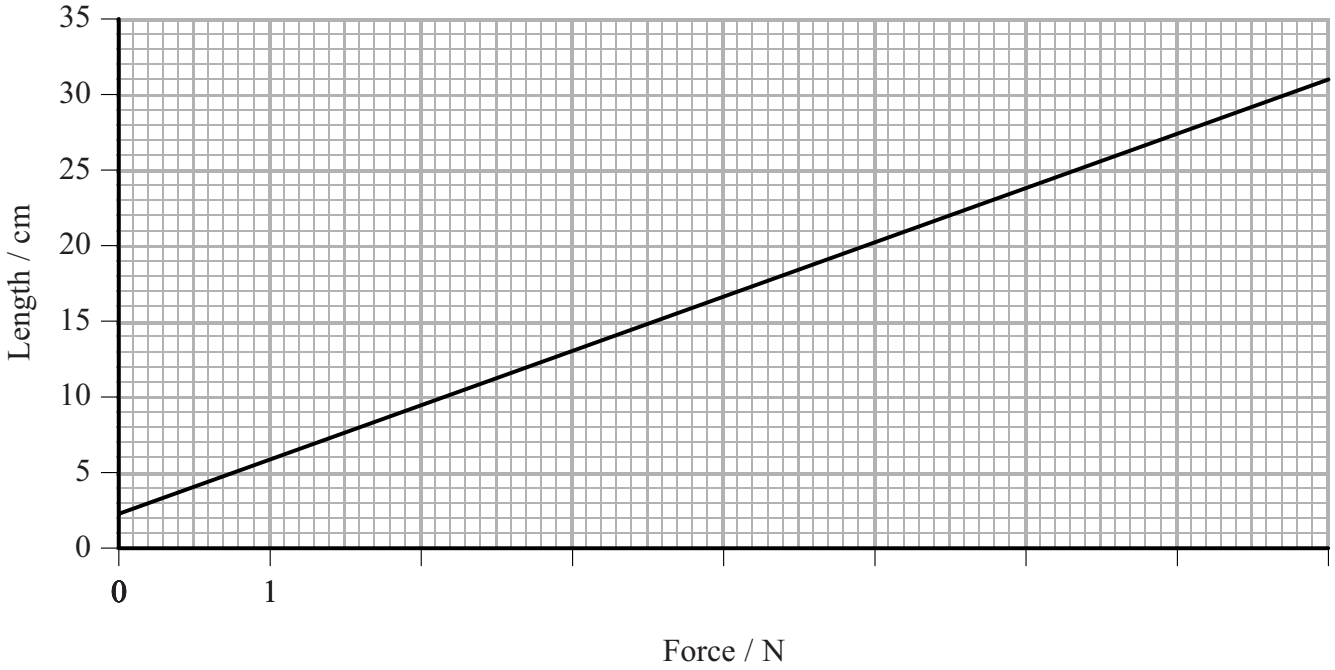
1 A student investigates how the length of a spring varies with force by hanging masses on it. The graph shows the results.



(a) The student concludes that the spring does **not** obey Hooke's law because the line does not pass through the origin.

Explain why this conclusion is incorrect.

(2)

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(b) Show that the spring constant is about 30 N m ^{1}.

(2)

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(c) When the student is removing the masses the spring is accidentally released when its length is 23 cm. The spring flies up into the air.

(i) Show that the energy stored in the spring is about 0.6 J when its length is 23 cm.

(2)

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(ii) Calculate the maximum height the spring could reach above its point of release.

mass of spring 5 g

(3)

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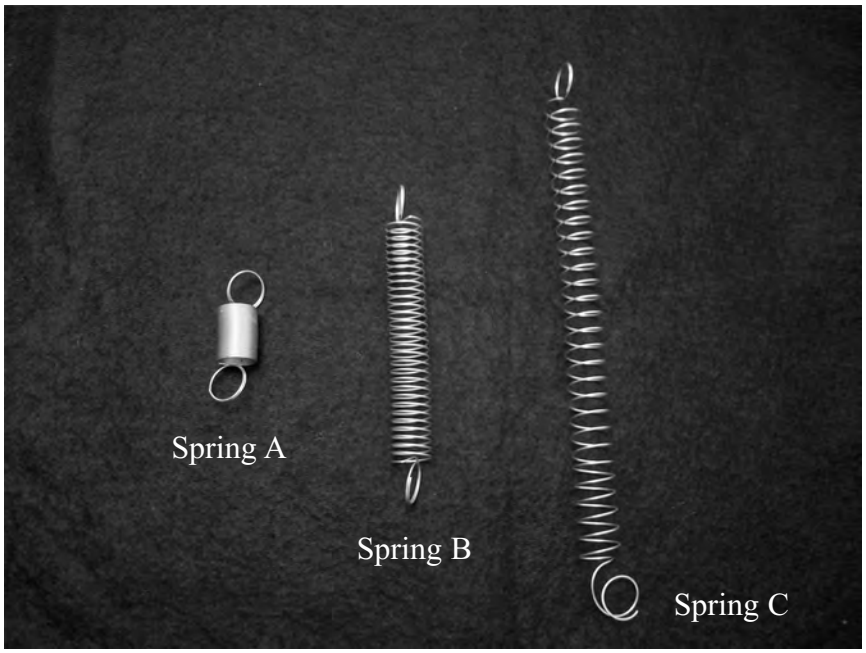
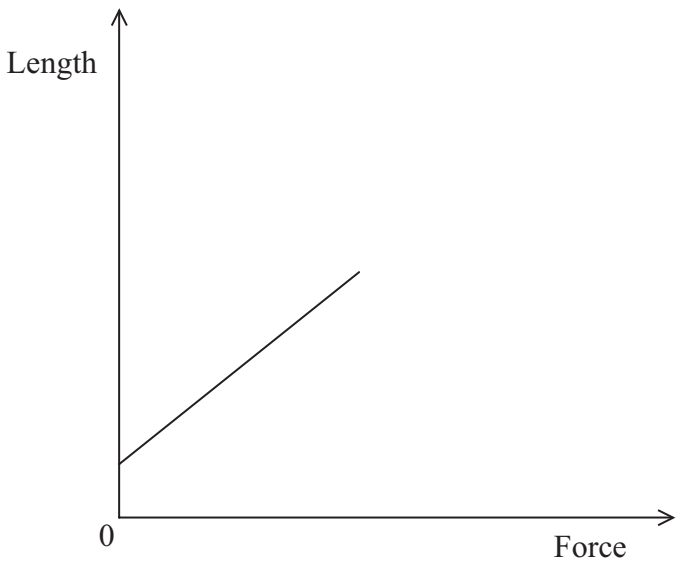
Maximum height .....

(d) Several other students carry out similar investigations using identical springs. The photograph shows some of their springs at the end of their investigations.



Spring A is the same length before and after the investigation. The graph for this spring is shown below.



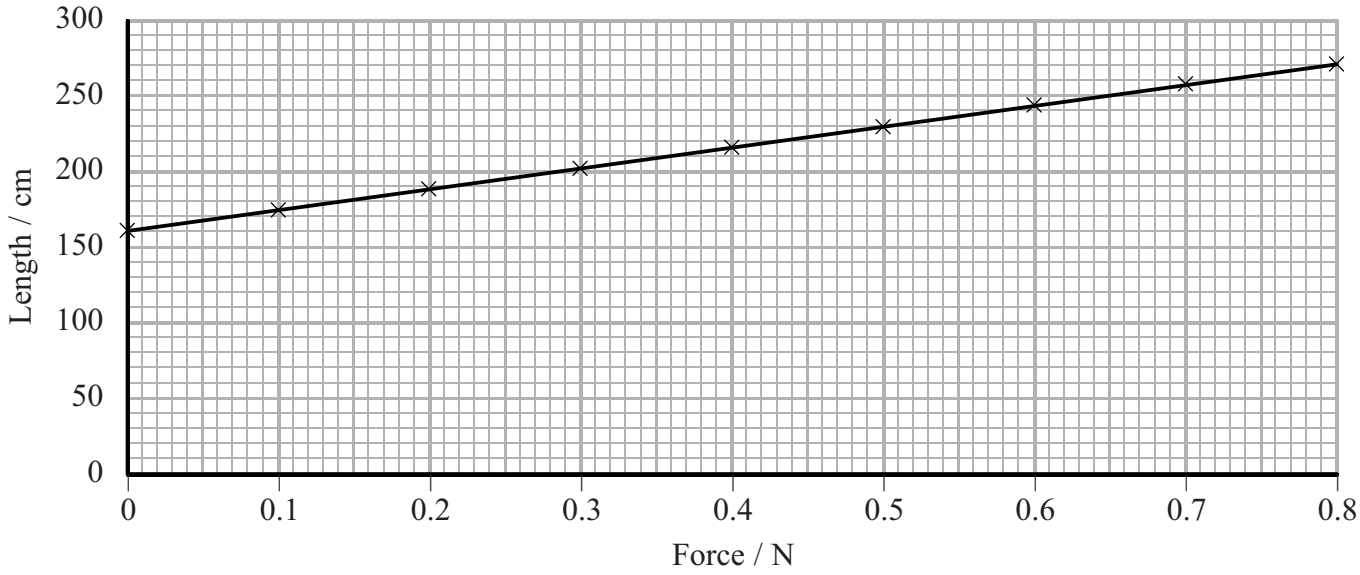
On the axes opposite sketch the graph for spring C and use it to help you describe the difference in the behaviour of springs A and C.

(6)

(Total for Question 15 marks)

2 A Slinky is a long spring made of metal. One end of a Slinky is fixed to the ceiling. The force acting on the Slinky was varied by hanging weights from the other end.

The graph shows the results.



(a) (i) Explain whether the results follow Hooke's law.

(2)

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(ii) Show that the stiffness of the Slinky is about 0.7 N m ^{1}.

(3)

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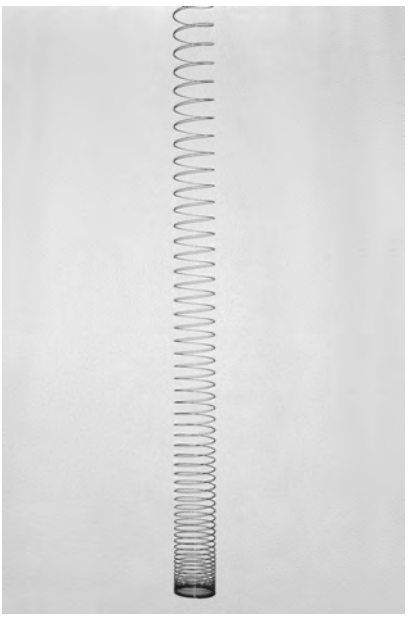
(iii) Calculate the elastic strain energy stored in the Slinky when the applied force is 0.70 N.

(3)

Elastic strain energy .....

(b) The photograph shows part of the Slinky hanging from a person's hand.



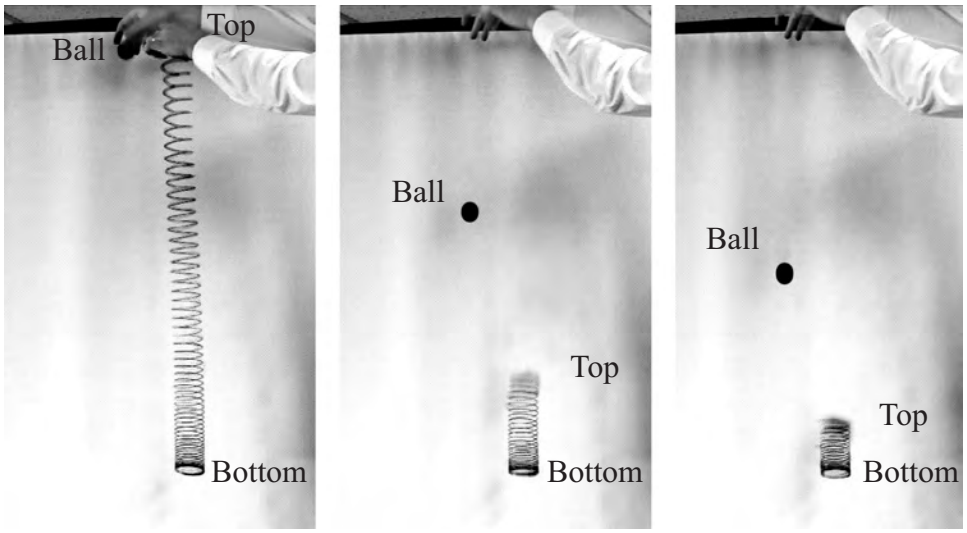
(i) Explain why the coils are extended more at the top than the bottom.

(2)

(ii) Mark and label the approximate position of the centre of gravity of the Slinky on the photograph above.

(1)

(iii) A ball is dropped from the same height, and at the same time, as the top of the Slinky is released. The three photographs below show what happens.



*(1) By considering the forces acting on the top coils of the Slinky, explain why they fall faster than the ball.

(3)

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(2) Suggest why the bottom coils remain in the same position in the three photographs.

(1)

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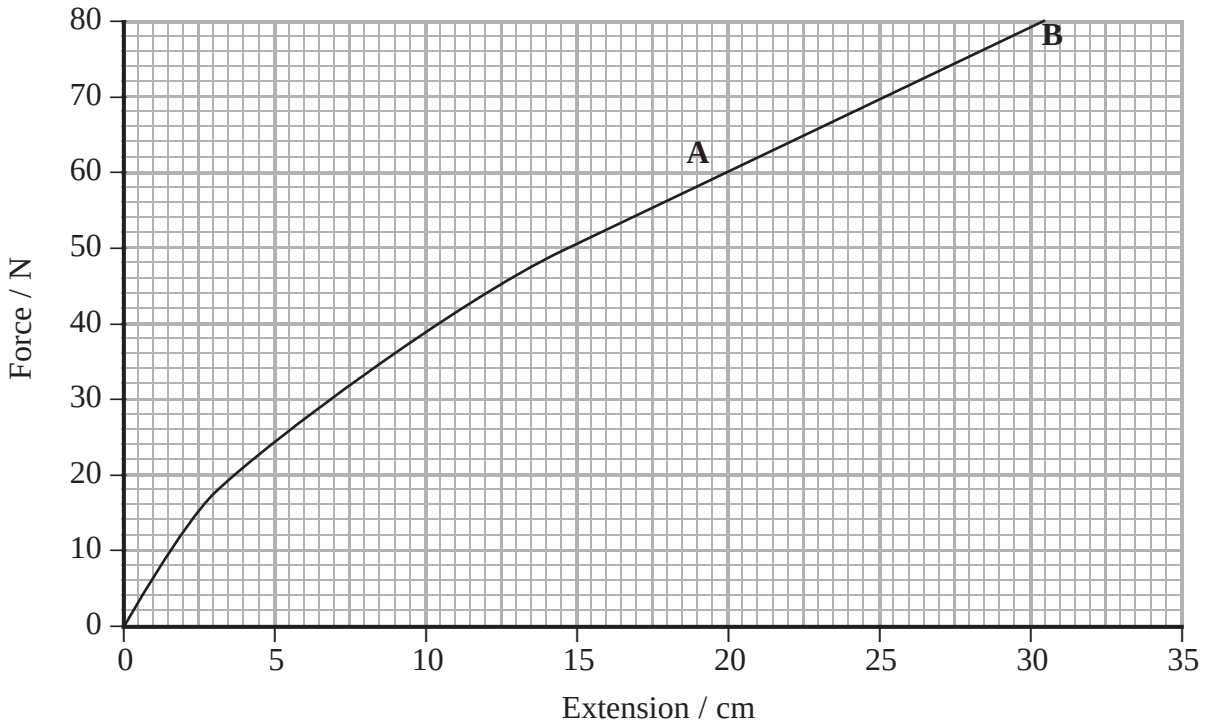
(Total for Question 15 marks)

3 The photographs show an exercise device and someone using it. The device contains two rubber cords which are extended when the device is used.

A student investigates the properties of the device by hanging weights on it and measuring the extension.

The student obtains the following graph for her results.



(a) The student notices that her graph is a straight line between A and B and concludes that the device obeys Hooke's law.

Comment on this conclusion.

(2)

(b) (i) Describe how the student could use the graph to obtain an estimate of the total work done.

(2)

(ii) The student sets up a spreadsheet to investigate the work done in stretching the device each time a weight is added.

	A	B	C	D
1	Total stretching force / N	Extension / cm	Change in extension / m	Work done (force × change in extension) / J
2	0	0.0	0.000	0.00
3	10	1.6	0.016	0.16
4	20	3.5	0.019	0.38
5	30	7.0	0.035	1.05
6	40	10.5	0.035	1.40
7	50	14.5	0.040	2.00
8	60	20.0	0.055	3.30
9	70	25.2	0.052	3.64
10	80	30.5	0.053	4.24
11			Total work done	16.17

Explain why this spreadsheet results in an over-estimate for the total work done.

(2)

(c) The student eats a packet of crisps and then uses the exercise device. The energy content in a packet of crisps is 540 kJ. During exercise this energy is converted and 25% of it is transferred to mechanical work.

The student extends the device fully 15 times in 1 minute. An accurate value for the work done in fully extending the device is 14.7 J.

Calculate the time it would take the student, working at this rate, to transfer 25% of the energy from the crisps to mechanical work.

(3)

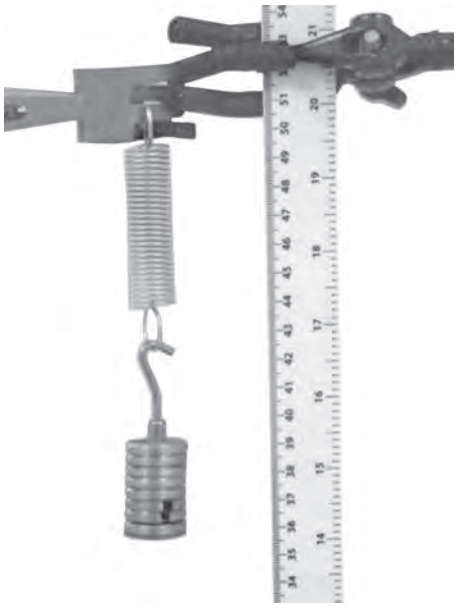
Time =

(d) Explain whether more or less work would be done applying the same maximum total stretching force to a similar exercise device with rubber cords of twice the cross-sectional area.

(2)

(Total for Question = 11 marks)

4 The apparatus shown can be used to determine the spring constant k of a spring.



*(a) Describe how the apparatus can be used to accurately obtain the measurements needed.

(4)

(b) Describe how the measurements would be used to determine a reliable value of *k*.

(3)

(c) State why it is important not to exceed the limit of proportionality of the spring.

(1)

(Total for Question = 8 marks)