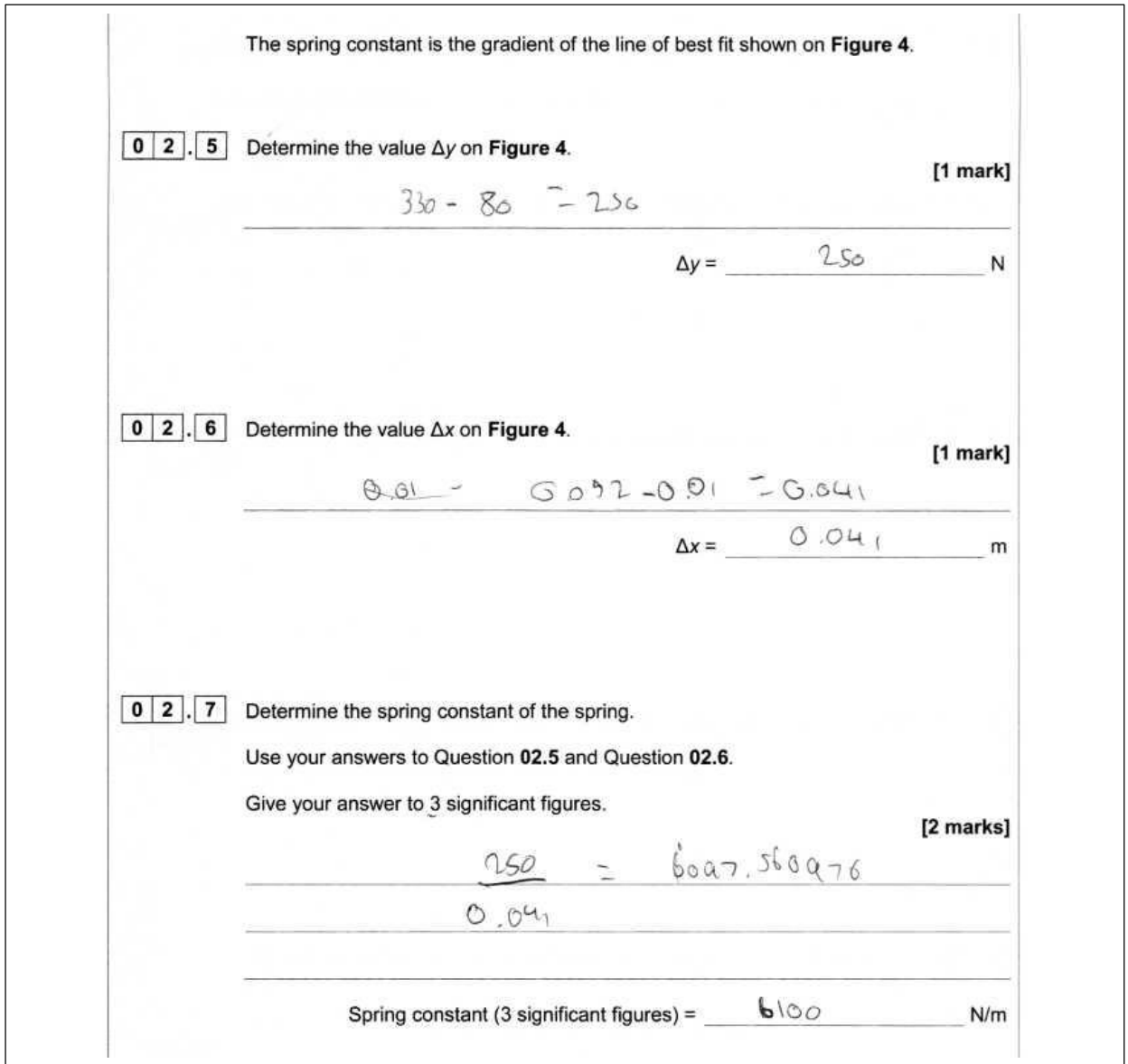
6.5.3 Forces and elasticity

Answer 09 · Examiner comments June 2024 | 8464/P/2H | Original Q2

02.7 This question was reasonably well answered, with 75% of students gaining at least 1 mark. The error carried forward (ecf) meant that students could use their answers from questions 02.5 and 02.6 and many students were able to gain 2 marks for doing so even if their previous answers were wrong.

About 20% of students were able to do the calculation correctly but then couldn't give the answer to 2 significant figures. An answer of 595 was frequently seen.



The spring constant is the gradient of the line of best fit shown on **Figure 4**.

02.5 Determine the value Δy on **Figure 4**. **[1 mark]**

330 - 80 = 250

$\Delta y =$ 250 N

02.6 Determine the value Δx on **Figure 4**. **[1 mark]**

0.01 - 0.092 - 0.01 = 0.041

$\Delta x =$ 0.041 m

02.7 Determine the spring constant of the spring.

Use your answers to Question **02.5** and Question **02.6**.

Give your answer to 3 significant figures. **[2 marks]**

250 = 6097.560976
0.041

Spring constant (3 significant figures) = 6100 N/m

When ecf is allowed, students who give one value incorrectly can still gain subsequent marks in the next part of the question.

In this example the student gained the mark for question 02.5 but not for question 02.6. In their answer to question 02.7 they were awarded the first mark for dividing their answer to question 02.5 by their answer to question 02.6 and the second mark for giving the correct answer to this calculation to the correct number of significant figures.

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