1(a). Two students are investigating springs and forces.

They measure how much a steel spring stretches with a range of different weights hung on it.

State **one** safety precaution the pupils should take when completing this experiment.

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[1]

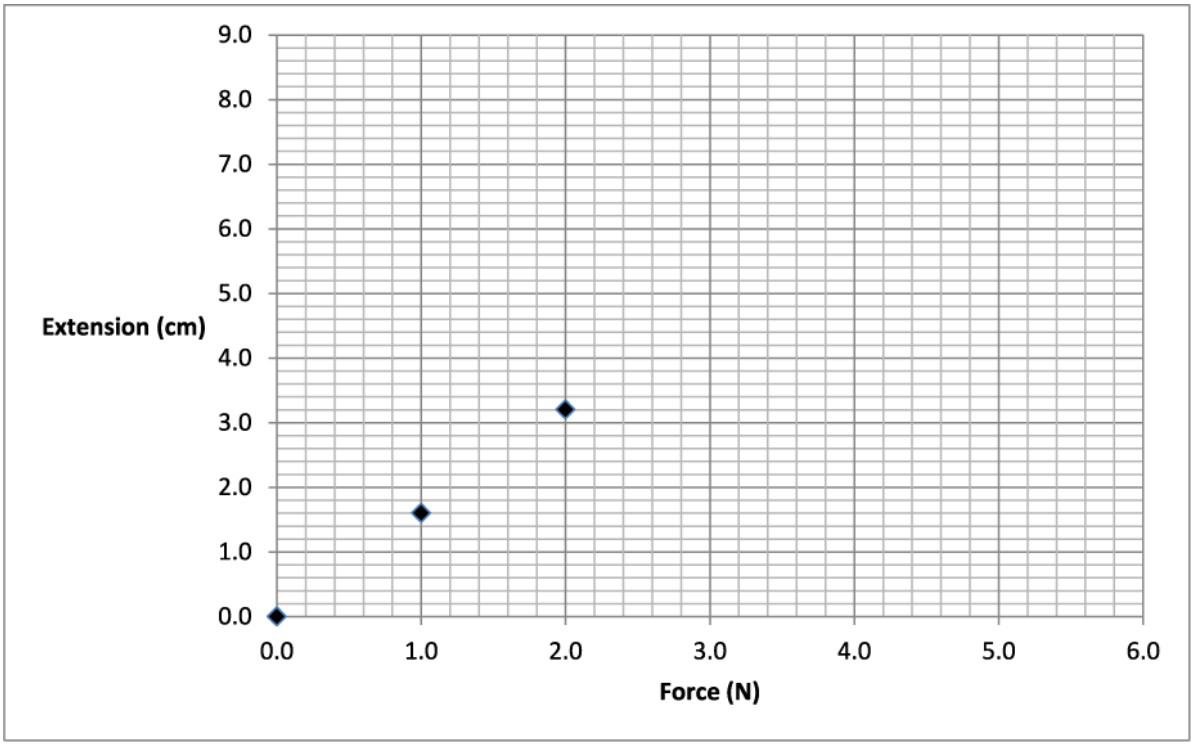
(b). They collect the following results.

Force (N)	Extension (cm)
0.0	0.0
1.0	1.6
2.0	3.2
3.0	6.0
4.0	6.4
5.0	8.0

Circle the outlier in the results for extension.

[1]

(c). They start to plot a graph of their results.



Plot the remaining points, **ignoring the outlier**, and draw a line of best fit.

[3]

(d). Using the data, calculate the spring constant of the spring when the force is 4.0 N.

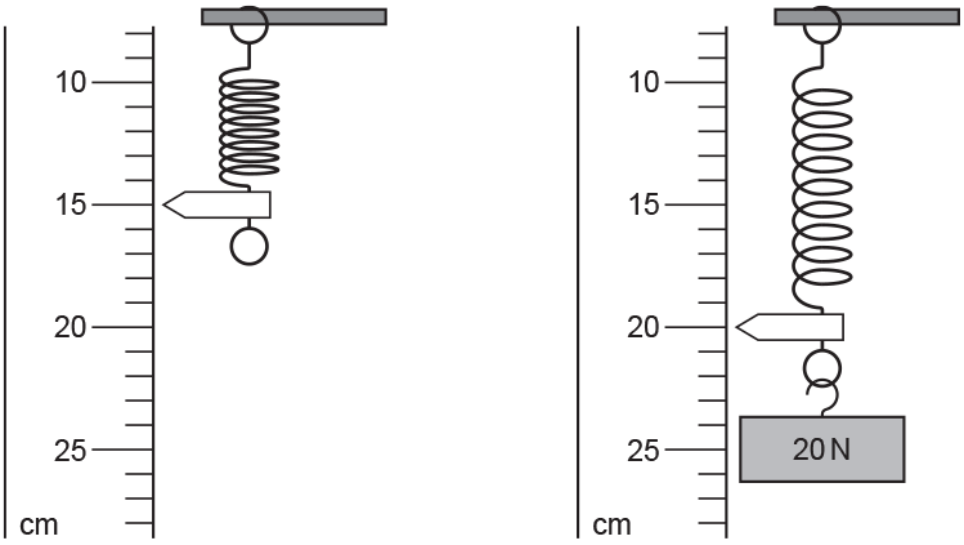
Force exerted = extension × spring constant

_____ N/m **[4]**

2(a). Ali hangs a spring next to a ruler with a centimetre scale, as shown in the diagram **A**.

He attaches a 20 newton (N) weight to the bottom of the spring.

The spring stretches as shown in **B**.



A **B**

(i) What is the correct extension (in **metres**) of the spring in diagram **B**?

Put a (ring) around the correct answer.

0.05 m 0.15 m 0.25 m 0.35 m **[1]**

(ii) Show that the spring constant is 400 N/m.

[3]

(b). Calculate the **energy stored** in the spring when it is stretched as in **A**.

Energy stored = ... J **[3]**

(c). When Ali adds another 20 N weight, the extension doubles.

Describe the relationship between force and extension.

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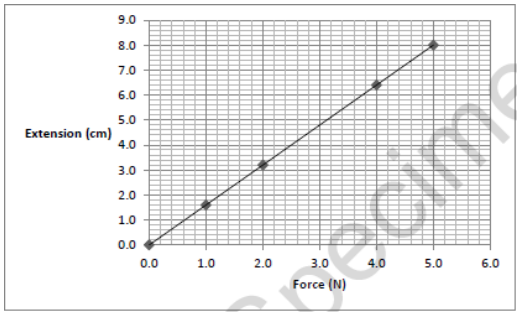
[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		Not to hang too much weight so not to break spring / careful with dropping masses (1)	1	**allow** any sensible suggestion for safety precaution
	b		6.0 (cm) circled	1	
	c		Marks correctly plotted (2) Correct best fit line (1)  	3	if outlier plotted give 2 marks only **allow** ECF from (b)
	d		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 62.5 (N/m) award 4 marks** Re-arrange equation to give spring constant = force ÷ extension (1) Use the table to find extension at 4N = 6.4 cm (1) Convert cm into m = 0.064 m (1) 4N ÷ 0.064 m = 62.5 (N/m) (1)	4	**allow** any other pair of numbers from table / graph that gives same answer
			Total	**9**	
2	a	i	0.05 m ✓	1 (AO 1.2)	**0.05 m** **0.15 m** **0.25 m** **0.35 m**

Question			Answer/Indicative content	Marks	Guidance
		ii	Recall and rearrange: spring constant = force ÷ extension ✓ = 20 ÷ 0.050 ✓ = <u>400</u> (N) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	ALLOW ECF from (a)(i) for first two marking points. ALLOW reverse argument. Must equal 400 (N) as this is 'show that'. <u>Examiner's Comments</u> In a 'show that' question, it is even more important for candidates to write down all their working. Here they need to recall and rearrange the equation to find the spring constant. However many of them select the equation to calculate the energy stored in a stretched spring from the formula list, as it refers to the spring constant. Candidates clearly know that the answer they should get is 400 N/m, so many of them just suggest multiplying 20 by 20 which does not gain credit.
	b		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (J) award 3 marks EITHER: select: ½ $k x^2$ ✓ energy stored = $0.5 \times 400 \times 0.050^2$ ✓ = 0.5 (J) ✓ OR Select: select: ½ $F x$ ✓ energy stored = 0.5 × 20 × 0.050 ✓ = 0.5 (J) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	ALLOW ECF from extension value in (a)(i) <u>Examiner's Comments</u> Most candidates were able to correctly select the equation to calculate energy stored in a spring and use the value 400 N/m given in part (a)(ii). This part of the question was well answered. Common errors were to use 20 as the value for spring constant or to forget to square the value for extension.

Question			Answer/Indicative content	Marks	Guidance
	c		(directly) proportional ✓	1 (AO 3.1a)	**ALLOW** linear **ALLOW** doubling the force doubles the extension. Examiner's Comments As this was a standard demand question, candidates were expected to realise that as the force doubles from 20 N to 40 N, the extension doubles, or that force is proportional to extension. Just stating that as force increases, extension increases was insufficient to gain the mark in this question.
			Total	8	