22 Which of the following correctly defines the terms *stress*, *strain* and *Young modulus*?

|	stress	strain	Young modulus
A	(force) x (area)	(extension) x (original length)	(stress) / (strain)
B	(force) x (area)	(extension) / (original length)	(stress) x (strain)
C	(force) / (area)	(extension) / (original length)	(stress) / (strain)
D	(force) / (area)	(extension) x (original length)	(stress) x (strain)

23 A wire is stretched by 8 mm when a load of 60 N is applied.

What will be the extension of a wire of the same material having four times the cross-sectional area and twice the original length, when the same load is applied?

A 2 mm   **B** 4 mm   **C** 8 mm   **D** 16 mm

24 The tension in a spring of natural length l_0 is first increased from zero to T_1, causing the length to increase to l_1. The tension is then reduced to T_2, causing the length to decrease to l_2 (as shown).
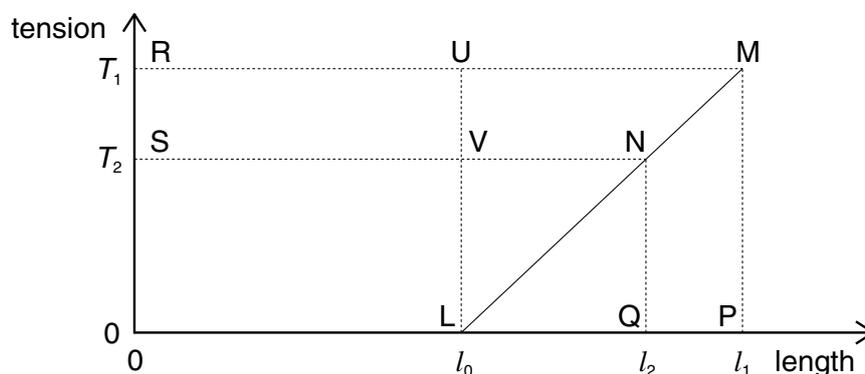
Which area of the graph represents the work done by the spring during this reduction in length?

A MLP   **B** MNQP   **C** MNSR   **D** MPLU

24 Two springs P and Q both obey Hooke's law. They have spring constants $2k$ and k respectively.

The springs are stretched, separately, by a force that is gradually increased from zero up to a certain maximum value, the same for each spring. The work done in stretching spring P is W_P, and the work done in stretching spring Q is W_Q.

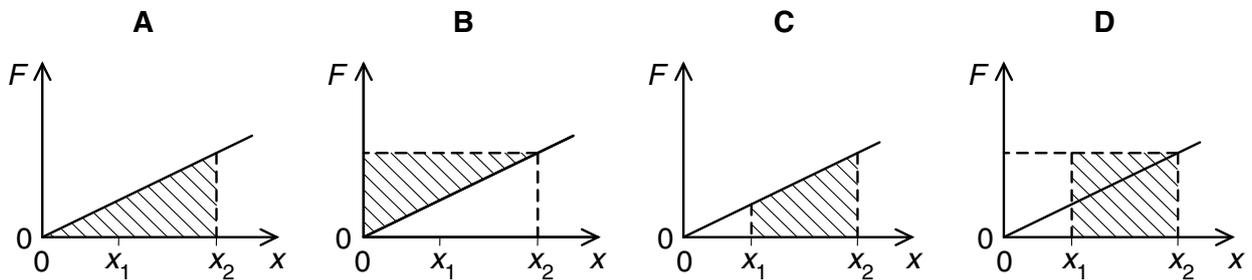How is W_P related to W_Q?

A $W_P = \frac{1}{4}W_Q$ **B** $W_P = \frac{1}{2}W_Q$ **C** $W_P = 2W_Q$ **D** $W_P = 4W_Q$

Elastic Properties

23 The variation of the extension x of a spring with applied force F is shown. 9702/1/O/N/02
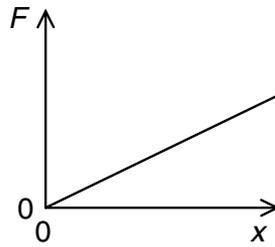
Which shaded area represents the work done when the extension is increased from x_1 to x_2?

A	B	C	D

19 A suspended copper wire is gradually loaded until it is stretched just beyond the elastic limit, and it is then gradually unloaded. 9702/01/M/J/03

Which graph (with arrows indicating the sequence) best illustrates the variation of the tensile stress with longitudinal strain?

A	B	C	D
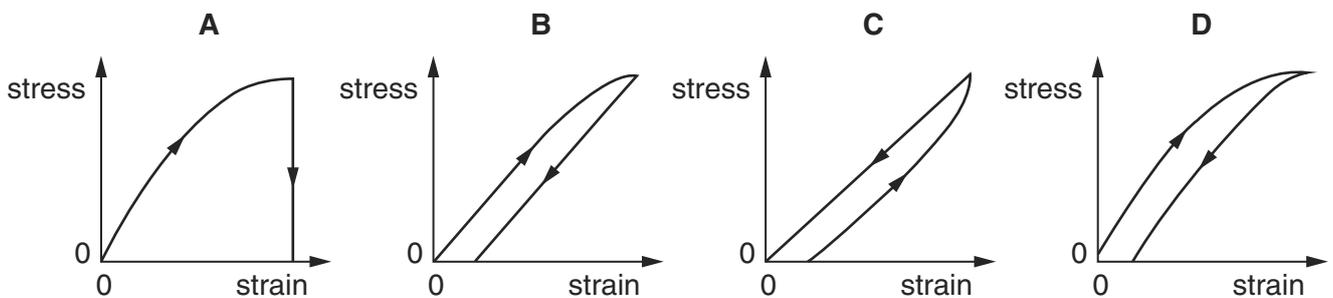
21 What is the ultimate tensile stress of a material? 9702/01/M/J/03

A   the stress at which the material becomes ductile

B   the stress at which the material breaks

C   the stress at which the material deforms plastically

D   the stress at which the material reaches its elastic limit

Elastic Properties

22 A beam, the weight of which may be neglected, is supported by three identical springs. When a weight W is hung from the middle of the beam, the extension of each spring is x.
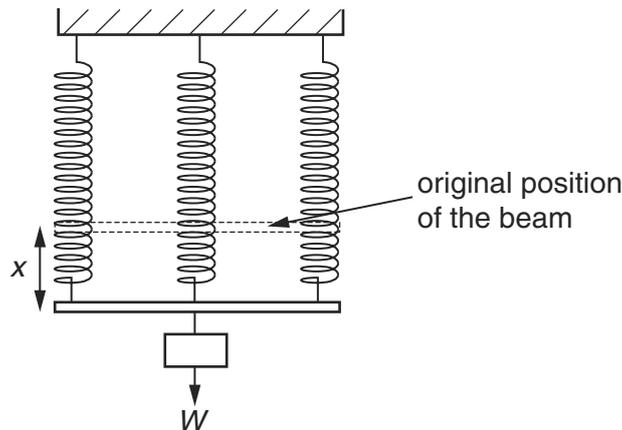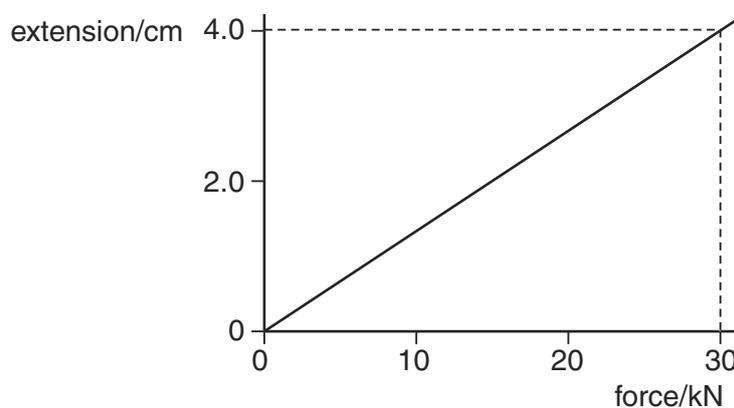

The middle spring and the weight are removed.

What is the extension when a weight of $2W$ is hung from the middle of the beam?

A $\dfrac{3x}{2}$ **B** $\dfrac{4x}{3}$ **C** $2x$ **D** $3x$

21 What is the Young modulus of a metal?

A extension / force

B force / extension

C strain / stress

D stress / strain

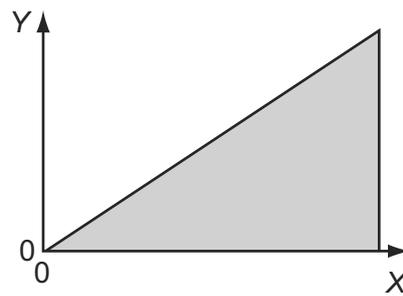**22** The graph shows how the extension of a spring varies with the force used to stretch it.

What is the strain energy stored in the spring when the extension is 4.0 cm?

A 60 J **B** 120 J **C** 600 J **D** 1200 J

Elastic Properties

22 The graph shown was plotted in an experiment on a metal wire. 9702/01/M/J/04

The shaded area represents the total strain energy stored in stretching the wire.

How should the axes be labelled?

	Y	X
A	force	extension
B	mass	extension
C	strain	energy
D	stress	strain

23 Nylon breaks when the stress within it reaches 1×10^9 Pa. 9702/01/M/J/04

Which range includes the heaviest load that could be lifted by a nylon thread of diameter 1 mm?

A 2 N to 20 N

B 20 N to 200 N
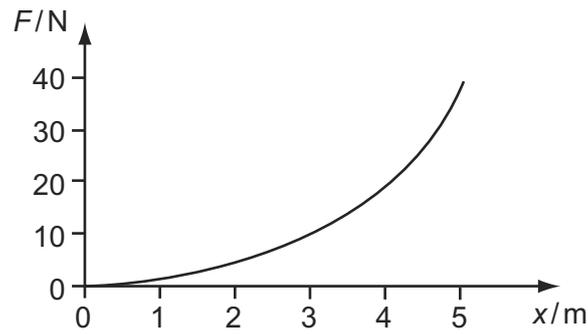
C 200 N to 2000 N

D 2000 N to 20 000 N

22 The table shows a load applied to four wires and the cross-sectional area of each. 9702/01/O/N/04

Which of the wires is subjected to the greatest stress?

	load / N	cross-sectional area / mm^2
A	1500	0.25
B	2000	1.0
C	3000	0.56
D	5000	2.3

Elastic Properties

23 The force *F* required to extend a sample of rubber by a distance *x* is found to vary as shown.
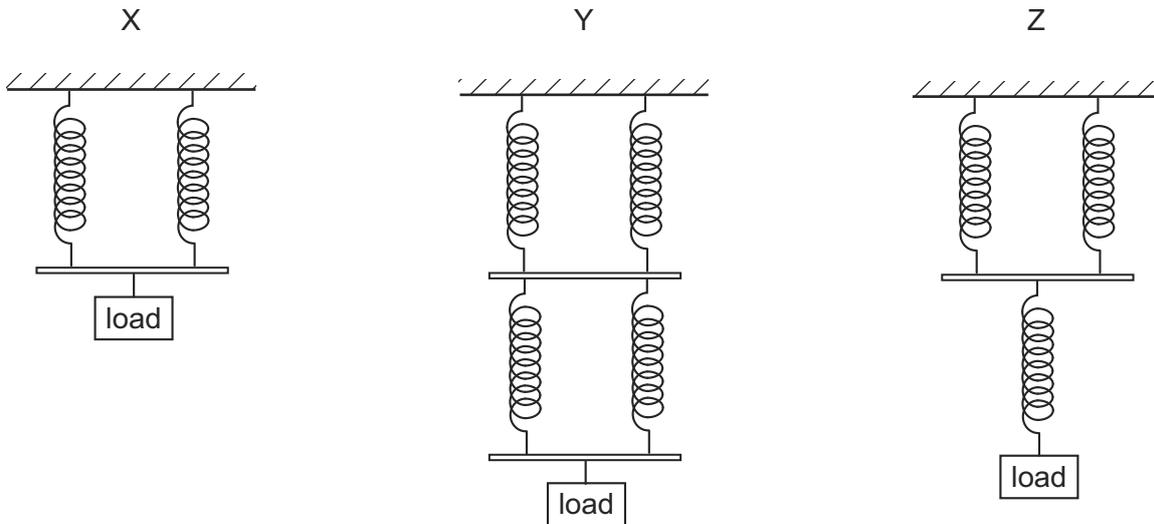
The energy stored in the rubber for an extension of 5 m is

A less than 100 J.

B 100 J.

C between 100 J and 200 J.

D more than 200 J.

20 A number of similar springs, each having the same spring constant, are joined in three arrangements X, Y and Z. The same load is applied to each.
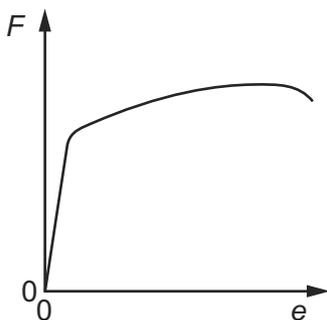

What is the order of increasing extension for these arrangements?

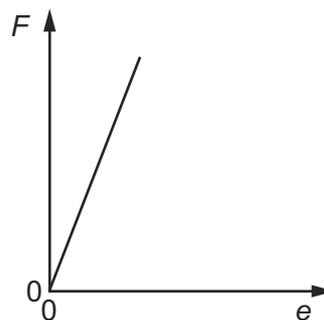|	smallest	⟶	largest
A	X	Y	Z
B	Z	X	Y
C	Z	Y	X
D	Y	X	Z

Elastic Properties

21 Cylindrical samples of steel, glass and rubber are each subjected to a gradually increasing tensile force F. The extensions e are measured and graphs are plotted as shown below.
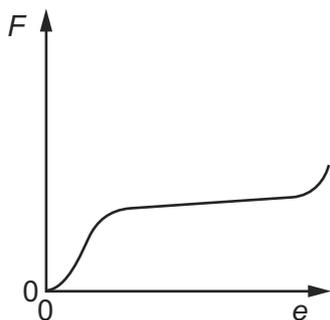
graph X   graph Y   graph Z

Which row correctly relates the graphs to the materials?

	steel	glass	rubber
A	X	Y	Z
B	X	Z	Y
C	Y	X	Z
D	Y	Z	X

22 Two steel wires P and Q have lengths l and $2l$ respectively, and cross-sectional areas A and $\dfrac{A}{2}$ respectively. Both wires obey Hooke's law.

What is the ratio $\dfrac{\text{tension in P}}{\text{tension in Q}}$ when both wires are stretched to the same extension?

A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** $\dfrac{2}{1}$ **D** $\dfrac{4}{1}$

21 In describing the behaviour of a spring, the spring constant is used.

Different loads are used to extend the spring by different amounts.

To find the spring constant, which quantities are required?

A the elastic limit and the loads

B the elastic limit, extensions and the length of the spring

C the loads and the extensions of the spring

D the loads and the length of the spring

23 What is the unit of the Young modulus?

**A** $N\,m^{-1}$ **B** $N\,m$ **C** $N\,m^{-2}$ **D** $N\,m^{2}$

Elastic Properties

21 A wire stretches 8 mm under a load of 60 N. 9702/01/O/N/05

A second wire of the same material, with half the diameter and a quarter of the original length of the first wire, is stretched by the same load.

Assuming that Hooke's law is obeyed, what is the extension of this wire?

A 1 mm   **B** 4 mm   **C** 8 mm   **D** 16 mm

20 A ductile material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below. 9702/01/O/N/05
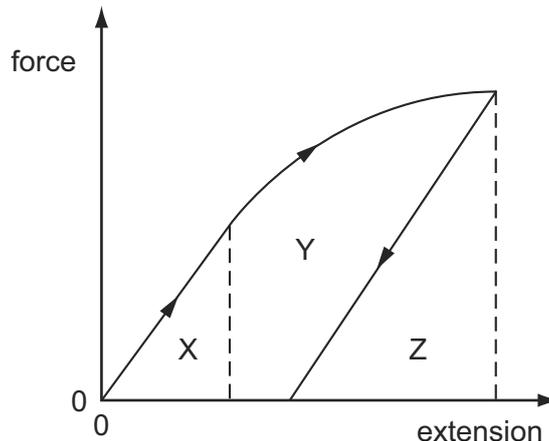
Which area represents the net work done on the sample?

A X   **B** X + Y   **C** Y + Z   **D** Z

22 The graph shows the behaviour of a sample of a metal when it is stretched until it starts to undergo plastic deformation. 9702/01/M/J/06
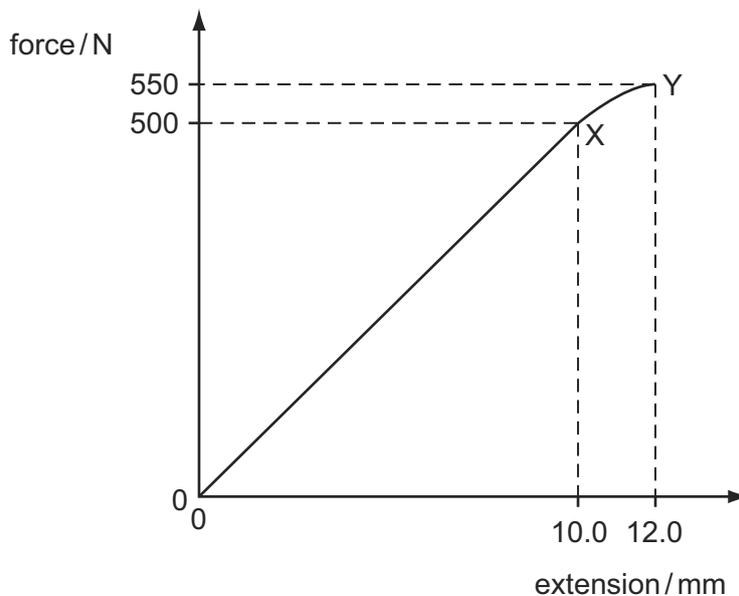
What is the total twork done in stretching the sample from zero extension to 12.0 mm?
Simplify the calculation by treating the region XY as a straight line.

A 3.30 J   **B** 3.55 J   **C** 3.60 J   **D** 6.60 J

Elastic Properties

22 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)? 9702/01/O/N/06

    A elastic limit
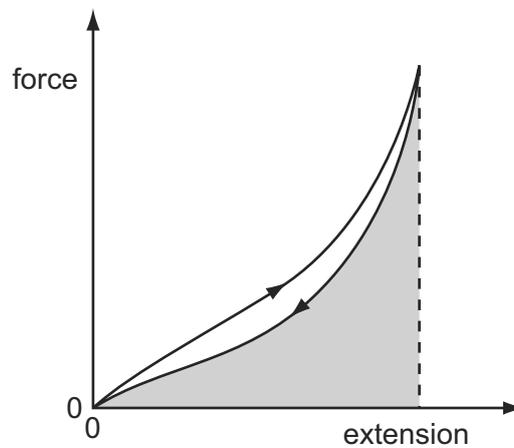
    B spring constant

    C stress

    D the Young modulus

17 A piece of copper is drawn into a continuous wire. 9702/01/M/J/07

What behaviour is the copper exhibiting?

    A brittle only

    B elastic only

   **C** plastic only

    D both brittle and elastic

18 The force-extension graph of a particular sample of rubber as a load is applied and then removed is shown. 9702/01/M/J/07

What does the shaded area represent?

    A the energy transformed into heat during the complete cycle

    B the recoverable elastic potential energy stored at maximum extension

    C the work done on the sample while loading

    D the work done on the sample while unloading

Elastic Properties

19 A spring of unextended length 0.50 m is stretched by a force of 2.0 N to a new length of 0.90 m. The variation of its length with tension is as shown. 9702/01/M/J/07
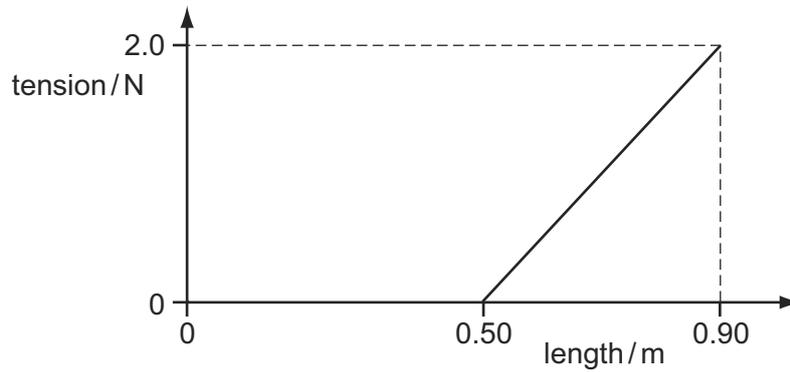
How much strain energy is stored in the spring?

A   0.40 J   **B**   0.80 J   **C**   0.90 J   **D**   1.8 J

20 A simple crane consists of a rigid vertical pillar supporting a horizontal beam. 9702/01/M/J/07
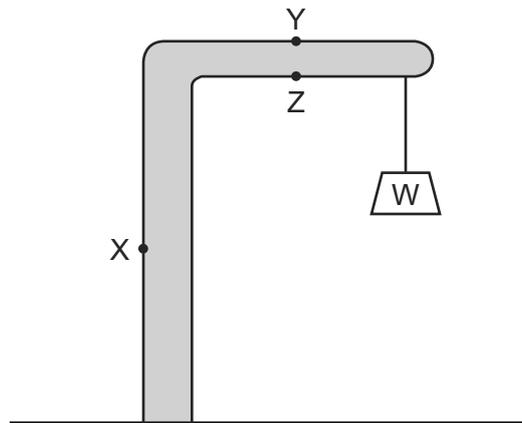
A weight W is lifted by a rope at the end of the beam.

What are the forces at points X, Y and Z due to the weight W?

	force at X	force at Y	force at Z
A	tension	compression	tension
B	tension	tension	compression
C	compression	tension	compression
D	compression	compression	compression

Elastic Properties

19 What is plastic deformation? 9702/01/O/N/07

    A Plastic deformation occurs when strain is not proportional to stress but when the load is removed the material returns to its original length.

    B Plastic deformation occurs if, when the load is removed, the material contracts but a permanent stretching has occurred.

    C Plastic deformation occurs until the extension is no longer proportional to the load.

    D Plastic deformation occurs when the material extends so that strain is directly proportional to stress.

20 The graph shows how the length of a particular rubber cord varies as force is applied. 9702/01/O/N/07
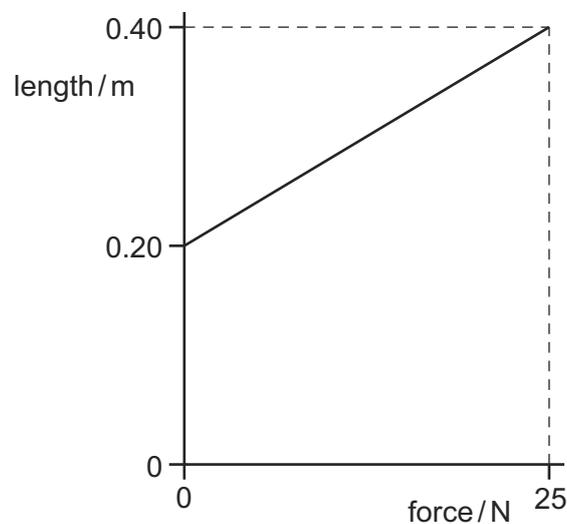
What is the maximum strain energy in this deformed rubber cord?

    A 2.5 J   **B** 5.0 J   **C** 7.5 J   **D** 10 J

24 The Young modulus of steel is determined using a length of steel wire and is found to have the value E.

Another experiment is carried out using a wire of the same steel, but of twice the length and half the diameter.

What value is obtained for the Young modulus in the second experiment? 9702/01/M/J/08

    A $\frac{1}{4}E$ **B** $\frac{1}{2}E$ **C** E **D** $2E$

19 Which properties best describe modelling clay? 9702/01/O/N/08

    A brittle and ductile

    B ductile and elastic

    C elastic and plastic

    D plastic and ductile

Elastic Properties

22 A sample of metal is subjected to a force which increases to a maximum value and then decreases back to zero. A force-extension graph for the sample is shown. 9702/01/M/J/08
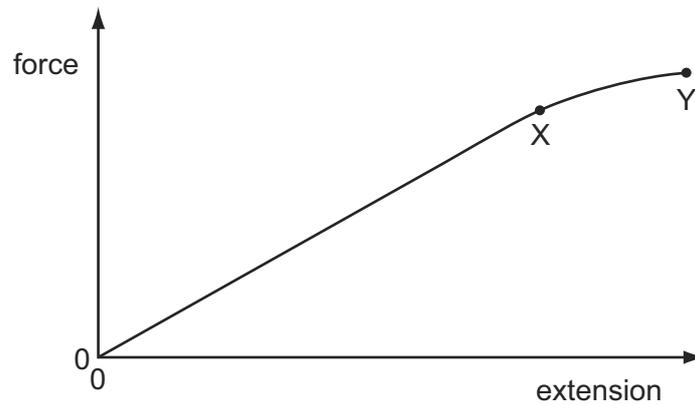
When the sample contracts it follows the same force-extension curve as when it was being stretched.

What is the behaviour of the metal between X and Y?

A   both elastic and plastic

B   elastic but not plastic

C   plastic but not elastic

D   not elastic and not plastic

23 A spring of original length 100 mm is compressed by a force. The graph shows the variation of the length L of the spring with the compressing force F. 9702/01/M/J/08
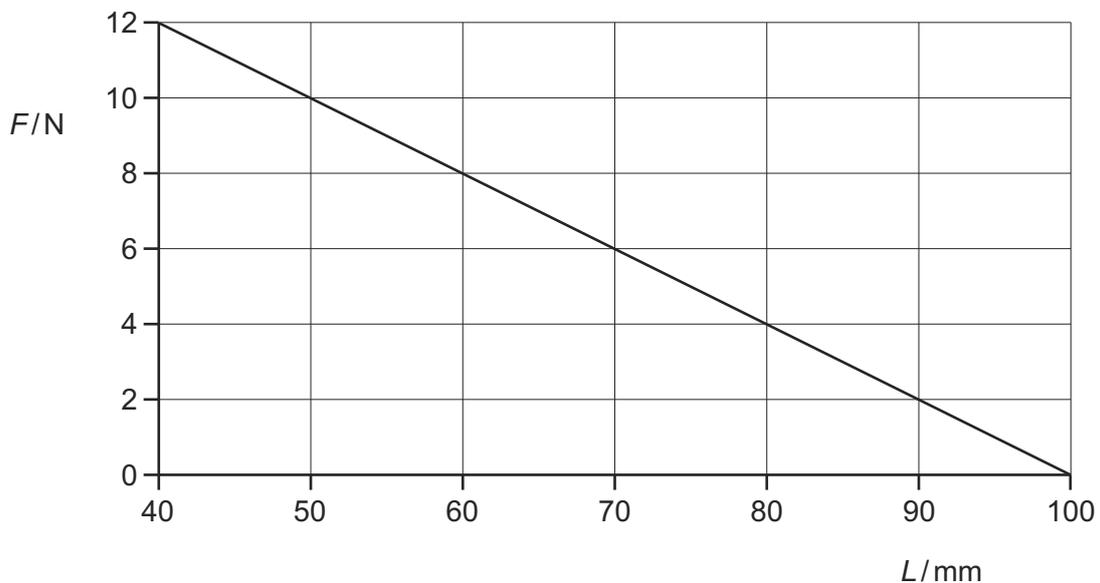
What is the energy stored in the spring when the length is 70 mm?

A   0.090 J   **B**   0.21 J   **C**   0.27 J   **D**   0.63 J

Elastic Properties

20 Why does the pressure of a gas increase when the gas is compressed at constant temperature?

    A The gas molecules collide more often with each other.

    B The gas molecules expand under pressure.

    C The gas molecules hit the walls of the container more frequently.

    D The gas molecules travel faster.

19 Four materials are formed into rods of the same dimensions. 9702/01/M/J/09

At room temperature, which can sustain the largest plastic deformation?

    A the ductile material aluminium

    B the brittle material carbon

    C the brittle material glass

    D the ductile material steel

20 Two steel wires P and Q have lengths l and $2l$ respectively, and cross-sectional areas A and $\dfrac{A}{2}$ respectively. Both wires obey Hooke's law. 9702/01/M/J/09

What is the ratio $\dfrac{\text{tension in P}}{\text{tension in Q}}$ when both wires are stretched to the same extension?

    A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** $\dfrac{2}{1}$ **D** $\dfrac{4}{1}$

21 A rubber band is stretched by hanging weights on it and the force-extension graph is plotted from the results. 9702/01/M/J/09
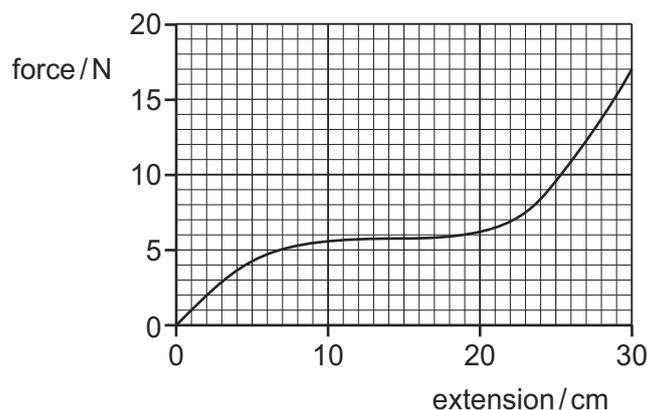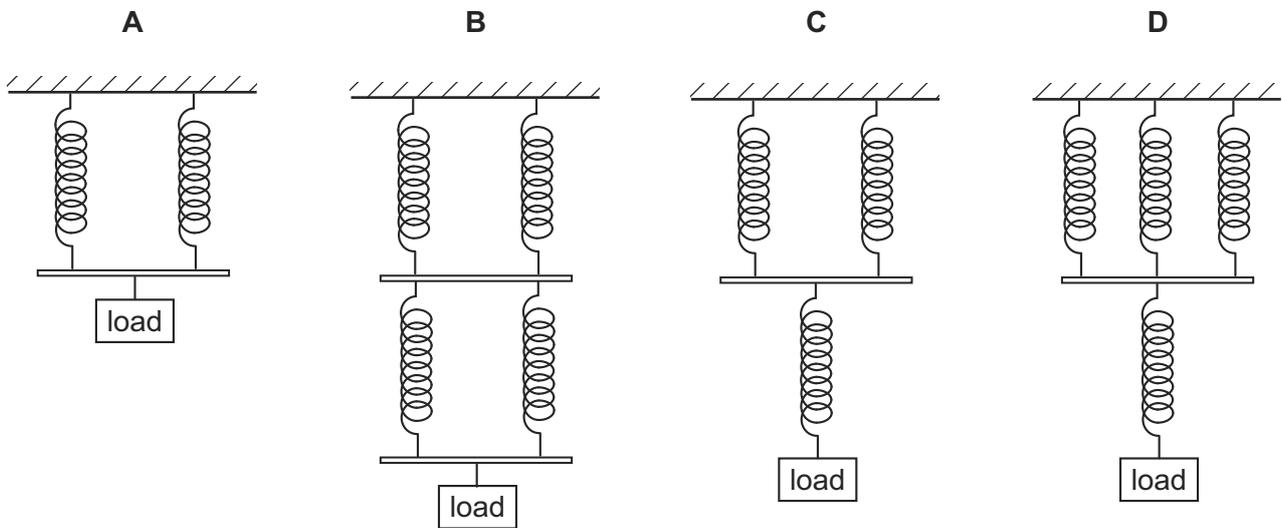

What is the best estimate of the strain energy stored in the rubber band when it is extended 30 cm?

    A 2.0 J   **B** 2.6 J   **C** 5.1 J   **D** 200 J

Elastic Properties

21 A number of similar springs, each having the same spring constant, are joined in four arrangements. The same load is applied to each.

Which arrangement gives the greatest extension?

A	B	C	D

22 The graphs show how force varies with extension and stress varies with strain for the loading of a metal wire. 9702/01/O/N/08
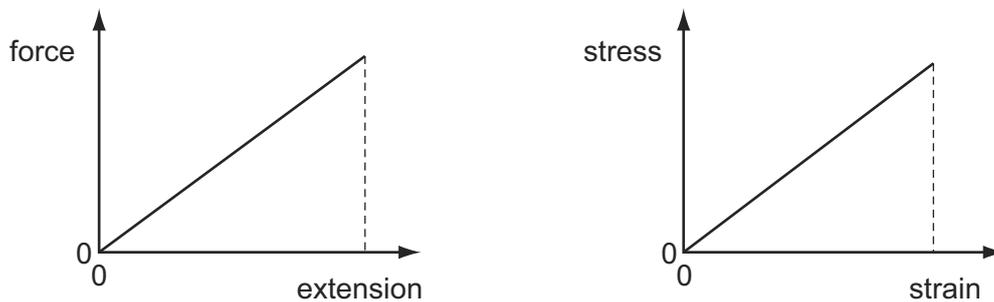
The Young modulus for this wire is equal to

A the gradient of the force-extension graph.

B the area between the force-extension graph and the extension axis.

C the gradient of the stress-strain graph.

D the area between the stress-strain graph and the strain axis.

23 For a wire, Hooke's law is obeyed for a tension F and extension x. The Young modulus for the material of the wire is E.

Which expression represents the elastic strain energy stored in the wire?

A $\frac{1}{2}Ex$ **B** Ex **C** $\frac{1}{2}Fx$ **D** Fx

Elastic Properties

20 Which row best defines elastic and plastic behaviour of a material? 9702/11/O/N/09

	elastic behaviour of a material	plastic behaviour of a material
A	extends only within the limit of proportionality	extends beyond the limit of proportionality
B	has a linear force-extension curve	has a horizontal force-extension curve
C	obeys Hooke's Law	extends continuously under a steady load
D	returns to its original shape and size	suffers permanent deformation

21 The graph shows the non-linear force-extension curve for a wire made from a new composite material. 9702/11/O/N/09
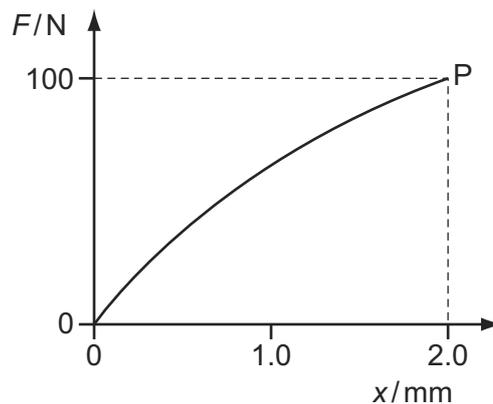
What could be the value of the strain energy stored in the wire when it is stretched to point P?

A 0.09 J   **B** 0.10 J   **C** 0.11 J   **D** 0.20 J

22 A steel string on an electric guitar has the following properties. 9702/11/O/N/09

diameter = 5.0×10^{-4} m

Young modulus = 2.0×10^{11} Pa

tension = 20 N
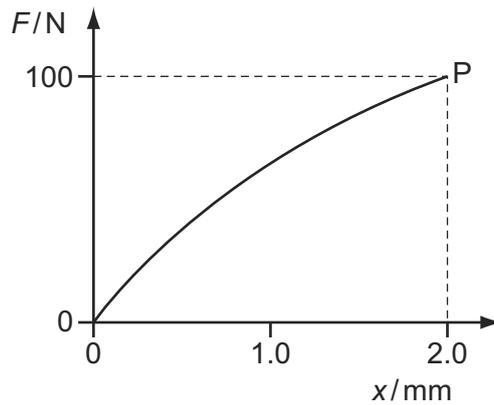
The string snaps, and contracts elastically.

By what percentage does a length l of a piece of the string contract?

A 5.1×10^{-4} %   **B** 5.1×10^{-2} %   **C** 1.3×10^{-4} %   **D** 1.3×10^{-2} %

19 Which row best defines elastic and plastic behaviour of a material? 9702/12/O/N/09

	elastic behaviour of a material	plastic behaviour of a material
A	extends only within the limit of proportionality	extends beyond the limit of proportionality
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D	returns to its original shape and size	suffers permanent deformation

Elastic Properties

20 The graph shows the non-linear force-extension curve for a wire made from a new composite material. 9702/12/O/N/09

F/N

100 ------------- P

0

0   1.0   2.0

x/mm

What could be the value of the strain energy stored in the wire when it is stretched to point P?

A   0.09 J   **B**   0.10 J   **C**   0.11 J   **D**   0.20 J

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19 In stress-strain experiments on metal wires, the stress axis is often marked in units of 10^8 Pa and the strain axis is marked as a percentage. This is shown for a particular wire in the diagram.

9702/11/M/J/10
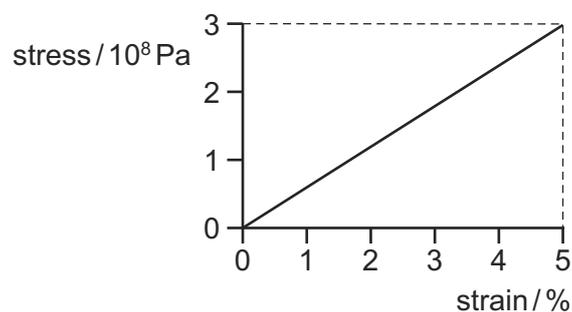
stress / 10^8 Pa

3

2

1

0

0   1   2   3   4   5

strain / %

What is the value of the Young modulus for the material of the wire?

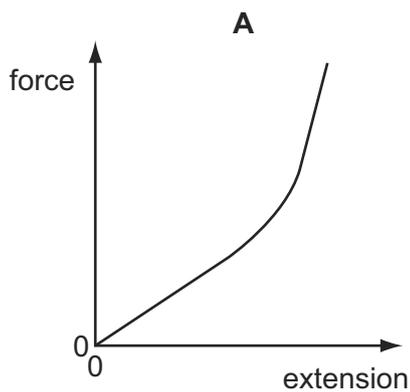**A** 6.0×10^7 Pa   **B** 7.5×10^8 Pa   **C** 1.5×10^9 Pa   **D** 6.0×10^9 Pa

Elastic Properties

20 A spring is compressed by a force. The graph shows the compressing force F plotted against the length L of the spring. 9702/11/M/J/10
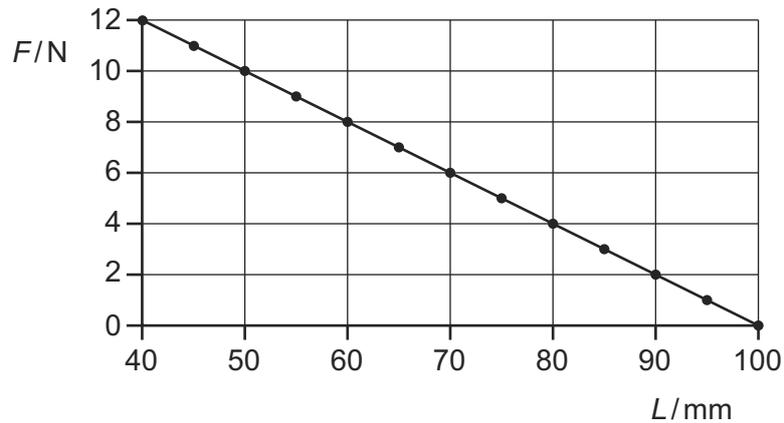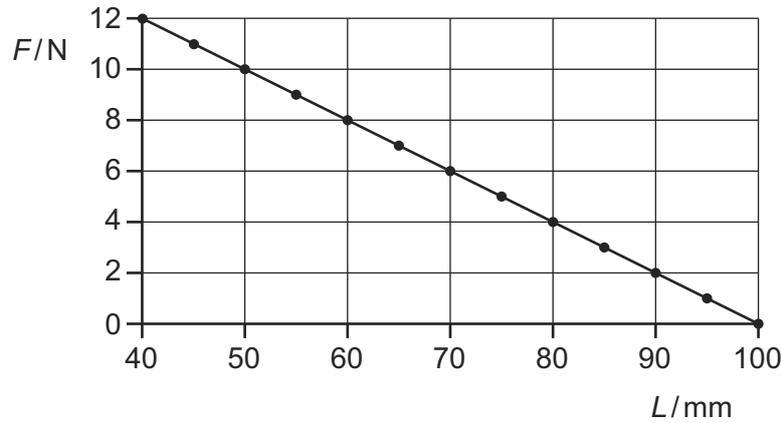

What is the spring constant of this spring?

A $0.2\,\mathrm{N\,m^{-1}}$ **B** $5\,\mathrm{N\,m^{-1}}$ **C** $100\,\mathrm{N\,m^{-1}}$ **D** $200\,\mathrm{N\,m^{-1}}$

21 Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point? 9702/11/M/J/10


Elastic Properties
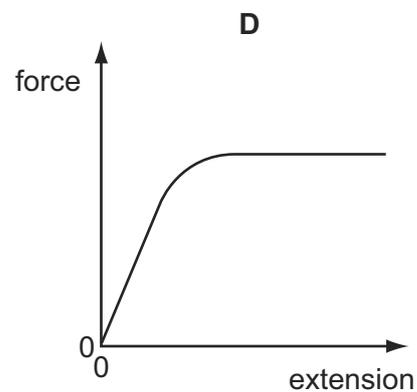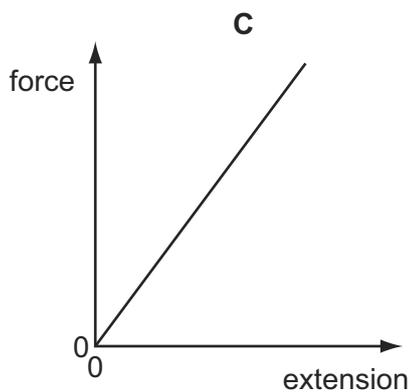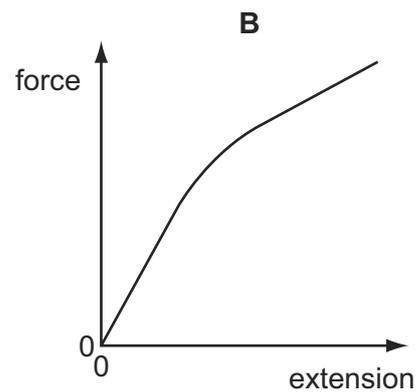
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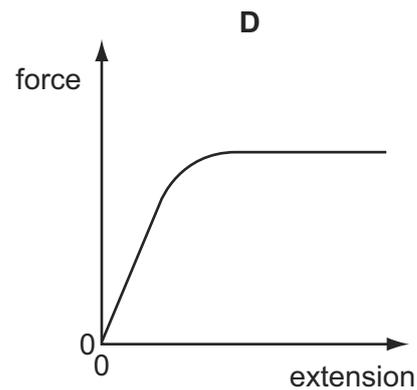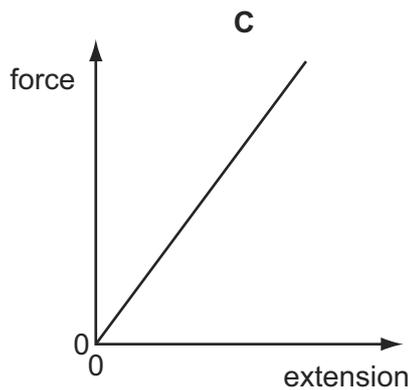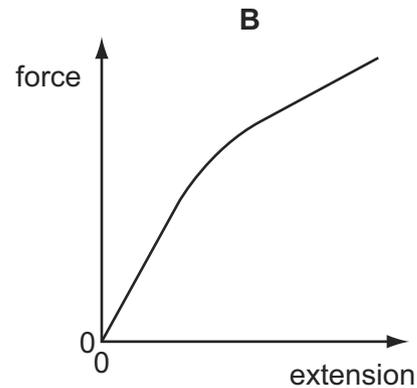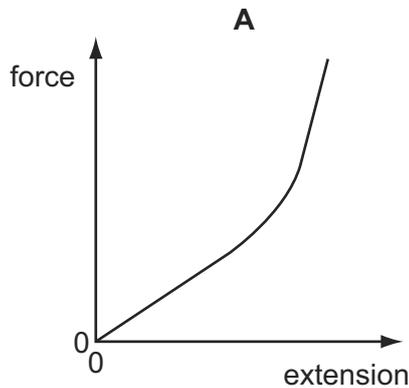

Elastic Properties
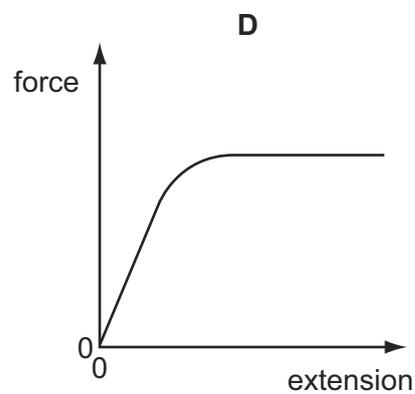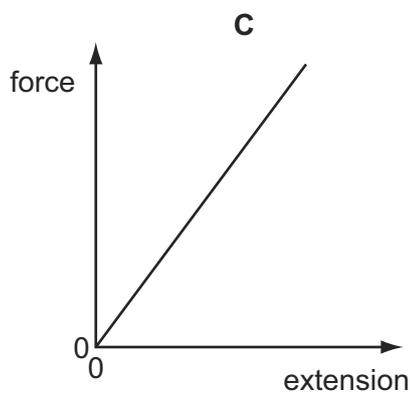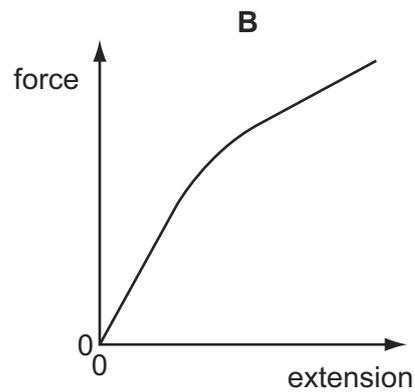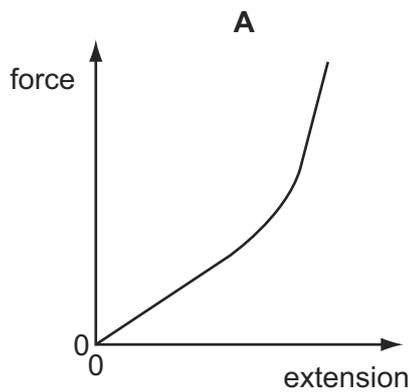
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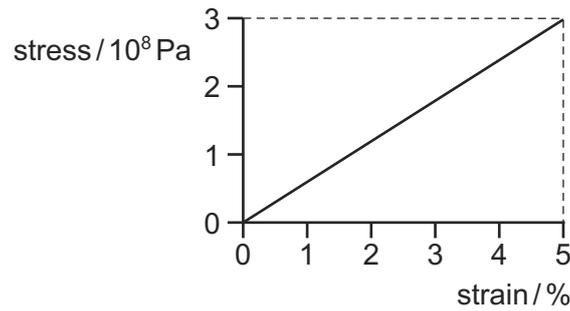
What is the value of the Young modulus for the material of the wire?

A 6.0×10^7 Pa   **B** 7.5×10^8 Pa   **C** 1.5×10^9 Pa   **D** 6.0×10^9 Pa

19 Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point?
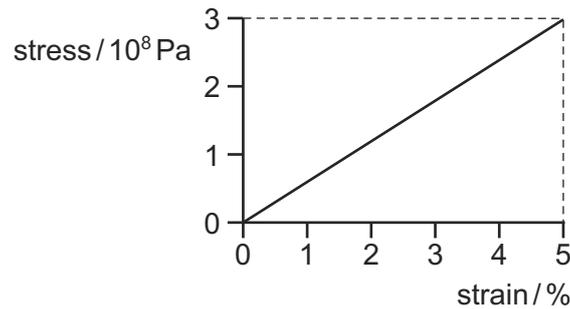

25 In which order of magnitude are the frequencies of electromagnetic waves in the visible spectrum?

A 10^{12} Hz   **B** 10^{13} Hz   **C** 10^{14} Hz   **D** 10^{15} Hz

Elastic Properties

20 In stress-strain experiments on metal wires, the stress axis is often marked in units of 10^8 Pa and the strain axis is marked as a percentage. This is shown for a particular wire in the diagram.

What is the value of the Young modulus for the material of the wire?

A 6.0×10^7 Pa   **B** 7.5×10^8 Pa   **C** 1.5×10^9 Pa   **D** 6.0×10^9 Pa

21 A spring is compressed by a force. The graph shows the compressing force F plotted against the length L of the spring.
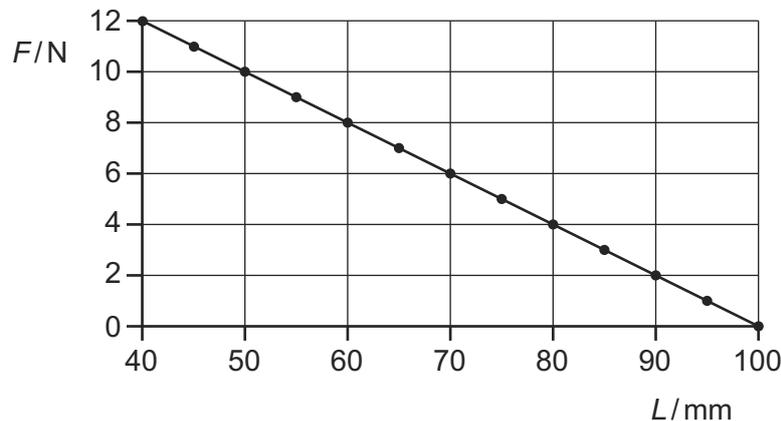
What is the spring constant of this spring?

A $0.2 \, \text{N m}^{-1}$ **B** $5 \, \text{N m}^{-1}$ **C** $100 \, \text{N m}^{-1}$ **D** $200 \, \text{N m}^{-1}$

22 Using monochromatic light, interference fringes are produced on a screen placed a distance D from a pair of slits of separation a. The separation of the fringes is x.

Both a and D are now doubled.

What is the new fringe separation?

A $\dfrac{x}{2}$ **B** x **C** $2x$ **D** $4x$

20 The pressure at sea level is approximately 100 000 Pa. The density of sea water is 1030 kg m^{-3}.

What is the approximate pressure 80 m below the surface of the sea?

A 100 000 Pa   **B** 180 000 Pa   **C** 800 000 Pa   **D** 900 000 Pa
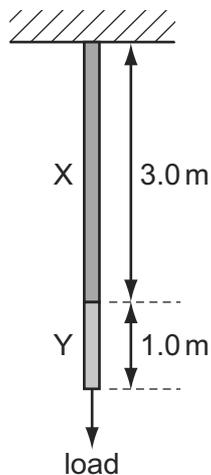
Elastic Properties

21 The graph shows how force depends on extension for a certain spring. 9702/11/O/N/10
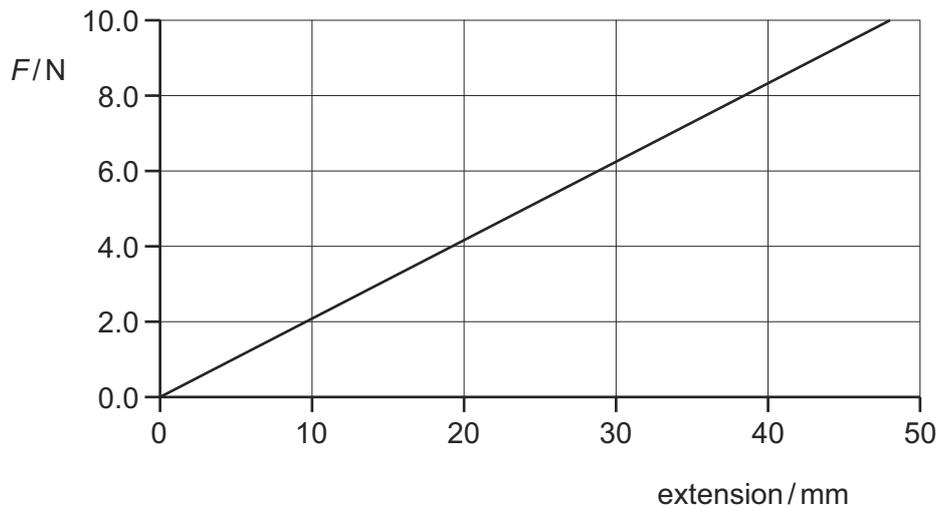
What is the energy stored in the spring when the extension is 30 mm?

A 0.095 J   **B** 0.19 J   **C** 0.25 J   **D** 0.95 J

22 A wire consists of a 3.0 m length of metal X joined to a 1.0 m length of metal Y. 9702/11/O/N/10

The cross-sectional area of the wire is uniform.

A load hung from the wire causes metal X to stretch by 1.5 mm and metal Y to stretch by 1.0 mm.

The same load is then hung from a second wire of the same cross-section, consisting of 1.0 m of metal X and 3.0 m of metal Y.

What is the total extension of this second wire?

A 2.5 mm   **B** 3.5 mm   **C** 4.8 mm   **D** 5.0 mm

Elastic Properties

21 Two wires P and Q are made from the same material. 9702/12/O/N/10

Wire P is initially twice the diameter and twice the length of wire Q. The same force, applied to each wire, causes the wires to extend elastically.

What is the ratio of the extension in P to that in Q?

A $\frac{1}{2}$ **B** 1 **C** 2 **D** 4

22 To determine the mass of food in a pan, a scale is used that has high sensitivity for small masses but low sensitivity for large masses. 9702/12/O/N/10

To do this, two springs are used, each with a different spring constant *k*. One of the springs has a low spring constant and the other has a high spring constant.

Which arrangement of springs would be suitable?


Elastic Properties
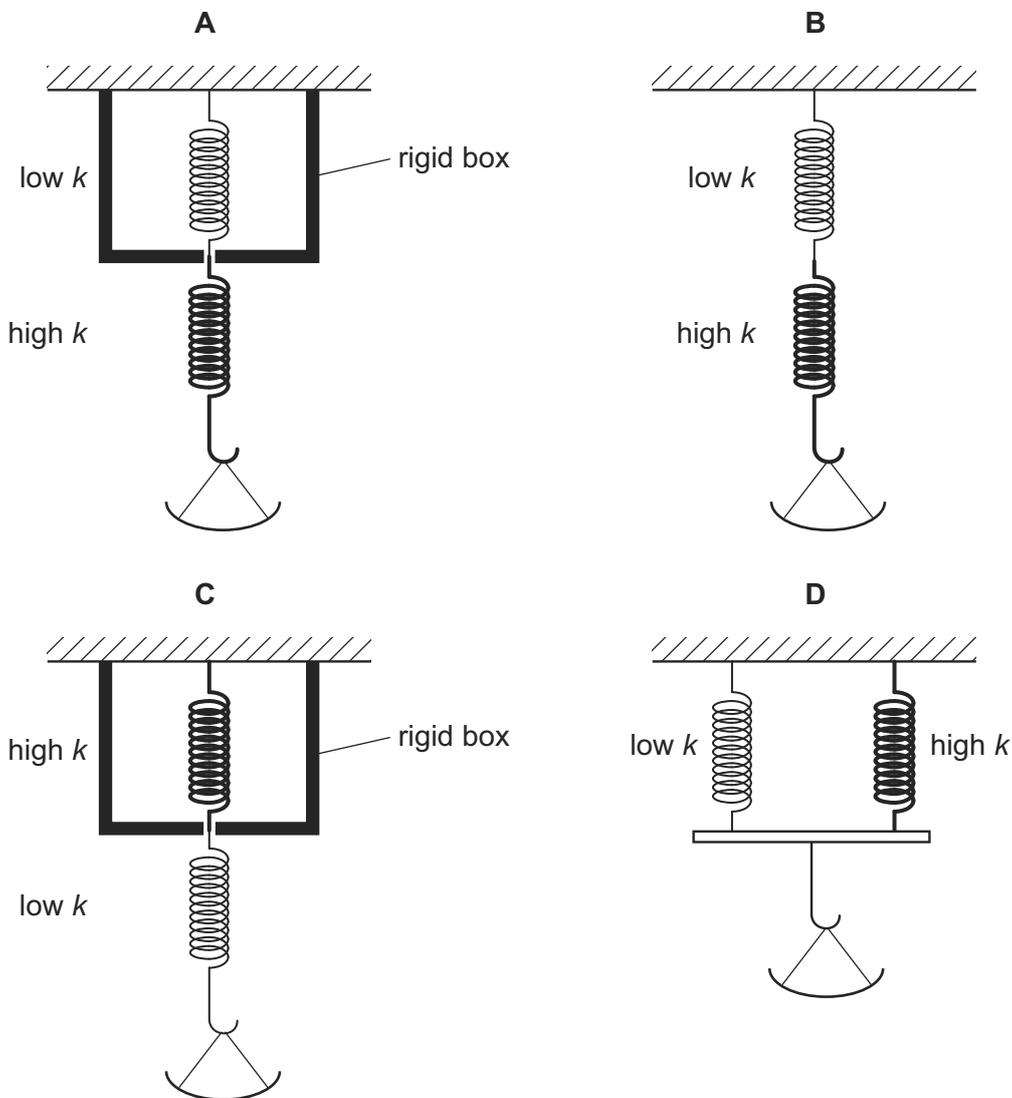
19 The graph shows how force depends on extension for a certain spring. 9702/13/O/N/10
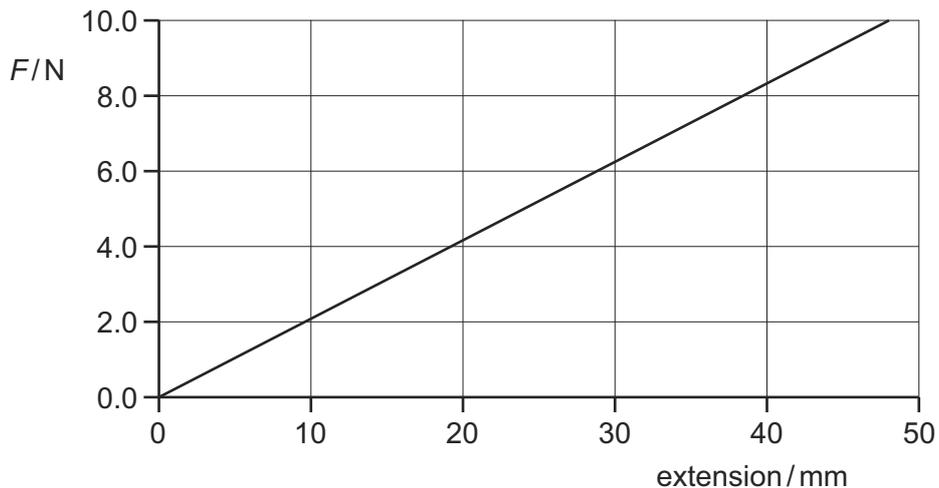
What is the energy stored in the spring when the extension is 30 mm?

A 0.095 J **B** 0.19 J **C** 0.25 J **D** 0.95 J

20 The Mariana Trench in the Pacific Ocean has a depth of about 10 km. 9702/13/O/N/10

Assuming that sea water is incompressible and has a density of about 1020 kg m^{-3}, what would be the approximate pressure at that depth?

A 10^5 Pa **B** 10^6 Pa **C** 10^7 Pa **D** 10^8 Pa

21 A wire consists of a 3.0 m length of metal X joined to a 1.0 m length of metal Y. 9702/13/O/N/10

The cross-sectional area of the wire is uniform.
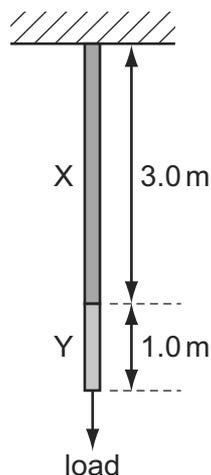
A load hung from the wire causes metal X to stretch by 1.5 mm and metal Y to stretch by 1.0 mm.

The same load is then hung from a second wire of the same cross-section, consisting of 1.0 m of metal X and 3.0 m of metal Y.
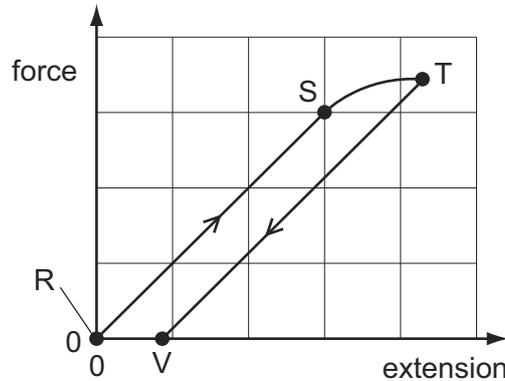
What is the total extension of this second wire?

A 2.5 mm **B** 3.5 mm **C** 4.8 mm **D** 5.0 mm

Elastic Properties

20 A long, thin metal wire is suspended from a fixed support and hangs vertically. Masses are suspended from its lower end.   9702/11/M/J/11

The load on the lower end is increased from zero and then decreased again back to zero.

The diagram shows the force-extension graph produced.

Where on the graph would the elastic limit be found?

A   anywhere between point R and point S

B   beyond point S but before point T

C   exactly at point S

D   exactly at point T

21 The Young modulus E can be determined from measurements made when a wire is stretched.

Which quantities would be measured in order to determine E?   9702/11/M/J/11

A	mass of stretching load	original length of wire	diameter of wire	extension of wire
B	mass of stretching load	new length of wire	cross-sectional area of wire	diameter of wire
C	mass of wire	original length of wire	cross-sectional area of wire	new length of wire
D	mass of wire	new length of wire	diameter of wire	extension of wire

23 The behaviour of a wire under tensile stress may be described in terms of the Young modulus E of the material of the wire and of the force per unit extension k of the wire.   9702/12/M/J/11

For a wire of length L and cross-sectional area A, what is the relation between E and k?

A $E = \dfrac{A}{kL}$ **B** $E = \dfrac{kA}{L}$ **C** $E = \dfrac{kL}{A}$ **D** $E = \dfrac{L}{kA}$

Elastic Properties

24 The diagram shows the structure of part of a mattress. 9702/12/M/J/11
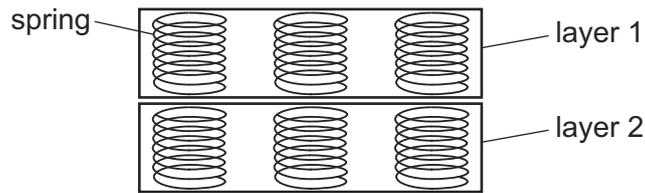
The manufacturer wants to design a softer mattress (one which will compress more for the same load).

Which change will **not** have the desired effect?

A using more layers of springs

B using more springs per unit area

C using springs with a smaller spring constant

D using springs made from wire with a smaller Young modulus

20 The Young modulus E can be determined from measurements made when a wire is stretched.

Which quantities would be measured in order to determine E? 9702/13/M/J/11

| A	mass of stretching load	original length of wire	diameter of wire	extension of wire
B	mass of stretching load	new length of wire	cross-sectional area of wire	diameter of wire
C	mass of wire	original length of wire	cross-sectional area of wire	new length of wire
D	mass of wire	new length of wire	diameter of wire	extension of wire

23 The Young modulus of steel is determined using a length of steel wire and is found to have the value E. 9702/11/O/N/11

Another experiment is carried out using a wire of the same steel, but of half the length and half the diameter.

What value is obtained for the Young modulus in the second experiment?

A $\frac{1}{2}E$ **B** E **C** $2E$ **D** $4E$

Elastic Properties

24 A rubber band is stretched and then relaxed to its original length. The diagram shows the force-extension graph for this process. 9702/11/O/N/11
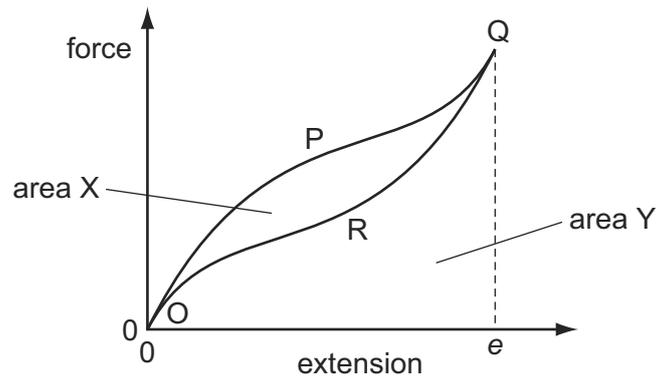
As the force is increased, the curve follows the path OPQ to extension *e*. As the force is reduced, the curve follows the path QRO to return to zero extension.

The area labelled X is between the curves OPQ and QRO. The area labelled Y is bounded by the curve QRO and the horizontal axis.

Which statement about the process is correct?

A Area X is the energy which heats the band as it is stretched to *e*.

B (Area X + area Y) is the minimum energy required to stretch the band to *e*.

C Area X is the elastic potential energy stored in the band when it is stretched to *e*.

D (Area Y – area X) is the net work done on the band during the process.

25 When describing the behaviour of a spring, the spring constant is used. 9702/11/O/N/11

Different loads are used to extend the spring by different amounts.

To find the spring constant, which quantities are required?

A the elastic limit and the loads

B the elastic limit, extensions and the length of the spring

C the loads and the extensions of the spring

D the loads and the length of the spring

21 The Young modulus of steel is determined using a length of steel wire and is found to have the value *E*.
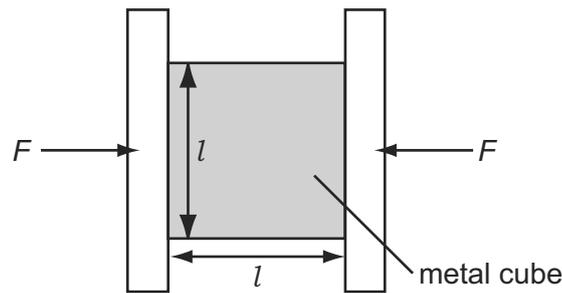
Another experiment is carried out using a wire of the same steel, but of half the length and half the diameter.

What value is obtained for the Young modulus in the second experiment? 9702/13/O/N/11

A $\frac{1}{2}E$ **B** *E* **C** 2*E* **D** 4*E*

Elastic Properties

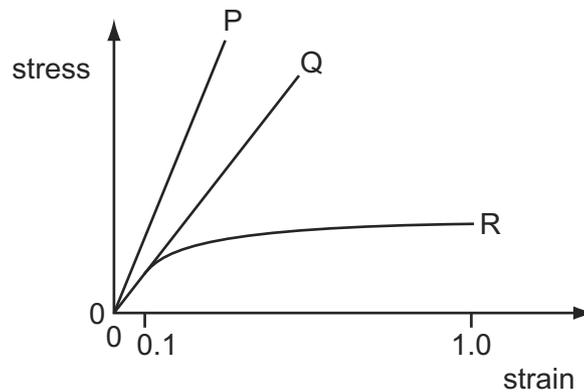**26** A metal cube of side l is placed in a vice and compressed elastically by two opposing forces F.

How will Δl, the amount of compression, relate to l?

A $\quad \Delta l \propto \dfrac{1}{l^2}$ **B** $\quad \Delta l \propto \dfrac{1}{l}$ **C** $\quad \Delta l \propto l$ **D** $\quad \Delta l \propto l^2$

21 The graph shows the relationship between stress and strain for three wires of the same linear dimensions but made from different materials.


Which statements are correct?

    1   The extension of P is approximately twice that of Q for the same stress.

    2   The ratio of the Young modulus for P to that of Q is approximately two.

    3   For strain less than 0.1, R obeys Hooke's law.

A 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

22 Which property of a metal wire depends on its Young modulus?

A ductility

B elastic limit

C spring constant

D ultimate tensile stress

Elastic Properties

22 The graph shows the effect of applying a force of up to 5 N to a spring.
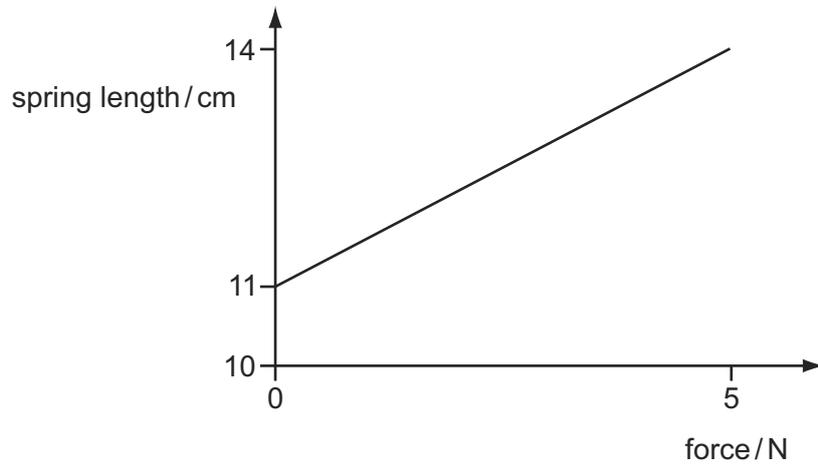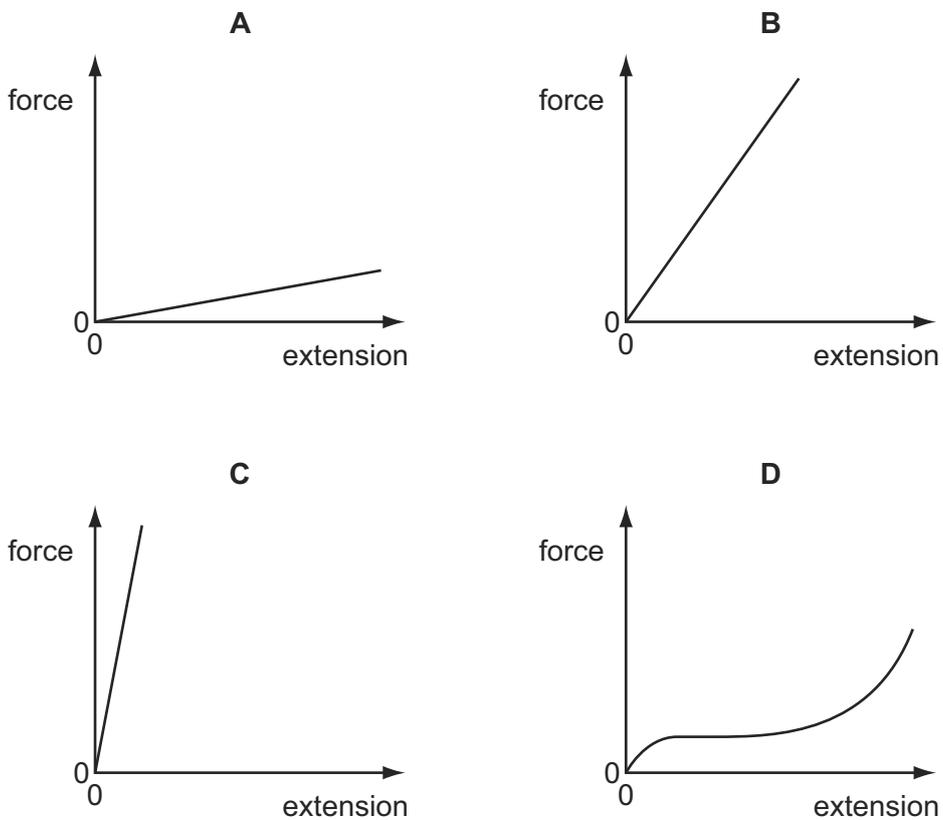

What is the total increase in length produced by a 7 N force, assuming the spring obeys Hooke's law?

A   4.2 cm   **B**   5.6 cm   **C**   15.2 cm   **D**   19.6 cm

23 The following force-extension graphs are drawn to the same scale.   9702/12/O/N/11

Which graph represents the deformed object with the greatest amount of elastic potential energy?

Elastic Properties

22 A rubber band is stretched and then relaxed to its original length. The diagram shows the force-extension graph for this process. 9702/13/O/N/11
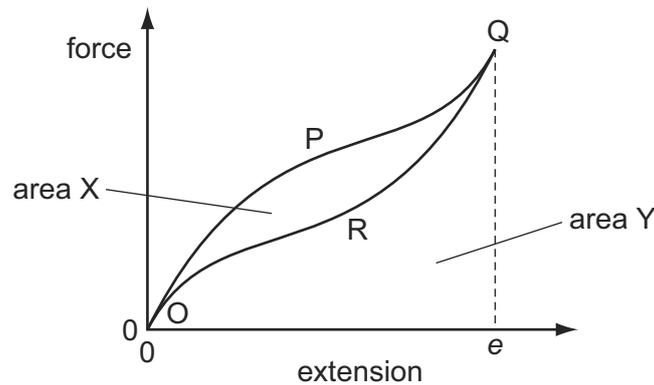
As the force is increased, the curve follows the path OPQ to extension e. As the force is reduced, the curve follows the path QRO to return to zero extension.

The area labelled X is between the curves OPQ and QRO. The area labelled Y is bounded by the curve QRO and the horizontal axis.

Which statement about the process is correct?

A Area X is the energy which heats the band as it is stretched to e.

B (Area X + area Y) is the minimum energy required to stretch the band to e.

C Area X is the elastic potential energy stored in the band when it is stretched to e.

D (Area Y – area X) is the net work done on the band during the process.

23 Which property of a metal wire depends on its Young modulus? 9702/11/M/J/12

A ductility

B elastic limit

C spring constant

D ultimate tensile stress

25 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)? 9702/11/M/J/12

A elastic limit

B spring constant

C stress

D Young modulus

Elastic Properties

24 The diagram shows a wire of diameter D and length L that is firmly clamped at one end between two blocks of wood. A load is applied to the wire which causes it to extend by an amount x.
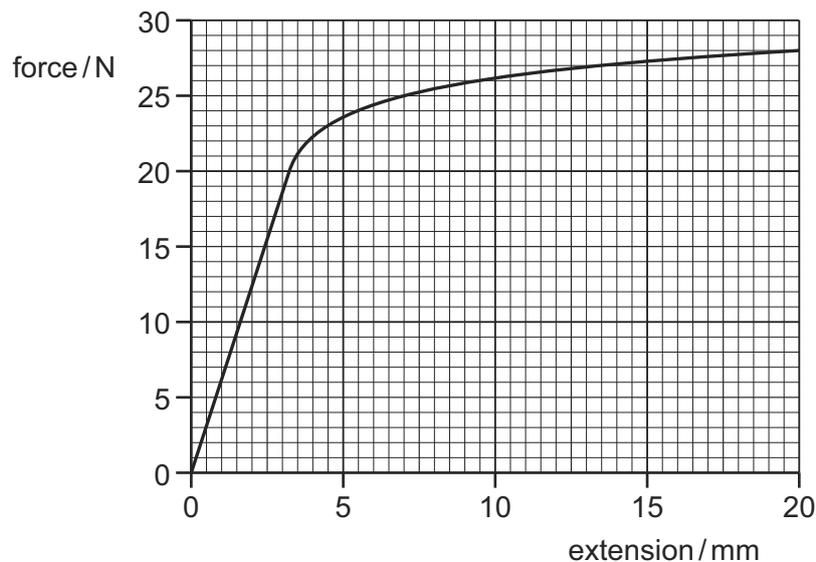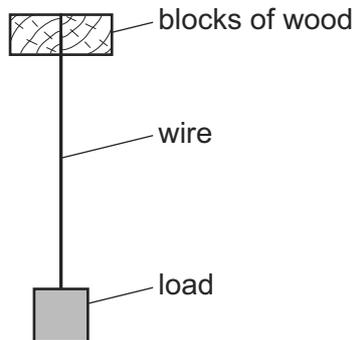
blocks of wood
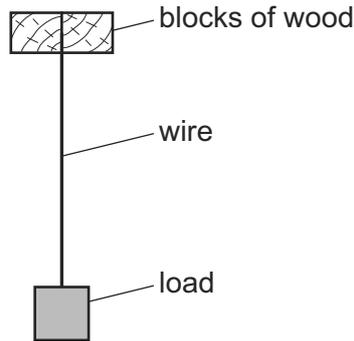
wire

load

By how much would a wire of the same material, but of diameter $2D$ and length $3L$, extend when the same load is applied?

A $\frac{2}{3}x$ **B** $\frac{3}{4}x$ **C** $\frac{4}{3}x$ **D** $\frac{3}{2}x$

24 The graph is a force-extension graph for a wire that is being stretched.

force / N

extension / mm

How much work needs to be done by the tensile force, to two significant figures, to cause an extension of 7.0 mm?

A 0.088 J   **B** 0.12 J   **C** 0.53 J   **D** 120 J

25 A wire stretches 8 mm under a load of 60 N.

A second wire of the same material, with half the diameter and a quarter of the original length of the first wire, is stretched by the same load.

Assuming that Hooke's law is obeyed, what is the extension of this wire?

A 1 mm   **B** 4 mm   **C** 8 mm   **D** 16 mm

Elastic Properties

20 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)?

    A   elastic limit

    B   spring constant

    C   stress

    D   Young modulus

21 The diagram shows a wire of diameter D and length L that is firmly clamped at one end between two blocks of wood. A load is applied to the wire which causes it to extend by an amount x.

By how much would a wire of the same material, but of diameter $2D$ and length $3L$, extend when the same load is applied?

    A $\frac{2}{3}x$ **B** $\frac{3}{4}x$ **C** $\frac{4}{3}x$ **D** $\frac{3}{2}x$

26 The diagram shows the force-extension graphs for two materials, of the same dimensions, loaded to fracture.
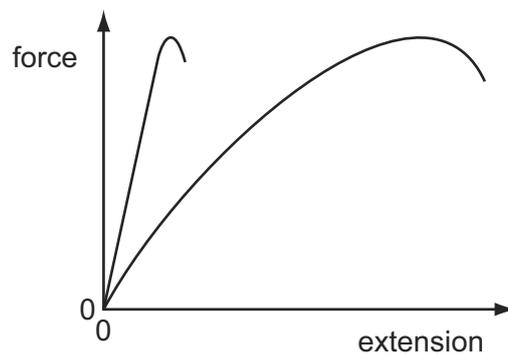
What describes the behaviour of the materials?

    A   Both materials are brittle.

    B   Both materials obey Hooke's law.

    C   Both materials are plastic.

    D   Both materials have the same ultimate tensile stress.

Elastic Properties

25 What leads to the conclusion that the movement of molecules is random?   9702/12/O/N/12

    A   evaporation of water at room temperature

    B   conduction of electricity in water

    C   convection currents in air

    D   motion of dust particles in air

27 Two wires, X and Y, are made from different metals and have different dimensions. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y. 9702/12/O/N/12

Both wires are extended with equal strain and obey Hooke's law.

What is the ratio $\dfrac{\text{tension in wire X}}{\text{tension in wire Y}}$?

    A $\frac{1}{8}$ **B** $\frac{1}{2}$ **C** 1   **D** 8

28 The diagram shows two identical loudspeakers driven in phase by a common audio-frequency source. 9702/12/O/N/12
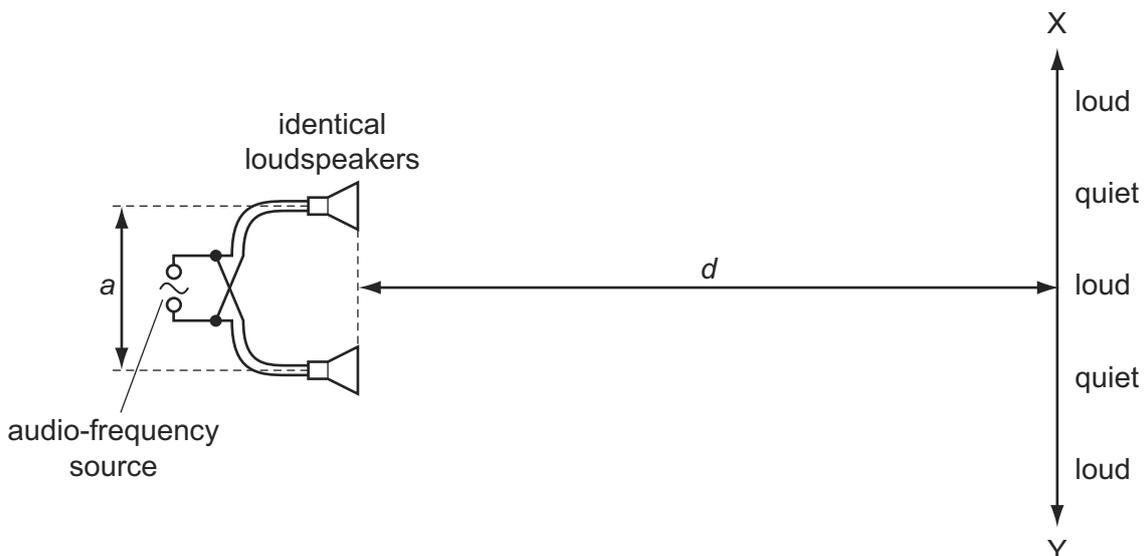

When a student moves along line XY, she notices that there are variations in the loudness of the sound. The regions in which the sound is heard are alternately loud and quiet as indicated on the diagram.

How may the distance between loud regions be reduced?

    A   decreasing the distance *a* between the speakers

    B   increasing distance *d*

    C   increasing the frequency of the audio-frequency source

    D   increasing the power output from the audio-frequency source

Elastic Properties

23 Three springs are arranged vertically as shown.
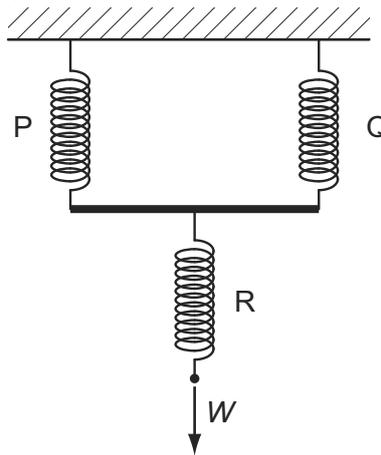

Springs P and Q are identical and have spring constant k. Spring R has spring constant $3k$.

What is the increase in the overall length of the arrangement when a force W is applied as shown?

A $\dfrac{5}{6}\dfrac{W}{k}$

B $\dfrac{4}{3}\dfrac{W}{k}$

C $\dfrac{7}{2}kW$

D $4\,kW$

24 The diagram shows the stress-strain graph for two wires X and Y of different materials up to their breaking points. Both wires have the same initial dimensions.
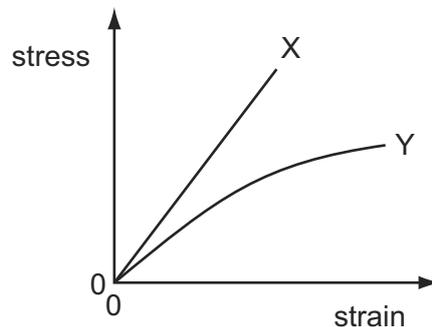
Which statement is **not** correct?

A   Material X extends elastically.

B   Material X extends more than material Y when loaded with the same force.

C   Material X has a larger ultimate tensile stress.

D   Material X is brittle.

Elastic Properties

25 A steel wire and a brass wire are joined end to end and are hung vertically with the steel wire attached to a point on the ceiling. The steel wire is twice as long as the brass wire and has half the diameter.

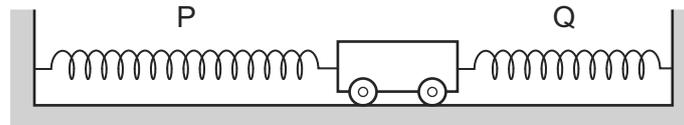A large mass is hung from the end of the brass wire so that both wires are stretched elastically.

The Young modulus for steel is 2.0×10^{11} Pa and for brass is 1.0×10^{11} Pa.

What is the ratio of the extension of the steel to the extension of the brass?

A 2 **B** 4 **C** 8 **D** 16

24 A trolley is held at rest between two steel springs.

Each spring has an unstretched length of 0.10 m.

Spring P has spring constant $60\,\mathrm{N\,m^{-1}}$.
Spring Q has spring constant $120\,\mathrm{N\,m^{-1}}$.

Spring P has an extension of 0.40 m.

What is the extension of spring Q?

A 0.10 m **B** 0.20 m **C** 0.30 m **D** 0.80 m

25 A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm.

The lift drops 1 mm when a man of mass 80 kg steps into the lift.
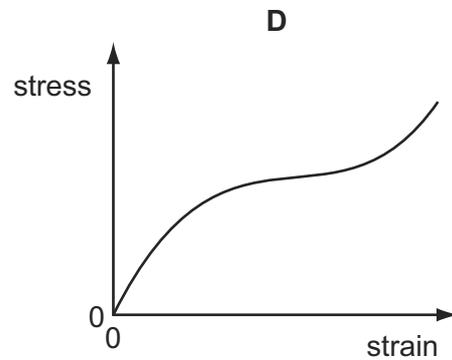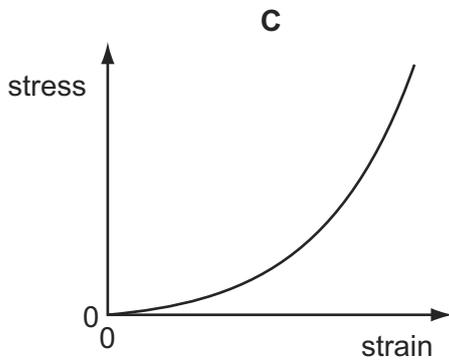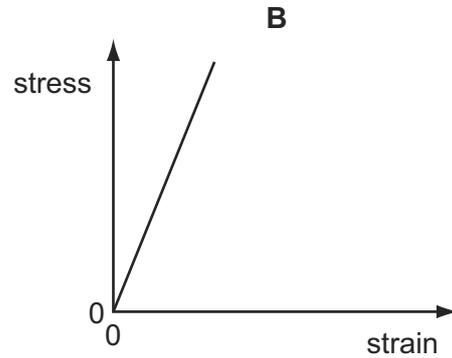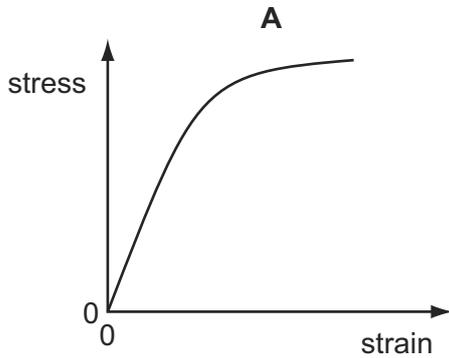
What is the best estimate of the value of the Young modulus of the steel?

A $2 \times 10^{10}\,\mathrm{N\,m^{-2}}$

B $4 \times 10^{10}\,\mathrm{N\,m^{-2}}$

C $2 \times 10^{11}\,\mathrm{N\,m^{-2}}$

D $4 \times 10^{11}\,\mathrm{N\,m^{-2}}$

Elastic Properties

22 The stress-strain graphs for four different materials are shown below.

Which diagram shows the stress-strain graph for a ductile metal?

A

stress

0
0   strain

B

stress

0
0   strain

C

stress

0
0   strain
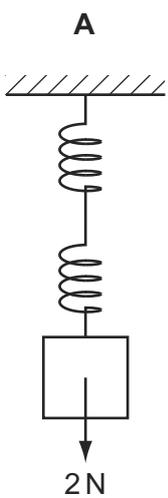
D

stress

0
0   strain

23 A number of identical springs, each having the same spring constant, are joined in four arrangements. A different load is applied to each arrangement.
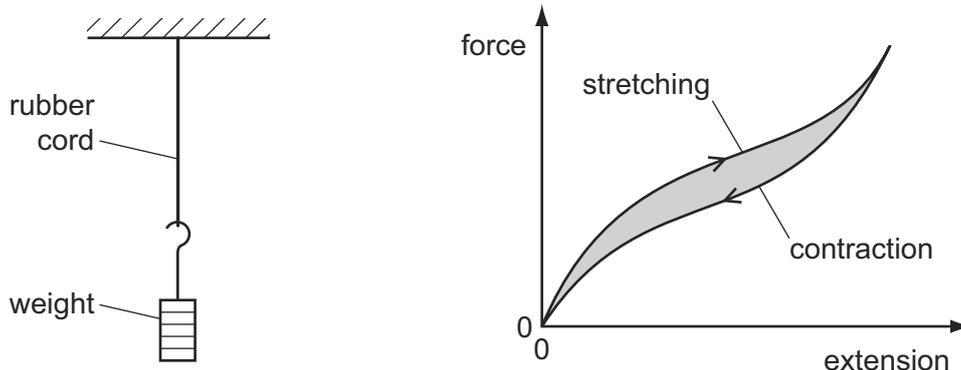
Which arrangement has the largest extension?

A

2 N

B

1 N

C

6 N

D

8 N

Elastic Properties
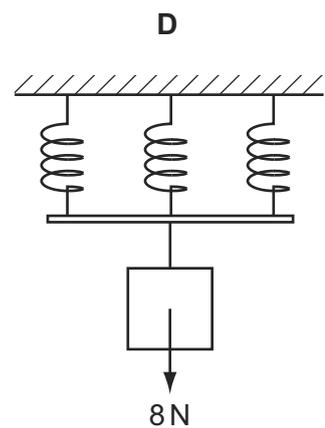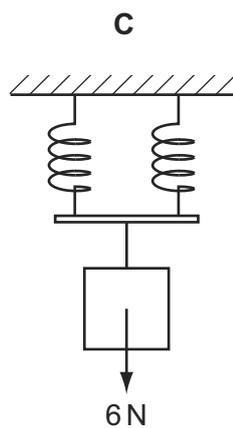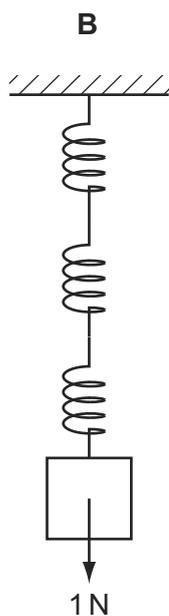
22 A rubber cord hangs from a rigid support. A weight attached to its lower end is gradually increased from zero, and then gradually reduced to zero.

The force-extension curve for contraction is below the force-extension curve for stretching.

What does the shaded area between the curves represent?

A the amount of elastic energy stored in the rubber

B the amount of thermal energy dissipated in the rubber

C the work done on the rubber cord during stretching

D the work done by the rubber cord during contraction

23 The diagram shows a large crane on a construction site lifting a cube-shaped load.
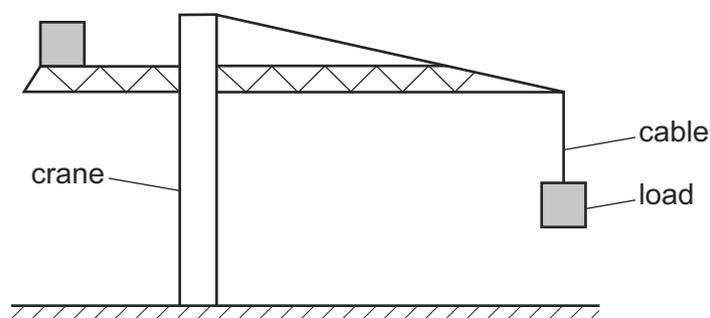
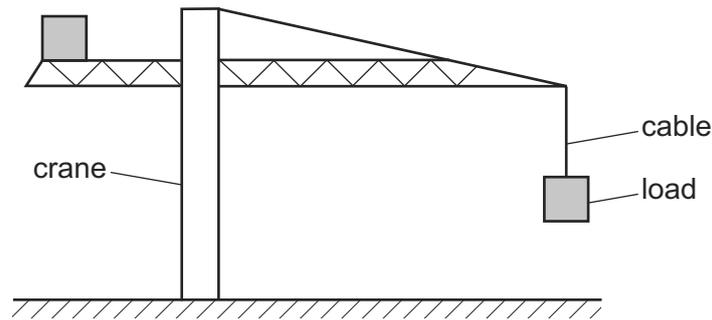A model is made of the crane, its load and the cable supporting the load.

The material used for each part of the model is the same as that in the full-size crane, cable and load. The model is one tenth full-size in all linear dimensions.

What is the ratio $\dfrac{\text{stress in the cable on the full-size crane}}{\text{stress in the cable on the model crane}}$?

A 10^0 **B** 10^1 **C** 10^2 **D** 10^3

21 What is the unit of the Young modulus?

A $N\,m^{-1}$ **B** $N\,m$ **C** $N\,m^{-2}$ **D** $N\,m^2$

Elastic Properties

19 The diagram shows a large crane on a construction site lifting a cube-shaped load.   9702/13/M/J/13


A model is made of the crane, its load and the cable supporting the load.

The material used for each part of the model is the same as that in the full-size crane, cable and load. The model is one tenth full-size in all linear dimensions.

What is the ratio $\dfrac{\text{extension of the cable on the full-size crane}}{\text{extension of the cable on the model crane}}$?

A 10^0 **B** 10^1 **C** 10^2 **D** 10^3

20 Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point?   9702/13/M/J/13

Elastic Properties
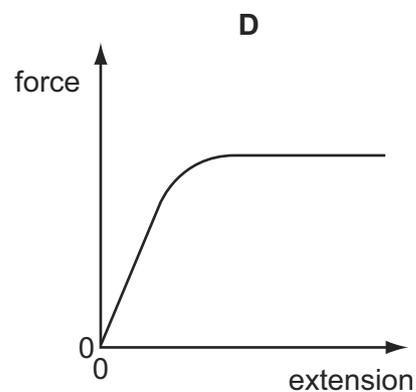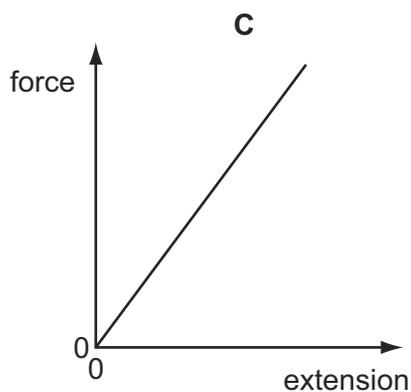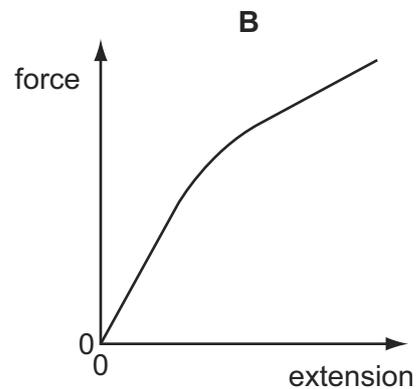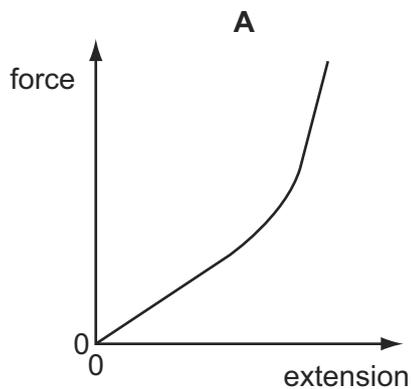
21 A spring is stretched over a range within which elastic deformation occurs. Its spring constant is $3.0 \, \text{N} \, \text{cm}^{-1}$.

Which row, for the stated applied force, gives the correct extension and strain energy?

	force /N	extension /cm	strain energy /mJ
A	3.0	1.0	1.5
B	6.0	2.0	120
C	12.0	3.0	180
D	24.0	8.0	960

15 A spring of unextended length 40 mm is suspended from a fixed point. A load of 16 N is applied to the free end of the spring. This causes the spring to extend so that its final length is five times its original length. The spring obeys Hooke's Law.

What is the energy stored in the spring due to this extension?

A 1.3 J   **B** 1.6 J   **C** 2.6 J   **D** 3.2 J

23 Which properties best describe modelling clay?

A brittle and ductile

B ductile and elastic

C elastic and plastic

D plastic and ductile

24 A steel spring has a spring constant of $150 \, \text{N} \, \text{m}^{-1}$. When a 25 N weight is hung from the spring, it has a stretched length of 55 cm.

What was the original length of the spring?

A 0.38 m   **B** 0.49 m   **C** 0.61 m   **D** 0.72 m

22 A lift is supported by two steel cables each of length 20 m.

Each of the cables consists of 100 parallel steel wires, each wire of cross-sectional area $3.2 \times 10^{-6} \, \text{m}^2$. The Young modulus of steel is $2.1 \times 10^{11} \, \text{N} \, \text{m}^{-2}$.

Which distance does the lift move downward when a man of mass 70 kg steps into it?

A 0.010 mm   **B** 0.020 mm   **C** 0.10 mm   **D** 0.20 mm

Elastic Properties

20 The stress-strain graphs for three different materials are shown, not drawn to the same scales.

9702/11/M/J/14
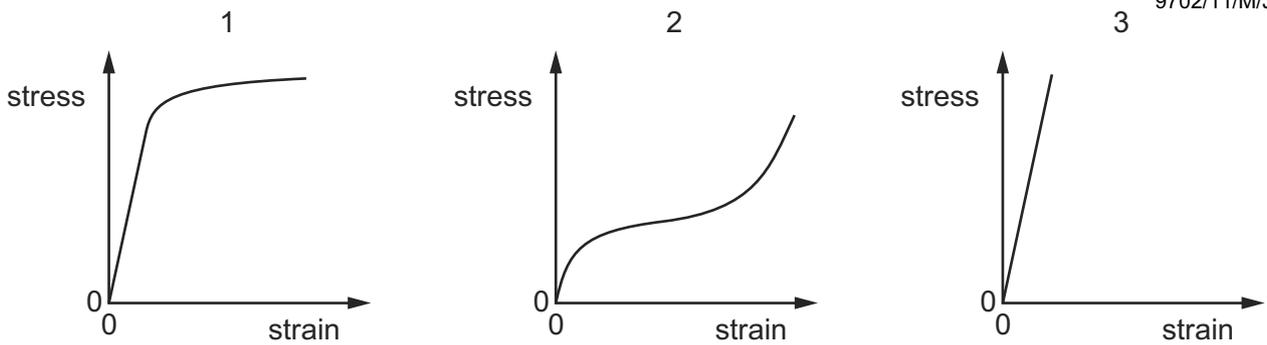
The three materials are copper, rubber and glass.
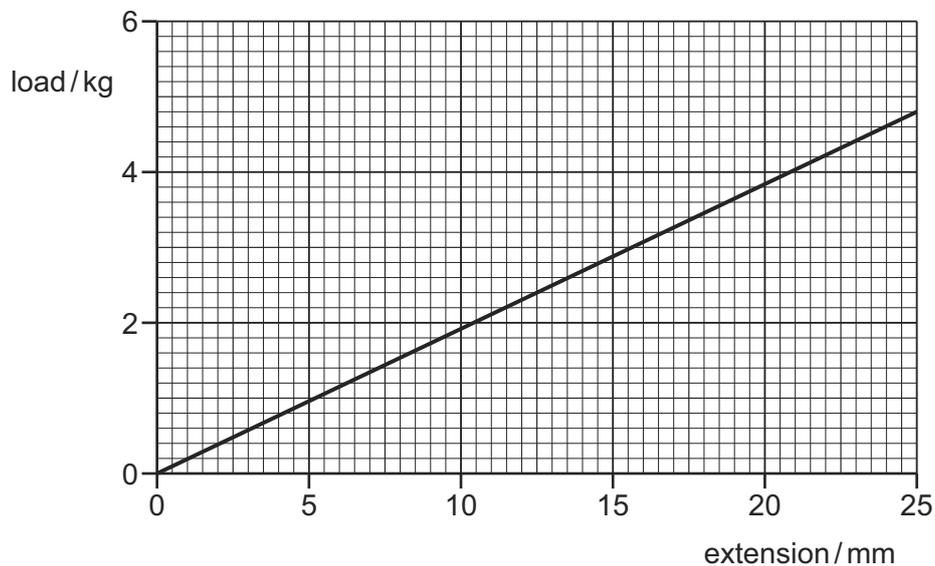
Which materials are represented by the graphs?

	1	2	3
A	copper	glass	rubber
B	copper	rubber	glass
C	glass	copper	rubber
D	glass	rubber	copper

21 The graph is a load-extension graph for a wire undergoing elastic deformation.

9702/11/M/J/14

How much work is done on the wire to increase the extension from 10 mm to 20 mm?

**A** 0.028 J   **B** 0.184 J   **C** 0.28 J   **D** 0.37 J

Elastic Properties

23 What is equal to the Young modulus of a material that is extended elastically within the limit of proportionality?

   A   area under the force-extension graph

   B   area under the stress-strain graph

   C   gradient of the force-extension graph

   D   gradient of the stress-strain graph

19 A sample of metal is subjected to a force which increases to a maximum value and then decreases back to zero. A force-extension graph for the sample is shown.
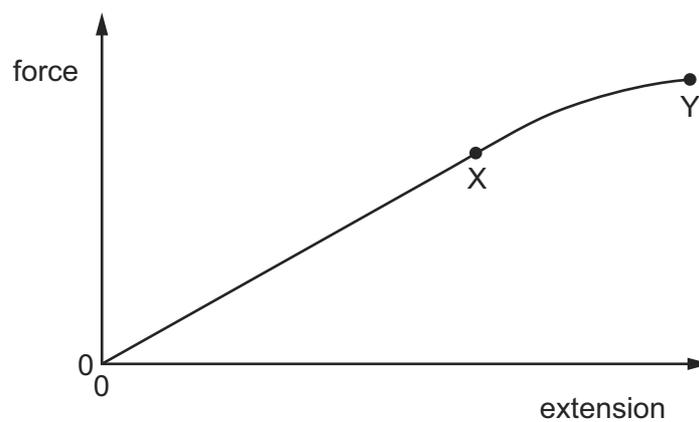
When the sample contracts it follows the same force-extension curve as when it was being stretched.

What is the behaviour of the metal between X and Y?

   A   both elastic and plastic

   B   not elastic and not plastic

   C   plastic but not elastic

   D   elastic but not plastic

23 An elastic material with a Young modulus E is subjected to a tensile stress S. Hooke's Law is obeyed.
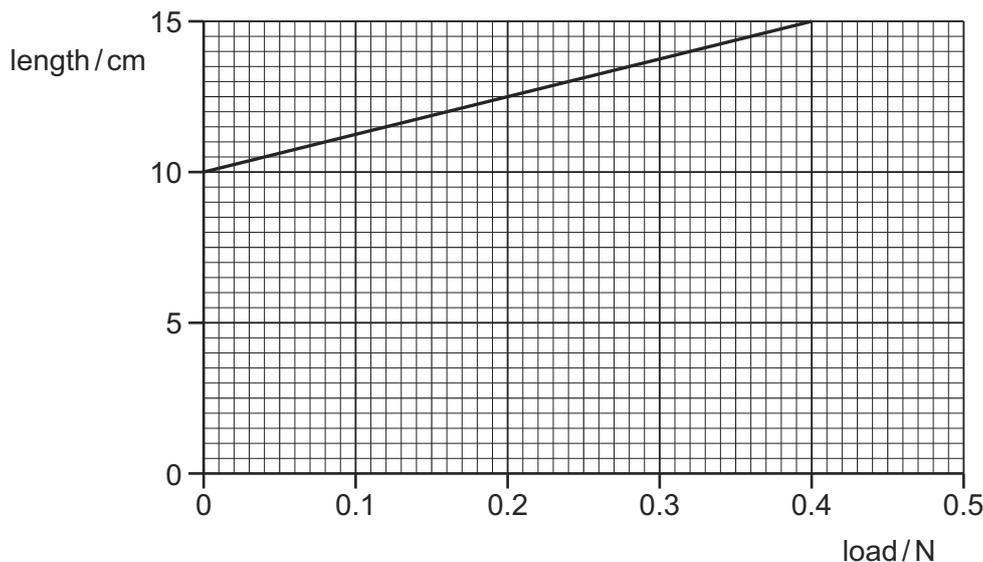
What is the expression for the elastic energy stored per unit volume of the material?

   A $\dfrac{S^2}{2E}$ **B** $\dfrac{S^2}{E}$ **C** $\dfrac{E}{2S^2}$ **D** $\dfrac{2E}{S^2}$

Elastic Properties

20 The graph shows the length of a spring as it is stretched by an increasing load.

What is the spring constant?

A $8.0 \, \text{N} \, \text{m}^{-1}$ **B** $2.7 \, \text{N} \, \text{m}^{-1}$ **C** $0.13 \, \text{N} \, \text{m}^{-1}$ **D** $0.080 \, \text{N} \, \text{m}^{-1}$

21 A composite rod is made by attaching a glass-reinforced plastic rod and a nylon rod end to end, as shown.
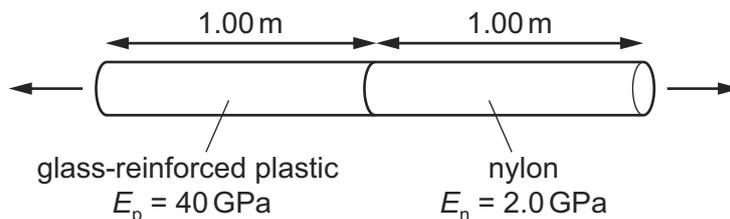
The rods have the same cross-sectional area and each rod is 1.00 m in length. The Young modulus E_p of the plastic is 40 GPa and the Young modulus E_n of the nylon is 2.0 GPa.

The composite rod will break when its total extension reaches 3.0 mm.

What is the greatest tensile stress that can be applied to the composite rod before it breaks?

A $7.1 \times 10^{-14} \, \text{Pa}$

B $7.1 \times 10^{-2} \, \text{Pa}$

**C** $5.7 \times 10^{6} \, \text{Pa}$

D $5.7 \times 10^{9} \, \text{Pa}$

**22** The Mariana Trench in the Pacific Ocean has a depth of about 10 km.

Assuming that sea water is incompressible and has a density of about $1020 \, \text{kg} \, \text{m}^{-3}$, what would be the approximate pressure at that depth?

A $10^{5} \, \text{Pa}$ **B** $10^{6} \, \text{Pa}$ **C** $10^{7} \, \text{Pa}$ **D** $10^{8} \, \text{Pa}$
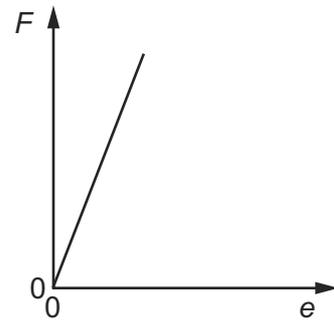
Elastic Properties

24 Cylindrical samples of steel, glass and rubber are each subjected to a gradually increasing tensile force *F*. The extensions *e* are measured and graphs are plotted as shown below.   9702/13/M/J/14
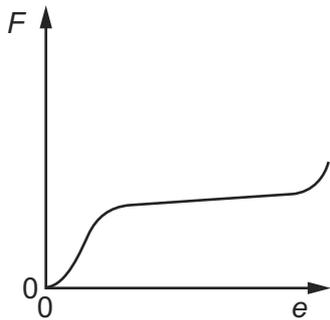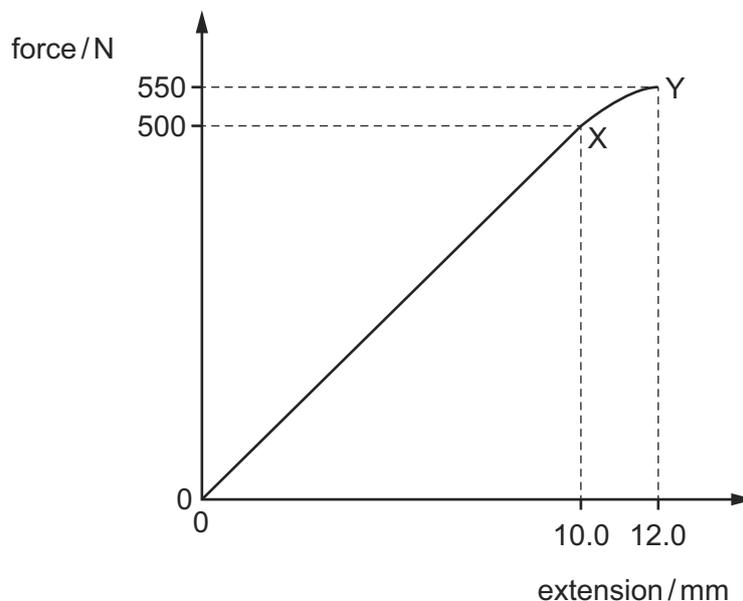

graph X   graph Y   graph Z
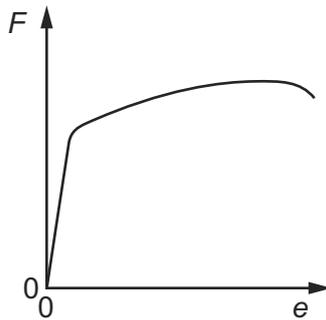
Which row correctly relates the graphs to the materials?

	steel	glass	rubber
A	X	Y	Z
B	X	Z	Y
C	Y	X	Z
D	Y	Z	X

24 The graph shows the behaviour of a sample of a metal when it is stretched until it starts to undergo plastic deformation.   9702/13/O/N/14

What is the total work done in stretching the sample from zero to 12.0 mm extension?
Simplify the calculation by treating the curve XY as a straight line.

**A**   3.30 J   **B**   3.55 J   **C**   3.60 J   **D**   6.60 J

Elastic Properties

23 What is meant by the ultimate tensile stress of a material?

    A   the maximum force that can be applied to a bar of the material before it bends

    B   the maximum inter-atomic force before the atomic bonds of the material break

    C   the maximum stretching force per unit cross-sectional area before the material breaks

    D   the maximum tensile force in a wire of the material before it breaks

25 Two springs, one with spring constant $k_1 = 4\,\mathrm{kN\,m^{-1}}$ and the other with spring constant $k_2 = 2\,\mathrm{kN\,m^{-1}}$, are connected as shown.
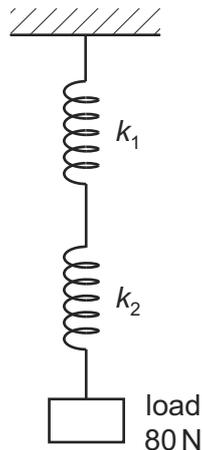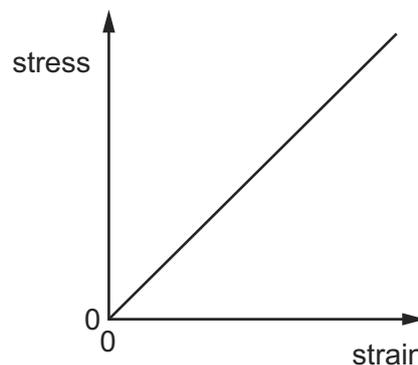

What is the total extension of the springs when supporting a load of 80 N?

    A   1.3 cm   **B**   4 cm   **C**   6 cm   **D**   60 cm

20 The stress-strain graph for a glass rod, up to the point at which it breaks, is shown below.

Which statement about the glass rod is correct?

    A   Hooke's law is obeyed for all values of stress up to the breaking point.

    B   The glass is ductile.

    C   The glass shows plastic deformation.

    D   When the cross-sectional area of the rod is doubled, the ultimate tensile stress of the rod is halved.

Elastic Properties

22 A steel bar of circular cross-section is under tension T, as shown.

The diameter of the wide portion is double the diameter of the narrow portion.

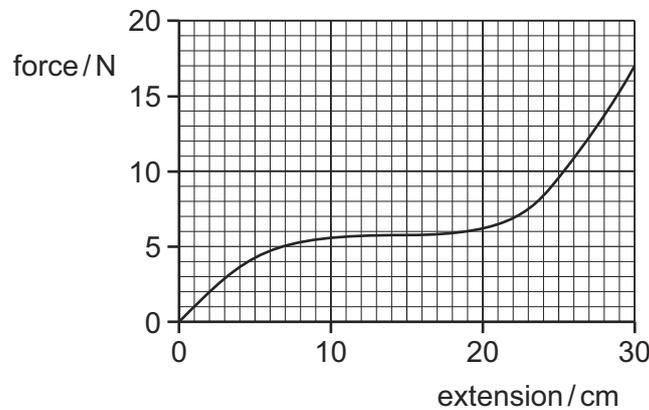What is the value of $\dfrac{\text{stress in the wide portion}}{\text{stress in the narrow portion}}$?

A 0.25 **B** 0.50 **C** 2.0 **D** 4.0

21 A rubber band is stretched by hanging weights on it and the force-extension graph is plotted from the results.

What is the best estimate of the strain energy stored in the rubber band when it is extended 30 cm?

A 1.8 J **B** 2.6 J **C** 5.1 J **D** 200 J

**21** To determine the Young modulus of a wire, several measurements are taken.

In which row can the measurement **not** be taken **directly** with the stated apparatus?

	measurement	apparatus
A	area of cross-section of wire	micrometer screw gauge
B	extension of wire	vernier scale
C	mass of load applied to wire	electronic balance
D	original length of wire	metre rule

Elastic Properties

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23 The graph shows the non-linear force-extension curve for a wire made from a new composite material.
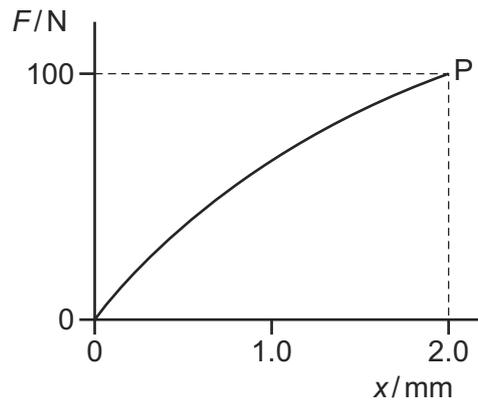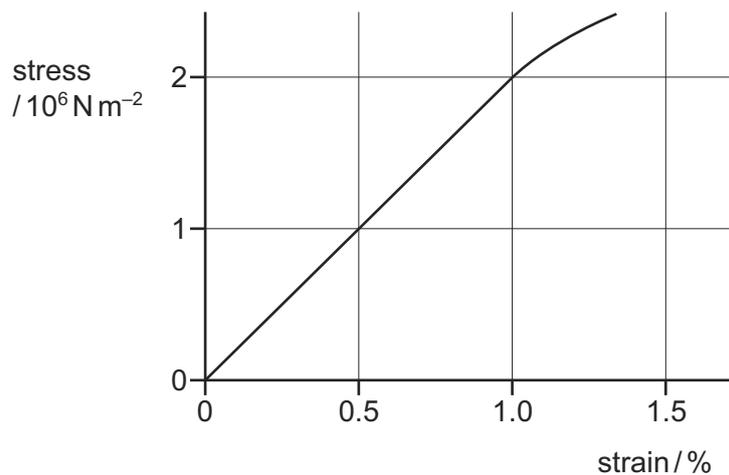
What could be the value of the strain energy stored in the wire when it is stretched elastically to point P?

A 0.09 J   **B** 0.10 J   **C** 0.11 J   **D** 0.20 J

24 The diagram shows the stress-strain graph for bone.

What is the Young modulus of bone?

A $1 \times 10^6 \, N \, m^{-2}$

B $2 \times 10^6 \, N \, m^{-2}$

C $1 \times 10^8 \, N \, m^{-2}$

D $2 \times 10^8 \, N \, m^{-2}$

Elastic Properties

22 A long, thin metal wire is suspended from a fixed support and hangs vertically. Masses are suspended from its lower end.

9702/12/M/J/15

The load on the lower end is increased from zero and then decreased again back to zero.
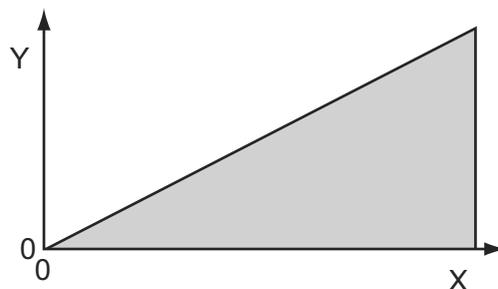
The diagram shows the force-extension graph produced.
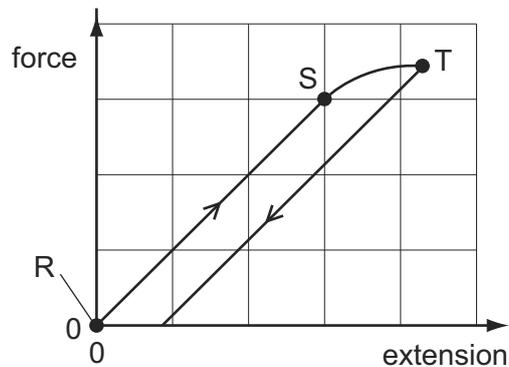
Where on the graph would the elastic limit be found?

A anywhere between point R and point S

B just beyond point S

C exactly at point S

D exactly at point T

**22** The graph shown was plotted in an experiment on a metal wire.

9702/11/M/J/15

The shaded area represents the total strain energy stored in stretching the wire.

How should the axes be labelled?

	Y	X
A	force	extension
B	mass	extension
C	strain	energy
D	stress	strain

Elastic Properties

23 The diagram represents a steel tube with wall thickness *w* which is small in comparison with the diameter of the tube.
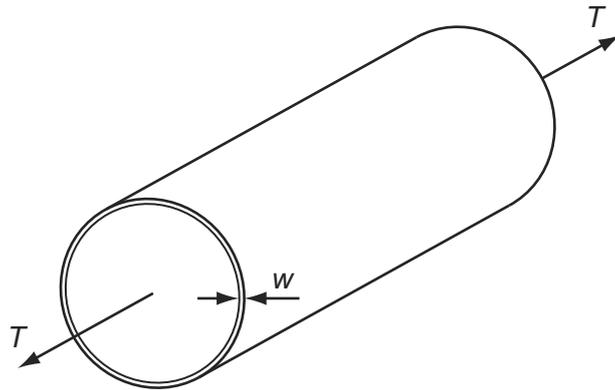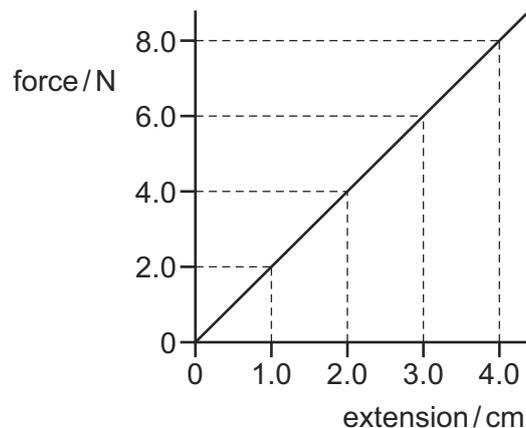
The tube is under tension, caused by a force *T*, parallel to the axis of the tube. To reduce the stress in the material of the tube, it is proposed to thicken the wall.

The tube diameter and the tension being constant, which wall thickness gives half the stress?

A $\dfrac{w}{2}$ **B** $\sqrt{2}\,w$ **C** $2w$ **D** $4w$

23 The variation with applied force of the extension of a spring is shown in the graph.

When there is no force applied to the spring, it has a length of 1.0 cm.

What is the **increase** in the strain energy stored in the spring when its **length** is increased from 2.0 cm to 3.0 cm?

A 0.020 J   **B** 0.030 J   **C** 0.040 J   **D** 0.050 J

Elastic Properties