1 The photograph shows what happens when soft mint sweets are dropped into a bottle containing a fizzy drink. There is a sudden release of gas which forces a long stream of fluid out of the bottle.

A student decides to calculate the amount of kinetic energy transferred to the fluid in this process. In one experiment, the student places the bottle at an angle of 50° to the horizontal, adds the sweets and measures the maximum horizontal distance travelled by the fluid. The student then calculates that the fluid left the bottle at a speed of 7.5 m s^{1}.

(a) (i) Show that the initial horizontal component of the fluid's velocity is about 5 m s^{1}.

(1)

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(ii) Show that the initial vertical component of the fluid's velocity is about 6 m s^{1}.

(1)

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....

(iii) Use these values to calculate the maximum horizontal distance travelled by the fluid. Assume the fluid leaves the bottle at ground level.

(4)

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Maximum distance ....

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(b) (i) Calculate the total amount of kinetic energy transferred to the fluid.

total mass of bottle, contents and sweets before the experiment 2.24 kg
total mass of bottle, contents and sweets after the experiment 0.79 kg

(2)

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Kinetic energy ....

(ii) Give a reason why your value of kinetic energy might be higher than the true value.

(1)

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(iii) Explain why your value of kinetic energy might be lower than the true value.

(2)

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(Total for Question 11 marks)

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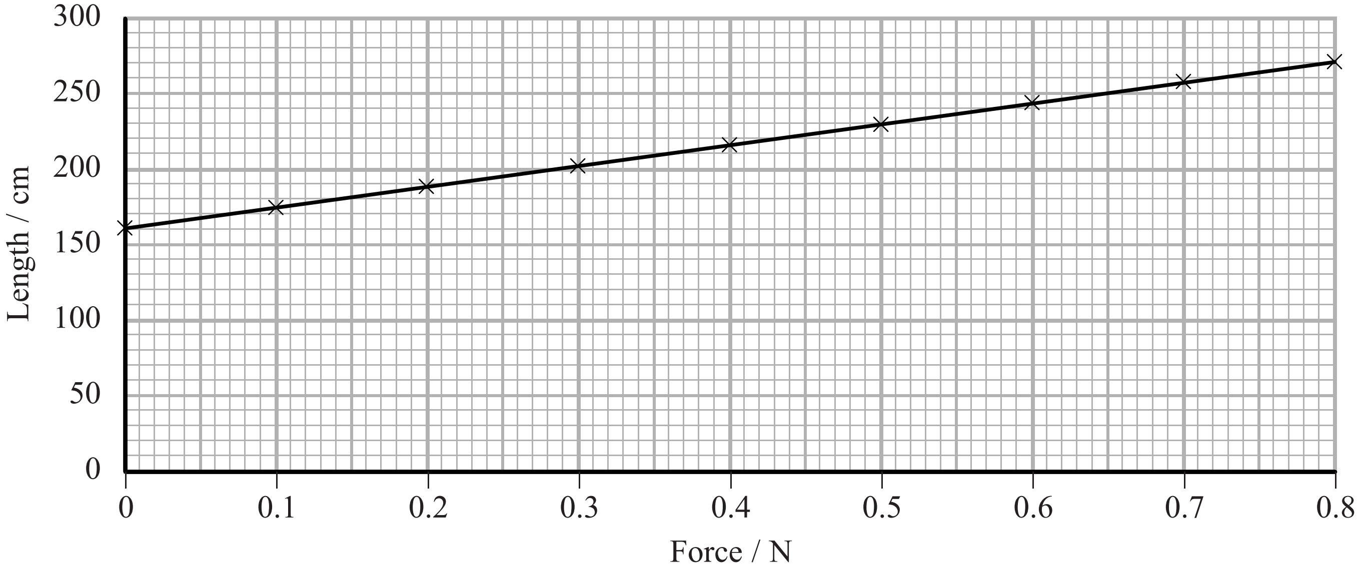
2 A Slinky is a long spring made of metal. One end of a Slinky is fixed to the ceiling. The force acting on the Slinky was varied by hanging weights from the other end.

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)

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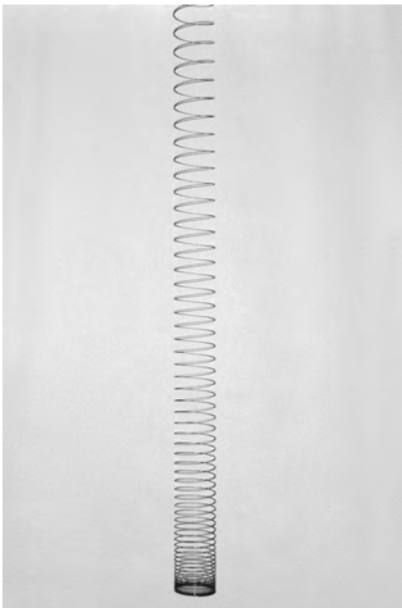
Elastic strain energy ....

(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)

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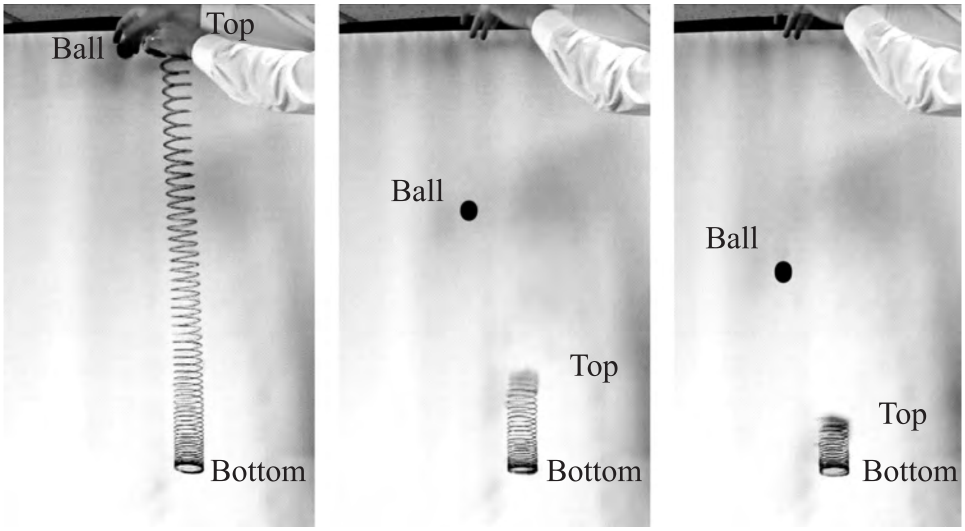
(iii) A ball is dropped from the same height, and at the same time, as the top of the Slinky is released. The three photographs below show what happens.



*(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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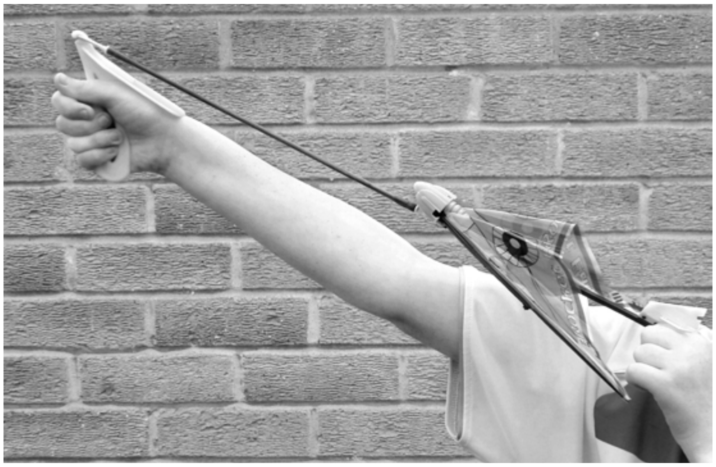
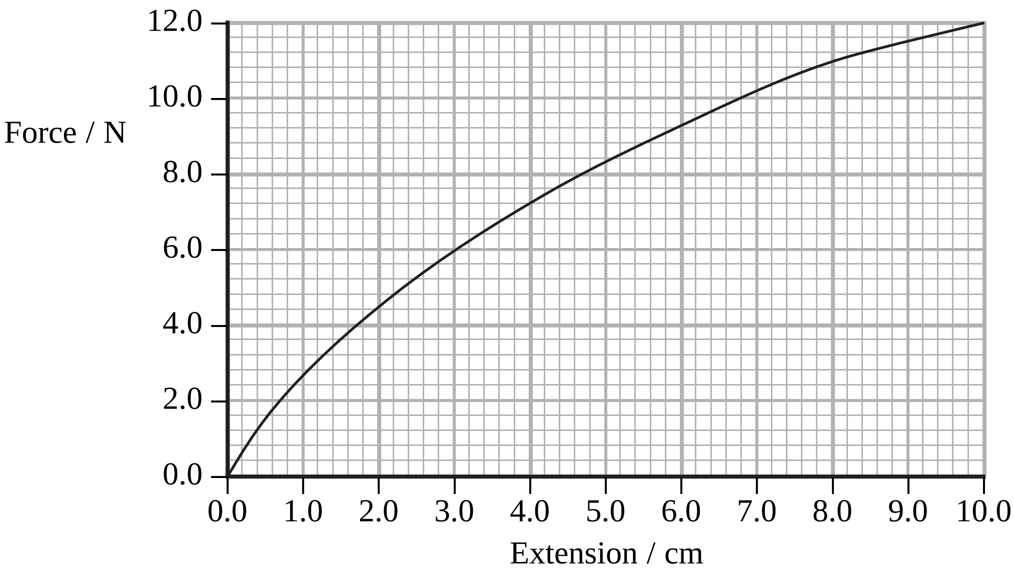
(Total for Question 15 marks)

*3 The photograph shows a long rubber band being used to launch a model aeroplane.



The following graph shows force against extension for the rubber band.



(a) Explain whether the rubber band obeys Hooke's law.

(2)

(b) Use the graph to show that the elastic strain energy stored in the rubber band when it has an extension of 10.0 cm is less than 0.8 J.

(3)

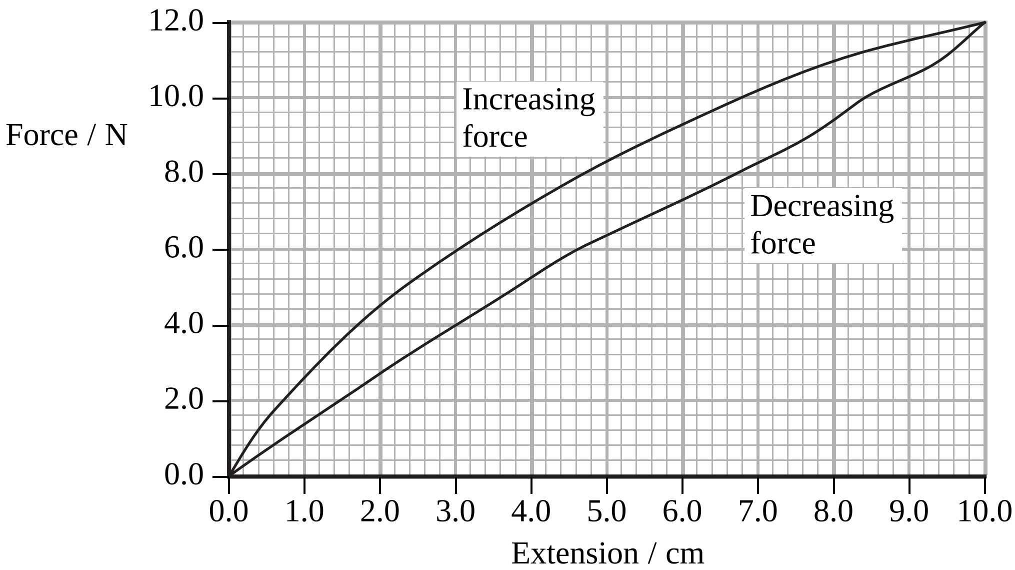
(c) The rubber band is extended by 10.0 cm before being released to launch the aeroplane. Calculate the maximum possible initial speed of the aeroplane.

Mass of aeroplane = 0.027 kg

(3)

Speed =

(d) The following graph shows two lines. Measurements were obtained by increasing the force on the band to 12 N and then decreasing the force.



(i) Describe the energy transfers taking place when the force on the band is increased and then decreased.

(2)

(ii) The maximum speed of the aeroplane will be less than that calculated in (c). Without further calculation use the graph to explain this.

(3)

(Total for Question = 13 marks)

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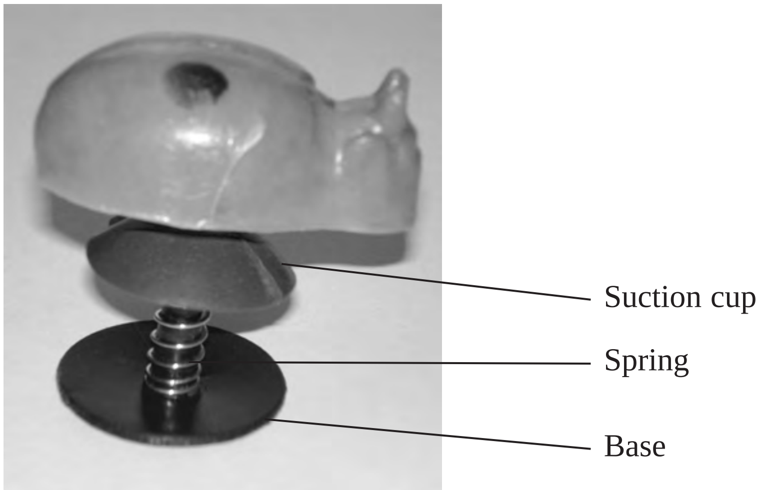
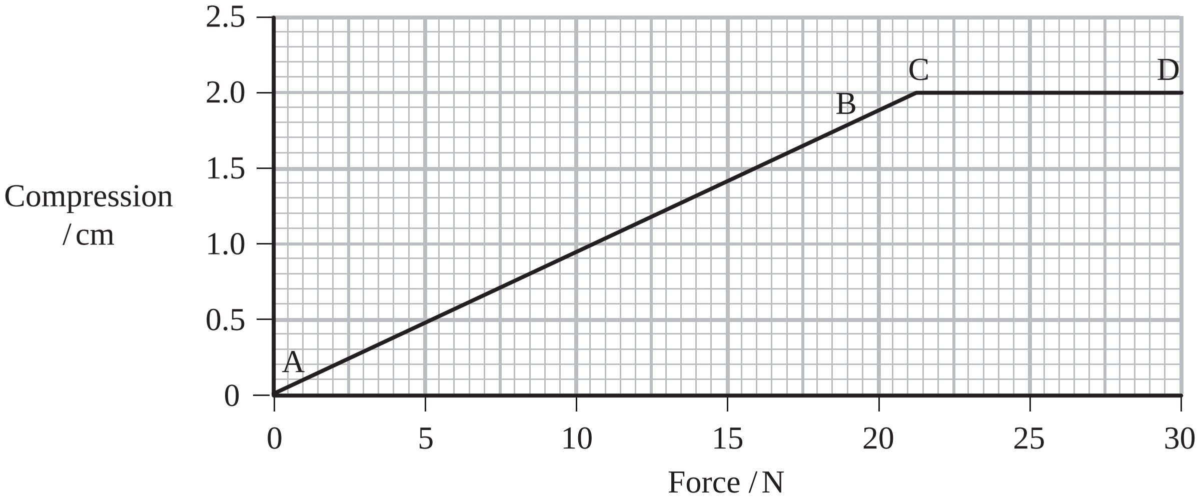
4 The picture shows a jumping toy on which a student carries out some experiments.



The top of the toy is pushed down, compressing the spring. The suction cup adheres to the base and holds the toy down. After a short time, the suction cup leaves the base, causing the toy to jump.

A compression–force graph is obtained for the spring in the toy.



(a) (i) Explain the shape of section AB of the graph.

(1)

....

....

(ii) Explain why section CD of the graph is horizontal.

(1)

....

....

....

(b) Show that the stiffness of the spring is about $1000\ N\ m^{-1}$.

(2)

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....

....

(c) As the suction cup is about to leave the base the compression of the spring is 0.018 m.

(i) Calculate the energy stored in the spring at this stage.

(2)

....

....

....

Energy stored = ...

(ii) Calculate the maximum possible height reached by the toy.

Mass of toy = 7.3×10^{-3} kg

(2)

....

....

....

Height = ...

(iii) State an assumption made in your calculation.

(1)

....

(d) The student uses a camera to video the movement of the toy in front of a metre rule. The video is then used to find the maximum height reached by the toy.

(i) Explain the advantage of using the video camera over making observations just by eye.

(2)

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(ii) The student repeats this procedure several times and records the following data:

0.45 m, 0.44 m, 0.36 m, 0.46 m, 0.45 m.

mean maximum height = 0.45 m

Why is the student justified in using 0.45 m as the mean?

(1)

....

....

(Total for Question = 12 marks)

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5 A car of mass 1200 kg is travelling at a speed of 25 m s^{-1}. During braking, 25% of the kinetic energy of the car is transferred to the brake pads.

Calculate the increase in temperature of the brake pads.

total mass of brake pads = 5.3 kg
specific heat capacity of brake pads = 450 J kg^{-1} K^{-1}

(4)

Increase in temperature =

(Total for Question = 4 marks)

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