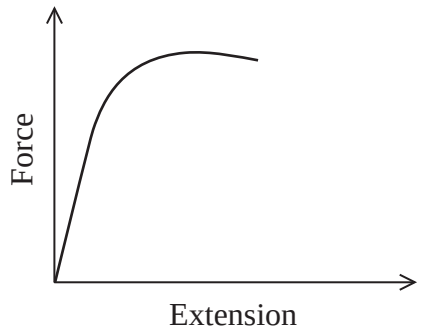
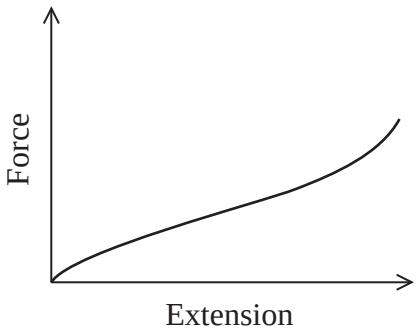
1 In a physics lesson the following graphs are given to the students. The graphs show the relationship between force and extension for samples of two different materials, A and B.



Sample A



Sample B

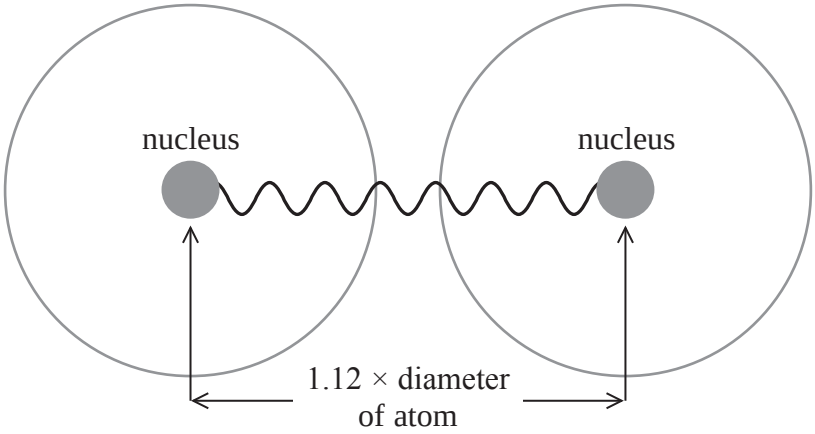
A student states that sample A obeys Hooke's law for small extensions and sample B does not.

Use the graphs to explain the validity of the student's statement.

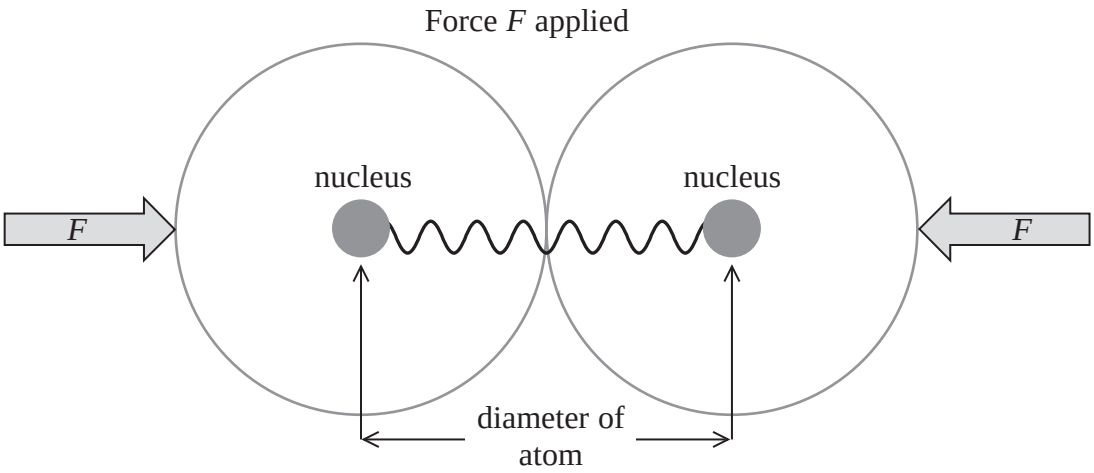
(3)

(Total for Question = 3 marks)

2 The forces between the two atoms in a molecule of hydrogen can be modelled using a spring. When in equilibrium the nuclei are separated by 1.12 × diameter of the atom.



(a) When the atoms are squashed together by a force *F*, the spring is under compression.



When the force *F* acts on the atoms, the separation between the nuclei becomes equal to the diameter of the atom.

Calculate the force *F*.

spring constant for hydrogen = 1130 N m^{-1}

diameter of an atom of hydrogen = 1.06 × 10^{-10} m

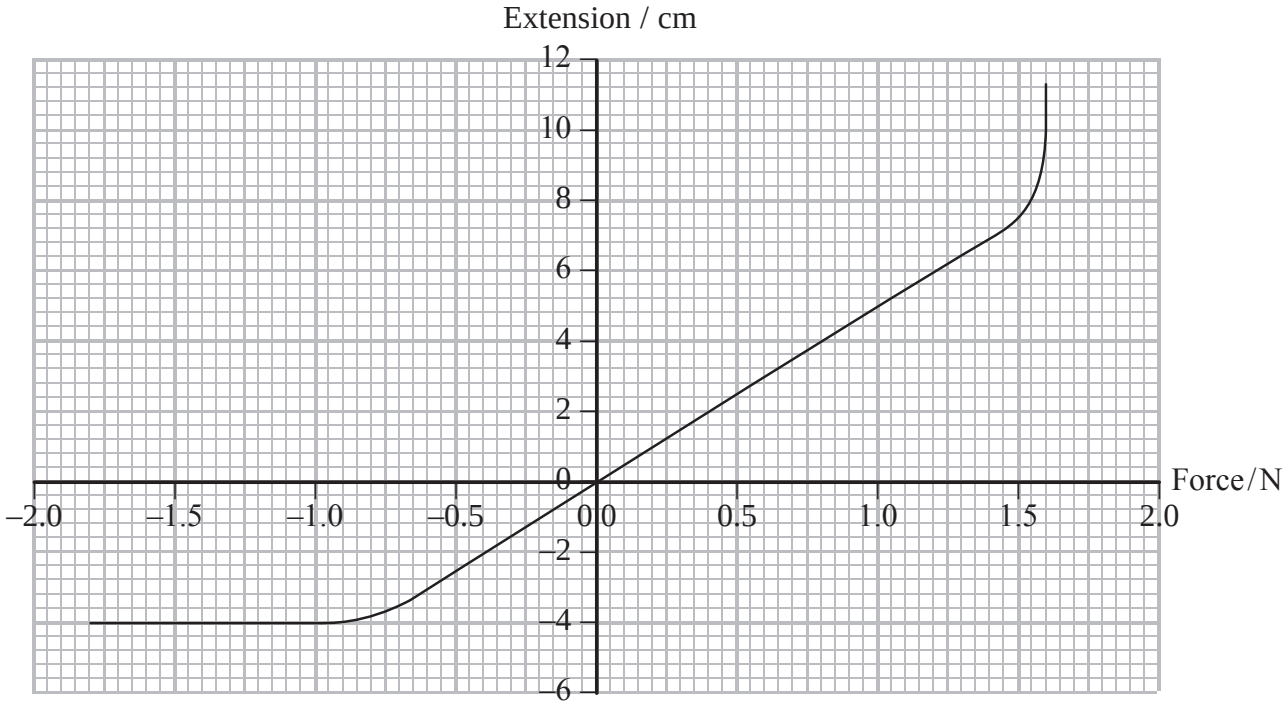
(3)

Force =

(b) A student carries out an experiment to model the forces between atoms.

A varying force is applied to the end of a spring. The student measures the length of the spring and calculates the extension for each force applied.

The student plots the following graph.



(i) Explain the shape of the graph.

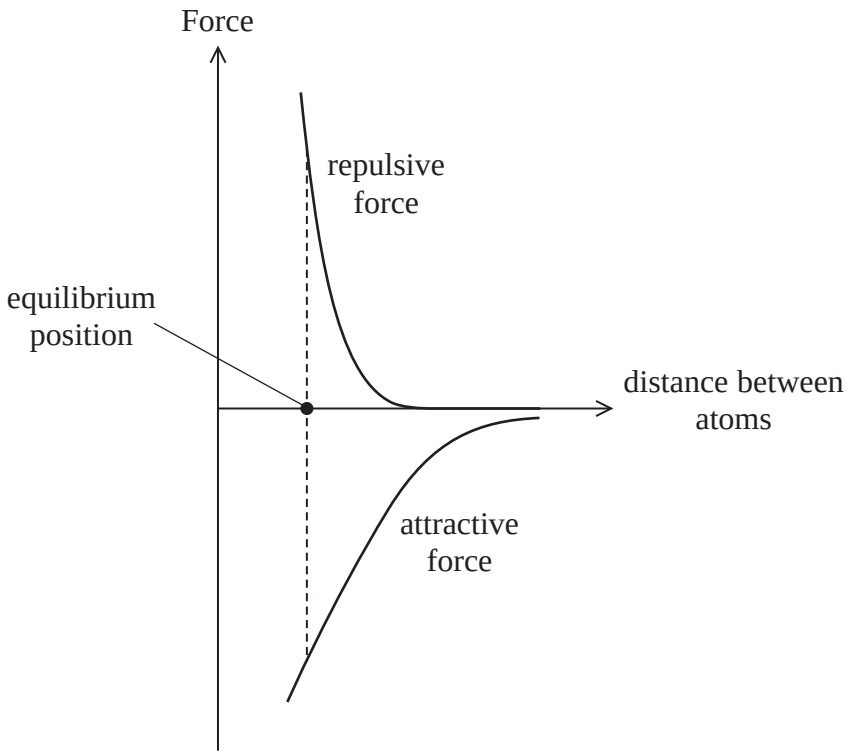
(3)

(ii) Use the graph to calculate the spring constant.

(2)

Spring constant =

*(c) The graph below shows how the forces acting between two atoms consist of a repulsive force and an attractive force. At the equilibrium position, the sum of these forces is zero.

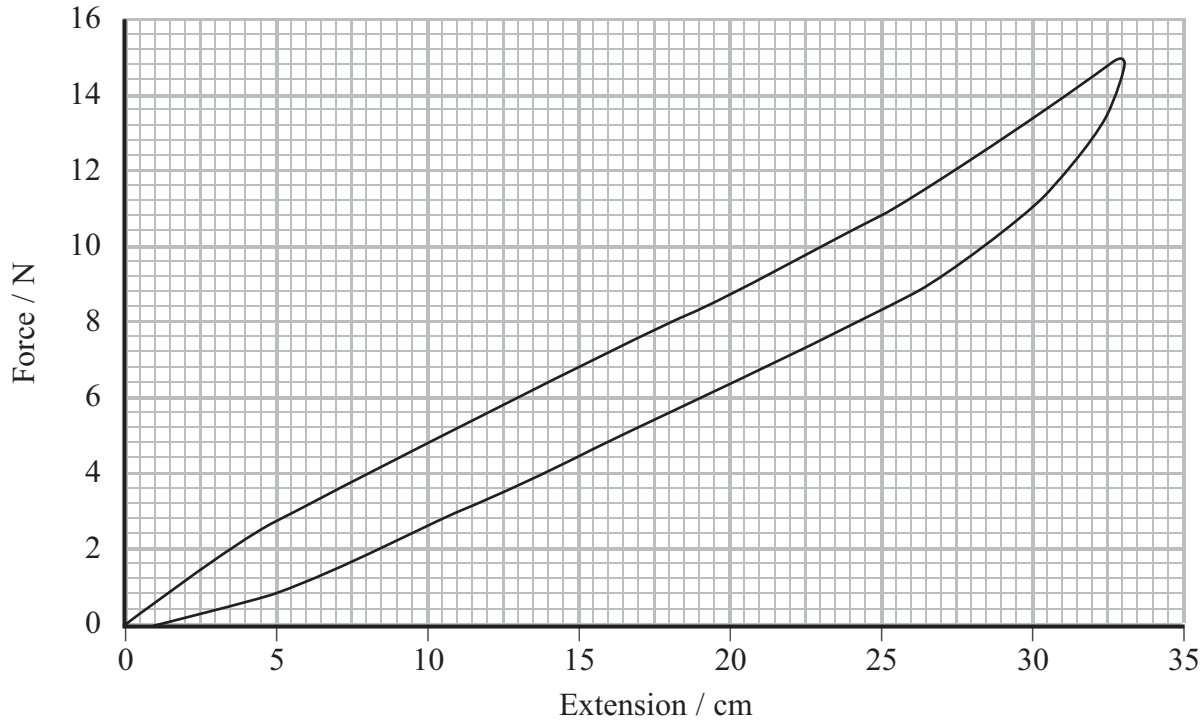


Use the graph to explain why the forces between atoms are attractive when they are pulled apart and repulsive when pushed together.

(3)

(Total for Question = 11 marks)

3 A student investigates the effect of varying the stretching force applied to the elastic waistband of some trousers.



The graph produced by the student shows the stretching force against extension for the elastic waistband. The top line was recorded as the force increased and the lower line as the force decreased.

(a) Explain whether the elastic waistband obeys Hooke's law.

(2)

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(b) Show that, in this investigation, the work done on the elastic waistband in stretching it is less than 3 J.

(2)

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(c) Suggest how the elastic properties of the waistband help in keeping the trousers in place.

(2)

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(d) The line for the decreasing force is lower than the line for the increasing force.

Explain the significance of this.

(2)

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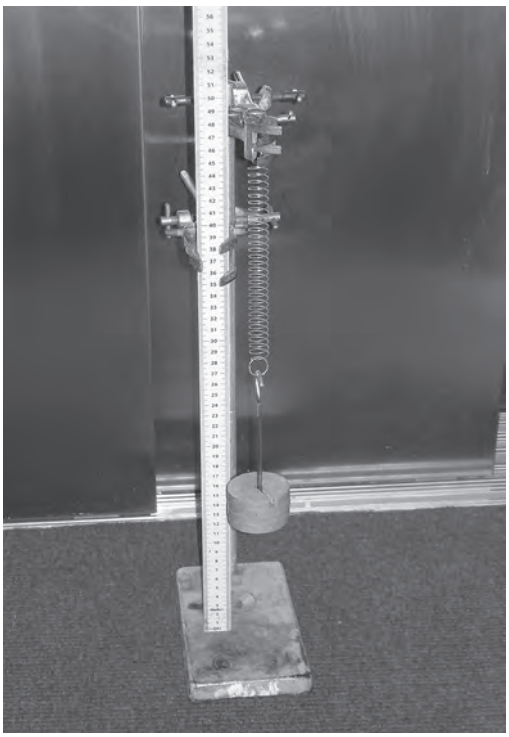
(Total for Question 8 marks)

4 A student uses a mass hanging on a spring to investigate the motion of a lift travelling between two floors.

The photograph shows the apparatus used which is placed in the lift.



(a) The weight of the mass hanging on the spring is 3.90 N.

It produces an extension of 12.2 cm.

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

(2)

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(b) The lift takes 7.0 s to travel between floors, starting and ending at rest.

The student makes a video of the apparatus and constructs the following table from the observations made. The student notes three phases of the motion.

Phase of motion	Duration of phase / s	Average extension of spring / cm	Average acceleration / m s ^{2}
Start	2.0	12.7	0.4
Middle	3.0	12.2	0.0
End	2.0	11.7	0.4

(i) Show that the spring exerts a force of about 4 N on the mass during the start phase.

(2)

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(ii) Show how the average acceleration during the start phase is calculated.

mass hanging on spring 0.40 kg

(2)

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(iii) Use the values in the table to calculate the speed at the end of the start phase.

(2)

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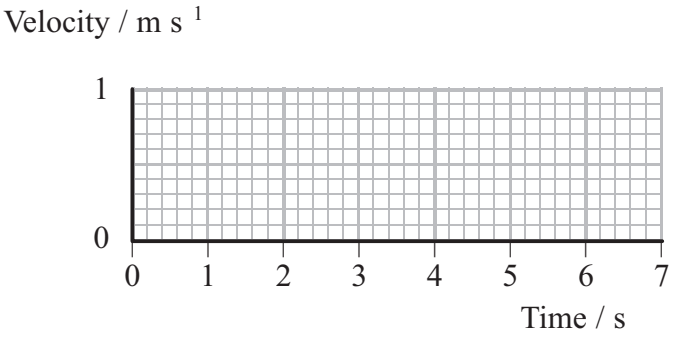
Speed .....

(iv) Complete the graph to show the motion of the lift.

(2)



(v) Use your graph to find the distance travelled between the floors.

(2)

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Distance .....

(vi) Explain how the data for the average extension of the spring shows that the lift is moving upwards.

(2)

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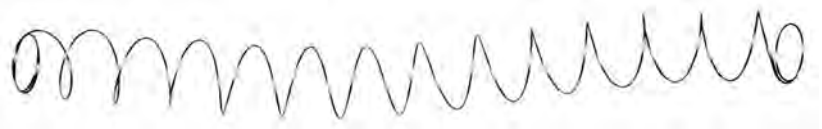
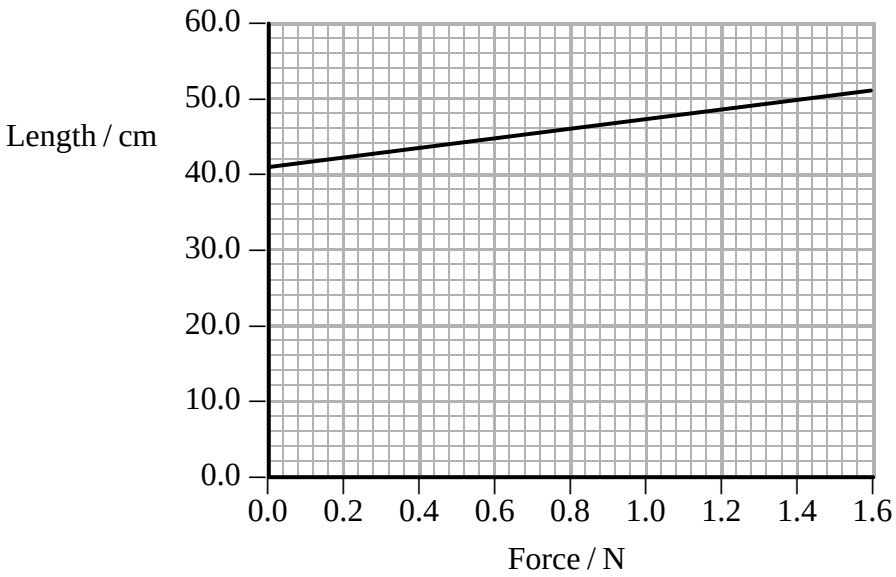
(Total for Question 14 marks)

5 The photograph shows a tin bought from a joke shop. When the lid is removed, a long spring, covered in fabric to resemble a snake, flies out of the tin.

The spring on its own is shown here.



The graph shows length against force for the spring.



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

(2)

(b) Show that the spring constant k of the spring is about 20 N m^{-1}.

(3)

k =

(c) The original length of the spring is 41.0 cm and the length of the tin is 9.0 cm.

(i) Calculate the force that must be applied to the spring to get it into the tin.

(2)

Force =

(ii) Calculate the energy stored in the spring when it is compressed to fit into the tin.

(2)

Energy =

(d) In fact the bottom of the tin contains a device that makes a squeak when the spring is released, making the internal length of the tin less than 9.0 cm.

Explain the effect this has on the speed at which the spring leaves the tin.

(3)

(Total for Question = 12 marks)

6 (a) A manufacturer of spring balances needs to select a spring that produces an extension of 0.80 cm for each 100 g mass added.

Show that the manufacturer will need to select a spring with a spring constant of about 120 N m^{-1}.

(3)

(b) The manufacturer states that the maximum mass that can be hung on the spring balance is 1.2 kg.

Explain why it is necessary to state the maximum mass.

(3)

(Total for Question = 6 marks)