1 A kite is held by a string and flies because of lift produced by the flow of air.

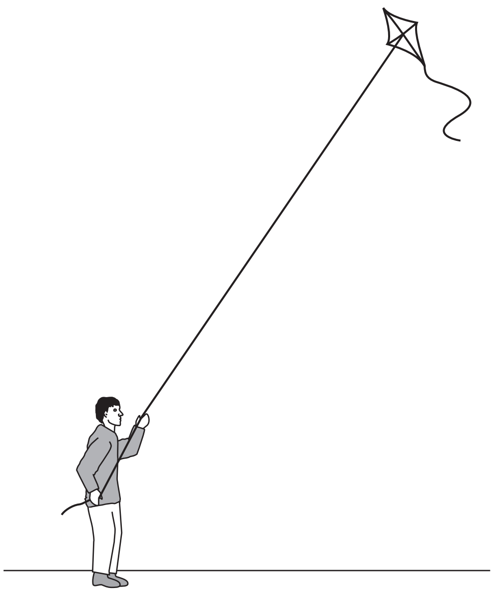


Figure 1

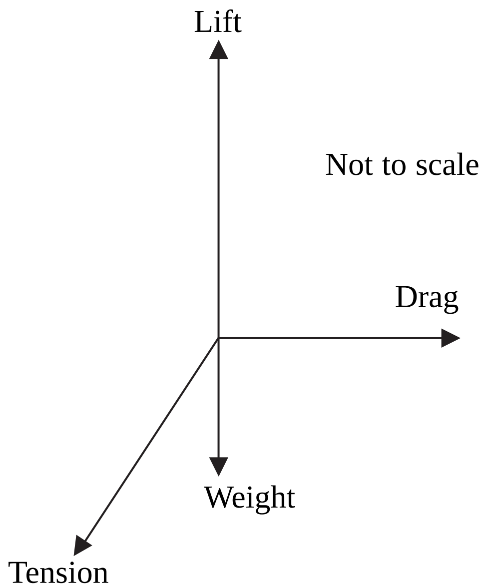


Figure 2

Figure 2 shows a free-body force diagram for the kite.

(a) Sketch a labelled vector diagram to show that the four forces are in equilibrium.

(1)

(b) The lift is 4.3 N, the drag is 6.0 N and the weight is 0.44 N.

Calculate the tension in the string. State its magnitude and direction from the horizontal.

(4)

Magnitude of tension =

Direction of tension from the horizontal =

(c) (i) The wind speed decreases so the girl flying this kite walks into the wind at a constant speed of 2.0 m s^{-1} to maintain the forces shown. Calculate the work done by the girl as she walks 25 m.

(2)

Work done =

(ii) Calculate the rate at which work is done by the girl.

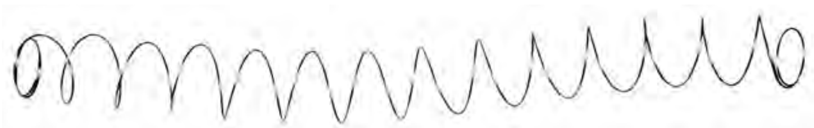
(2)

Rate at which work is done =

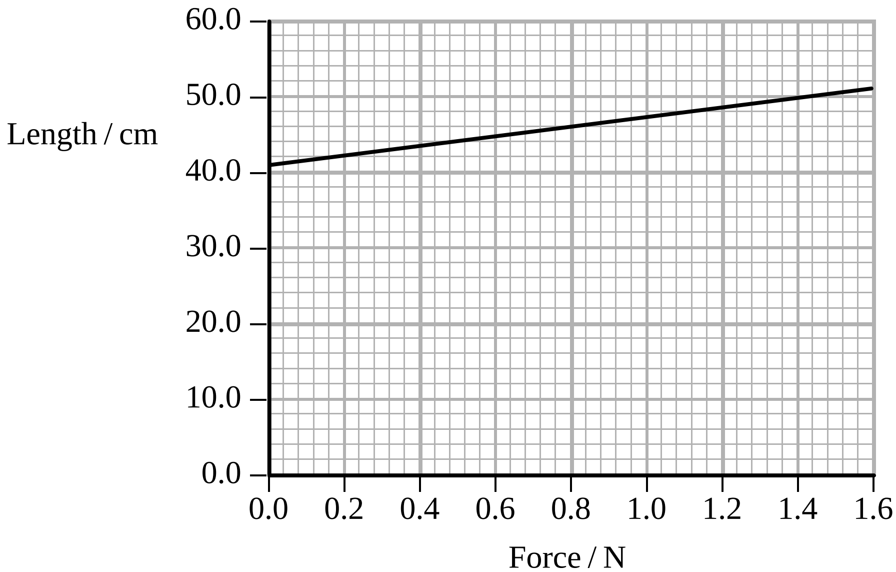
(Total for Question = 9 marks)

*2 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)

3 Champagne bottles are often opened by ‘firing’ the cork out of the bottle. The world record for the horizontal distance travelled by a fired cork is 53 m.

The high pressure inside the bottle produces an average force of 150 N on the cork as it leaves the bottle. This force acts on the cork over a distance of 2.5×10^{-2} m.

(a) Show that the work done on the cork is about 4 J.

(2)

(b) Calculate the maximum speed at which the cork could leave the bottle.

mass of cork = 7.5×10^{-3} kg

(2)

Speed =

(c) The cork is fired from ground level at an angle of 40° to the horizontal with a speed of 32 m s^{-1}.

(i) Show that the vertical component of the velocity is about 20 m s^{-1}.

(1)

(ii) Calculate the horizontal distance travelled by the cork through the air.

(5)

Distance =

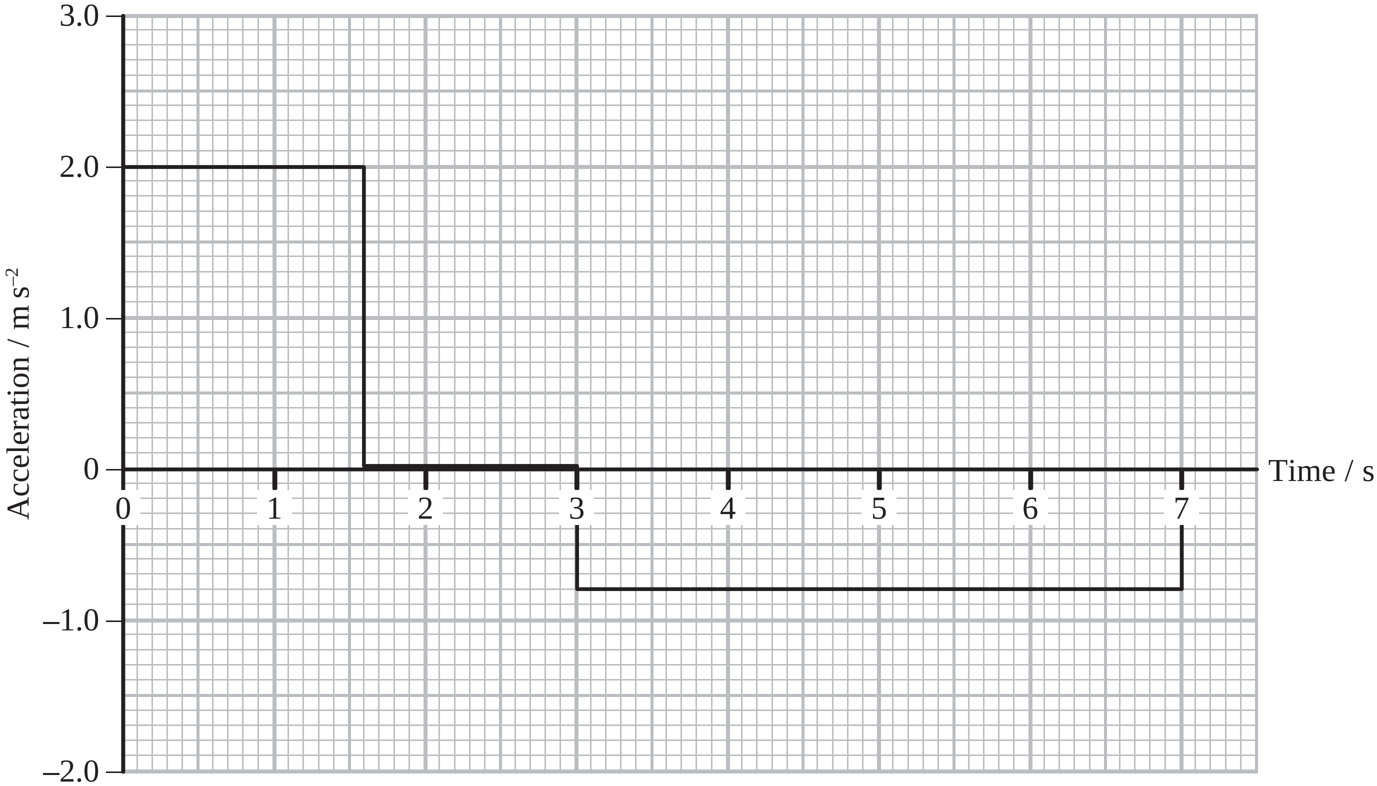
(d) Suggest an explanation for the difference between your calculated value and the world record distance.

(2)

(Total for Question = 12 marks)

4 The toy aeroplane in the photograph has a spring mechanism connected to the wheels. When the aeroplane is pulled backwards, the wheels rotate backwards and a spring is compressed. When the aeroplane is released, the force from the spring propels the aeroplane forwards.

The aeroplane is pulled backwards, released and then moves forward in a straight line along a flat surface. The simplified acceleration-time graph for the forward motion of the aeroplane is shown.

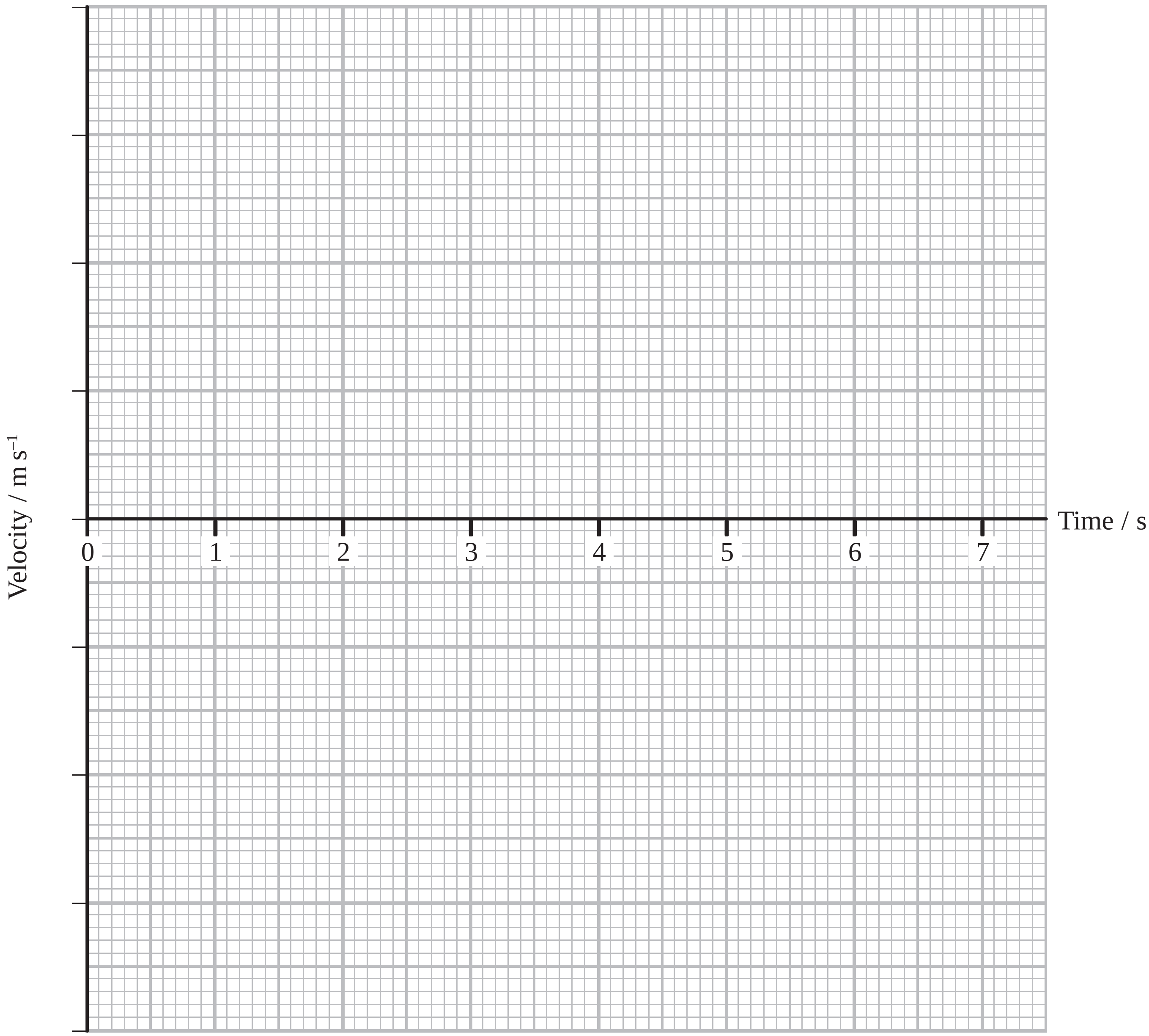


(a) Show that the maximum velocity of the aeroplane is about 3 m s^{-1}.

(2)

(b) On the axes below draw the corresponding velocity-time graph for the aeroplane.

(3)



(c) Calculate the total distance travelled by the aeroplane after release.

(3)

(d) (i) Calculate the maximum kinetic energy of the aeroplane.

mass of aeroplane = 0.12 kg

(2)

Maximum kinetic energy =

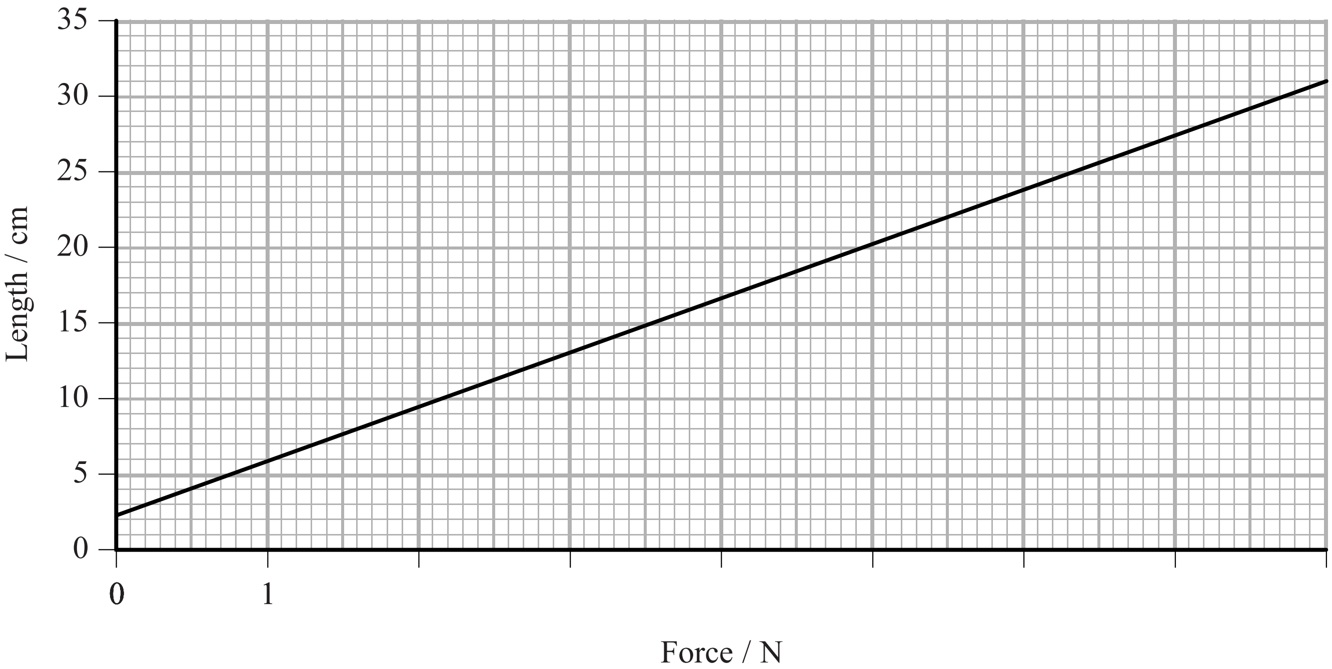
(ii) Calculate the mean power developed by the spring mechanism during the period of acceleration.

(2)

Mean power developed =

(Total for Question = 12 marks)

5 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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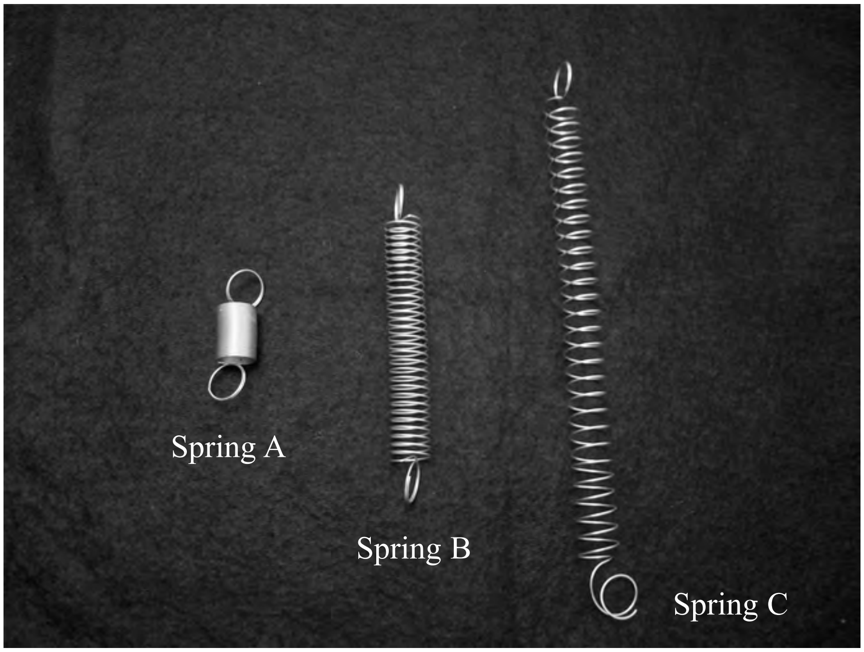
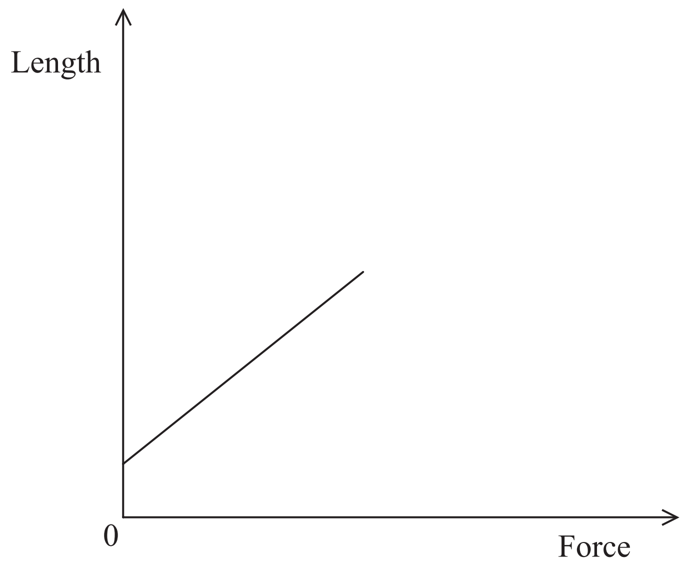
Maximum height ....

(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)

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(Total for Question 15 marks)