1)

(a) State *Hooke's law*.

....

.... **[1]**

(b) Fig. 6.1 shows a force against extension graph for a spring.

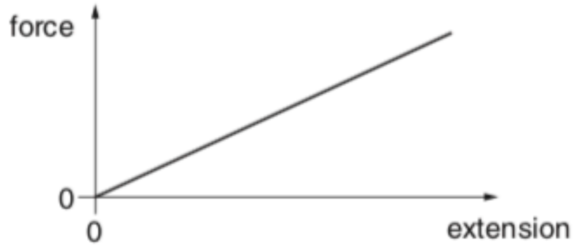

Fig. 6.1

Describe how such a force against extension graph can be used to determine

(i) the *force constant* of the spring

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(ii) the *work done* on the spring.

....

.... **[1]**

(c) Two identical springs are connected end-to-end (series). The force constant of each spring is k. The free ends of the springs are pulled apart as shown in Fig. 6.2.

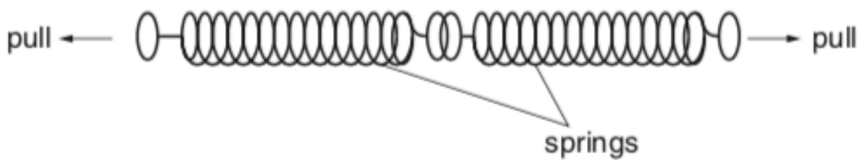

Fig. 6.2

Explain why the force constant of this combination of two springs in series is $\frac{k}{2}$.

....

....

.... **[2]**

(d) **(i)** Define the *Young modulus* of a material and state the condition when it applies.

....

....

.... **[2]**

(ii) A guitar string has length 0.70 m and cross-sectional area 0.20 mm^2. A constant tension of 4.2 N is applied to the string causing a strain of 0.015. Calculate

1 the stress in the string

stress = ... Pa **[2]**

2 the Young modulus of the material of the string

Young modulus = ... Pa **[2]**

3 the elastic potential energy (stored energy) in the string.

energy = ... J **[3]**

[Total: 14]

2)

The force against length graph for a spring is shown in Fig. 6.1.

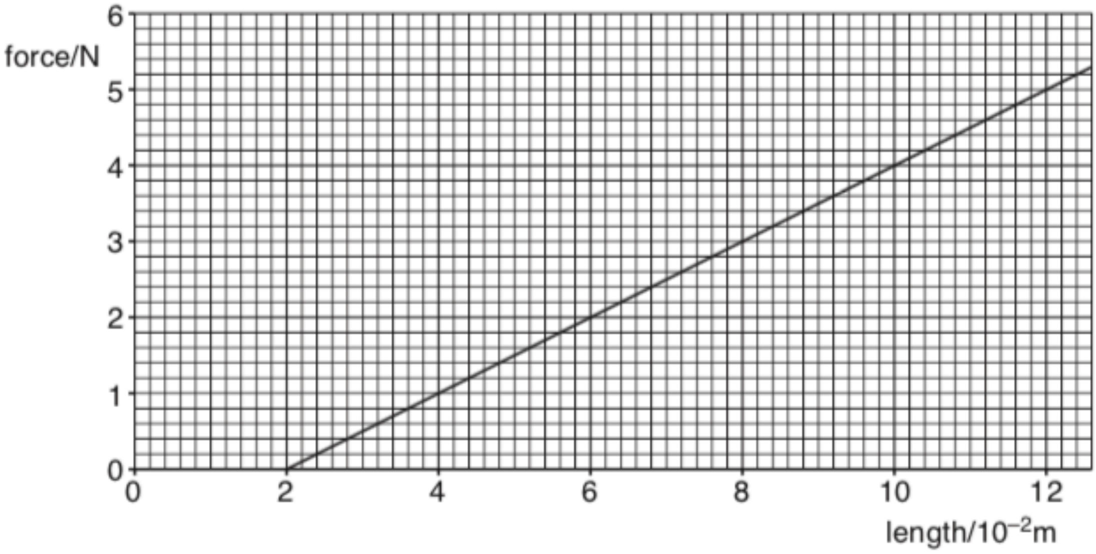

Fig. 6.1

(a) Explain why the graph does not pass through the origin.

....

.... **[1]**

(b) State what feature of the graph shows that the spring obeys Hooke's law.

....

.... **[1]**

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ... $N\,m^{-1}$ **[2]**

(d) Calculate the work done on the spring when its length is increased from 2.0×10^{-2} m to 8.0×10^{-2} m.

work done = ... J **[2]**

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 6.2 shows the displacement *s* against time *t* graph for the mass.

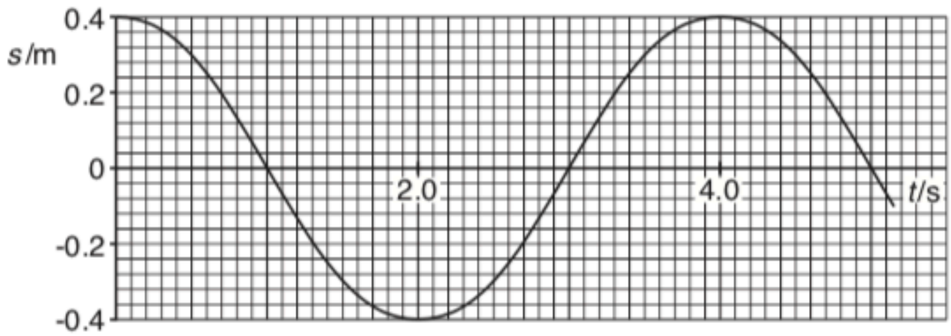

Fig. 6.2

Explain how you can use Fig. 6.2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

....

....

....

.... **[2]**

[Total: 8]

3)

A sample of wire is tested in the laboratory. Fig. 8.1 shows the force, *F* against extension, *x* graph for this wire.

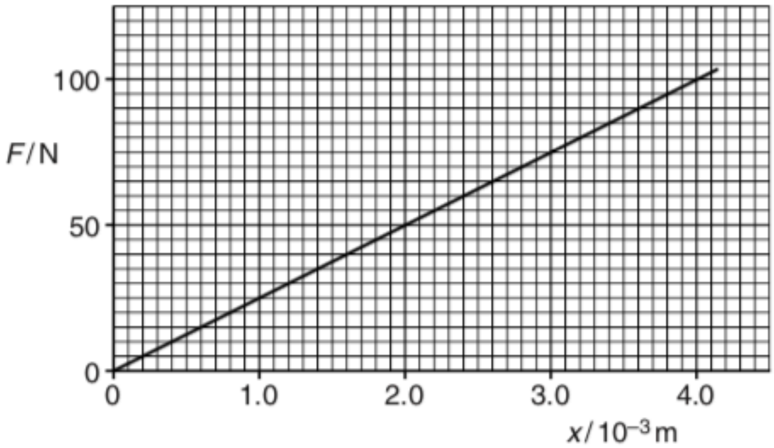

Fig. 8.1

(a) Explain how the graph shows that the wire obeys Hooke's law.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(b) State what the gradient of the graph represents.

.... **[1]**

(c) The initial length of the wire is 1.60 m. The radius of the wire is 2.8×10^{-4} m. Use the graph and this information to determine the Young modulus of the material of the wire.

Young modulus = ... Pa **[3]**

(d) The test is repeated for another wire made from the same material, having the same length but **half** the diameter. Explain how the force against extension graph for this wire will differ from the graph of Fig. 8.1.

....

....

....

....

.... **[2]**

(e) It is very dangerous if the wire under stress suddenly breaks. The elastic potential energy of the strained wire is converted into kinetic energy. Show that the 'whiplash' speed v of the wire is directly proportional to the extension x of the wire.

....

....

.... **[2]**

[Total: 9]

4)

A glider of mass 0.180 kg is placed on a horizontal frictionless air track. One end of the glider is attached to a compressible spring of force constant 50 N m^{-1}. The glider is pushed against a fixed support so that the spring compresses by 0.070 m, see Fig. 6.2. The glider is then released.

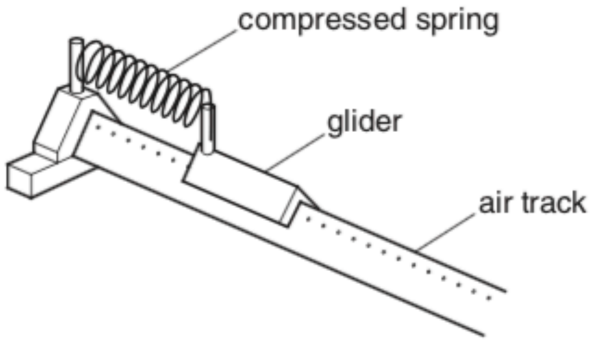

Fig. 6.2

(i) Calculate the horizontal acceleration of the glider **immediately** after release.

acceleration = ... m s^{-2} **[3]**

(ii) After release, the spring exerts a force on the glider for a time of 0.094 s. Calculate the average rate of work done by the spring on the glider.

average rate of work done = ... J s^{-1} **[2]**

5)

Fig. 7.2 shows a mechanism for firing a table tennis ball vertically into the air.

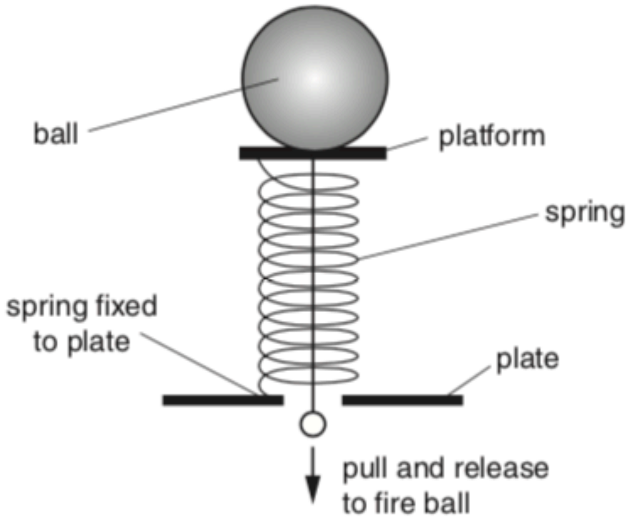

Fig. 7.2

The spring has a force constant of $75\,\text{N m}^{-1}$. The ball is placed on the platform at the top of the spring.

(i) The spring is compressed by 0.085 m by pulling the platform. Calculate the force exerted by the compressed spring on the ball **immediately** after the spring is released. Assume both the spring and the platform have negligible mass.

force = ...N **[2]**

(ii) The mass of the ball is 2.5×10^{-3} kg. Calculate the initial acceleration of the ball.

acceleration = ... m s^{-2} **[1]**

(iii) Calculate the maximum height that could be gained by the ball. Assume all the elastic potential energy of the spring is converted into gravitational potential energy of the ball.

height = ... m **[3]**

[Total: 11]

6)

(a) Define the *force constant* of a spring.

....

.... **[1]**

(b) Fig. 3.1 shows a trolley attached by two **stretched** springs **A** and **B** to fixed supports.

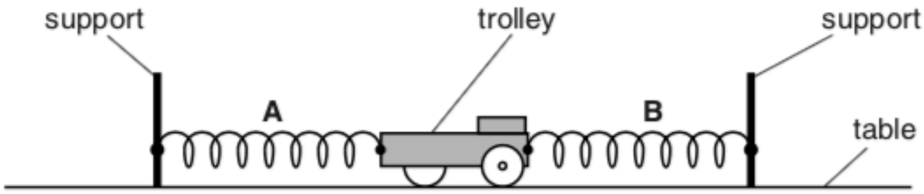

Fig. 3.1

The trolley is on a horizontal table and at rest. The springs **A** and **B** are identical.

(i) On Fig. 3.1, draw an arrow to show the direction of the force exerted by spring **A** on the trolley. Label this arrow **F**. **[1]**

(ii) The mass of the trolley is 0.80 kg. The force constant of each spring is $14\,\mathrm{N\,m^{-1}}$. A student pulls the trolley to the left as shown in Fig. 3.2.

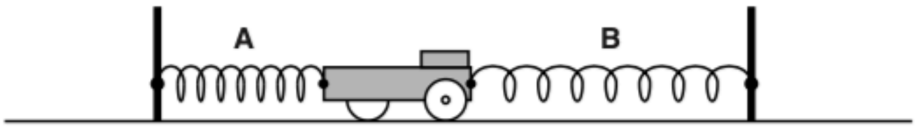

Fig. 3.2

The extension of spring **A** is 0.30 m and the extension of spring **B** is 0.50 m. The student releases the trolley. Calculate the **initial** values of

1 the acceleration of the trolley

acceleration = ... $m\,s^{-2}$ **[3]**

2 the ratio

$$\frac{\text{elastic potential energy for spring } \mathbf{B}}{\text{elastic potential energy for spring } \mathbf{A}}.$$

ratio = ... **[2]**

(iii) Explain why the acceleration of the trolley decreases as it travels a small distance to the right.

....

.... **[1]**

(iv) State and explain how the acceleration in your answer to **(ii)1** would be different when a heavy object is fixed to the trolley.

....

....

....

.... **[2]**

[Total: 10]

7)

A light spring of unextended length 2.0 cm is hung from a fixed point. An object of weight 3.0 N is hung from the other end of the spring. Fig. 7.1 shows the length of the spring when the object is in equilibrium.

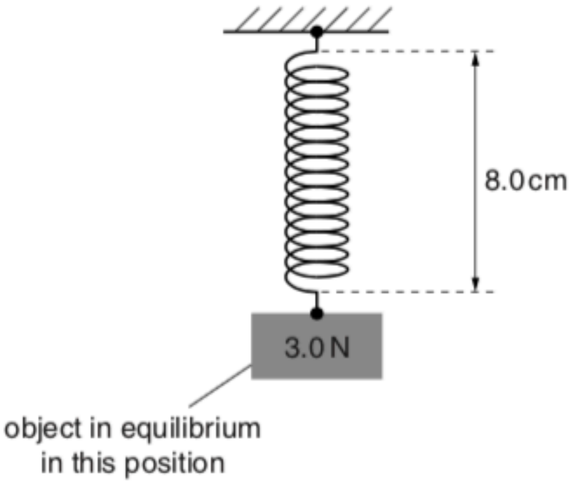

Fig. 7.1

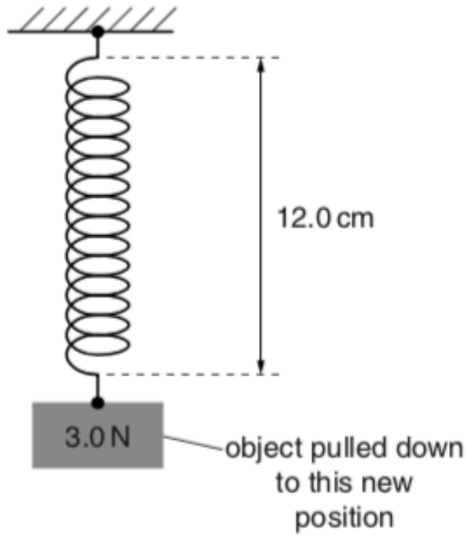

Fig. 7.2

(a) Show that the force constant of the spring is $50\,\text{N}\,\text{m}^{-1}$.

[1]

(b) The object is pulled vertically downwards. Fig. 7.2 shows the new length of the spring.

(i) Calculate the change in the elastic potential energy ΔE in the spring.

ΔE = ... J **[3]**

(ii) The object is released from its position shown in Fig. 7.2. Calculate the initial upward acceleration *a* of the object.

a = ... $m\,s^{-2}$ **[3]**

[Total: 7]

8)

(a) **(i)** Define the *force constant* of a spring.

....

.... **[1]**

(ii) Fig. 6.1 shows a load supported by two identical springs arranged in parallel.

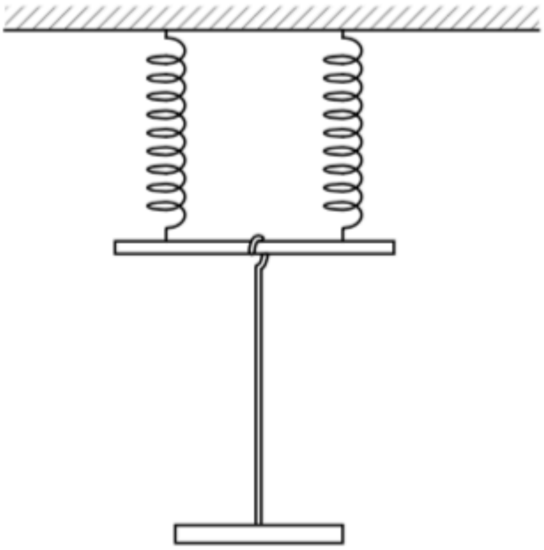

Fig. 6.1

Explain why the force constant of the parallel arrangement of springs is twice the force constant of one spring.

....

....

.... **[1]**

(b) Fig. 6.2 shows a thin strip of aluminium which is secured by a clamp stand.

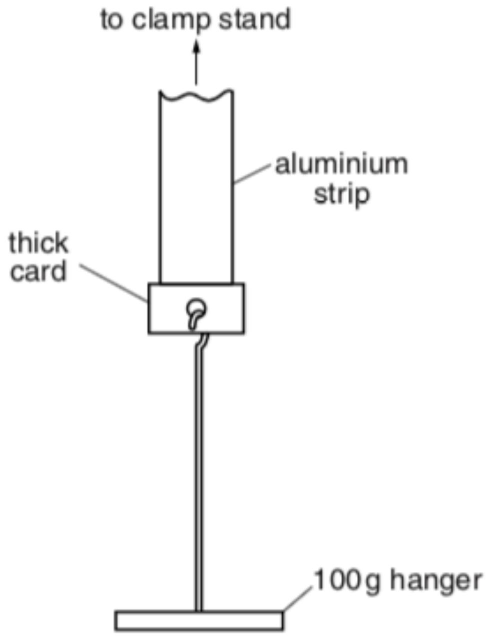

Fig. 6.2

The width of the strip has been measured to be 1.0 cm. A piece of thick card is taped to the lower end of the strip. A 100 g mass hanger is hooked through the card as shown in Fig. 6.2. A number of 100 g slotted masses and a micrometer are also available.

Describe how you would use the equipment to determine the **breaking stress** of aluminium.

....

....

....

....

....

....

....

....

....

.... **[3]**

(c) Fig. 6.3 shows the graph of stress against strain for a wire made from a ductile material.

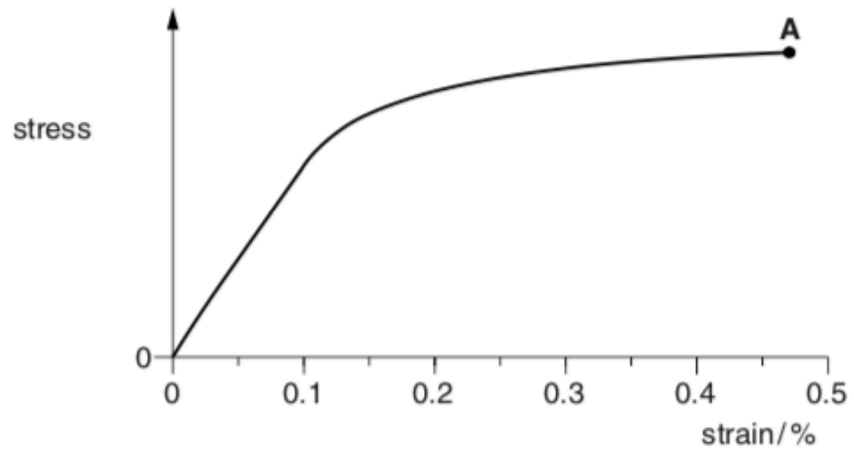

Fig. 6.3

(i) Describe the behaviour of the wire when the strain is less than 0.05%.

....

....

.... **[1]**

(ii) The wire is used to support a heavy load. The strain in the wire is 0.3%. Describe what happens to the wire when the load is removed.

....

....

.... **[1]**

(iii) A student suggests that the ratio of stress to strain at point **A** is equal to the Young modulus of the material. Explain whether or not this suggestion is correct.

....

....

.... **[1]**