A student carried out an experiment to determine the Young modulus of a material in the form of a wire. The original length and diameter of the wire were measured. A load was applied to the wire and the corresponding extended length was measured.

8 Which of the following combinations of original length and diameter would produce the greatest extension for a given load?

	Original length	Diameter
☒ A	long	large
☒ B	long	small
☒ C	short	large
☒ D	short	small

(Total for Question 8 = 1 mark)

10 A student investigated Hooke's law using the equipment shown. As each additional load was added, the new position of a marker along a metre rule was recorded and the extension calculated.
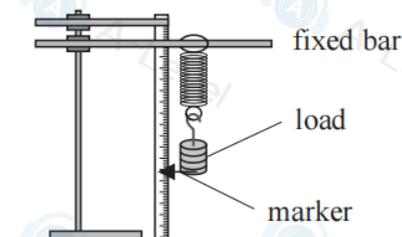
The investigation was repeated with an additional identical spring, arranged as shown.
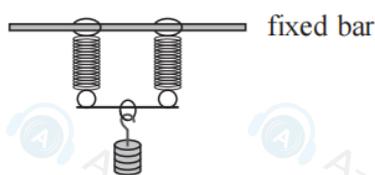
For a given applied load, which of the following statements is correct?

☒ A The extension is doubled because the spring constant is doubled.

☒ B The extension is doubled because the spring constant is halved.

☒ C The extension is halved because the spring constant is doubled.

☒ D The extension is halved because the spring constant is halved.

(Total for Question 10 = 1 mark)

9 A force is applied to stretch two wires, P and Q, until the wires break. Each wire is made of a different metal.

The stress-strain graph for each wire is shown.
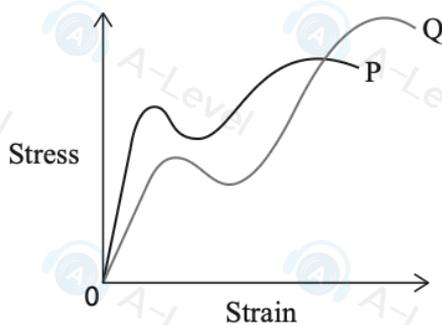
Which of the following statements is correct?

☒ **A** P has a greater breaking stress than Q.

☒ **B** P has a greater breaking strain than Q.

☒ **C** P has a greater yield stress than Q.

☒ **D** P has a lower Young modulus than Q.

(Total for Question 9 = 1 mark)

9 A student attached one end of a wire to a support. The student added masses to the other end of the wire, as shown. The student measured the corresponding extension for each added mass.
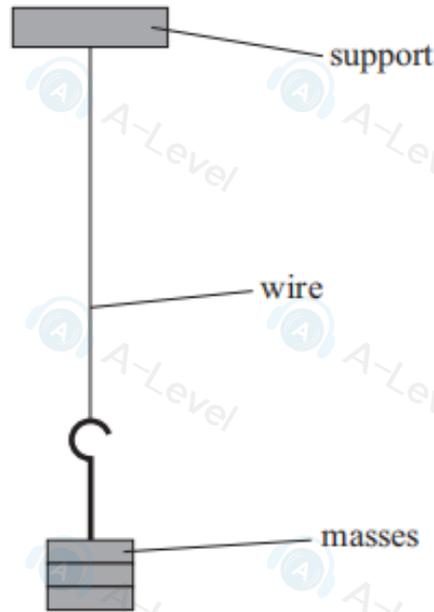
The wire broke when the extension was small.

The student replaced the wire with a second wire made of the same material. The second wire had a larger extension before breaking.

Which of the following produced this result?

☒ **A** The second wire had a greater diameter.

☒ **B** The second wire had a longer length.

☒ **C** The second wire had a smaller diameter.

☒ **D** The second wire had a shorter length.

(Total for Question 9 = 1 mark)

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2 A cylinder of weight 1.5 N is placed on top of a vertical spring, and the spring compresses by 3.0 cm as shown.
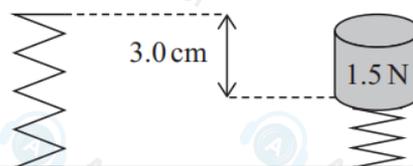
What is the spring constant of the spring?

A $0.02\,\text{Nm}^{-1}$

B $0.5\,\text{Nm}^{-1}$

C $2.0\,\text{Nm}^{-1}$

D $50\,\text{Nm}^{-1}$

(Total for Question 2 = 1 mark)

Questions 5 and 6 refer to the information below.

A student stretches a spring of original length p to a length q by applying an increasing force. The graph shows how the length of the spring changes as the student increases the force from zero to a magnitude R.
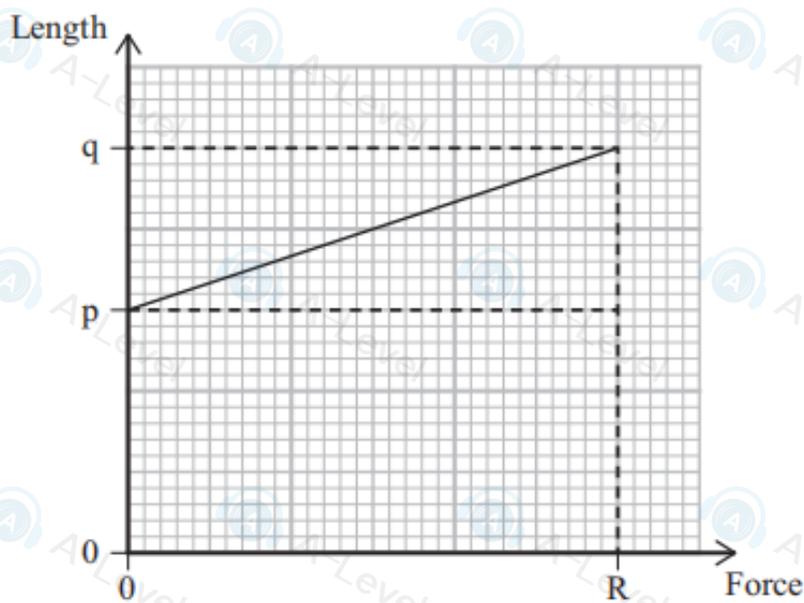
5   Which of the following expressions gives the stiffness of the spring?

$\boxtimes$ A $\dfrac{q-p}{R}$

$\boxtimes$ B $\dfrac{q}{R}$

$\boxtimes$ C $\dfrac{R}{q}$

$\boxtimes$ D $\dfrac{R}{q-p}$

(Total for Question 5 = 1 mark)

3 A spring is stretched by applying a force of $3.0\,\text{N}$. The elastic strain energy stored by the spring is $0.04\,\text{J}$.

Which of the following expressions gives the extension, in m, of the spring?

☒ **A** $\dfrac{2 \times 0.04}{3.0}$

☒ **B** $\sqrt{\dfrac{2 \times 0.04}{3.0}}$

☒ **C** $\sqrt{\dfrac{3.0}{2 \times 0.04}}$

☒ **D** $\dfrac{3.0}{2 \times 0.04}$

(Total for Question 3 = 1 mark)

Questions 8 and 9 refer to the information below.

A student carried out an experiment to determine the Young modulus of a material in the form of a wire. The original length and diameter of the wire were measured. A load was applied to the wire and the corresponding extended length was measured.

8 Which of the following combinations of original length and diameter would produce the greatest extension for a given load?

	Original length	Diameter
☒ **A**	long	large
☒ **B**	long	small
☒ **C**	short	large
☒ **D**	short	small

(Total for Question 8 = 1 mark)

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9 The diameter of the wire was measured using a micrometer and found to be $0.35\,\text{mm}$. The micrometer reads to the nearest $0.01\,\text{mm}$.

Which of the following is the most appropriate percentage uncertainty to use with this measurement?

☒ **A** 2.9%

☒ **B** 5.8%

☒ **C** 3%

☒ **D** 6%

(Total for Question 9 = 1 mark)

16 A student suspended a spring from a retort stand and hung a mass from the free end of the spring.

(a) Show that the extension of the spring was about 0.05 m.

weight of mass on spring = 0.88 N
spring constant of spring = 18 N m^{-1}

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(b) The mass on the spring was placed in a measuring cylinder of water and the mass moved upwards a distance y, as shown, then remained stationary.
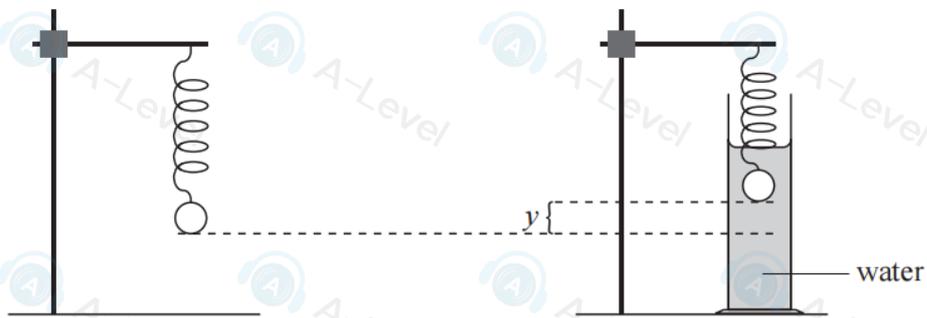
The free-body force diagram for the mass in water is shown.

upthrust ↑↑ tension in the spring

weight
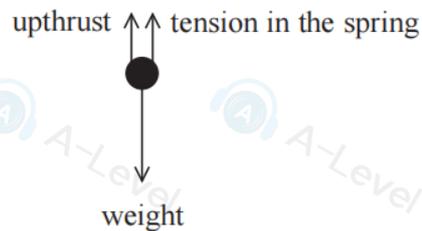
(i) Explain why the stationary position of the mass was higher in water than in air.

(3)

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(ii) Determine y. You may assume that the extension of the spring when the mass
was in air was 0.050 m.

(4)

density of water $= 1.0 \times 10^3 \, \text{kg m}^{-3}$
spring constant of spring $= 18 \, \text{N m}^{-1}$
volume of mass $= 3.4 \times 10^{-5} \, \text{m}^3$
weight of mass on spring $= 0.88 \, \text{N}$

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$y =$ ....

*(c) The student replaced the water in the measuring cylinder with oil. The value of y decreased.

Explain why y decreased.

(3)

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(Total for Question 16 = 12 marks)

18 A physicist investigates the behaviour of materials used in packaging.

(a) A sample of plastic ribbon is supported so that it hangs vertically. A mass of 960 g is used to apply a vertical load and the sample of plastic ribbon extends.

Calculate the strain produced in the sample of plastic ribbon due to the load.

(4)

Young modulus of plastic ribbon = 2.5×10^9 Pa
width of plastic ribbon sample = 1.0×10^{-2} m
thickness of plastic ribbon sample = 1.0×10^{-4} m

Strain = ...

(b) When a plastic ribbon is pulled over a sharp edge and then released, the ribbon becomes permanently curled, as shown.

Physicists investigating this effect carried out a series of experiments using the equipment shown.
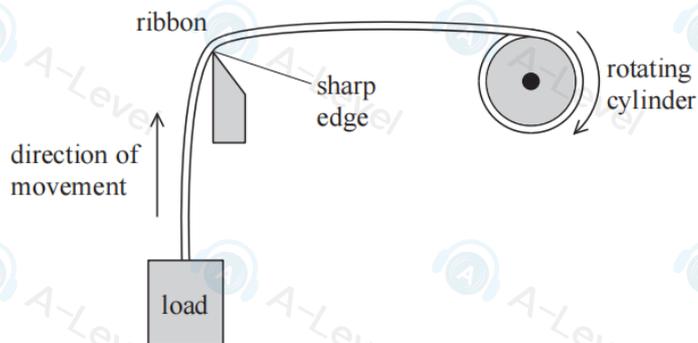
A rotating cylinder pulls the ribbon over a sharp edge. A tension is created in the ribbon by attaching a load to the free end.

As the ribbon is pulled over the sharp edge, the tension in its upper surface is greater than the tension in its lower surface. When the tension is removed, the ribbon curls.

Suggest why the difference in the two tensions causes the ribbon to become permanently curled.

(3)

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(c) The physicists repeated their investigation by pulling the ribbon with different tensions, over a round edge and over a sharp edge. The graph shows how the diameter of the curl varied with the tension for each edge.
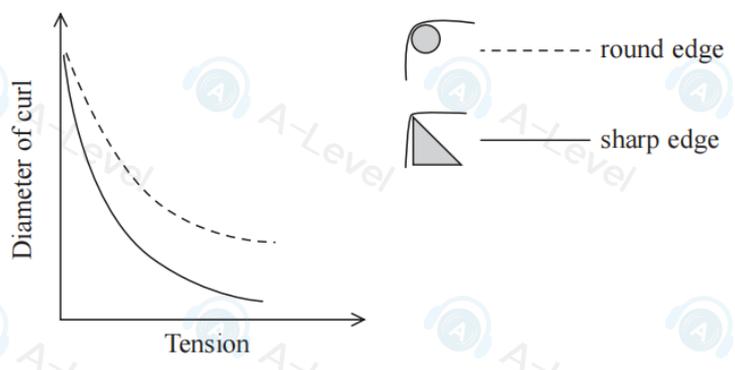
(i) State how the diameter of the curl varies with tension for a given edge.

(1)

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(ii) State how the diameter of the curl is affected by the shape of the edge for a given tension.

(1)

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(iii) Reducing the speed of the rotating cylinder decreases the diameter of the curls.

Explain why.

(2)

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(Total for Question 18 = 11 marks)

16 A student carried out an experiment to determine the Young modulus of copper.

*(a) The student clamped one end of a copper wire to the bench. The wire passed over a pulley and masses were added to the other end of the wire.

A metre rule was fixed to the bench and a marker fixed to the wire, as shown.

The student measured the diameter of the copper wire.

Describe the other measurements that need to be made using this apparatus and how they will be used to determine the Young modulus of copper.

You should define the meanings of any symbols you use.

(6)

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(b) Another student attaches a weight of 5.0 N to a copper wire of diameter 0.56 mm.

Calculate the extension of the wire.

length of wire = 2.5 m
Young modulus of copper = 1.1×10^{11} Pa

(4)

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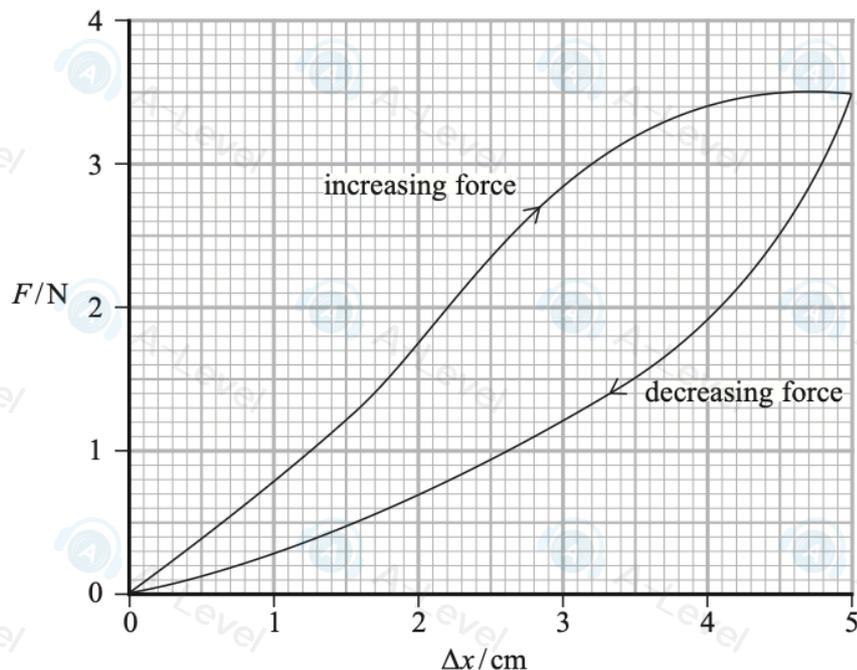
Extension = ...

(Total for Question 16 = 10 marks)

11 A student applied a force F to a rubber band. The student measured the corresponding extension, Δx, as F was increased and then decreased.

The graph shows how Δx varied as F was increased and then decreased.

(a) State how the graph shows that the rubber band deformed elastically.

(1)

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(b) The work done on the rubber band as F increased is greater than the work done by the rubber band as F was decreased.

There is a difference in these values because heating occurred.

Determine the energy that caused heating as F was increased and then decreased to zero.

(3)

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Energy that caused heating = ...

(Total for Question 11 = 4 marks)

11 A student carried out an experiment to determine the spring constant of a spring. The diagram shows the arrangement of the equipment used.
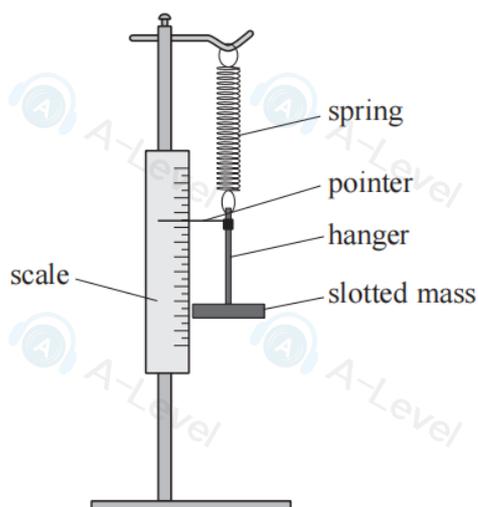
Each time a slotted mass was added to the hanger, the position of the pointer was recorded and the extension of the spring calculated.

(a) Describe how the student could use a graphical method to determine the spring constant of the spring.

(3)

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(b) State **two** ways in which this method contributes to an accurate value for the spring constant.

(2)

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(Total for Question 11 = 5 marks)