CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



EXAM QUESTION PACK

6 DEFORMATION OF SOLIDS

SCORE	PERCENTAGE
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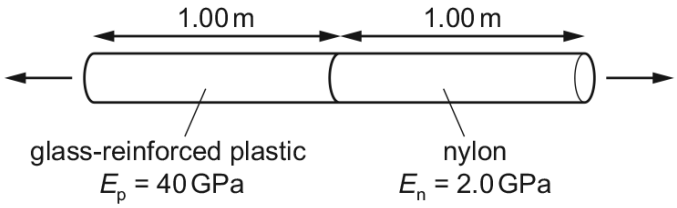
Chapter 7

Deformation of solids

7.1 Stress and strain

638. 9702_m20_qp_12 Q: 19

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 2.9×10^6 Pa

B 5.7×10^6 Pa

C 2.9×10^9 Pa

D 5.7×10^9 Pa

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639. 9702_s20_qp_11 Q: 16

A mass attached to the lower end of a spring bounces up and down.

At which points in the path of the mass do the gravitational potential energy of the mass (GPE), the elastic potential energy in the spring (EPE) and the kinetic energy of the mass (KE) have their highest values?

	GPE	EPE	KE
A	bottom	middle	top
B	bottom	top	middle
C	top	bottom	middle
D	top	bottom	top

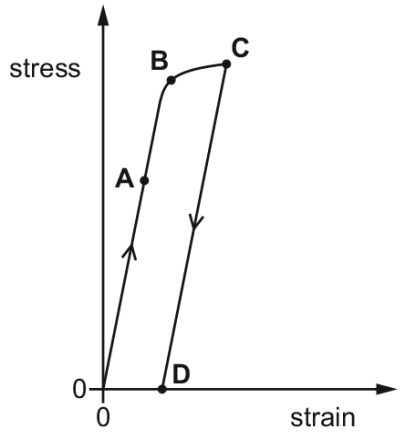
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640. 9702_s20_qp_11 Q: 20

A tensile force is used to extend a sample of a material. The force is then removed.

The variation with strain of the applied stress is shown on the graph.

Which point on the graph could represent the elastic limit for the material?

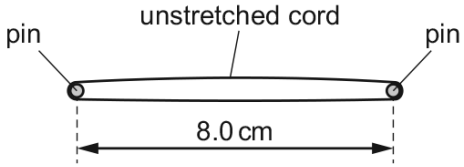


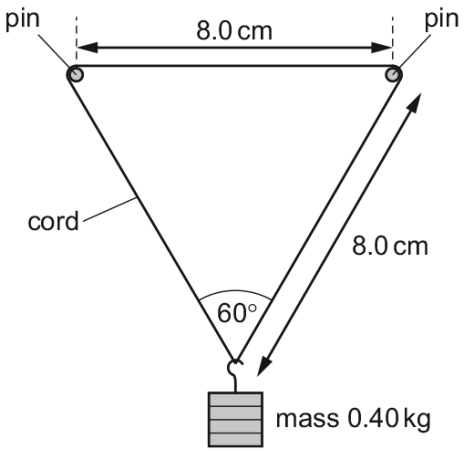
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641. 9702_s20_qp_12 Q: 18

An elastic cord of unstretched total length 16.0 cm and cross-sectional area $2.0 \times 10^{-6}\,m^2$ is held horizontally by two smooth pins a distance 8.0 cm apart.

The cord obeys Hooke's law. A load of mass 0.40 kg is suspended centrally on the cord. The angle between the two sides of the cord supporting the load is 60°.



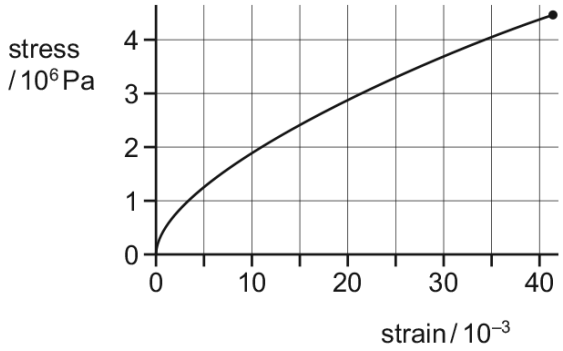


What is the Young modulus of the cord material?

A $5.7 \times 10^5\,Pa$ **B** $1.1 \times 10^6\,Pa$ **C** $2.3 \times 10^6\,Pa$ **D** $3.9 \times 10^6\,Pa$

642. 9702_s20_qp_12 Q: 19

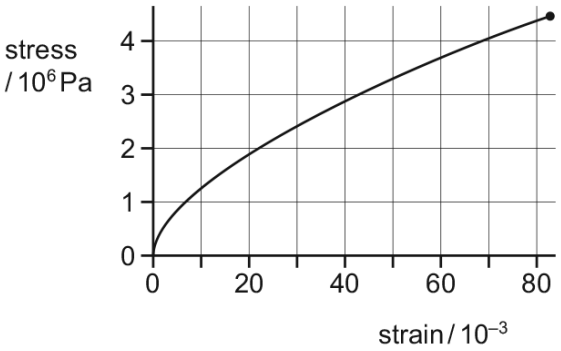
A student is investigating the mechanical properties of a metal. He applies different loads to a long thin wire up to its breaking point, and measures the extension of the wire for each load. He then plots a graph of stress against strain.



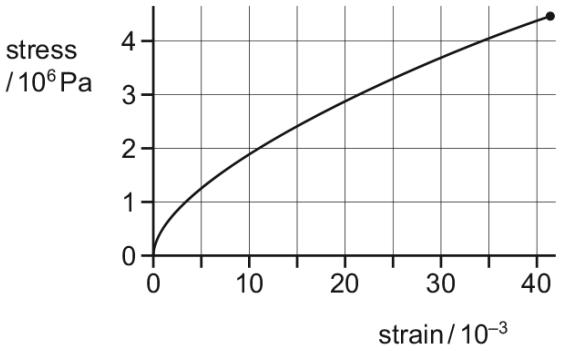
The student repeats the experiment with a wire made from the same metal, with twice the original length and half the diameter.

Which graph is obtained?

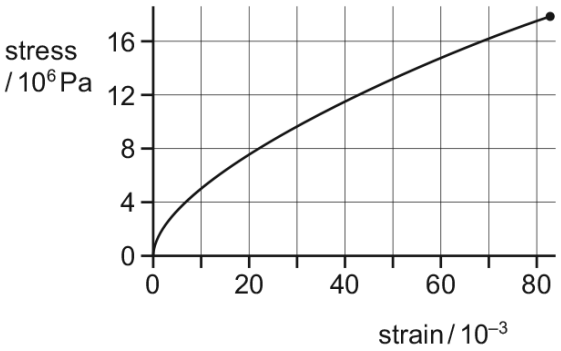
A



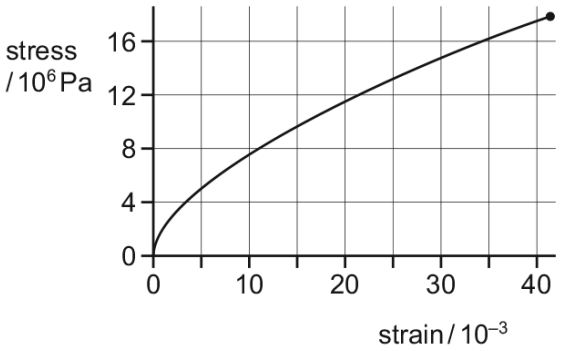
B



C

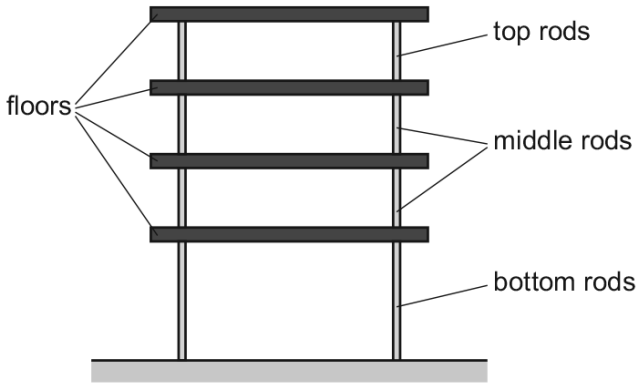


D



643. 9702_s20_qp_13 Q: 20

The diagram shows a simplified model of a building with four identical heavy floors.



The spacing of the bottom floor from the ground is twice that of the spacing between the floors. Between each floor are equal numbers of vertical steel supporting rods of negligible mass compared with the floors. The rods are of different diameters so that the stress in each rod is the same.

What is the ratio $\frac{\text{diameter of bottom rods}}{\text{diameter of top rods}}$?

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

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644. 9702_m19_qp_12 Q: 19

A metal wire, fixed at one end, has length l and cross-sectional area A. The wire extends a distance e when mass m is hung from the other end of the wire.

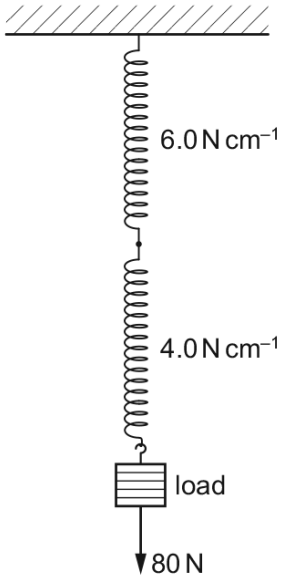
What is an expression for the Young Modulus E of the metal?

A $E = \frac{ml}{Ae}$ **B** $E = \frac{mgl}{Ae}$ **C** $E = \frac{me}{Al}$ **D** $E = \frac{mge}{Al}$

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645. 9702_m19_qp_12 Q: 20

A spring has a spring constant of 6.0 N cm^{-1}. It is joined to another spring whose spring constant is 4.0 N cm^{-1}. A load of 80 N is suspended from this composite spring.



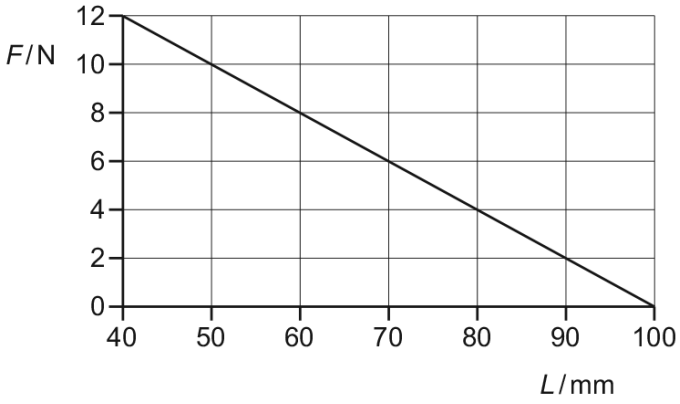
What is the extension of this composite spring?

A 8.0 cm **B** 16 cm **C** 17 cm **D** 33 cm

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646. 9702_s19_qp_11 Q: 20

A spring of original length 100 mm is compressed by a force. The graph shows the variation of the compressing force F with the length L of the spring.



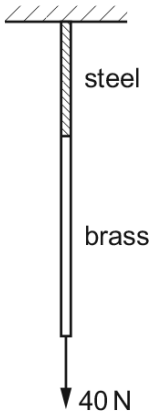
What is the energy stored in the spring when the length is 70 mm?

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

---

647. 9702_s19_qp_11 Q: 21

A 0.80 m length of steel wire and a 1.4 m length of brass wire are joined together. The combined wires are suspended from a fixed support and a force of 40 N is applied, as shown.



The Young modulus of steel is 2.0×10^{11} Pa.

The Young modulus of brass is 1.0×10^{11} Pa.

Each wire has a cross-sectional area of 2.4×10^{-6} m^2.

The wires obey Hooke's law.

What is the total extension? Ignore the weights of the wires.

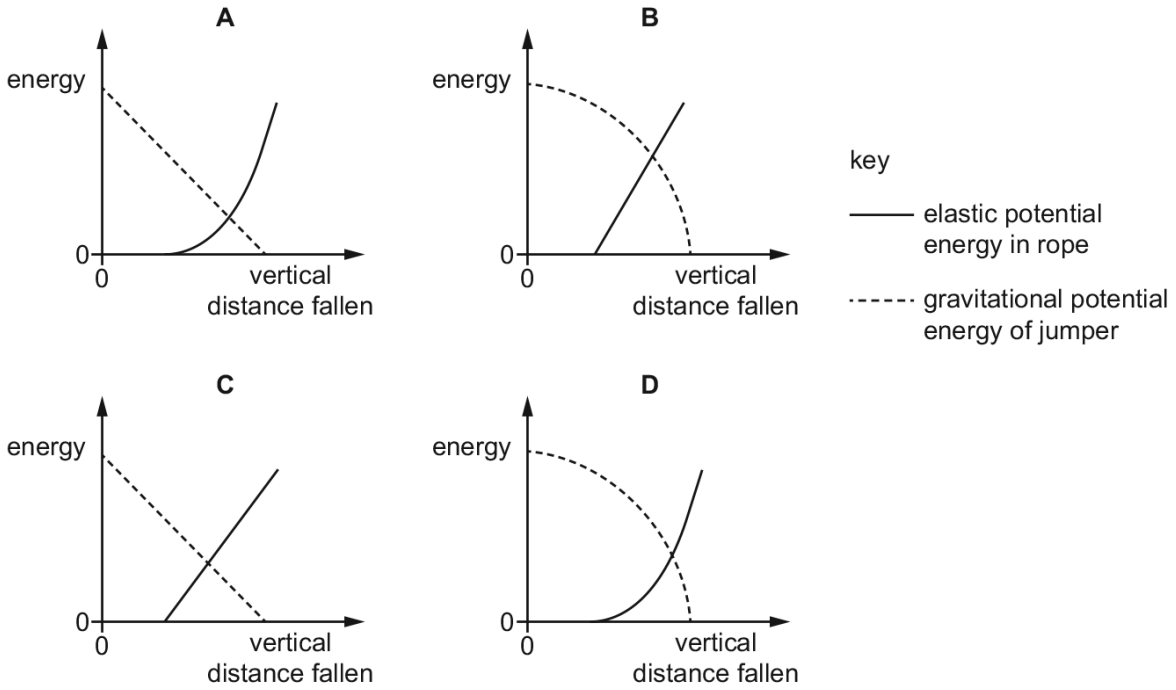
A 1.7×10^{-4} m **B** 3.0×10^{-4} m **C** 3.9×10^{-4} m **D** 9.0×10^{-4} m

648. 9702_s19_qp_12 Q: 18

A bungee jumper jumps off a high bridge, when attached to it by a long elastic rope which obeys Hooke's law.

The gravitational potential energy of the jumper is measured relative to the lowest point reached by the jumper.

Which graph shows the variation of the gravitational potential energy of the jumper, and the elastic potential energy in the rope, with the vertical distance fallen from the top of the bridge?



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649. 9702_s19_qp_12 Q: 20

A wire X is stretched by a force and gains elastic potential energy E.

The same force is applied to wire Y of the same material, with the same initial length but twice the diameter of wire X. Both wires obey Hooke's law.

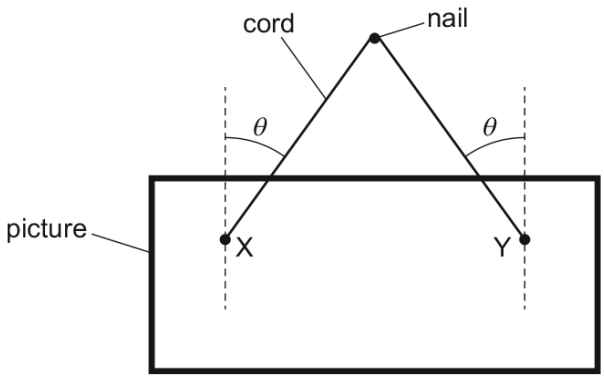
What is the gain in elastic potential energy of wire Y?

A $0.25E$ **B** $0.5E$ **C** $2E$ **D** $4E$

---

650. 9702_s19_qp_13 Q: 11

A picture is suspended from a nail by a single cord connected to two points X and Y on the picture. There is negligible friction between the cord and the nail so that the tension in both sides of the cord is the same. The picture hangs symmetrically, as shown.



The tension in the cord is T. The angle between the cord and the vertical is θ on both sides.

Which statement is correct?

A Increasing the length of the cord, with points X and Y in the same place on the picture, would reduce the tension in the cord.

B Moving points X and Y further apart on the picture while keeping the length of the cord constant would reduce the tension in the cord.

C Moving points X and Y to the top edge of the picture while keeping their distance apart constant and the length of the cord constant would reduce the tension in the cord.

D The weight of the picture is equal to $T\cos\theta$.

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651. 9702_s19_qp_13 Q: 19

Four solid steel rods, each of length 2.0 m and cross-sectional area 250 mm^2, equally support an object weighing 10 kN. The weight of the object causes the rods to contract by 0.10 mm. The rods obey Hooke's law.

What is the Young modulus of steel?

A $2.0 \times 10^8\,N\,m^{-2}$

B $2.0 \times 10^{11}\,N\,m^{-2}$

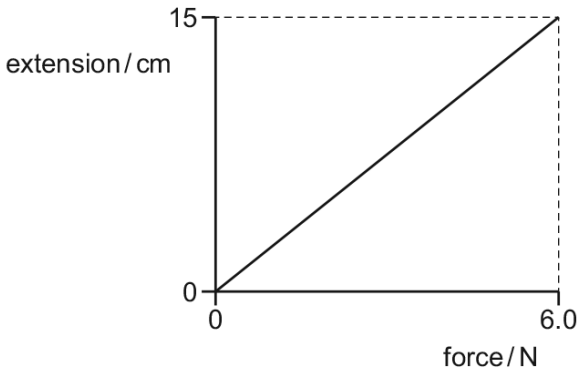
C $8.0 \times 10^8\,N\,m^{-2}$

D $8.0 \times 10^{11}\,N\,m^{-2}$

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652. 9702_w19_qp_11 Q: 19

An extension–force graph for a spring is shown.



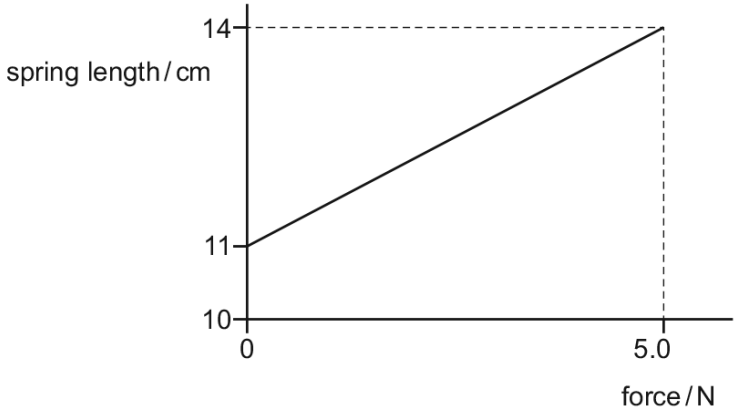
What is the spring constant of the spring?

A $0.025\,\text{N m}^{-1}$ **B** $0.40\,\text{N m}^{-1}$ **C** $2.5\,\text{N m}^{-1}$ **D** $40\,\text{N m}^{-1}$

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653. 9702_w19_qp_12 Q: 18

The graph shows the effect of applying a force of up to 5.0 N to a spring.



The spring obeys Hooke's law for forces up to 7.0 N.

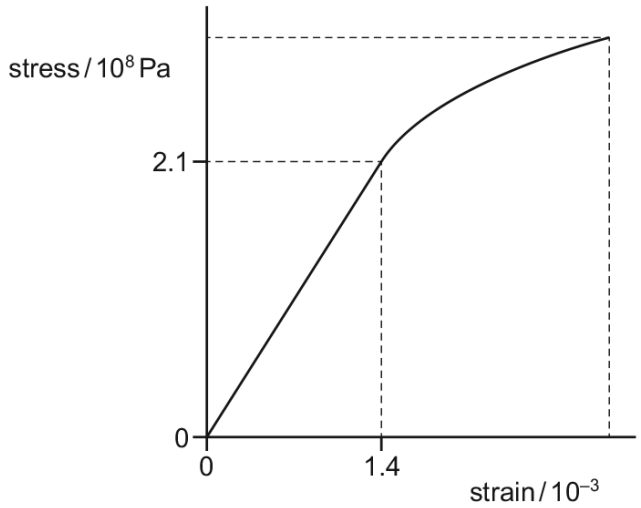
What is the total extension of the spring produced by a 7.0 N force?

A 4.2 cm **B** 5.6 cm **C** 15 cm **D** 20 cm

---

654. 9702_w19_qp_13 Q: 19

The stress–strain graph for a wire is shown.



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

A 6.7×10^{-12} Pa

B 6.7×10^{-9} Pa

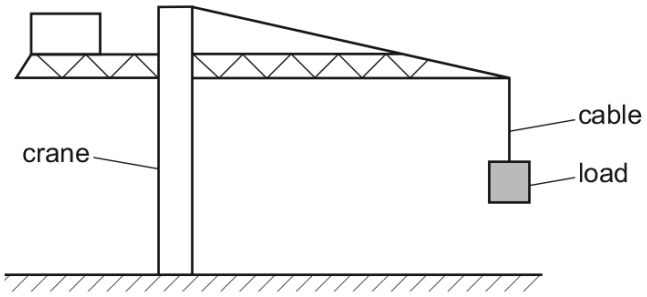
C 1.5×10^{8} Pa

D 1.5×10^{11} Pa

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655. 9702_m18_qp_12 Q: 20

The diagram shows a large crane on a construction site lifting a cube-shaped load at a constant speed.



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.

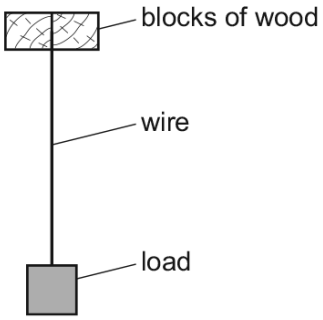
What is the ratio $\frac{\text{stress in the cable on the full-size crane}}{\text{stress in the cable on the model crane}}$?

A 0.1 **B** 1 **C** 10 **D** 100

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656. 9702_s18_qp_11 Q: 18

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 extends its length by x.



A second wire is made of the same material, but of diameter $2D$ and length $3L$. Both wires obey Hooke's law.

What is the extension of the second wire when the same load is applied?

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

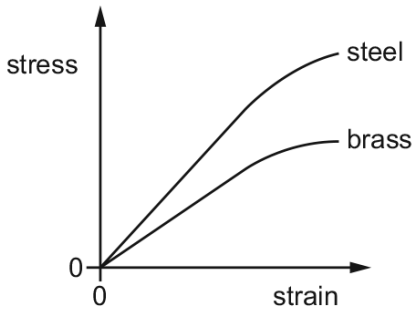
657. 9702_s18_qp_11 Q: 19

Two wires, one made of brass and the other of steel, are stretched in an experiment. Both wires obey Hooke's law during this experiment.

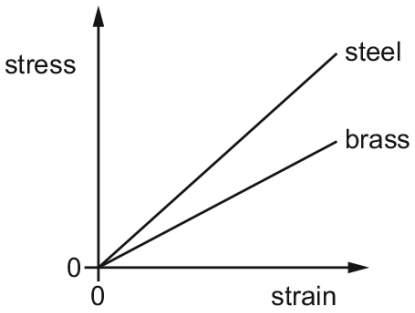
The Young modulus for brass is less than the Young modulus for steel.

Which graph shows how the stress varies with strain for both wires in this experiment?

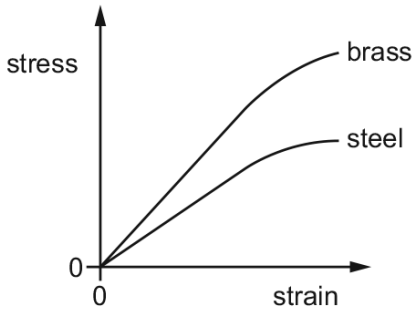
A



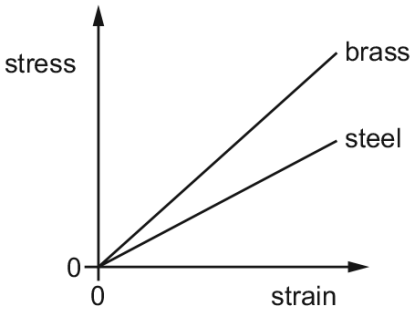
B



C



D



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658. 9702_s18_qp_12 Q: 20

An elastic material with Young modulus E is subjected to a tensile stress S. Hooke's law is obeyed.

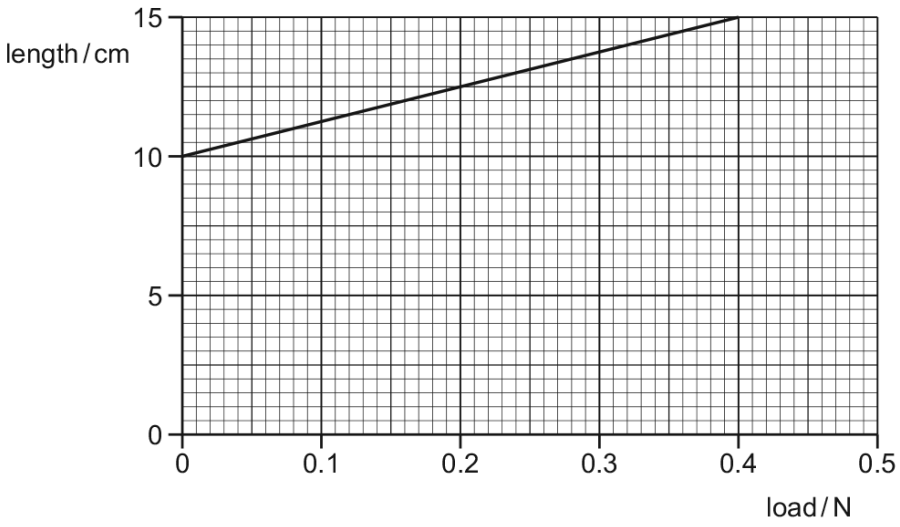
What is the expression for the elastic energy stored per unit volume of the material?

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

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659. 9702_s18_qp_12 Q: 21

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



What is the spring constant of the spring?

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

---

660. 9702_s18_qp_13 Q: 18

Data for a steel wire on an electric guitar are listed.

diameter = 5.0×10^{-4} m

Young modulus = 2.0×10^{11} Pa

tension = 20 N

The wire snaps and contracts elastically. Assume the wire obeys Hooke's law.

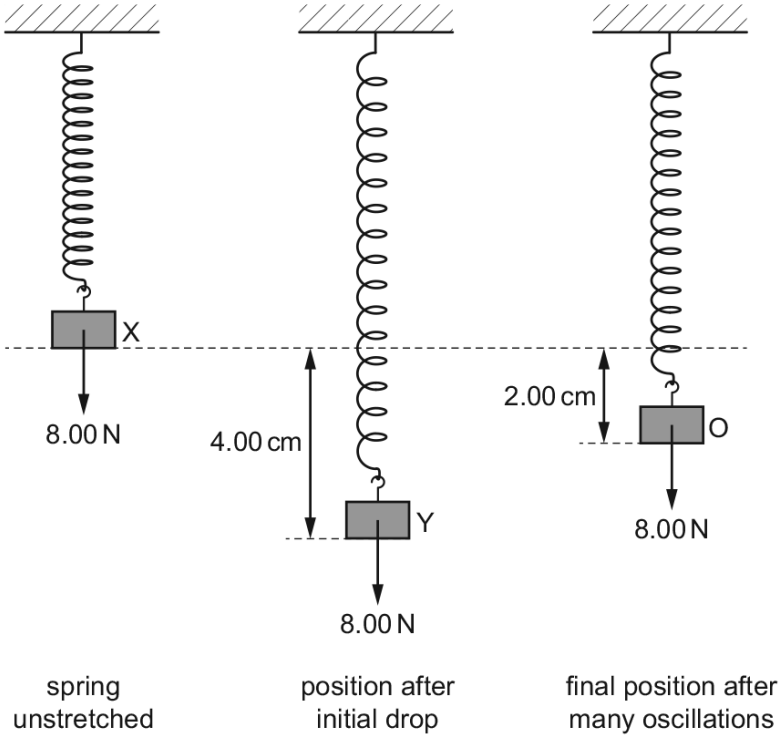
By what percentage does the length l of a piece of the wire contract?

A $1.3 \times 10^{-4}\,\%$ **B** $5.1 \times 10^{-4}\,\%$ **C** $1.3 \times 10^{-2}\,\%$ **D** $5.1 \times 10^{-2}\,\%$

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661. 9702_w18_qp_11 Q: 16

An 8.00 N weight is attached to the lower end of a spring which is fixed at its upper end. The weight is initially held at rest at position X and the spring is unstretched. The weight is then released and falls to position Y, which is 4.00 cm below X. The weight oscillates and then eventually comes to rest at O, which is 2.00 cm below X.

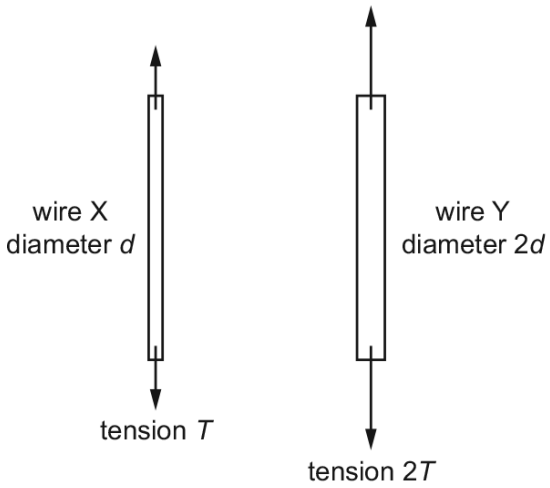


How much energy is lost from the system?

A 0.04 J **B** 0.08 J **C** 0.16 J **D** 0.32 J

662. 9702_w18_qp_11 Q: 18

Two wires X and Y are made from the same material. Wire Y has twice the diameter and experiences twice the tension of wire X. The wires obey Hooke's law and have the same original length.



Wire X has extension e.

What is the extension of wire Y?

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

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663. 9702_w18_qp_11 Q: 19

What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis) for a wire obeying Hooke's law?

A elastic limit

B spring constant

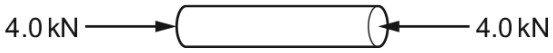
C stress

D Young modulus

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664. 9702_w18_qp_12 Q: 20

A metal cylinder is able to withstand a compressive force of 4.0 kN without deforming plastically.



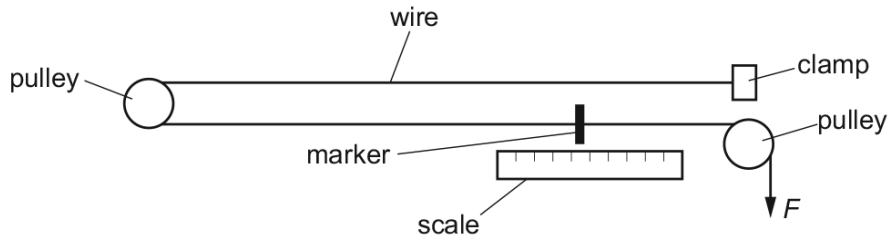
The cylinder has cross-sectional area A and would be at its elastic limit when a stress σ is applied.

What is a possible pair of values for A and σ?

	A / m^2	σ / MPa
A	1.5×10^{-5}	50
B	1.5×10^{-5}	80
C	7.5×10^{-5}	50
D	7.5×10^{-5}	80

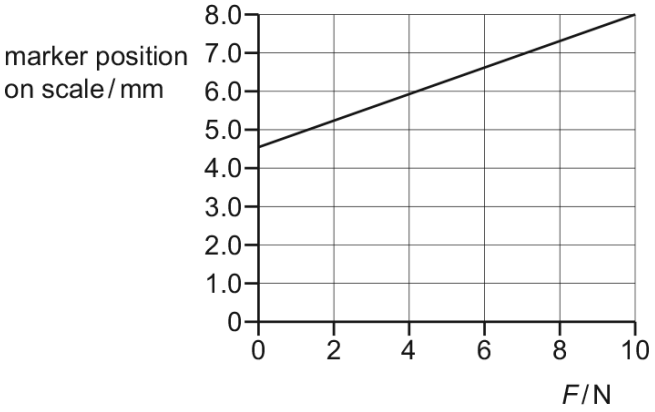
665. 9702_w18_qp_13 Q: 19

In an experiment to measure the Young modulus of a metal, a wire of the metal of diameter 0.25 mm is clamped, as shown.



The wire passes from a clamp, around a frictionless pulley, and then to a second frictionless pulley where loads F are applied to it. A marker is attached to the wire so that the total length of wire between the clamp and the marker is initially 3.70 m. A scale is fixed near to this marker.

The graph shows how the reading on the scale varies with F.



What is the Young modulus of the metal?

A 5.5×10^{10} Pa

B 9.4×10^{10} Pa

C 1.6×10^{11} Pa

D 2.2×10^{11} Pa

666. 9702_m17_qp_12 Q: 20

Two wires X and Y are made of different metals. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y.

The wires are extended with the same strain and obey Hooke's law.

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

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

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667. 9702_s17_qp_11 Q: 20

A wire of diameter d and length l hangs vertically from a fixed point. The wire is extended by hanging a mass M on its end. The Young modulus of the wire is E. The acceleration of free fall is g.

Which equation is used to determine the extension x of the wire?

A $x = \frac{Ml}{\pi d^2 E}$ **B** $x = \frac{Mgl}{\pi d^2 E}$ **C** $x = \frac{4Mgl}{\pi dE}$ **D** $x = \frac{4Mgl}{\pi d^2 E}$

---

668. 9702_s17_qp_12 Q: 20

What are the units of stress, strain and the Young modulus?

	stress	strain	Young modulus
A	newton	metre	pascal
B	newton	no unit	newton
C	pascal	metre	newton
D	pascal	no unit	pascal

---

669. 9702_s17_qp_13 Q: 18

Two wires with the same Young modulus E and cross-sectional area A, but different lengths L, are subject to different tensile forces F. The extension e of each wire is the same.

The column headings in the table show four different quantities.

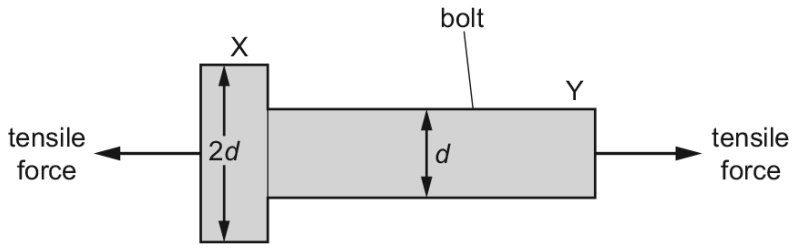
Which quantities have the same value and which quantities have different values for the two wires?

	$\frac{FL}{e}$	$\frac{Ae}{L}$	$\frac{E}{FL}$
A	different	different	same
B	different	same	same
C	same	different	different
D	same	different	same

---

670. 9702_w17_qp_12 Q: 20

A bolt is subjected to a tensile force, as shown.



The bolt has a circular cross-section. At end X the diameter is $2d$. At end Y the diameter is d.

What is the ratio $\frac{\text{stress at Y}}{\text{stress at X}}$?

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

---

671. 9702_w17_qp_12 Q: 21

A rectangular block of steel supporting a very large component of a bridge has a height of 15 cm and a cross-section of 20 cm × 12 cm. It is designed to compress 1 mm when under maximum, evenly distributed, load.

The Young modulus of steel is $2.0 \times 10^{11}\,\text{N m}^{-2}$.

What is the maximum load it can support?

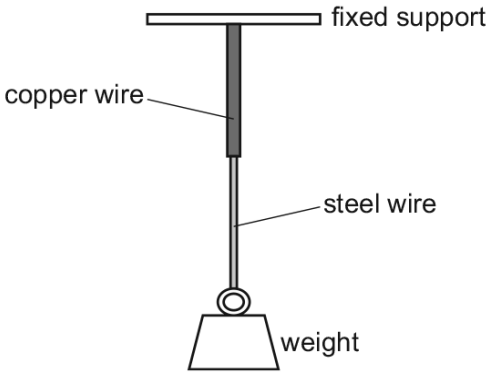
A 32 MN **B** 56 GN **C** 720 GN **D** 32 TN

---

672. 9702_m16_qp_12 Q: 19

The Young modulus of steel is twice that of copper.

A 50 cm length of copper wire of diameter 2.0 mm is joined to a 50 cm length of steel wire of diameter 1.0 mm, making a combination wire of length 1.0 m, as shown.



The combination wire is stretched by a weight added to its end. Both the copper and the steel wires obey Hooke's law.

What is the ratio $\frac{\text{extension of steel wire}}{\text{extension of copper wire}}$?

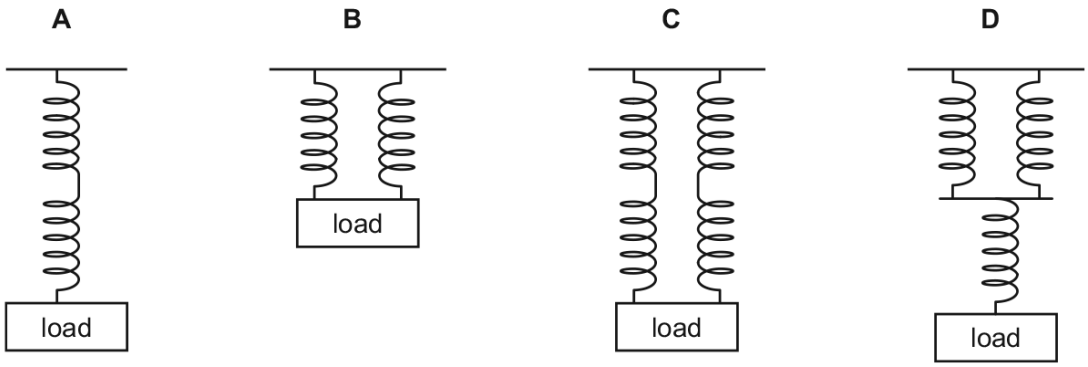
A 4 **B** 2 **C** 1 **D** 0.5

---

673. 9702_s16_qp_11 Q: 20

A number of identical springs are joined in four arrangements.

Which arrangement has the same spring constant as a single spring?



---

674. 9702_s16_qp_12 Q: 20

A spring balance consists of a spring of length 20.0 cm with a hook attached.

When a fish of mass 3.0 kg is suspended from the hook, the new length of the spring is 27.0 cm.

What is the spring constant of the spring?

A $4.2\,\mathrm{N\,m^{-1}}$ **B** $43\,\mathrm{N\,m^{-1}}$ **C** $110\,\mathrm{N\,m^{-1}}$ **D** $420\,\mathrm{N\,m^{-1}}$

---

675. 9702_s16_qp_13 Q: 21

A metal wire of cross-sectional area $0.20\,\mathrm{mm^2}$ hangs vertically from a fixed point. A load of 84 N is then attached to the lower end of the wire. The wire obeys Hooke's law and increases in length by 0.30%.

What is the Young modulus of the metal of the wire?

A $1.4 \times 10^5\,\mathrm{Pa}$

B $1.4 \times 10^8\,\mathrm{Pa}$

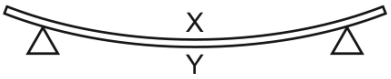
C $1.4 \times 10^9\,\mathrm{Pa}$

D $1.4 \times 10^{11}\,\mathrm{Pa}$

---

676. 9702_s16_qp_13 Q: 22

The diagram shows a beam supported on two pivots.



Which statement describes the state of the top surface X and of the bottom surface Y?

A Both X and Y are in compression.

B Both X and Y are in tension.

C X is in compression and Y is in tension.

D X is in tension and Y is in compression.

---

677. 9702_w16_qp_11 Q: 22

A copper wire hangs vertically from a fixed point. A load is attached to the lower end of the wire producing an extension x. The wire obeys Hooke's law.

Which single change gives an extension $2x$?

A Halve the cross-sectional area of the wire.

B Halve the diameter of the wire.

C Halve the length of the wire.

D Halve the load on the wire.

---

678. 9702_w16_qp_12 Q: 22

Four solid steel rods, each of length 2.0 m and cross-sectional area 250 mm^2, equally support an object weighing 10 kN. The weight of the object causes the rods to contract by 0.10 mm.

What is the Young modulus of steel?

A $2.0 \times 10^8\,N\,m^{-2}$

B $2.0 \times 10^{11}\,N\,m^{-2}$

C $8.0 \times 10^8\,N\,m^{-2}$

D $8.0 \times 10^{11}\,N\,m^{-2}$

---

679. 9702_w16_qp_13 Q: 22

A copper wire hangs vertically from a fixed point. A load is attached to the lower end of the wire producing an extension x. The wire obeys Hooke's law.

Which single change gives an extension $2x$?

A Halve the cross-sectional area of the wire.

B Halve the diameter of the wire.

C Halve the length of the wire.

D Halve the load on the wire.

---

680. 9702_s15_qp_12 Q: 21

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

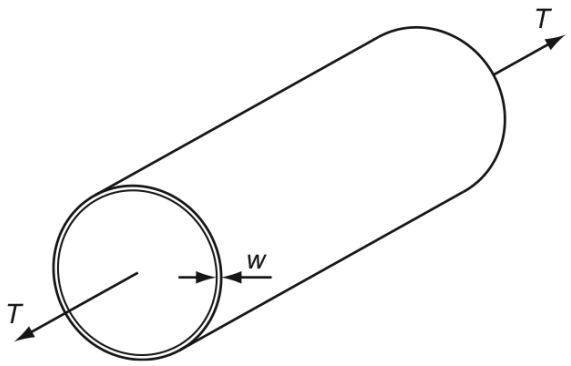
In which row can the measurement **not** be taken **directly** with the stated apparatus?

	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

---

681. 9702_s15_qp_12 Q: 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?

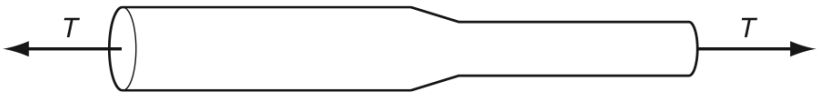
A $\frac{w}{2}$ **B** $\sqrt{2}\,w$ **C** $2w$ **D** $4w$

---

682. 9702_s15_qp_13 Q: 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.



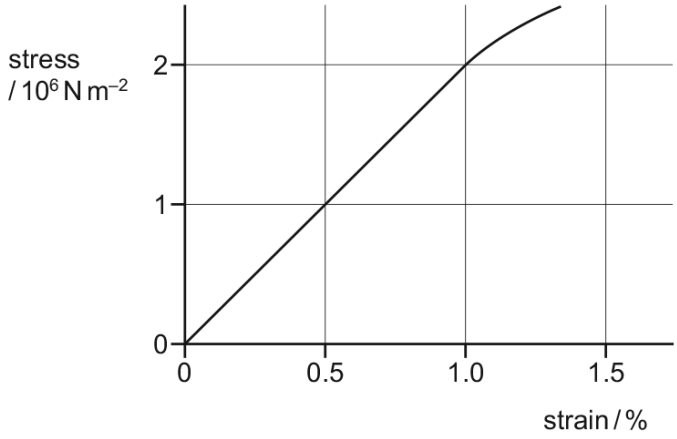
What is the value of $\frac{\text{stress in the wide portion}}{\text{stress in the narrow portion}}$?

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

---

683. 9702_s15_qp_13 Q: 24

The diagram shows the stress-strain graph for bone.



What is the Young modulus of bone?

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

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

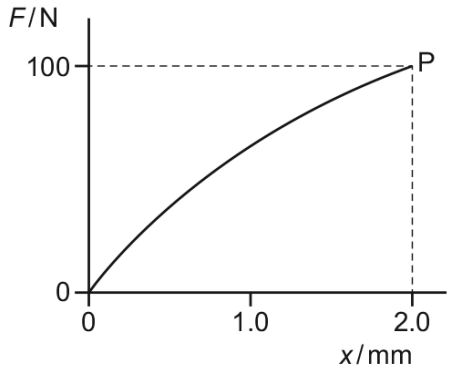
C $1 \times 10^8\,\text{N m}^{-2}$

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

7.2 Elastic and plastic behaviour

684. 9702_m20_qp_12 Q: 20

The graph shows the non-linear force–extension curve for a wire made from a new composite material.



What is the best estimate of the work done in stretching the wire to point P?

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

---

685. 9702_s20_qp_11 Q: 21

A tensile force is applied to an unstretched rubber band, causing it to stretch. The tensile force is then removed.

Which statement about the rubber band **must** be correct?

A If the rubber band stretches elastically and plastically, all the work done by the force is converted to thermal energy in the rubber.

B If the rubber band stretches elastically, it obeys Hooke's law.

C If the rubber band stretches elastically, the gradient of the force–extension graph represents the work done by the force.

D If the rubber band stretches plastically, the rubber band will be longer after the force is removed than it was before the force is applied.

---

686. 9702_s20_qp_12 Q: 20

Which statement describes what is meant by the plastic deformation of a material?

A It always obeys Hooke's law.

B It does not return to its original length when the extending force is removed.

C It never obeys Hooke's law.

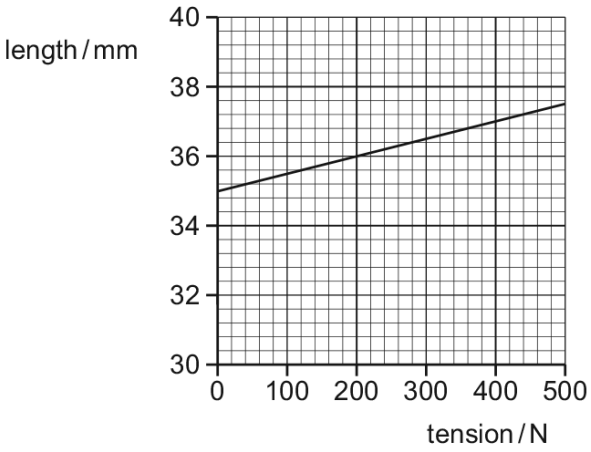
D It returns to its original length when the extending force is removed.

---

687. 9702_s20_qp_13 Q: 21

The Achilles tendon in a rabbit's leg is stretched when the rabbit jumps.

The graph shows the variation with tension of the length of the tendon.



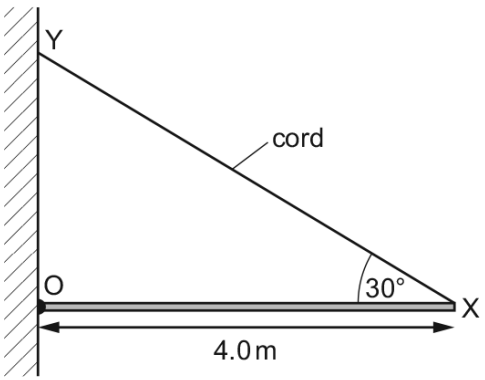
What is the strain energy in the tendon when the tension is 400 N?

A 0.40 J **B** 0.80 J **C** 2.4 J **D** 7.4 J

---

688. 9702_m19_qp_12 Q: 13

A uniform horizontal beam OX, 4.0 m long and weighing 100 N, is hinged at a wall at point O. It is supported by a cord XY which is attached to the wall at Y.



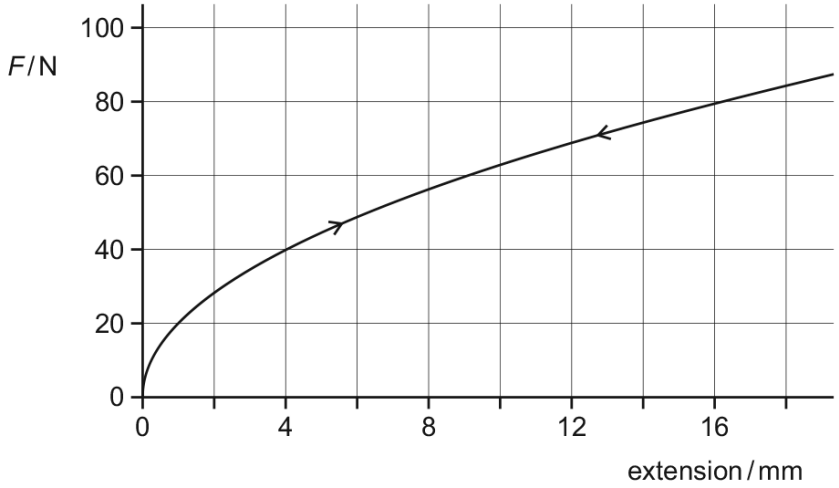
What is the tension in the cord?

A 50 N **B** 58 N **C** 86 N **D** 100 N

---

689. 9702_m19_qp_12 Q: 21

The graph shows the extension of a sample of a type of rubber as different loads F are applied and then gradually removed.



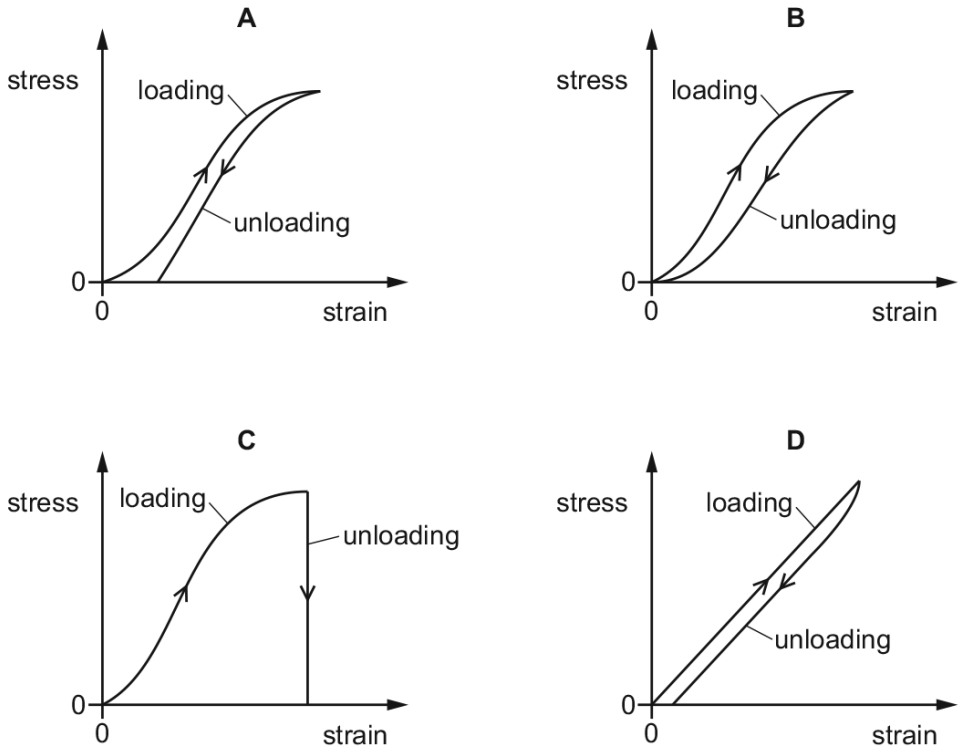
What is the best estimate of the strain energy in the rubber when a load of 80 N is applied?

A 0.40 J **B** 0.64 J **C** 0.88 J **D** 1.3 J

690. 9702_s19_qp_12 Q: 22

The stress-strain graphs for loading and unloading four different materials are shown.

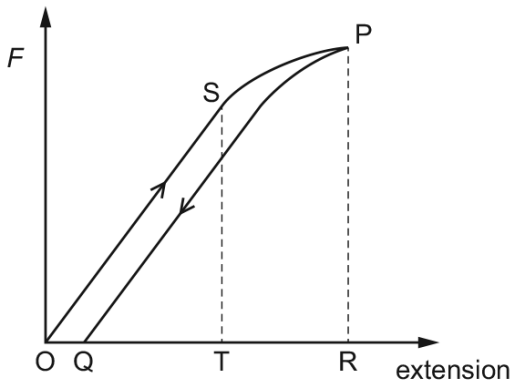
Which material exhibits purely elastic behaviour?



691. 9702_s19_qp_13 Q: 20

A wire is attached at one end to a fixed point. A tensile force F is applied to the other end of the wire, causing it to extend. This is shown on the graph by the line OSP.

The force F is then gradually reduced to zero and the wire contracts. This is shown on the graph by the line PQ.



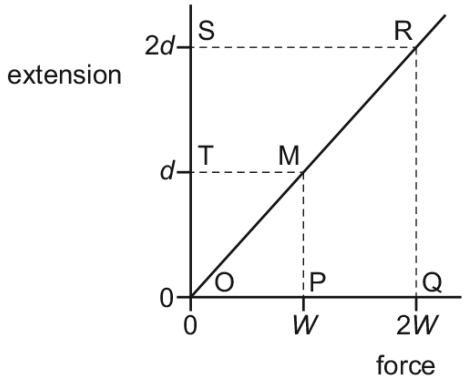
Which area on the graph represents the work done by the wire as it contracts?

A OSTO **B** OSPRO **C** QPRQ **D** OSPQO

---

692. 9702_w19_qp_11 Q: 20

A wire is extended by a force. The graph shows how the extension of the wire varies with the force applied.



Initially a force W gives an extension d. The force is then increased to $2W$. This increases the extension to $2d$.

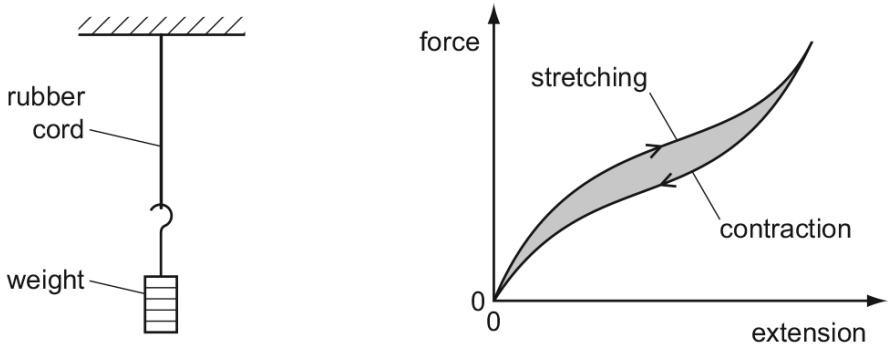
Which area of the graph represents the work done by the force when the force increases from W to $2W$?

A ORQ **B** OQRS **C** ORS **D** TMRS

---

693. 9702_w19_qp_12 Q: 19

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 elastic potential energy stored in the rubber cord

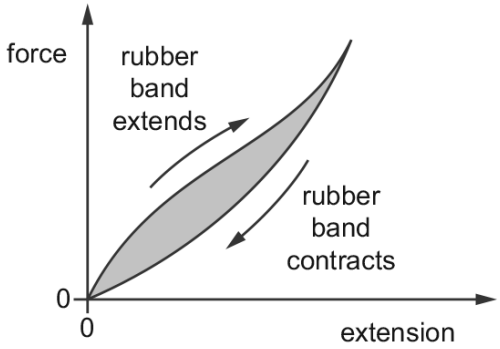
B the thermal energy dissipated in the rubber cord

C the work done on the rubber cord during stretching

D the work done by the rubber cord during contraction

694. 9702_w19_qp_13 Q: 20

The diagram shows a force–extension graph for a rubber band as the band is extended and then the stretching force is decreased to zero.



What can be deduced from the graph?

A The rubber band does not return to its original length when the force is decreased to zero.

B The rubber band obeys Hooke's law for the extensions shown.

C The rubber band remains elastic for the extensions shown.

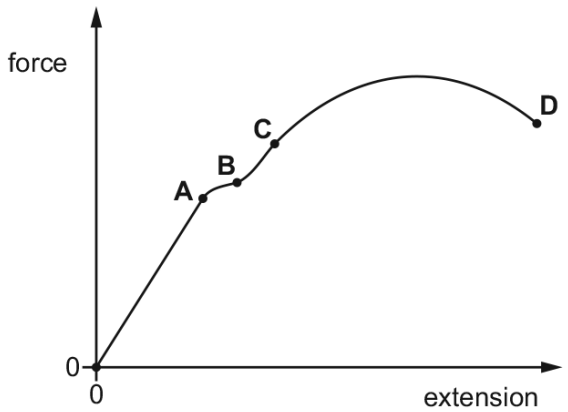
D The shaded area represents the work done in extending the rubber band.

---

695. 9702_m18_qp_12 Q: 19

The force-extension graph of a metal wire is shown.

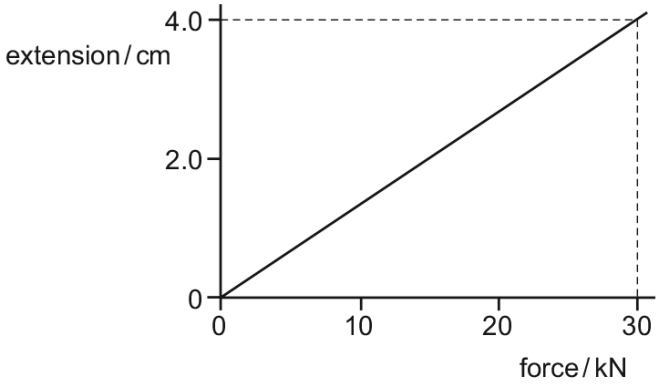
At which point on the graph does the metal wire stop obeying Hooke's law?



---

696. 9702_s18_qp_13 Q: 19

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

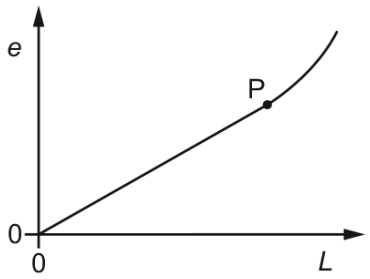


What is the strain energy in the spring when the extension is 4.0 cm?

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

697. 9702_w18_qp_11 Q: 20

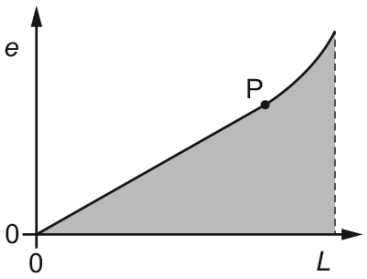
Forces are applied to the ends of a rod so that its length increases. The variation with load L of the extension e of the rod is shown.



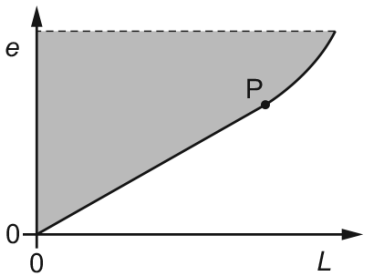
The point P is the elastic limit.

Which shaded area represents the work done during the plastic deformation of the rod?

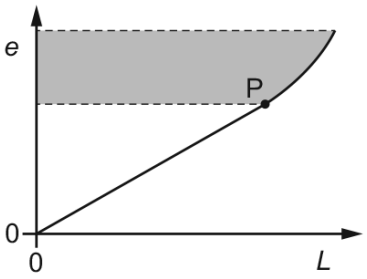
A



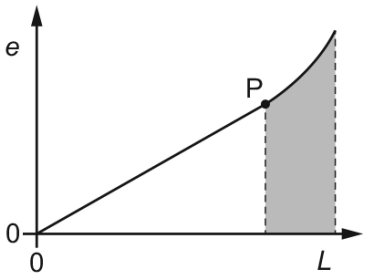
B



C

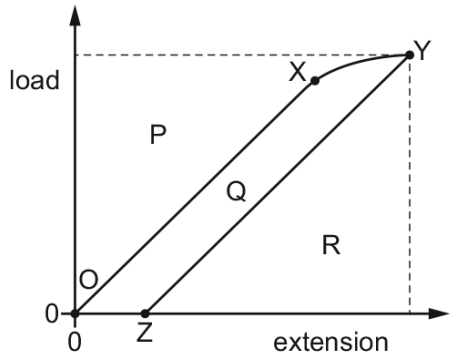


D



698. 9702_w18_qp_12 Q: 21

A wire has both elastic and plastic properties. When it is slowly loaded, its extension varies with load as shown by line OXY. The removal of the load is represented by line YZ. This creates areas P, Q and R on the graph.



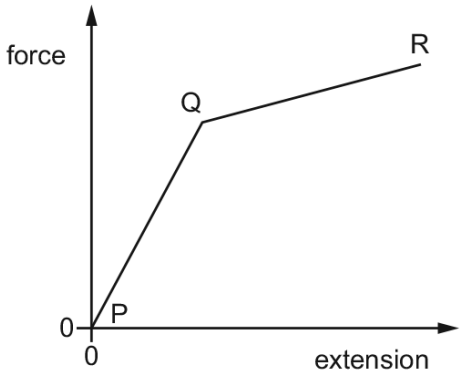
Which area represents the maximum elastic potential energy stored in the wire?

A P **B** Q **C** Q + R **D** R

---

699. 9702_w18_qp_13 Q: 20

A scientist is investigating the properties of a new material. She plots a force-extension graph for the material up to its breaking point.



Which statement **must** be correct?

A The area under the graph from P to R is the strain energy stored in the material.

B The area under the graph from P to R is the work done in stretching the material.

C The material stretches elastically from Q to R.

D The material stretches plastically from P to Q.

---

700. 9702_m17_qp_12 Q: 21

A weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm. The column obeys Hooke's law when compressed.

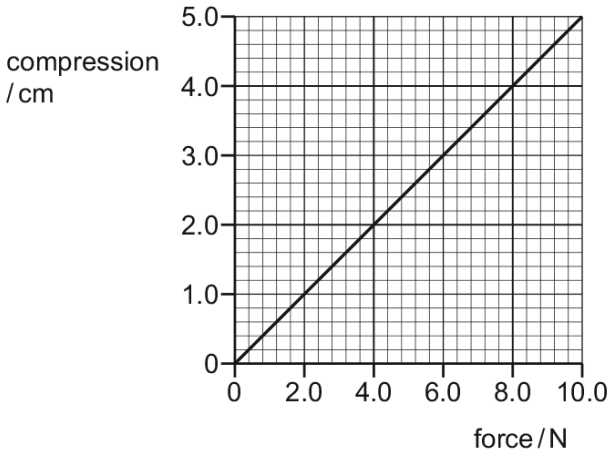
How much energy is stored in the compressed column?

A 15 J **B** 30 J **C** 15 kJ **D** 30 kJ

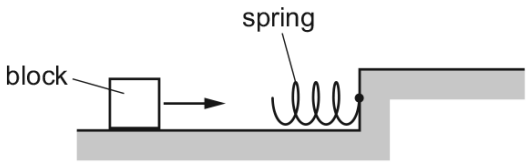
---

701. 9702_s17_qp_11 Q: 21

The variation of the compression of a spring with the force applied to it is shown in the graph.



A block slides along a horizontal frictionless surface towards the spring, as shown.



The block is brought to rest by the spring. When the spring reaches a compression of 4.0 cm, all of the kinetic energy of the block is transferred to the elastic potential energy of the spring.

What is the kinetic energy of the block when it first makes contact with the spring?

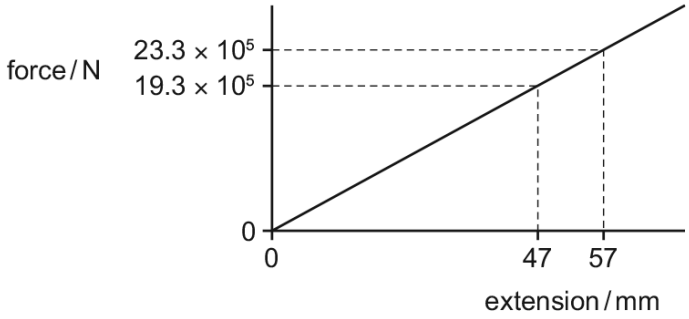
A 0.16 J **B** 0.32 J **C** 16 J **D** 32 J

---

702. 9702_s17_qp_12 Q: 19

A cable on a suspension bridge supports a weight of 19.3×10^5 N. This weight causes the cable to stretch by 47 mm.

A lorry crossing the bridge then increases the force on the cable to 23.3×10^5 N. The force-extension graph for the cable is shown.

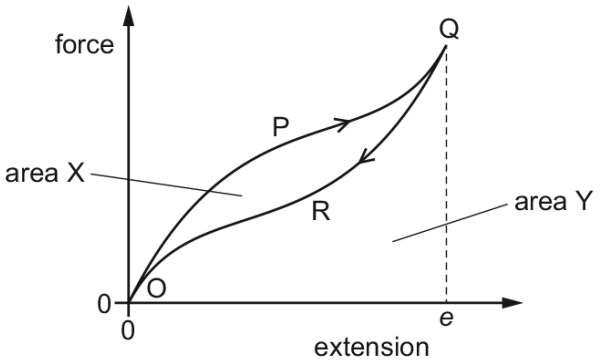


What is the **increase** in strain energy in the cable when the lorry is crossing the bridge?

A 21 kJ **B** 23 kJ **C** 45 kJ **D** 66 kJ

703. 9702_s17_qp_12 Q: 21

A rubber band is stretched and then relaxed to its original length. The diagram shows the force-extension graph for this process.



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 extension *e*.

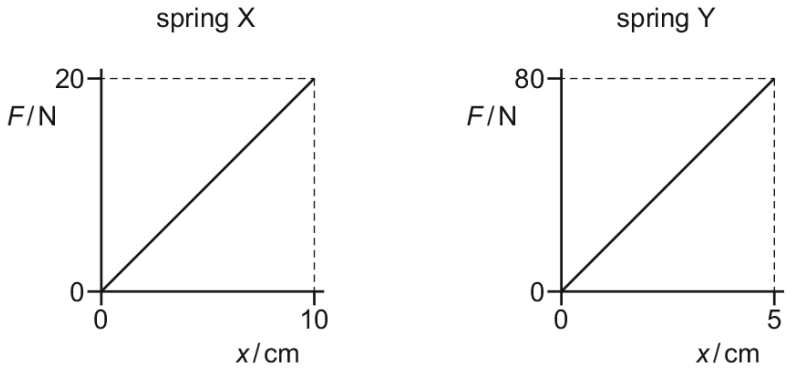
B (Area X + area Y) is the minimum energy required to stretch the band to extension *e*.

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

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

704. 9702_s17_qp_13 Q: 19

Two springs X and Y stretch elastically. The graphs show the variation with extension x of the force F applied to each spring.



Which statement is correct?

A When each spring is given the same extension, the energy stored in Y is 4 times the energy stored in X.

B When each spring is given the same extension, the energy stored in Y is 8 times the energy stored in X.

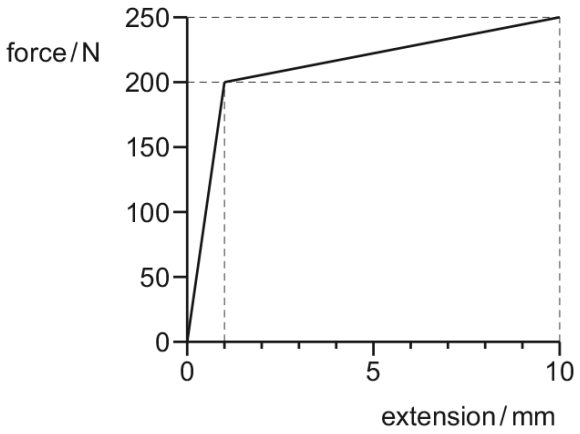
C When the same force is applied to each spring, the energy stored in Y is 4 times the energy stored in X.

D When the same force is applied to each spring, the energy stored in Y is 8 times the energy stored in X.

---

705. 9702_s17_qp_13 Q: 20

The diagram shows the force-extension graph for a steel wire, up to its breaking point.



What is the best estimate of the work done to break the wire?

A 2.1 J **B** 2.3 J **C** 2.4 J **D** 2.5 J

---

706. 9702_w17_qp_11 Q: 20

A spring is loaded with weights. When the weights are removed, the spring returns to its original length.

The spring is then loaded with heavier weights. When the weights are removed, the spring is longer than it was originally.

Which types of deformation are shown by this experiment?

A both elastic and plastic deformation

B elastic deformation only

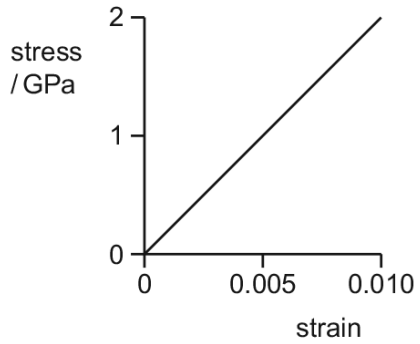
C neither elastic nor plastic deformation

D plastic deformation only

---

707. 9702_w17_qp_11 Q: 21

The stress-strain graph for a metal is shown.



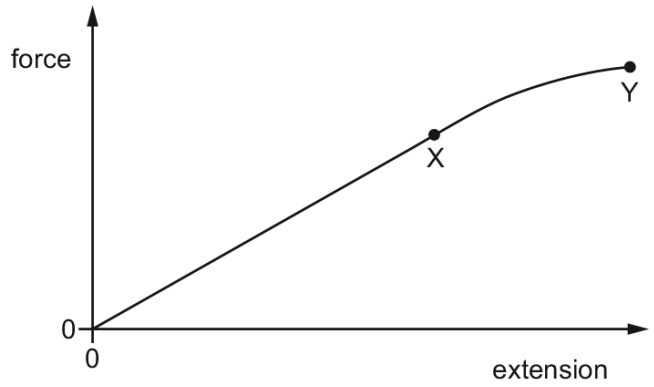
What is the strain energy per unit volume of a rod made from this metal when the strain of the rod is 0.010?

A $10\,\text{kJ m}^{-3}$ **B** $100\,\text{kJ m}^{-3}$ **C** $1.0\,\text{MJ m}^{-3}$ **D** $10\,\text{MJ m}^{-3}$

---

708. 9702_w17_qp_13 Q: 20

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

---

709. 9702_w17_qp_13 Q: 21

A load is hung from the end of a metal wire. The load is increased and the wire stretches elastically. The table shows the length of the wire for different loads.

load / kN	length / mm
0	500.0
1.0	502.0
2.0	504.0
3.0	506.0
4.0	508.0

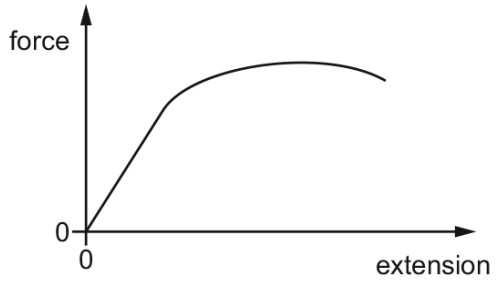
When the load is 4.0 kN, what is the strain energy stored in the wire?

A 16 J **B** 32 J **C** 1.0 kJ **D** 2.0 kJ

---

710. 9702_m16_qp_12 Q: 18

A metal wire is stretched by a load. The force-extension graph is shown.



What is represented by the area under the whole graph?

A the change in gravitational potential energy of the wire

B the energy that would be released from the wire if the final load was removed

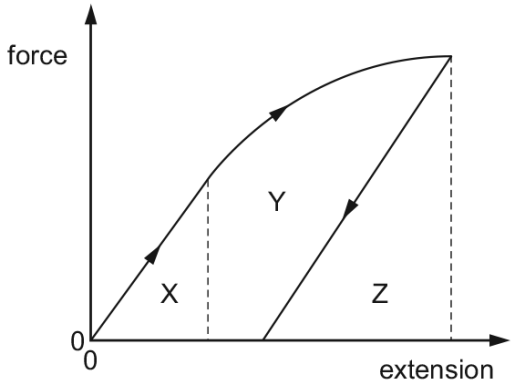
C the energy transferred into heat energy in the wire

D the work done in stretching the wire

---

711. 9702_s16_qp_11 Q: 21

A sample of 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.



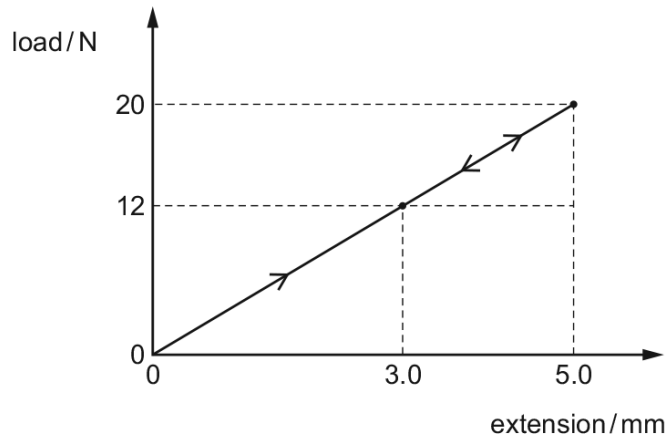
Which area represents the net work done on the sample?

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

---

712. 9702_s16_qp_12 Q: 21

A metal wire is attached at one end to a fixed point and a load is hung from the other end so that the wire hangs vertically. The load is increased from zero to 20 N. This causes the wire to extend elastically by 5.0 mm. The load is then reduced to 12 N and the extension decreases to 3.0 mm.



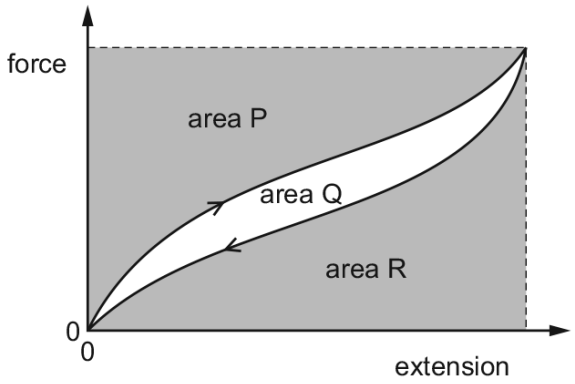
How much strain energy is released during the unloading process?

A 0.8×10^{-2} J **B** 1.8×10^{-2} J **C** 2.4×10^{-2} J **D** 3.2×10^{-2} J

---

713. 9702_s16_qp_13 Q: 20

The diagram shows the force-extension graph for a sample of material. The sample is stretched and then returns to its original length.



Which area represents the work done to stretch the sample?

A P + Q **B** P only **C** Q + R **D** R only

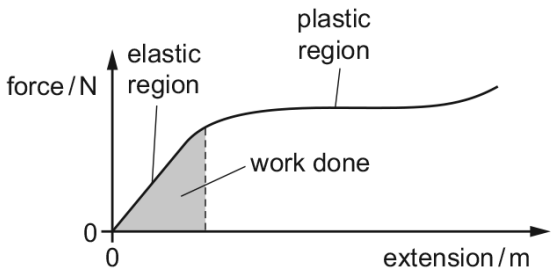
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714. 9702_w16_qp_11 Q: 21

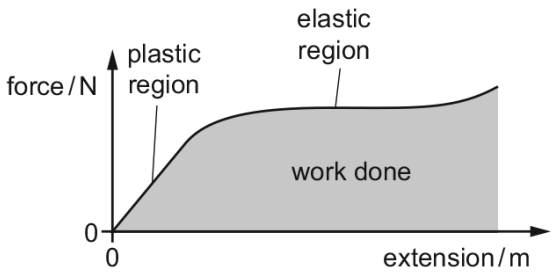
A metal wire is stretched to breaking point and the force-extension graph is plotted.

Which graph is correctly labelled with the elastic region, the plastic region and the area representing the work done to stretch the wire until it breaks?

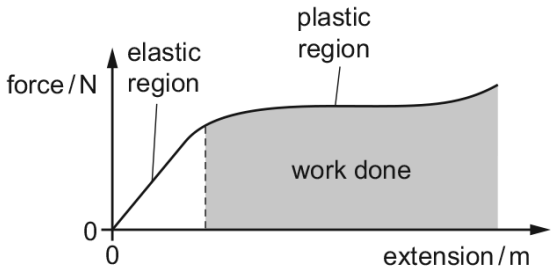
A



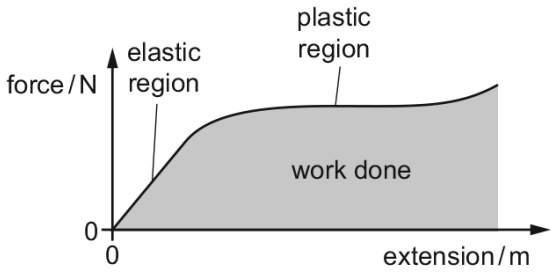
B



C

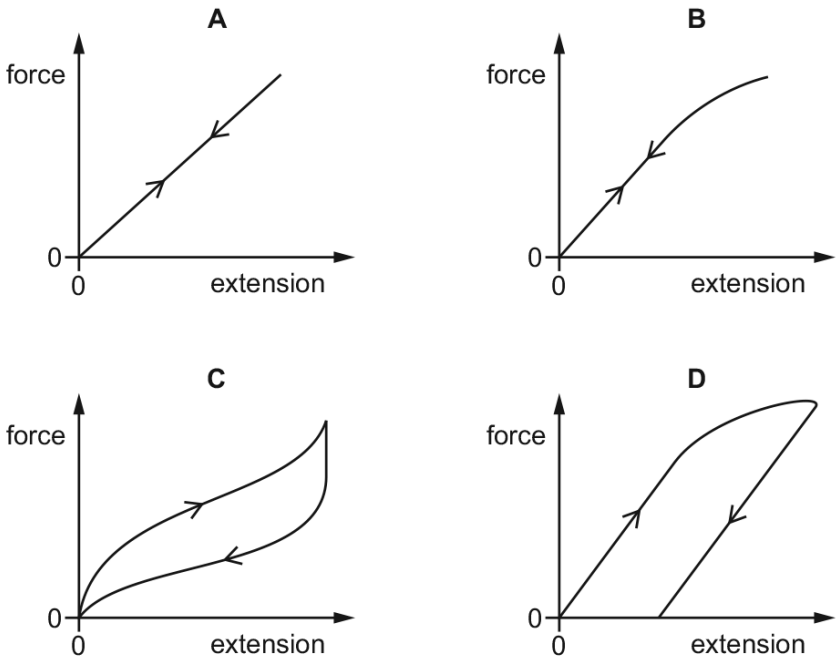


D



715. 9702_w16_qp_12 Q: 21

Which force-extension graph shows plastic deformation of a sample of material?

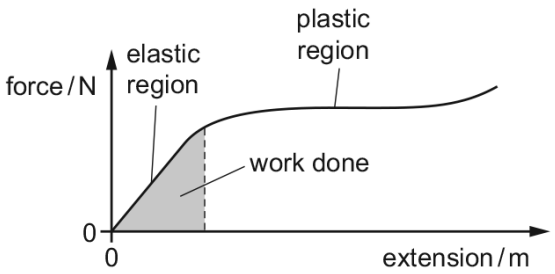


716. 9702_w16_qp_13 Q: 21

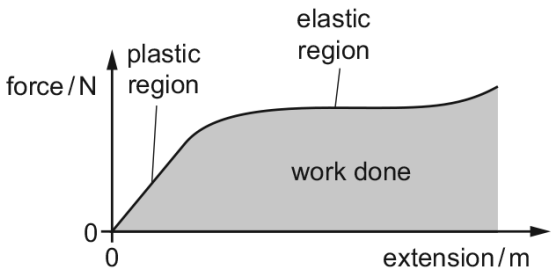
A metal wire is stretched to breaking point and the force-extension graph is plotted.

Which graph is correctly labelled with the elastic region, the plastic region and the area representing the work done to stretch the wire until it breaks?

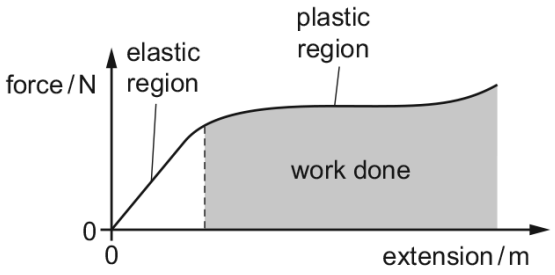
A



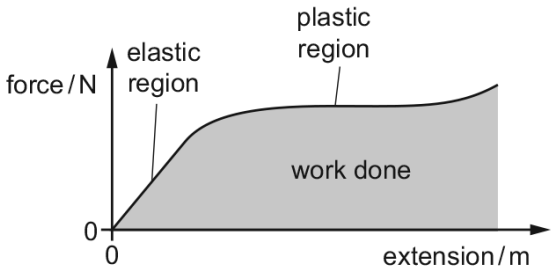
B



C

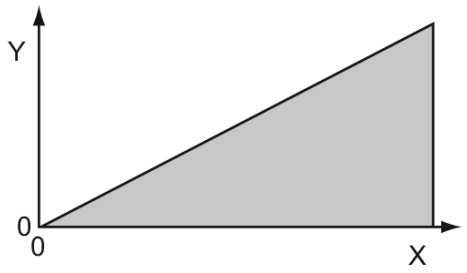


D



717. 9702_s15_qp_11 Q: 22

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



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

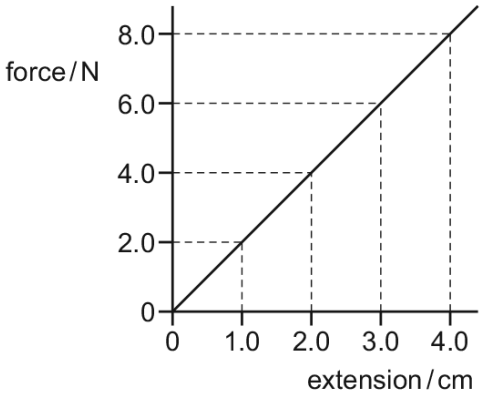
How should the axes be labelled?

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

---

718. 9702_s15_qp_11 Q: 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

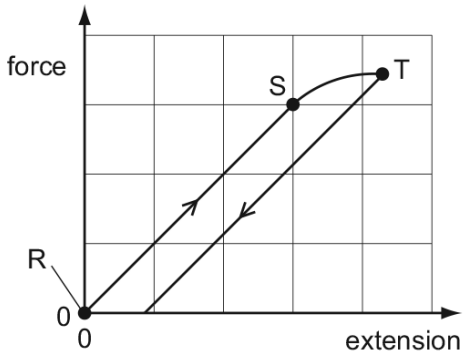
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719. 9702_s15_qp_12 Q: 22

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

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

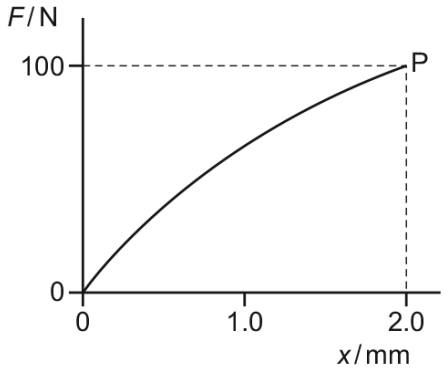
C exactly at point S

D exactly at point T

---

720. 9702_s15_qp_13 Q: 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

Chapter 7

Deformation of solids

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7.1 Stress and strain

104. 9702_m20_qp_22 Q: 3

(a) State what is meant by *work done*.

.....

.....

..... [1]

(b) A skier is pulled along horizontal ground by a wire attached to a kite, as shown in Fig. 3.1.

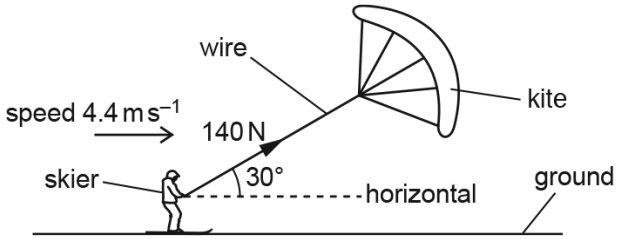


Fig. 3.1 (not to scale)

The skier moves in a straight line along the ground with a constant speed of 4.4 m s^{-1}. The wire is at an angle of 30° to the horizontal. The tension in the wire is 140 N.

(i) Calculate the work done by the tension to move the skier for a time of 30 s.

work done = ... J [3]

(ii) The weight of the skier is 860 N. The vertical component of the tension in the wire and the weight of the skier combine so that the skier exerts a downward pressure on the ground of 2400 Pa.

Determine the total area of the skis in contact with the ground.

area = ... m^2 [3]

(iii) The wire attached to the kite is uniform. The stress in the wire is 9.6×10^6 Pa.

Calculate the diameter of the wire.

diameter = ... m [2]

(c) The variation with extension x of the tension F in the wire in **(b)** is shown in Fig. 3.2.

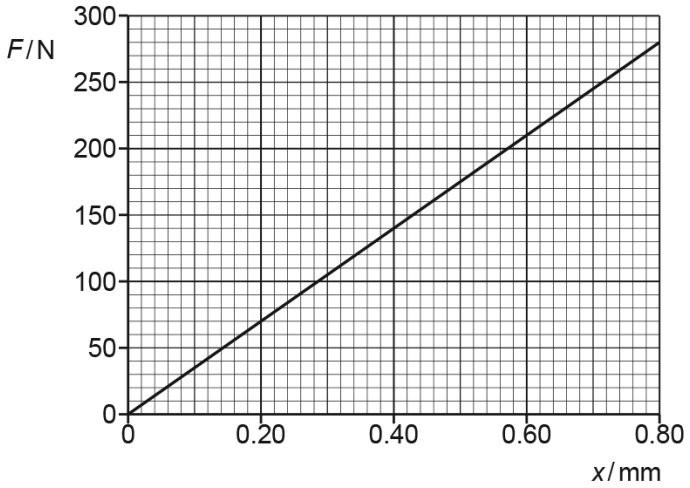


Fig. 3.2

A gust of wind increases the tension in the wire from 140 N to 210 N.

Calculate the change in the strain energy stored in the wire.

change in strain energy = ... J [3]

[Total: 12]

105. 9702_w19_qp_23 Q: 4

A ball X moves along a horizontal frictionless surface and collides with another ball Y, as illustrated in Fig. 4.1.

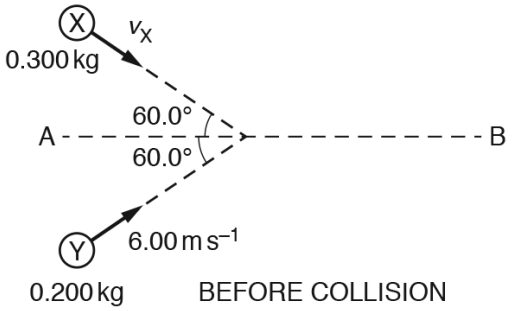


Fig. 4.1 (not to scale)

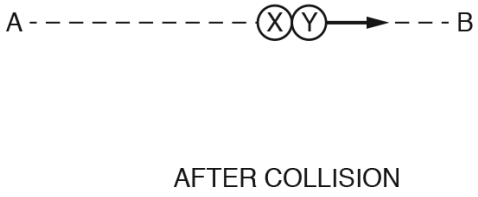


Fig. 4.2 (not to scale)

Ball X has mass 0.300 kg and initial velocity v_X at an angle of 60.0° to line AB.
Ball Y has mass 0.200 kg and initial velocity 6.00 m s^{-1} at an angle of 60.0° to line AB.
The balls stick together during the collision and then travel along line AB, as illustrated in Fig. 4.2.

(a) (i) Calculate, to three significant figures, the component of the initial momentum of ball Y that is perpendicular to line AB.

component of momentum = ... kg m s^{-1} [2]

(ii) By considering the component of the initial momentum of each ball perpendicular to line AB, calculate, to three significant figures, v_X.

v_X = ...m s^{-1} [1]

(iii) Show that the speed of the two balls after the collision is 2.4 m s^{-1}.

[2]

(b) The two balls continue moving together along the horizontal frictionless surface towards a spring, as illustrated in Fig. 4.3.

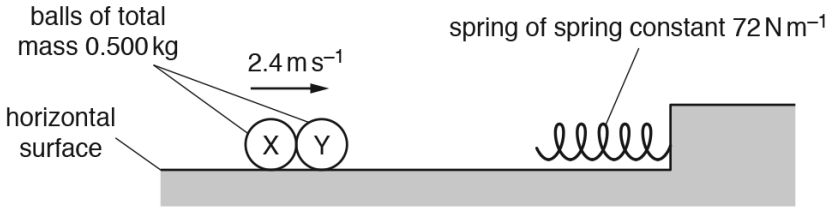


Fig. 4.3

The balls hit the spring and remain stuck together as they decelerate to rest. All the kinetic energy of the balls is converted into elastic potential energy of the spring. The energy E stored in the spring is given by

$$E = \frac{1}{2}kx^2$$

where k is the spring constant of the spring and x is its compression.
The spring obeys Hooke's law and has a spring constant of $72\,\text{N m}^{-1}$.

(i) Determine the maximum compression of the spring caused by the two balls.

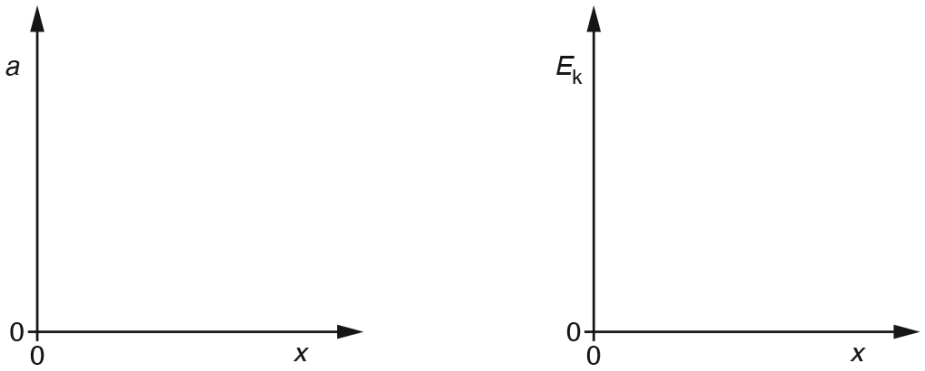
maximum compression = ... m [3]

(ii) On Fig. 4.4, sketch graphs to show the variation with compression x of the spring, from zero to maximum compression, of:

1. the magnitude of the deceleration a of the balls

2. the kinetic energy E_k of the balls.

Numerical values are not required.



[3]

Fig. 4.4

[Total: 11]

106. 9702_m18_qp_22 Q: 3

(a) For the deformation of a wire under tension, define

(i) *stress*,

.....

.....[1]

(ii) *strain*.

.....

.....[1]

(b) A wire is fixed at one end so that it hangs vertically. The wire is given an extension x by suspending a load F from its free end. The variation of F with x is shown in Fig. 3.1.

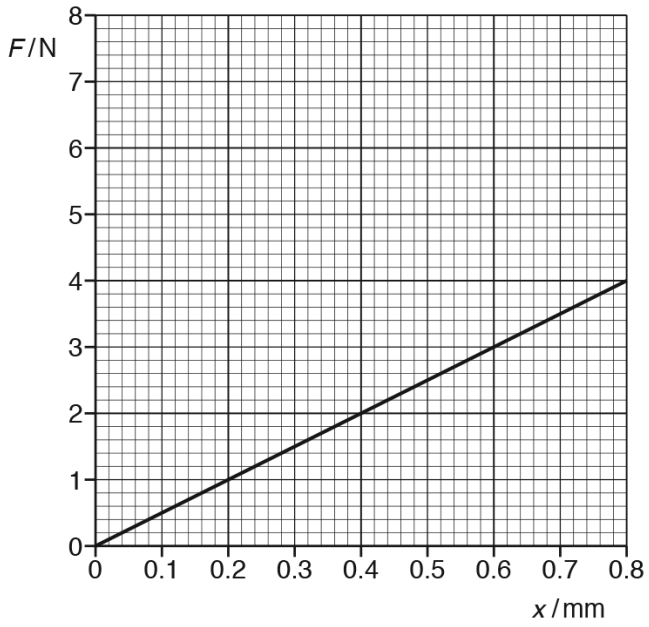


Fig. 3.1

The wire has cross-sectional area $9.4 \times 10^{-8}\,m^2$ and original length 2.5 m.

(i) Describe how measurements can be taken to determine accurately the cross-sectional area of the wire.

.....

.....

.....

.....

.....[3]

(ii) Determine the Young modulus E of the material of the wire.

E = ... Pa [2]

(iii) **Use Fig. 3.1** to calculate the increase in the energy stored in the wire when the load is increased from 2.0 N to 4.0 N.

increase in energy = ... J [2]

(c) The wire in **(b)** is replaced by a new wire of the same material. The new wire has twice the length and twice the diameter of the old wire. The new wire also obeys Hooke's law.

On Fig. 3.1, sketch the variation with extension x of the load F for the new wire from $x = 0$ to $x = 0.80$ mm. [2]

[Total: 11]

---

107. 9702_s18_qp_21 Q: 2

(a) State Newton's first law of motion.

.....

.....[1]

(b) A block of weight 15 N hangs by a wire from a remotely controlled aircraft, as shown in Fig. 2.1.

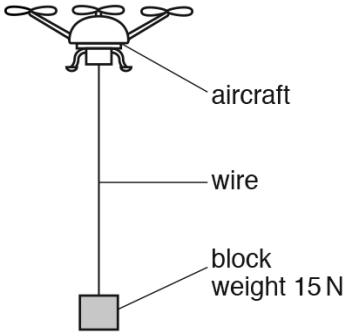


Fig. 2.1

The aircraft is used to move the block only in a vertical direction. The force on the block due to air resistance is negligible.

The variation with time t of the vertical velocity v of the block is shown in Fig. 2.2.
The velocity is taken to be positive in the upward direction.

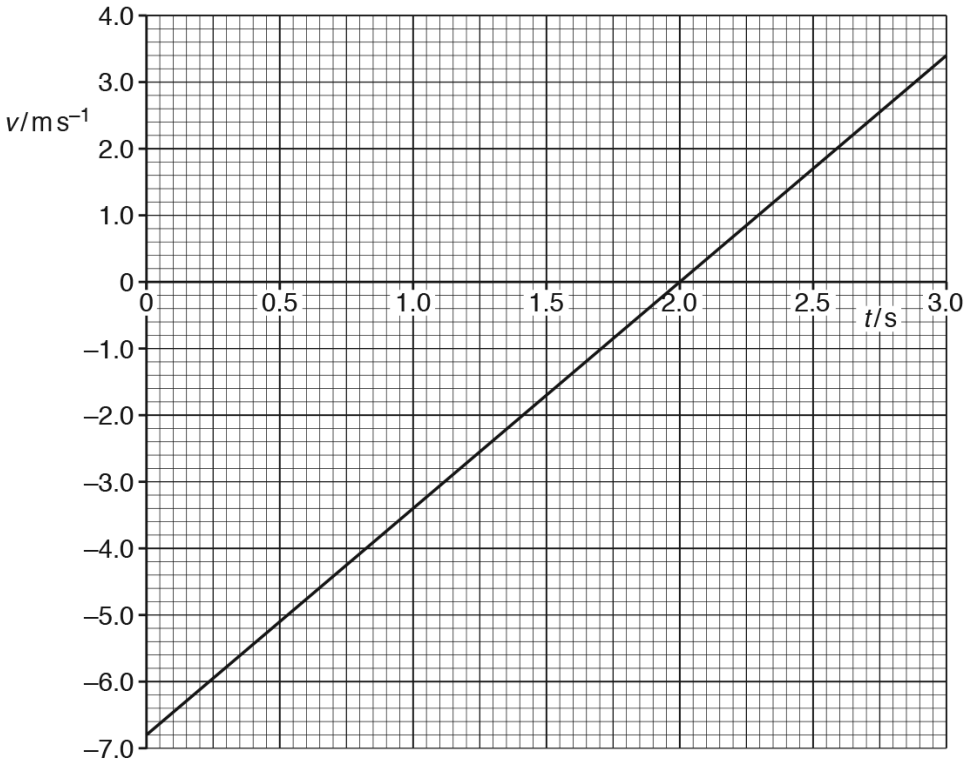


Fig. 2.2

(i) Determine, for the block,

1. the displacement from time $t = 0$ to $t = 3.0\,\text{s}$,

magnitude of displacement = ... m

direction of displacement .....

[3]

2. the change in gravitational potential energy from time $t = 0$ to $t = 3.0\,\text{s}$.

change in gravitational potential energy = ... J [2]

(ii) Calculate the magnitude of the acceleration of the block at time $t = 2.0\,\text{s}$.

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

(iii) Use your answer in **(b)(ii)** to show that the tension T in the wire at time $t = 2.0\,\text{s}$ is 20 N.

(iv) The wire has a cross-sectional area of $2.8 \times 10^{-5}\,m^2$ and is made from metal of Young modulus $1.7 \times 10^{11}\,Pa$. The wire obeys Hooke's law.

Calculate the strain of the wire at time $t = 2.0\,s$.

strain = ... [3]

(v) At some time after $t = 3.0\,s$ the tension in the wire has a constant value of 15 N.

State and explain whether it is possible to deduce that the block is moving vertically after $t = 3.0\,s$.

.....

.....

.....

.....[2]

[Total: 15]

108. 9702_s18_qp_22 Q: 5

A solid cylinder is lifted out of oil by a wire attached to a motor. Fig. 5.1 shows two different positions X and Y of the cylinder during the lifting process.

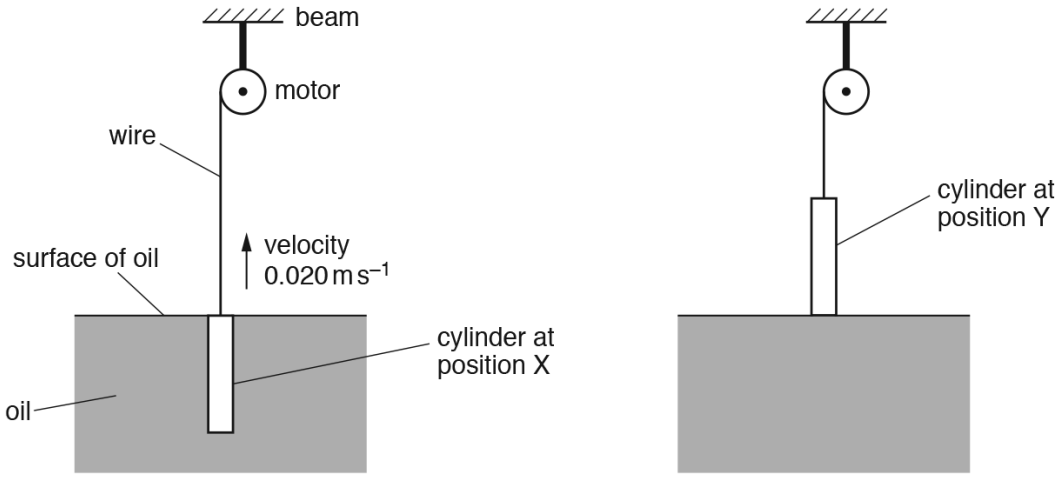


Fig. 5.1

The motor is fixed to an overhead beam.
The cylinder has cross-sectional area 0.018 m^2, length 1.2 m and weight 560 N.
The density of the oil is 940 kg m^{-3}.

Throughout the lifting process, the cylinder moves vertically upwards with a constant velocity of 0.020 m s^{-1}. The viscous force of the oil acting on the cylinder is negligible.

(a) Calculate the density of the cylinder.

density = ... kg m^{-3} [2]

(b) For the cylinder at position X, show that the upthrust due to the oil is 200 N.

[2]

(c) Calculate, for the moving cylinder at position X,

(i) the tension in the wire,

tension = ... N [1]

(ii) the power output of the motor.

power = ... W [2]

(d) The cylinder is raised with constant velocity from position X to position Y.

(i) State and explain the variation, if any, of the power output of the motor as the cylinder is raised. Numerical values are not required.

.....

.....

.....

.....

.....[3]

(ii) The rate of energy output of the motor is less than the rate of increase of gravitational potential energy of the cylinder. Without calculation, explain this difference.

.....

.....[1]

[Total: 11]

109. 9702_w18_qp_23 Q: 1

(a) Mass, length and time are all SI base quantities.

State two other SI base quantities.

1. .....

2. .....
[2]

(b) A wire hangs between two fixed points, as shown in Fig. 1.1.

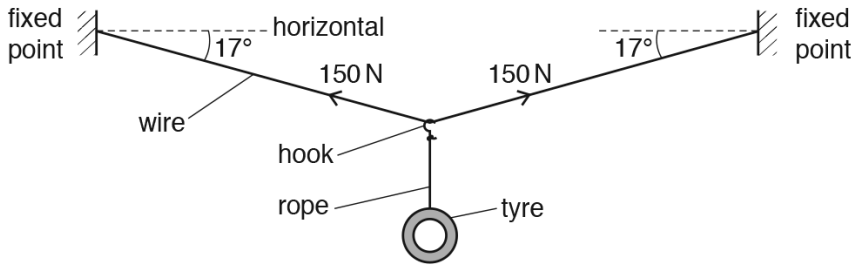


Fig. 1.1 (not to scale)

A child's swing is made by connecting a car tyre to the wire using a rope and a hook. The system is in equilibrium with the wire hanging at an angle of 17° to the horizontal. The tension in the wire is 150 N. Assume that the rope and hook have negligible weight.

(i) Determine the weight of the tyre.

weight = ... N [2]

(ii) The wire has a cross-sectional area of $7.5\,\text{mm}^2$ and is made of metal of Young modulus $2.1 \times 10^{11}\,\text{Pa}$. The wire obeys Hooke's law.

Calculate, for the wire,

1. the stress,

stress = ... Pa [2]

2. the strain.

strain = ... [2]

[Total: 8]

---

110. 9702_s17_qp_22 Q: 3

The Young modulus of the material of a wire can be determined using the apparatus shown in Fig. 3.1.

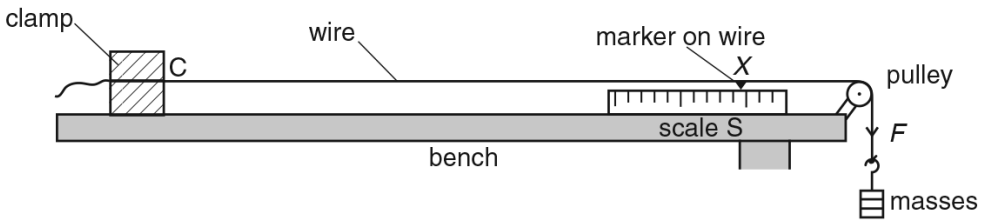


Fig. 3.1

One end of the wire is clamped at C and a marker is attached to the wire above a scale S. A force to extend the wire is applied by attaching masses to the other end of the wire.

The reading X of the marker on the scale S is determined for different forces F applied to the end of the wire. The variation with X of F is shown in Fig. 3.2.

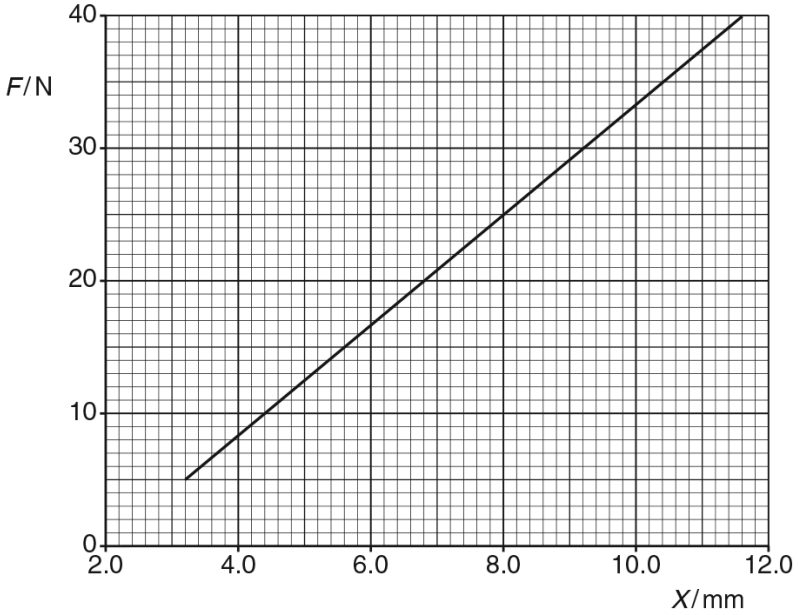


Fig. 3.2

(a) The length of the wire from C to the marker for $F = 0$ is 3.50 m. The diameter of the wire is 0.38 mm.

Use the gradient of the line in Fig. 3.2 to determine the Young modulus E of the material of the wire in TPa.

E = ... TPa [3]

(b) The experiment is repeated with a thicker wire of the same material and length.

State how the range of the force F must be changed to obtain the same range of scale readings as in Fig. 3.2.

.....

.....

.....[1]

[Total: 4]

---

111. 9702_w17_qp_21 Q: 4

(a) Define *strain*.

.....

.....[1]

(b) A wire is designed to ensure that its strain does not exceed 4.0×10^{-4} when a force of 8.0 kN is applied. The Young modulus of the metal of the wire is 2.1×10^{11} Pa. It may be assumed that the wire obeys Hooke's law.

For a force of 8.0 kN, calculate, for the wire,

(i) the maximum stress,

maximum stress = ... Pa [2]

(ii) the minimum cross-sectional area.

minimum cross-sectional area = ... m^2 [2]

[Total: 5]

112. 9702_w17_qp_22 Q: 3

A spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially held so that the spring has zero extension, as shown in Fig. 3.1.

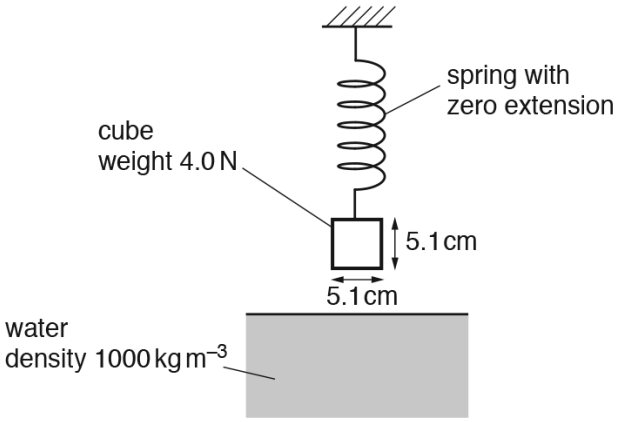


Fig. 3.1

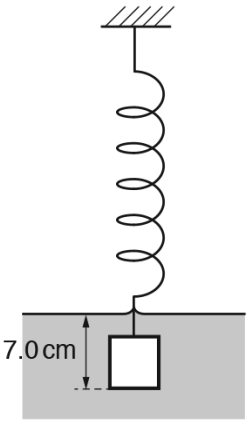


Fig. 3.2

The cube has weight 4.0N and sides of length 5.1cm. The cube is released and sinks into water as the spring extends. The cube reaches equilibrium with its base at a depth of 7.0cm below the water surface, as shown in Fig. 3.2.
The density of the water is 1000kgm^{-3}.

(a) Calculate the difference in the pressure exerted by the water on the bottom face and on the top face of the cube.

difference in pressure = ... Pa [2]

(b) Use your answer in **(a)** to show that the upthrust on the cube is 1.3N.

[2]

(c) Calculate the force exerted on the spring by the cube when it is in equilibrium in the water.

force = ... N [1]

(d) The spring obeys Hooke's law and has a spring constant of $30\,\text{N}\,\text{m}^{-1}$.

Determine the initial height above the water surface of the base of the cube before it was released.

height above surface = ... cm [3]

(e) The cube in the water is released from the spring.

(i) Determine the initial acceleration of the cube.

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

(ii) Describe and explain the variation, if any, of the acceleration of the cube as it sinks in the water.

.....

.....

.....[2]

[Total: 12]

113. 9702_s16_qp_22 Q: 3

(a) Define the *Young modulus*.

.....

.....[1]

(b) The Young modulus of steel is 1.9×10^{11} Pa. The Young modulus of copper is 1.2×10^{11} Pa.

A steel wire and a copper wire each have the same cross-sectional area and length. The two wires are each extended by equal forces.

(i) Use the definition of the Young modulus to determine the ratio

$$\frac{\text{extension of the copper wire}}{\text{extension of the steel wire}}.$$

ratio = ...[3]

(ii) The two wires are each extended by a force. Both wires obey Hooke's law.

On Fig. 3.1, sketch a graph for each wire to show the variation with extension of the force.

Label the line for steel with the letter **S** and the line for copper with the letter **C**.



Fig. 3.1

[1]

[Total: 5]

114. 9702_w16_qp_22 Q: 3

(a) State the two conditions for an object to be in equilibrium.

1. .....

.....

2. .....

.....
[2]

(b) A uniform beam AC is attached to a vertical wall at end A. The beam is held horizontal by a rigid bar BD, as shown in Fig. 3.1.

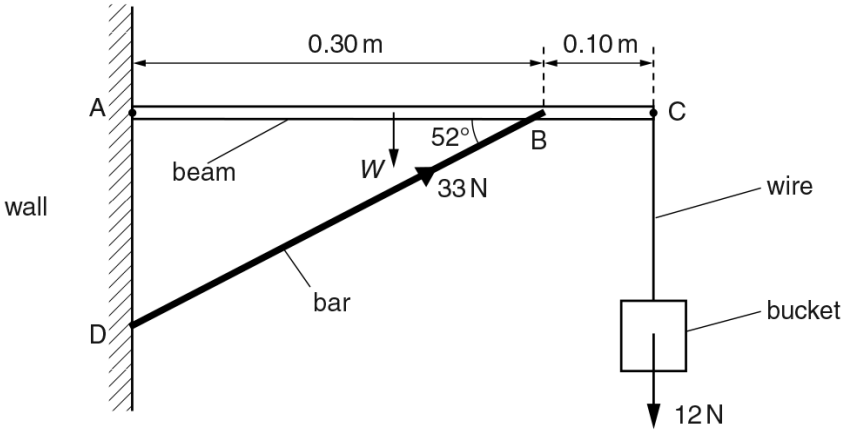


Fig. 3.1 (not to scale)

The beam is of length 0.40 m and weight *W*. An empty bucket of weight 12 N is suspended by a light metal wire from end C. The bar exerts a force on the beam of 33 N at 52° to the horizontal. The beam is in equilibrium.

(i) Calculate the vertical component of the force exerted by the bar on the beam.

component of the force = ... N [1]

(ii) By taking moments about A, calculate the weight *W* of the beam.

W = ... N [3]

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(c) The metal of the wire in **(b)** has a Young modulus of 2.0×10^{11} Pa.
Initially the bucket is empty. When the bucket is filled with paint of weight 78 N, the strain of the wire increases by 7.5×10^{-4}. The wire obeys Hooke's law.

Calculate, for the wire,

(i) the increase in stress due to the addition of the paint,

increase in stress = ... Pa [2]

(ii) its diameter.

diameter = ... m [3]

[Total: 11]

7.2 Elastic and plastic behaviour

115. 9702_s20_qp_23 Q: 3

(a) State the principle of moments.

.....

.....

..... [2]

(b) In a bicycle shop, two wheels hang from a horizontal uniform rod AC, as shown in Fig. 3.1.

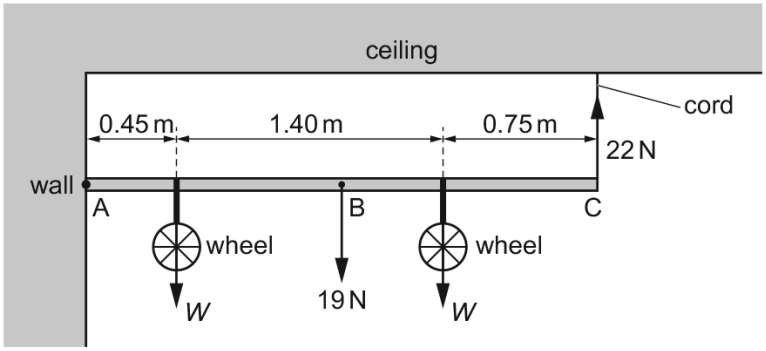


Fig. 3.1 (not to scale)

The rod has weight 19 N and is freely hinged to a wall at end A. The other end C of the rod is attached by a vertical elastic cord to the ceiling. The centre of gravity of the rod is at point B. The weight of each wheel is *W* and the tension in the cord is 22 N.

(i) By taking moments about end A, show that the weight *W* of each wheel is 14 N.

[2]

(ii) Determine the magnitude and the direction of the force acting on the rod at end A.

magnitude = ... N

direction .....

[2]

(c) The unstretched length of the cord in **(b)** is 0.25 m. The variation with length L of the tension F in the cord is shown in Fig. 3.2.

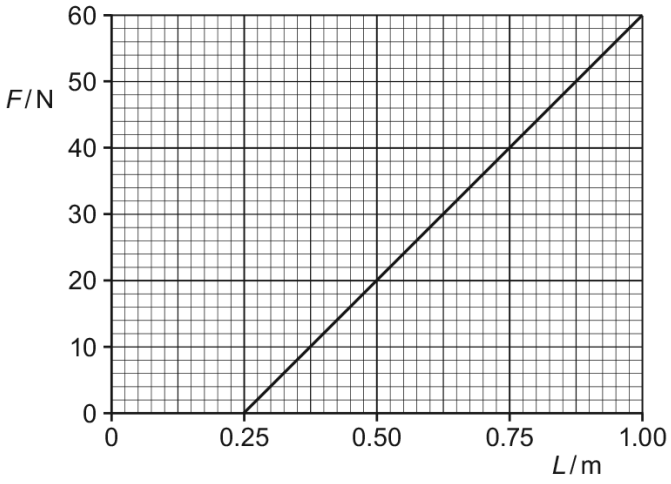


Fig. 3.2

(i) State and explain whether Fig. 3.2 suggests that the cord obeys Hooke's law.

.....

.....

..... [2]

(ii) Calculate the spring constant k of the cord.

k = ... $N\,m^{-1}$ [2]

(iii) On Fig. 3.2, shade the area that represents the work done to extend the cord when the tension is increased from $F = 0$ to $F = 40\,N$. [1]

[Total: 11]

116. 9702_w20_qp_21 Q: 4

(a) Define, for a wire:

(i) *stress*

.....

..... [1]

(ii) *strain*.

.....

..... [1]

(b) **(i)** A school experiment is performed on a metal wire to determine the Young modulus of the metal. A force is applied to one end of the wire which is fixed at the other end. The variation of the force F with extension x of the wire is shown in Fig. 4.1.

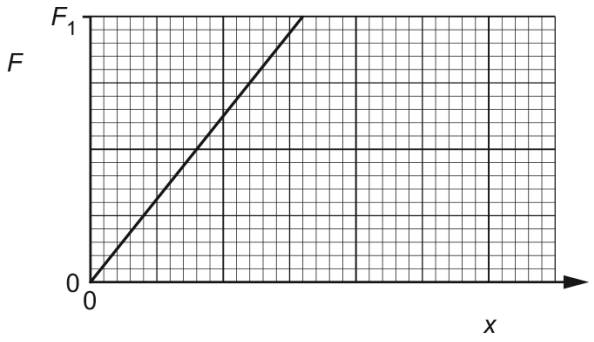


Fig. 4.1

The maximum force applied to the wire is F_1.

The gradient of the graph line in Fig. 4.1 is G. The wire has initial length L and cross-sectional area A.

Determine an expression, in terms of A, G and L, for the Young modulus E of the metal.

E = ... [2]

(ii) A student repeats the experiment in **(b)(i)** using a new wire that has twice the diameter of the first wire. The initial length of the wire and the metal of the wire are unchanged.

On Fig. 4.1, draw the graph line representing the new wire for the force increasing from $F = 0$ to $F = F_1$. [2]

(iii) Another student repeats the original experiment in **(b)(i)**, increasing the force beyond F_1 to a new maximum force F_2. The new graph obtained is shown in Fig. 4.2.

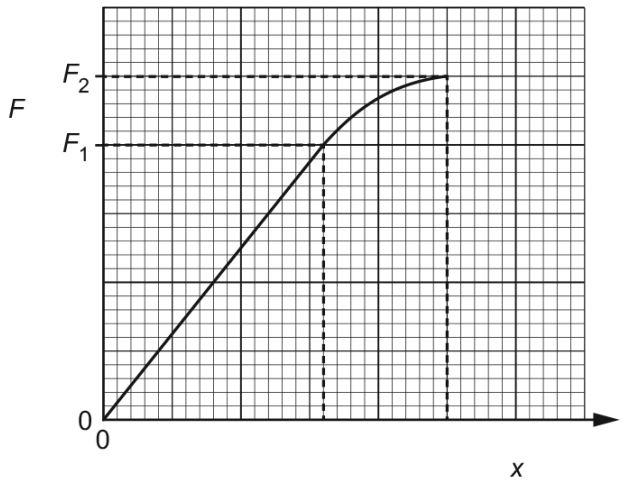


Fig. 4.2

1. On Fig. 4.2, shade an area that represents the work done to extend the wire when the force is increased from F_1 to F_2. [1]

2. Explain how the student can check that the elastic limit of the wire was not exceeded when force F_2 was applied.

.....

.....

..... [1]

(iv) Each student in the class performs the experiment in **(b)(i)**. The teacher describes the values of the Young modulus calculated by the students as having high accuracy and low precision.

Explain what is meant by *low precision*.

.....

..... [1]

[Total: 9]

117. 9702_w20_qp_22 Q: 3

(a) A spring is fixed at one end and is compressed by applying a force to the other end. The variation of the force F acting on the spring with its compression x is shown in Fig. 3.1.

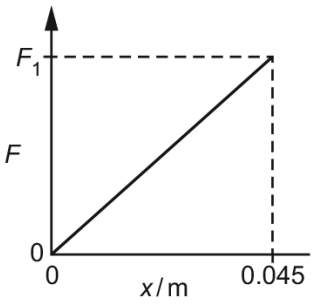


Fig. 3.1

A compression of 0.045 m is produced when a force F_1 acts on the spring. The spring has a spring constant of 800 N m^{-1}.

(i) Determine F_1.

F_1 = ... N [2]

(ii) Use Fig. 3.1 to show that, for a compression of 0.045 m, the elastic potential energy of the spring is 0.81 J.

[2]

(b) A child's toy uses the spring in **(a)** to launch a ball of mass 0.020 kg vertically into the air. The ball is initially held against one end of the spring which has a compression of 0.045 m. The spring is then released to launch the ball. The kinetic energy of the ball as it leaves the toy is 0.72 J.

(i) The toy converts the elastic potential energy of the spring into the kinetic energy of the ball. Use the information in **(a)(ii)** to calculate the percentage efficiency of this conversion.

efficiency = ... % [1]

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(ii) Determine the initial momentum of the ball as it leaves the toy.

momentum = ... N s [3]

(c) The ball in **(b)** leaves the toy at point A and moves vertically upwards through the air. Point B is the position of the ball when it is at maximum height *h* above point A, as illustrated in Fig. 3.2.

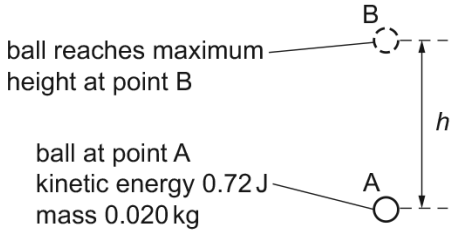


Fig. 3.2 (not to scale)

The gravitational potential energy of the ball increases by 0.60 J as it moves from A to B.

(i) Calculate *h*.

h = ... m [2]

(ii) Determine the average force due to air resistance acting on the ball for its movement from A to B.

average force = ... N [2]

(iii) When there is air resistance, the ball takes time T to move from A to B.

State and explain whether the time taken for the ball to move from A to its maximum height will be more than, less than or equal to time T if there is **no** air resistance.

.....

..... [1]

[Total: 13]

---

118. 9702_w20_qp_23 Q: 4

(a) State Hooke's law.

.....

..... [1]

(b) A spring is fixed at one end. A compressive force F is applied to the other end. The variation of the force F with the compression x of the spring is shown in Fig. 4.1.

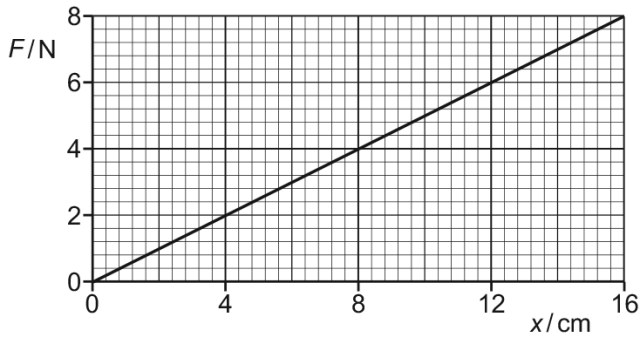


Fig. 4.1

Show that the elastic potential energy of the spring is 0.64 J when its compression is 16.0 cm.

[2]

(c) The spring in **(b)** is used to project a toy car along a track from point X to point Y, as illustrated in Fig. 4.2.

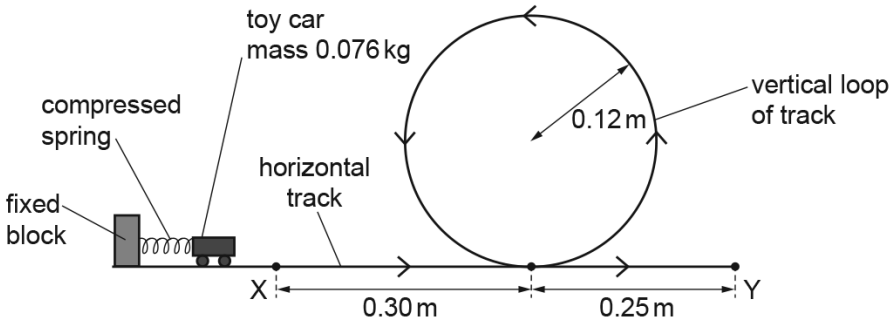


Fig. 4.2 (not to scale)

The spring is initially given a compression of 16.0 cm. The car of mass 0.076 kg is held against one end of the compressed spring. When the spring is released it projects the car forward. The car leaves the spring at point X with kinetic energy that is equal to the initial elastic potential energy of the compressed spring.

The car follows the track around a vertical loop of radius 0.12 m and then passes point Y. Assume that friction and air resistance are negligible.

Calculate:

(i) the speed of the car at X

speed = ... $m\,s^{-1}$ [2]

(ii) the kinetic energy of the car when it is at the top of the loop

kinetic energy = ... J [3]

(iii) the speed of the car at Y.

speed = ... $m\,s^{-1}$ [1]

(d) In practice, a resistive force due to friction and air resistance acts on the car so that its kinetic energy at Y is 0.23 J less than its kinetic energy at X.

Determine the average resistive force acting on the car for its movement from X to Y.

average resistive force = ... N [3]

[Total: 12]

119. 9702_s19_qp_21 Q: 3

The variation with extension x of the force F acting on a spring is shown in Fig. 3.1.

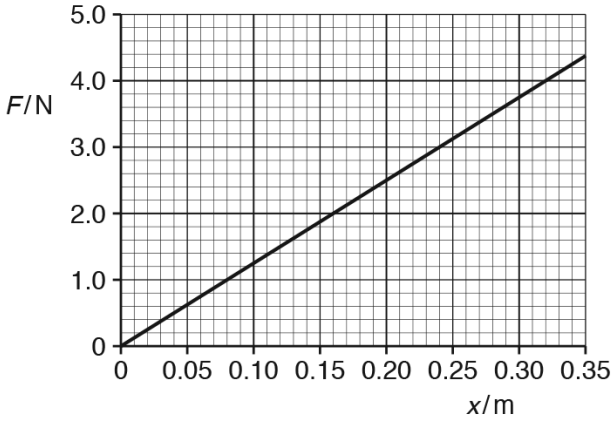


Fig. 3.1

The spring of unstretched length 0.40 m has one end attached to a fixed point, as shown in Fig. 3.2.

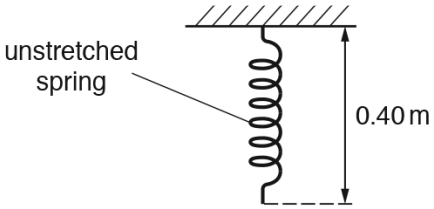


Fig. 3.2

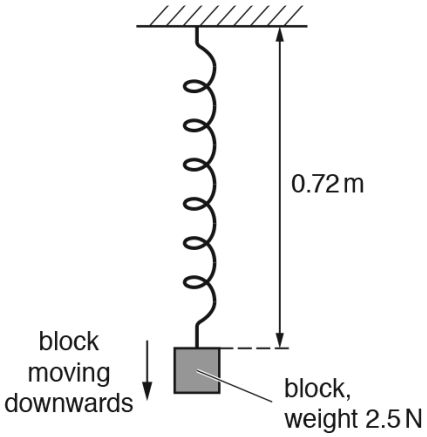


Fig. 3.3

A block of weight 2.5 N is then attached to the spring. The block is then released and begins to move downwards. At one instant, as the block is continuing to move downwards, the spring has a length of 0.72 m, as shown in Fig. 3.3.

Assume that the air resistance and the mass of the spring are both negligible.

(a) For the change in length of the spring from 0.40 m to 0.72 m:

(i) use Fig. 3.1 to show that the increase in elastic potential energy of the spring is 0.64 J

[2]

(ii) calculate the decrease in gravitational potential energy of the block of weight 2.5 N.

decrease in potential energy = ... J [2]

(b) Use the information in **(a)(i)** and your answer in **(a)(ii)** to determine, for the instant when the length of the spring is 0.72 m:

(i) the kinetic energy of the block

kinetic energy = ... J [1]

(ii) the speed of the block.

speed = ... $m\,s^{-1}$ [2]

[Total: 7]

120. 9702_s18_qp_23 Q: 4

(a) Define the *Young modulus* of a material.

.....

.....[1]

(b) A metal rod is compressed, as shown in Fig. 4.1.

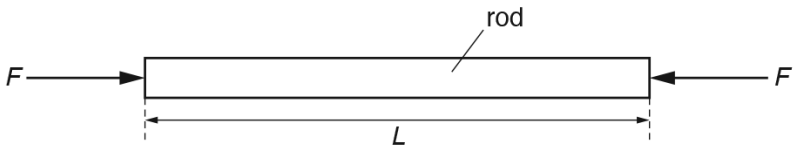


Fig. 4.1

The variation with compressive force F of the length L of the rod is shown in Fig. 4.2.

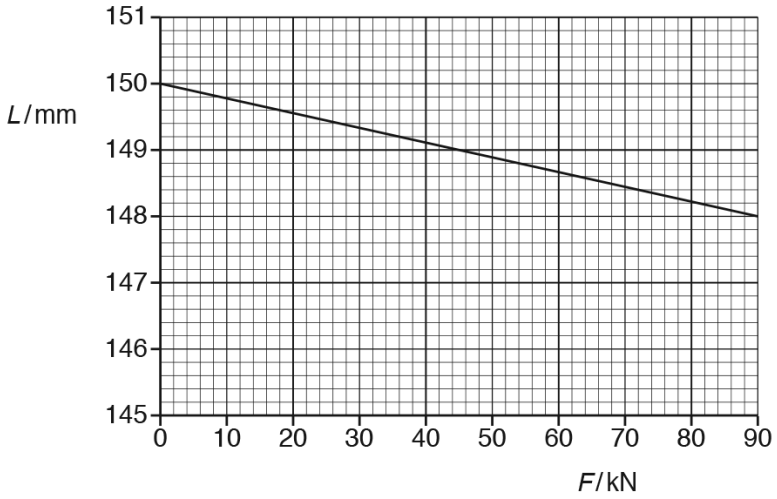


Fig. 4.2

Use Fig. 4.2 to

(i) determine the spring constant k of the rod,

k = ... $N\,m^{-1}$ [2]

(ii) determine the strain energy stored in the rod for $F = 90\,\text{kN}$.

strain energy = ... J [3]

(c) The rod in **(b)** has cross-sectional area A and is made of metal of Young modulus E. It is now replaced by a new rod of the same original length. The new rod has cross-sectional area $A/3$ and is made of metal of Young modulus $2E$. The compression of the new rod obeys Hooke's law.

On Fig. 4.2, sketch the variation with F of the length L for the new rod from $F = 0$ to $F = 90\,\text{kN}$. [2]

[Total: 8]

---

121. 9702_m17_qp_22 Q: 2

(a) State the *principle of conservation of momentum*.

.....

.....

.....[2]

(b) Two blocks, A and B, are on a horizontal frictionless surface. The blocks are joined together by a spring, as shown in Fig. 2.1.

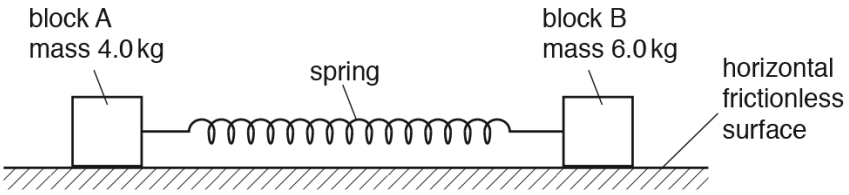


Fig. 2.1

Block A has mass 4.0 kg and block B has mass 6.0 kg.

The variation of the tension *F* with the extension *x* of the spring is shown in Fig. 2.2.

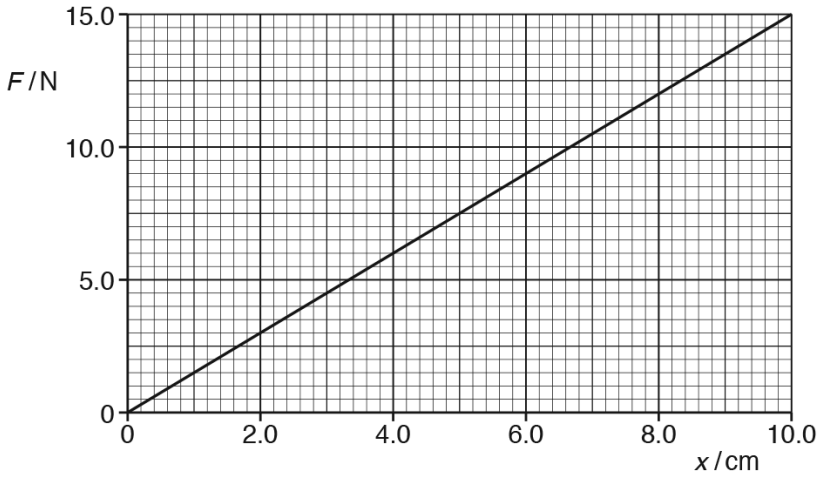


Fig. 2.2

The two blocks are held apart so that the spring has an extension of 8.0 cm.

(i) Show that the elastic potential energy of the spring at an extension of 8.0 cm is 0.48 J.

[2]

(ii) The blocks are released from rest at the same instant. When the extension of the spring becomes zero, block A has speed v_A and block B has speed v_B.

For the instant when the extension of the spring becomes zero,

1. use conservation of momentum to show that

$$\frac{\text{kinetic energy of block A}}{\text{kinetic energy of block B}} = 1.5$$

[3]

2. use the information in **(b)(i)** and **(b)(ii)1** to determine the kinetic energy of block A. It may be assumed that the spring has negligible kinetic energy and that air resistance is negligible.

kinetic energy of block A = ...J [2]

(iii) The blocks are released at time $t = 0$.

On Fig. 2.3, sketch a graph to show how the momentum of block A varies with time t until the extension of the spring becomes zero.
Numerical values of momentum and time are not required.

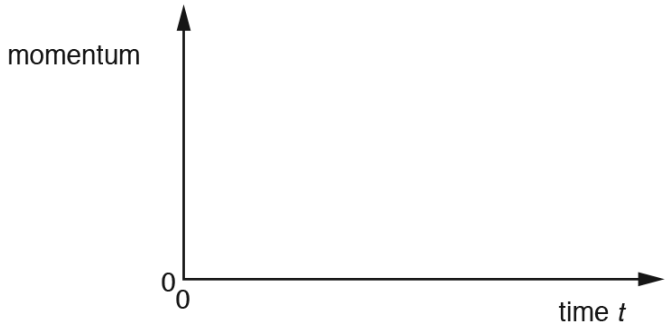


Fig. 2.3

[2]

[Total: 11]

122. 9702_s17_qp_23 Q: 4

A spring is supported so that it hangs vertically, as shown in Fig. 4.1.

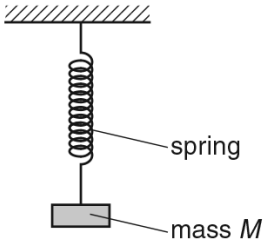


Fig. 4.1

Different masses are attached to the lower end of the spring. The extension x of the spring is measured for each mass M. The variation with x of M is shown in Fig. 4.2.

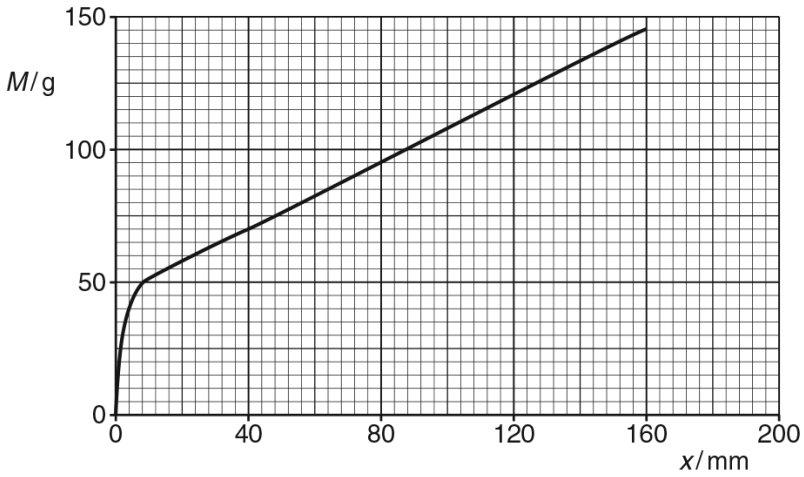


Fig. 4.2

(a) State and explain whether the spring obeys Hooke's law.

.....

.....[1]

(b) State the form of energy stored in the spring due to the addition of the masses.

.....[1]

(c) Describe how to determine whether the extension of the spring is elastic.

.....

.....[1]

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(d) Calculate the work done on the spring as it is extended from $x = 40.0\,\text{mm}$ to $x = 160\,\text{mm}$.

work done = ...J [3]

[Total: 6]

---

123. 9702_m16_qp_22 Q: 3

(a) State what is meant by

(i) *work done*,

.....

..... [1]

(ii) *elastic potential energy*.

.....

..... [1]

(b) A block of mass 0.40 kg slides in a straight line with a constant speed of 0.30 m s^{-1} along a horizontal surface, as shown in Fig. 3.1.

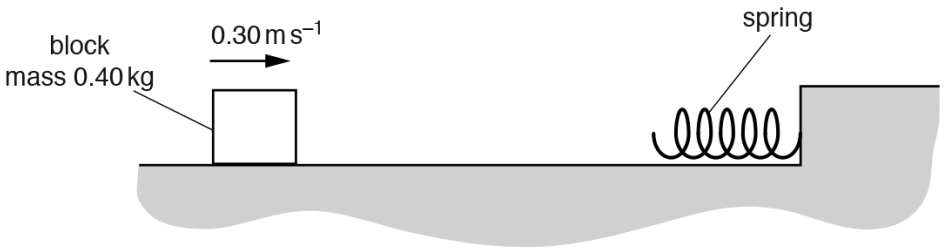


Fig. 3.1

The block hits a spring and decelerates. The speed of the block becomes zero when the spring is compressed by 8.0 cm.

(i) Calculate the initial kinetic energy of the block.

kinetic energy = ... J [2]

(ii) The variation of the compression x of the spring with the force F applied to the spring is shown in Fig. 3.2.

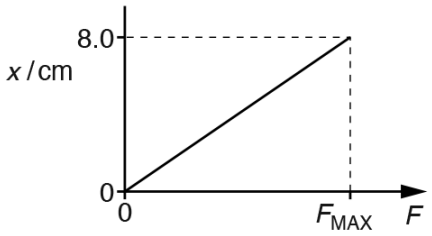


Fig. 3.2

Use your answer in **(b)(i)** to determine the maximum force F_{MAX} exerted on the spring by the block.
Explain your working.

F_{MAX} = ... N [3]

(iii) Calculate the maximum deceleration of the block.

deceleration = ... $m\,s^{-2}$ [1]

(iv) State and explain whether the block is in equilibrium

1. before it hits the spring,

.....

.....

2. when its speed becomes zero.

.....

.....
[2]

(c) The energy E stored in a spring is given by

$$E = \frac{1}{2}kx^2$$

where k is the spring constant of the spring and x is its compression.

The mass m of the block in **(b)** is now varied. The initial speed of the block remains constant and the spring continues to obey Hooke's law.

On Fig. 3.3, sketch the variation of the maximum compression x_0 of the spring with mass m.

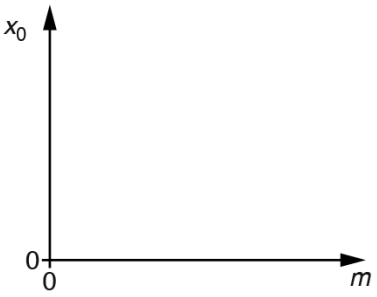


Fig. 3.3 [2]

[Total: 12]

124. 9702_s16_qp_21 Q: 4

(a) State what is meant by *elastic potential energy*.

.....

.....[1]

(b) A spring is extended by applying a force. The variation with extension x of the force F is shown in Fig. 4.1 for the range of values of x from 20 cm to 40 cm.

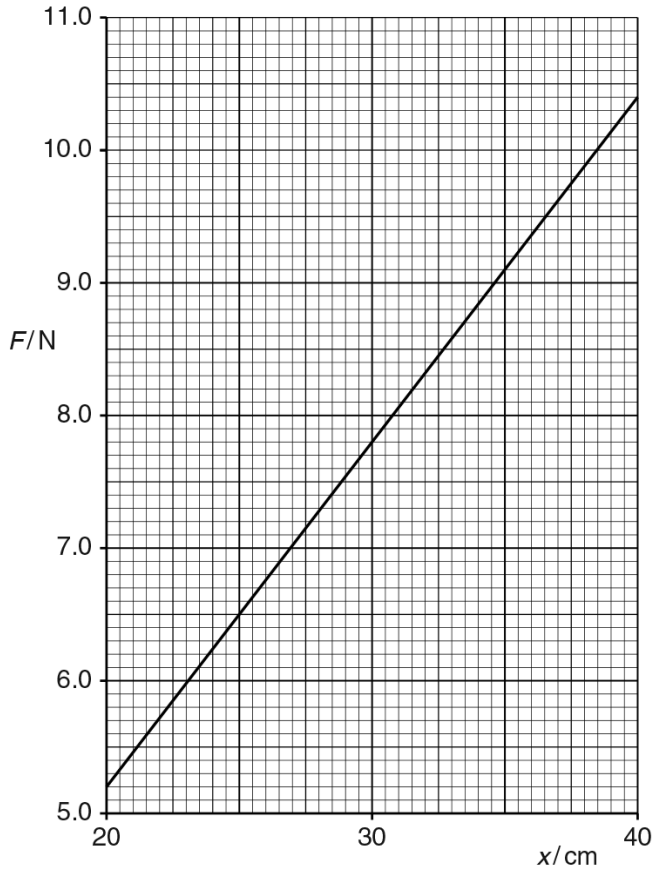


Fig. 4.1

(i) Use data from Fig. 4.1 to show that the spring obeys Hooke's law for this range of extensions.

.....

.....

.....[2]

(ii) Use Fig. 4.1 to calculate

1. the spring constant,

spring constant = ... $N m^{-1}$ [2]

2. the work done extending the spring from $x = 20\,cm$ to $x = 40\,cm$.

work done = ... J [3]

(c) A force is applied to the spring in **(b)** to give an extension of 50 cm.

State how you would check that the spring has not exceeded its elastic limit.

.....

.....[1]

[Total: 9]

---

125. 9702_w16_qp_21 Q: 3

(a) State Hooke's law.

.....

.....[1]

(b) The variation with compression x of the force F acting on a spring is shown in Fig. 3.1.

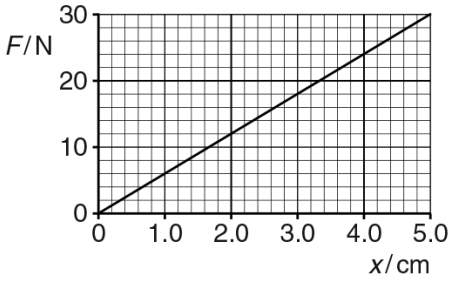


Fig. 3.1

The spring is fixed to the closed end of a horizontal tube. A block is pushed into the tube so that the spring is compressed, as shown in Fig. 3.2.

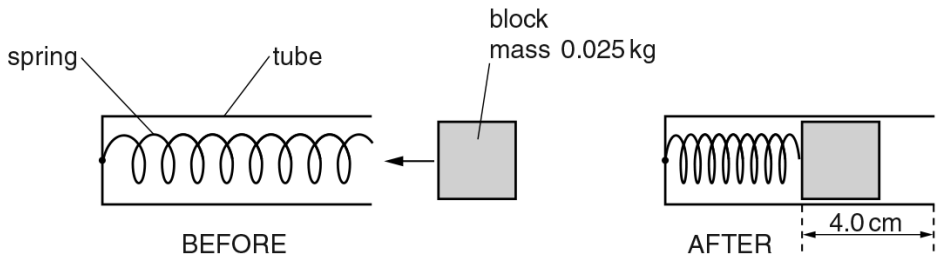


Fig. 3.2 (not to scale)

The compression of the spring is 4.0 cm. The mass of the block is 0.025 kg.

(i) Calculate the spring constant of the spring.

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

(ii) Show that the work done to compress the spring by 4.0 cm is 0.48 J.

[2]

(iii) The block is now released and accelerates along the tube as the spring returns to its original length. The block leaves the end of the tube with a speed of $6.0\,m\,s^{-1}$.

1. Calculate the kinetic energy of the block as it leaves the end of the tube.

kinetic energy = ... J [2]

2. Assume that the spring has negligible kinetic energy as the block leaves the tube. Determine the average resistive force acting against the block as it moves along the tube.

resistive force = ... N [3]

(iv) Determine the efficiency of the transfer of elastic potential energy from the spring to the kinetic energy of the block.

efficiency = ... [2]

[Total: 12]

126. 9702_w16_qp_23 Q: 3

(a) State Hooke's law.

.....

.....[1]

(b) The variation with compression x of the force F acting on a spring is shown in Fig. 3.1.

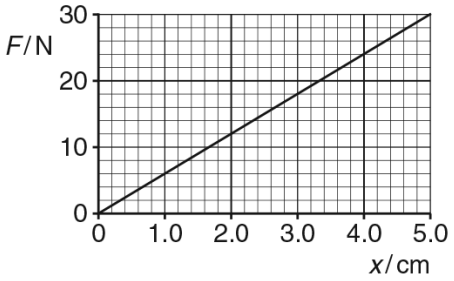


Fig. 3.1

The spring is fixed to the closed end of a horizontal tube. A block is pushed into the tube so that the spring is compressed, as shown in Fig. 3.2.

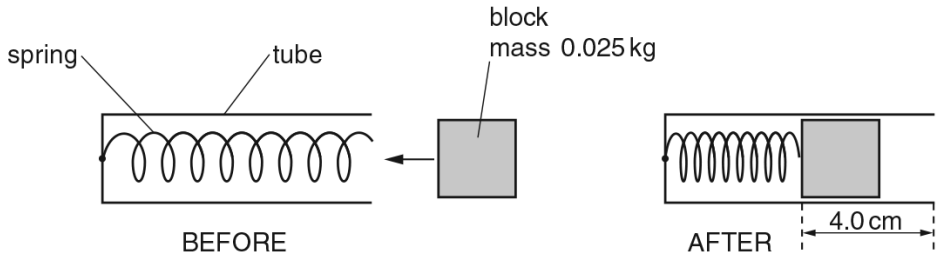


Fig. 3.2 (not to scale)

The compression of the spring is 4.0 cm. The mass of the block is 0.025 kg.

(i) Calculate the spring constant of the spring.

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

(ii) Show that the work done to compress the spring by 4.0 cm is 0.48 J.

[2]

(iii) The block is now released and accelerates along the tube as the spring returns to its original length. The block leaves the end of the tube with a speed of 6.0 m s^{-1}.

1. Calculate the kinetic energy of the block as it leaves the end of the tube.

kinetic energy = ... J [2]

2. Assume that the spring has negligible kinetic energy as the block leaves the tube. Determine the average resistive force acting against the block as it moves along the tube.

resistive force = ... N [3]

(iv) Determine the efficiency of the transfer of elastic potential energy from the spring to the kinetic energy of the block.

efficiency = ... [2]

[Total: 12]

127. 9702_s15_qp_21 Q: 4

A spring is kept horizontal by attaching it to points A and B, as shown in Fig. 4.1.

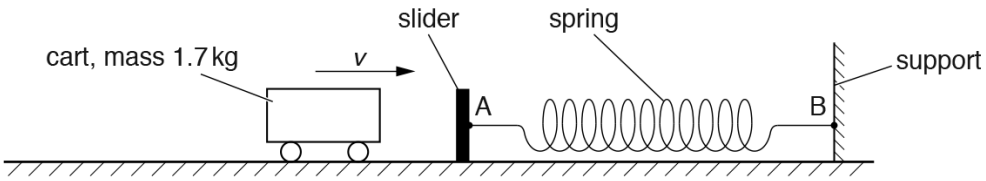


Fig. 4.1

Point A is on a movable slider and point B is on a fixed support. A cart of mass 1.7 kg has horizontal velocity v towards the slider. The cart collides with the slider. The spring is compressed as the cart comes to rest. The variation of compression x of the spring with force F exerted on the spring is shown in Fig. 4.2.

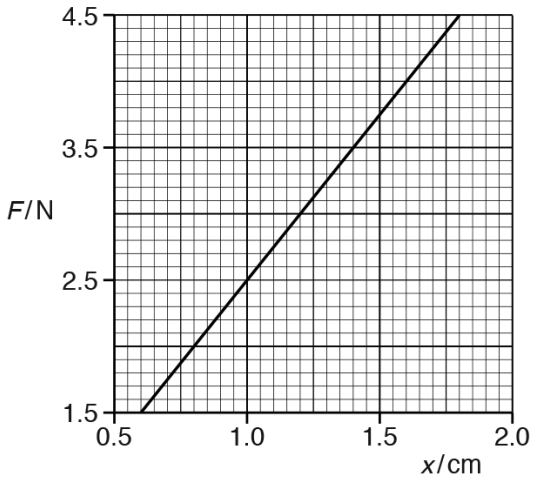


Fig. 4.2

Fig. 4.2 shows the compression of the spring for F = 1.5 N to F = 4.5 N. The cart comes to rest when F is 4.5 N.

(a) Use Fig. 4.2 to

(i) show that the compression of the spring obeys Hooke's law,

.....

.....

.....[2]

(ii) determine the spring constant of the spring,

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

(iii) determine the elastic potential energy E_P stored in the spring due to the cart being brought to rest.

E_P = ... J [3]

(b) Calculate the speed v of the cart as it makes contact with the slider. Assume that all the kinetic energy of the cart is converted to the elastic potential energy of the spring.

speed = ... $\mathrm{m\,s^{-1}}$ [2]

---

128. 9702_w15_qp_22 Q: 3

A trolley T moves at speed 1.2 m s^{-1} along a horizontal frictionless surface. The trolley collides with a stationary block on the end of a fixed spring, as shown in Fig. 3.1.

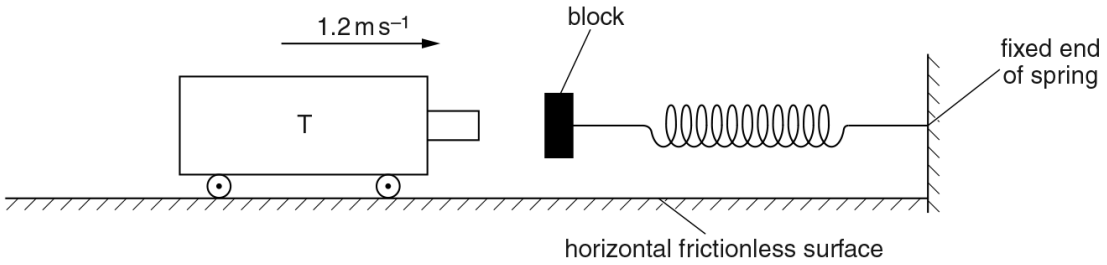


Fig. 3.1

The mass of T is 250 g. T compresses the spring by 5.4 cm as it comes to rest.
The relationship between the force F applied to the block and the compression x of the spring is shown in Fig. 3.2.

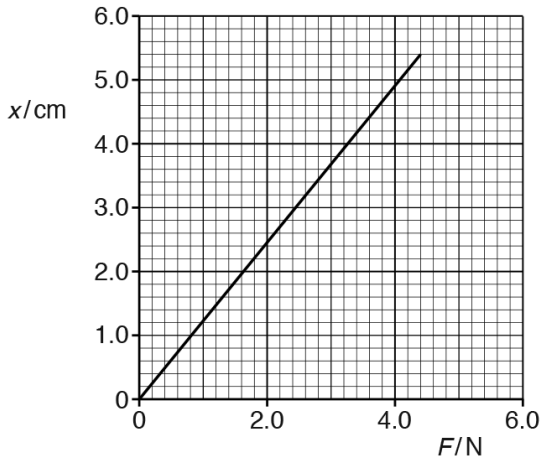


Fig. 3.2

(a) Use Fig. 3.2 to determine

(i) the spring constant of the spring,

spring constant = ... N m^{-1} [2]

(ii) the work done by T compressing the spring by 5.4 cm.

work done = ... J [2]

(b) The spring then expands and causes T to move in a direction opposite to its initial direction. At the time that T loses contact with the block, it is moving at a speed of $0.75\,m\,s^{-1}$.

From the time that T is in contact with the block,

(i) describe the energy changes,

.....

.....

.....

.....[2]

(ii) determine the change in momentum of T.

change in momentum = ... N s [2]

---

1 Which of the following correctly defines the terms *stress*, *strain* and *Young modulus*? 9702/1/M/J/02/Q22

	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)

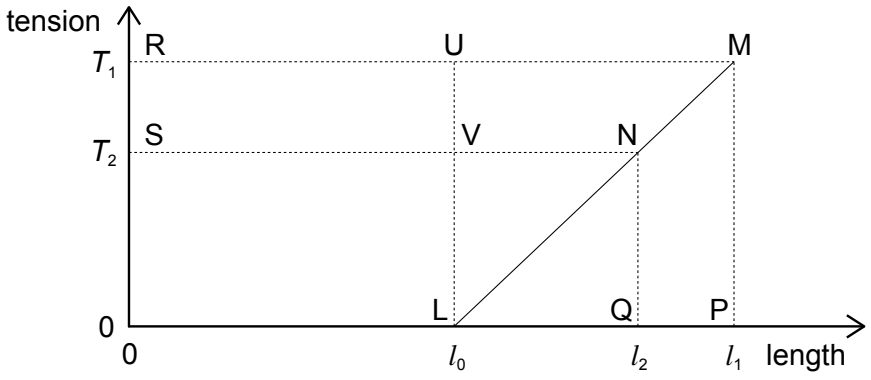
2 A wire is stretched by 8 mm when a load of 60 N is applied. 9702/1/M/J/02/Q23

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

3 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).

9702/1/M/J/02/Q24



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

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

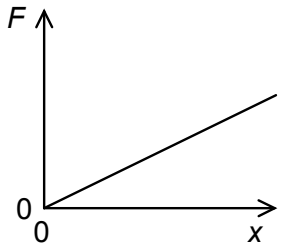
The springs are stretched, separately, by a force that is gradually increased from zero up to a certain maximum value, the same for each spring. The work done in stretching spring P is W_P, and the work done in stretching spring Q is W_Q.

9702/1/O/N/02/Q24

How is W_P related to W_Q?

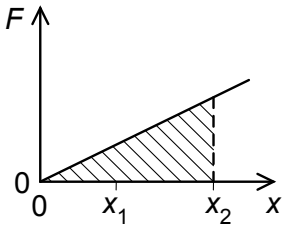
A $W_P = \frac{1}{4}W_Q$ **B** $W_P = \frac{1}{2}W_Q$ **C** $W_P = 2W_Q$ **D** $W_P = 4W_Q$

5 The variation of the extension x of a spring with applied force F is shown. 9702/1/O/N/02/Q23

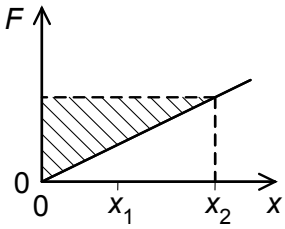


Which shaded area represents the work done when the extension is increased from x_1 to x_2?

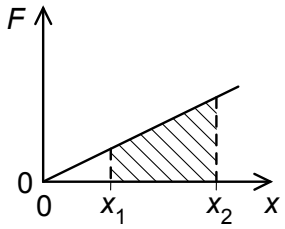
A



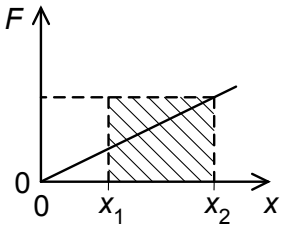
B



C



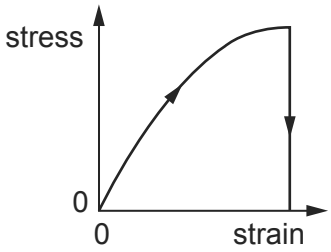
D



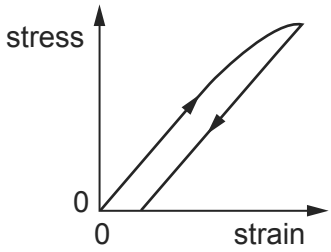
6 A suspended copper wire is gradually loaded until it is stretched just beyond the elastic limit, and it is then gradually unloaded. 9702/01/M/J/03/Q19

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

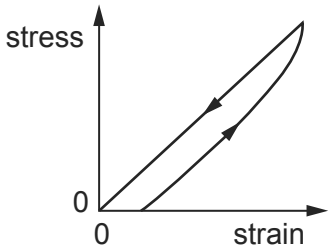
A



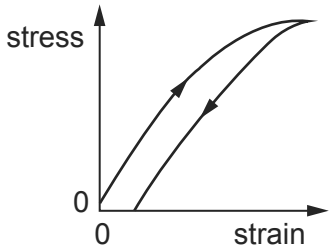
B



C



D



7 What is the ultimate tensile stress of a material? 9702/01/M/J/03/Q21

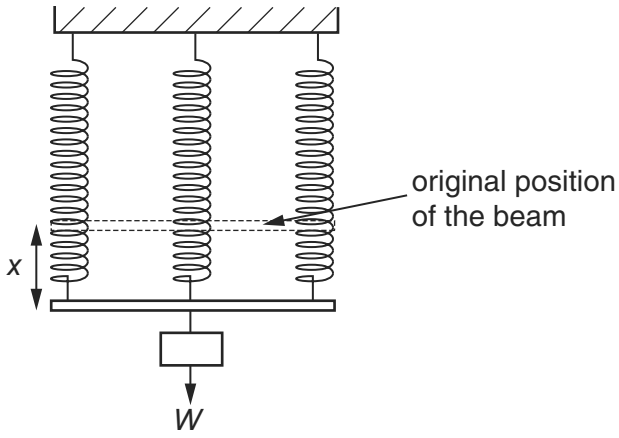
A the stress at which the material becomes ductile

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

8 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. 9702/01/M/J/03/Q22



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

9 What is the Young modulus of a metal? 9702/01/O/N/03/Q21

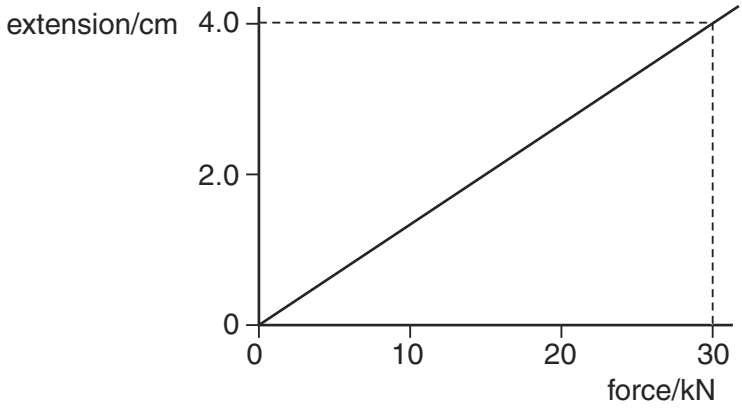
A extension / force

B force / extension

C strain / stress

D stress / strain

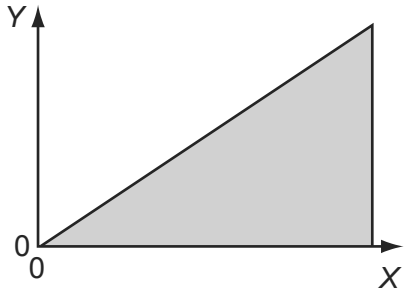
10 The graph shows how the extension of a spring varies with the force used to stretch it. 9702/01/O/N/03/Q22



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

11 The graph shown was plotted in an experiment on a metal wire. 9702/01/M/J/04/Q22



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

12 Nylon breaks when the stress within it reaches 1×10^9 Pa. 9702/01/M/J/04/Q23

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

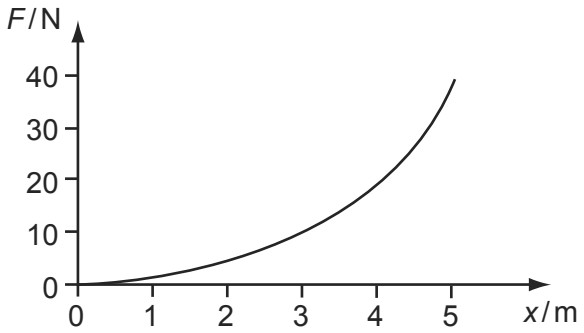
13 The table shows a load applied to four wires and the cross-sectional area of each. 9702/01/O/N/04/Q22

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

14 The force F required to extend a sample of rubber by a distance x is found to vary as shown.

9702/01/O/N/04/Q23



The energy stored in the rubber for an extension of 5 m is

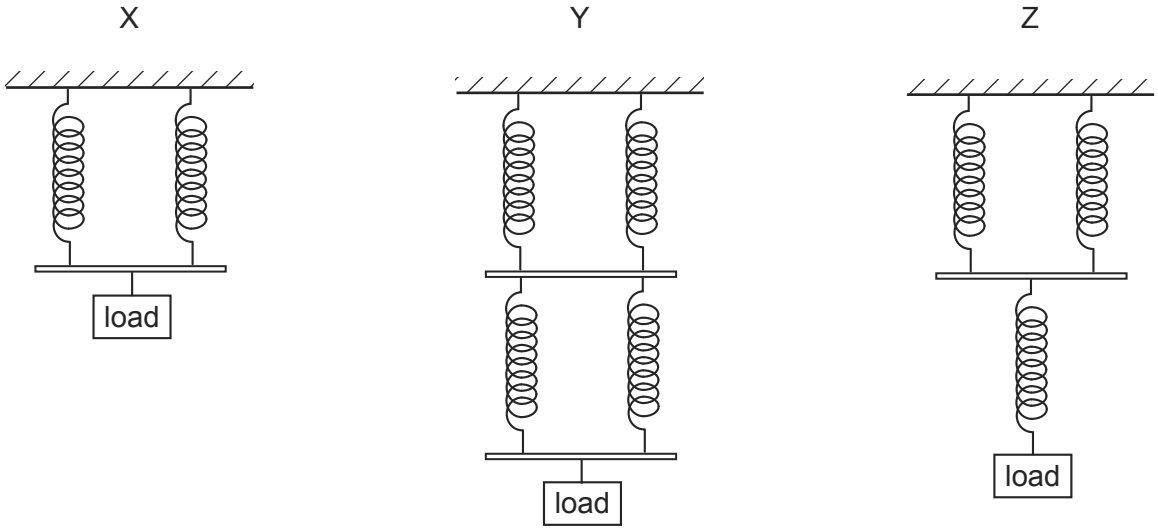
A less than 100 J.

B 100 J.

C between 100 J and 200 J.

D more than 200 J.

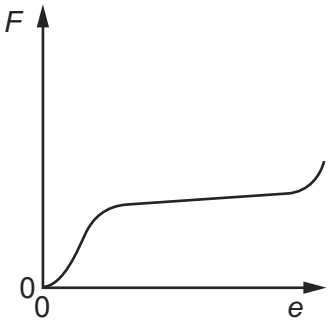
15 A number of similar springs, each having the same spring constant, are joined in three arrangements X, Y and Z. The same load is applied to each. 9702/01/M/J/05/Q20



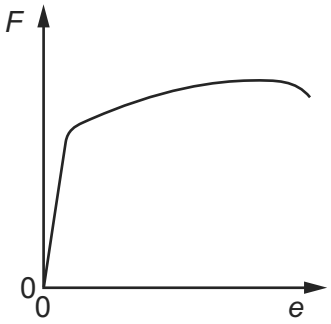
What is the order of increasing extension for these arrangements?

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

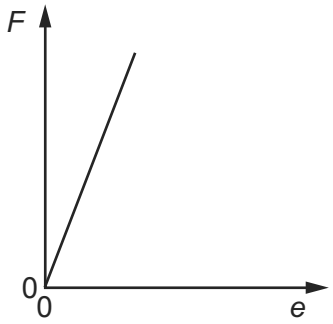
16 Cylindrical samples of steel, glass and rubber are each subjected to a gradually increasing tensile force F. The extensions e are measured and graphs are plotted as shown below. 9702/01/M/J/05/Q21



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

17 Two steel wires P and Q have lengths l and $2l$ respectively, and cross-sectional areas A and $\frac{A}{2}$ respectively. Both wires obey Hooke's law. 9702/01/M/J/05/Q22

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

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

18 In describing the behaviour of a spring, the spring constant is used. 9702/01/M/J/06/Q21

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

19 What is the unit of the Young modulus? 9702/01/O/N/06/Q23

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

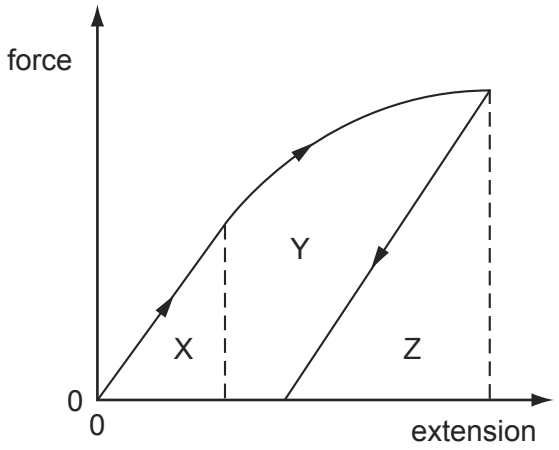
20 A wire stretches 8 mm under a load of 60 N. 9702/01/O/N/05/Q21

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

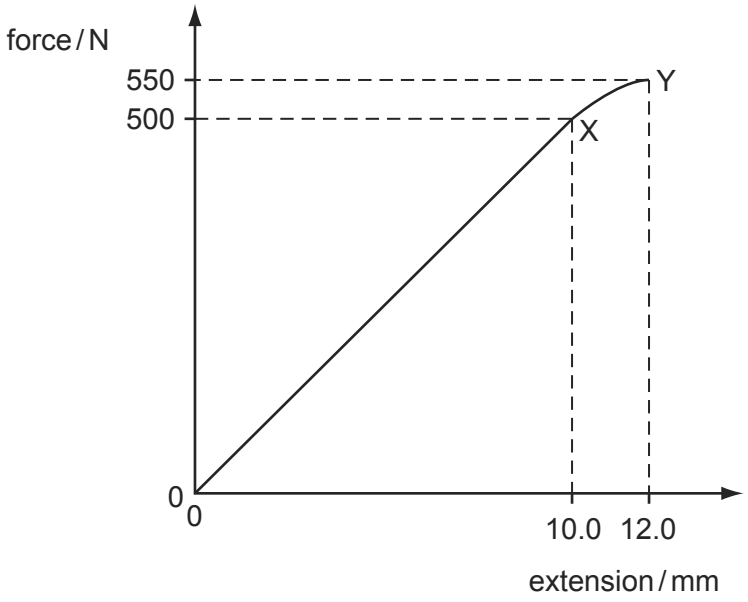
21 A ductile material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below. 9702/01/O/N/05/Q20



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/Q22



What is the total work 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

23 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)? 9702/01/O/N/06/Q22

A elastic limit

B spring constant

C stress

D the Young modulus

24 A piece of copper is drawn into a continuous wire. 9702/01/M/J/07/Q17

What behaviour is the copper exhibiting?

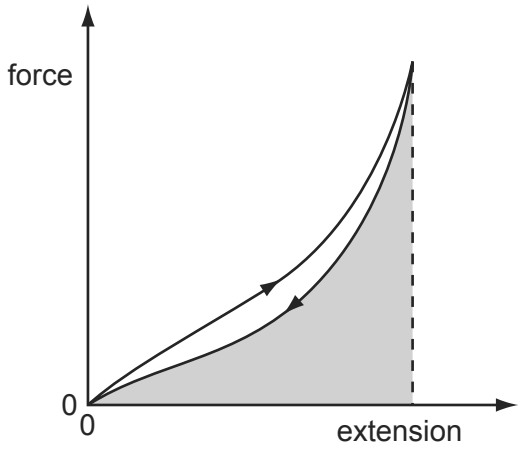
A brittle only

B elastic only

C plastic only

D both brittle and elastic

25 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/Q18



What does the shaded area represent?

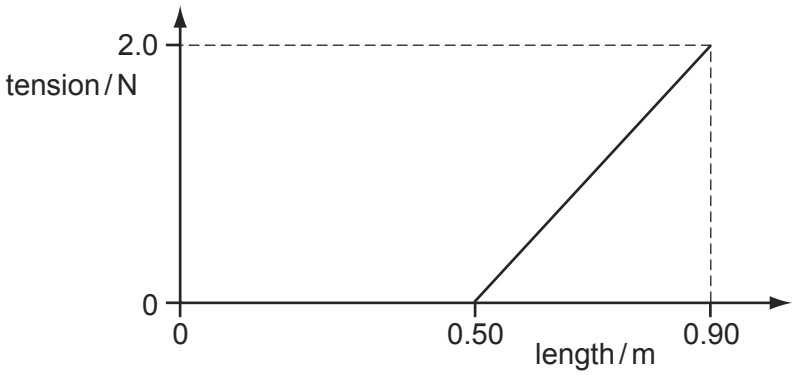
A the energy transformed into heat during the complete cycle

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

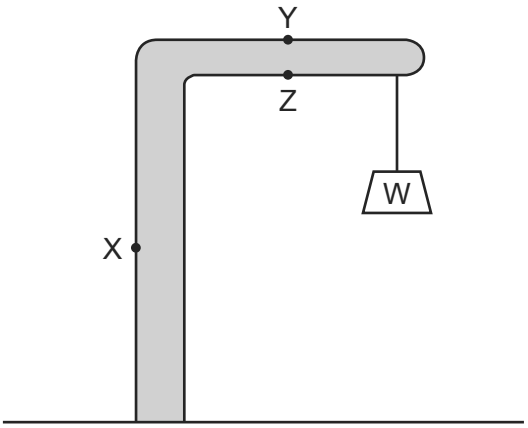
26 A spring of unextended length 0.50 m is stretched by a force of 2.0 N to a new length of 0.90 m. The variation of its length with tension is as shown. 9702/01/M/J/07/Q19



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

27 A simple crane consists of a rigid vertical pillar supporting a horizontal beam. 9702/01/M/J/07/Q20



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

28 What is plastic deformation? 9702/01/O/N/07/Q19

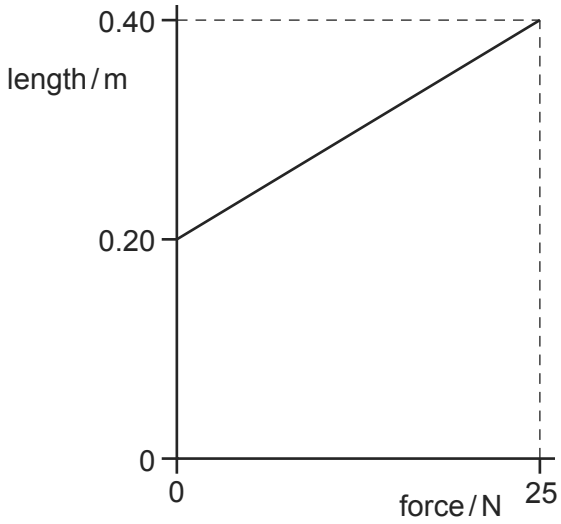
A Plastic deformation occurs when strain is not proportional to stress but when the load is removed the material returns to its original length.

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.

29 The graph shows how the length of a particular rubber cord varies as force is applied. 9702/01/O/N/07/Q20



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

30 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/Q24

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

31 Which properties best describe modelling clay? 9702/01/O/N/08/Q19

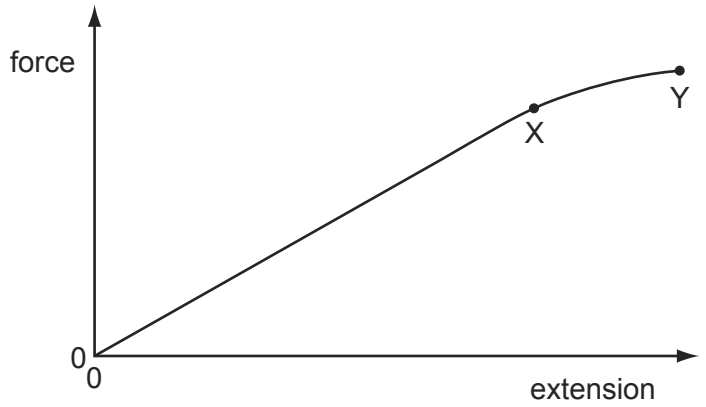
A brittle and ductile

B ductile and elastic

C elastic and plastic

D plastic and ductile

32 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/Q22



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?

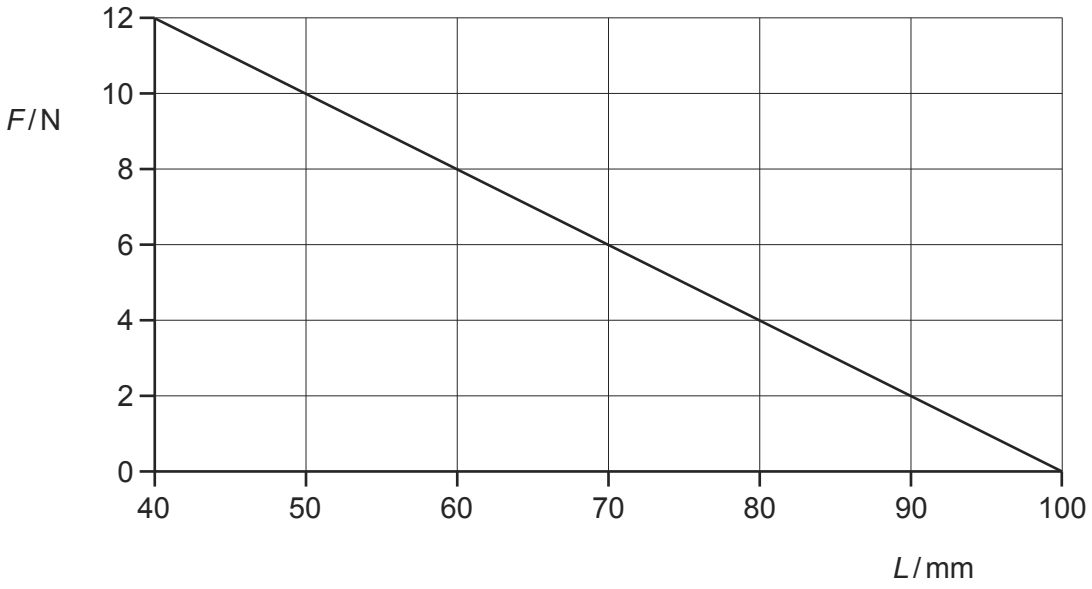
A both elastic and plastic

B elastic but not plastic

C plastic but not elastic

D not elastic and not plastic

33 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/Q23



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

34 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.

35 Four materials are formed into rods of the same dimensions. 9702/01/M/J/09/Q19

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

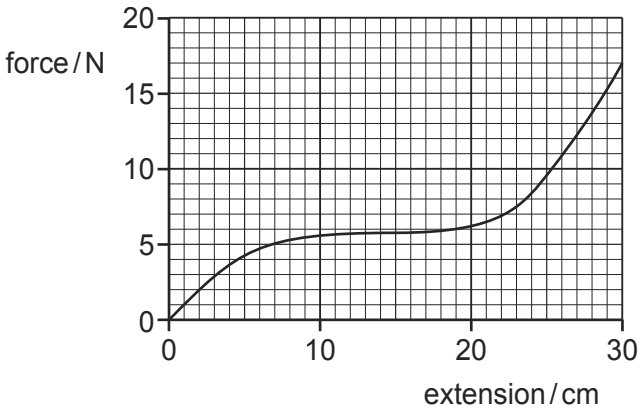
D the ductile material steel

36 Two steel wires P and Q have lengths l and $2l$ respectively, and cross-sectional areas A and $\frac{A}{2}$ respectively. Both wires obey Hooke's law. 9702/01/M/J/09/Q20

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

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

37 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/Q21

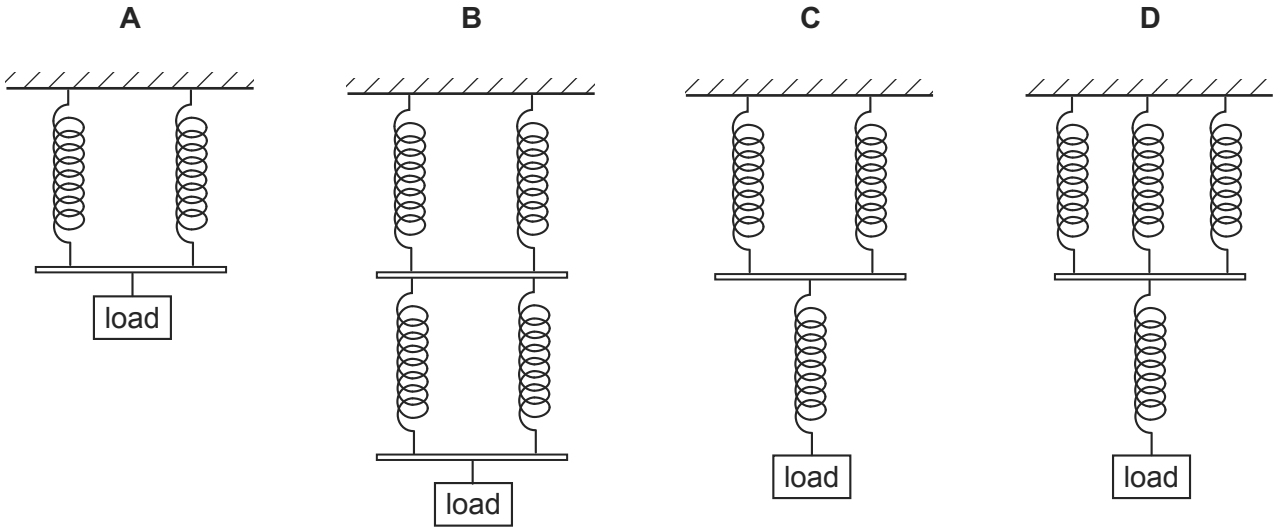


What is the best estimate of the strain energy stored in the rubber band when it is extended 30 cm?

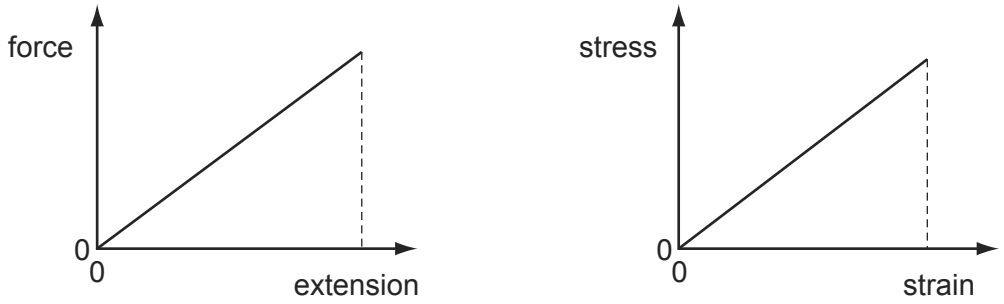
A 2.0 J **B** 2.6 J **C** 5.1 J **D** 200 J

38 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?



39 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/Q22



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.

40 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.

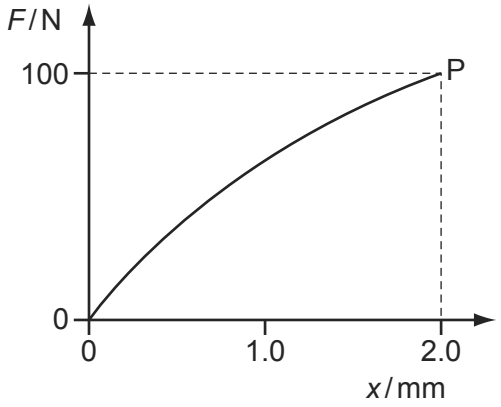
Which expression represents the elastic strain energy stored in the wire?

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

41 Which row best defines elastic and plastic behaviour of a material? 9702/11/O/N/09/Q20

	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

42 The graph shows the non-linear force-extension curve for a wire made from a new composite material. 9702/11/O/N/09/Q21



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

43 A steel string on an electric guitar has the following properties. 9702/11/O/N/09/Q22

diameter = 5.0×10^{-4} m

Young modulus = 2.0×10^{11} Pa

tension = 20 N

The string snaps, and contracts elastically.

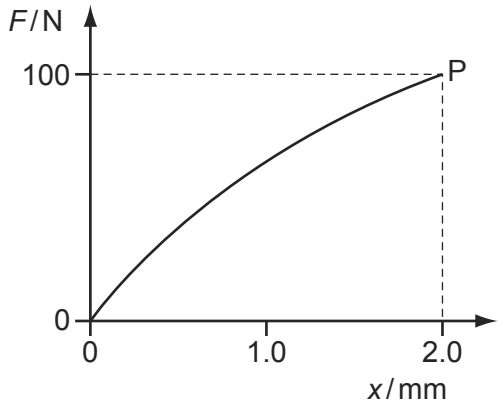
By what percentage does a length l of a piece of the string contract?

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

44 Which row best defines elastic and plastic behaviour of a material? 9702/12/O/N/09/Q19

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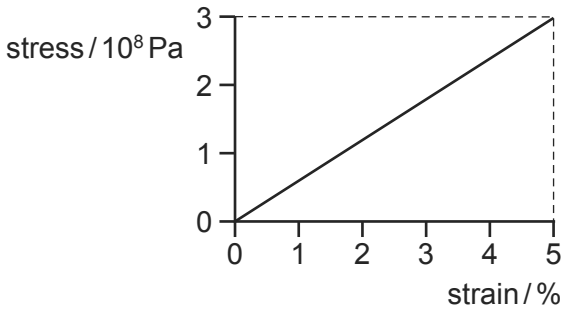
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A 5.1×10^{-4} % **B** 5.1×10^{-2} % **C** 1.3×10^{-4} % **D** 1.3×10^{-2} %

47 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.

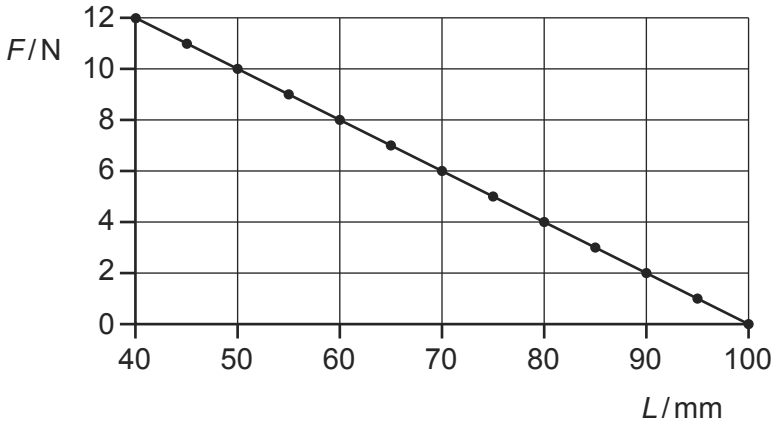
9702/11/M/J/10/Q19



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

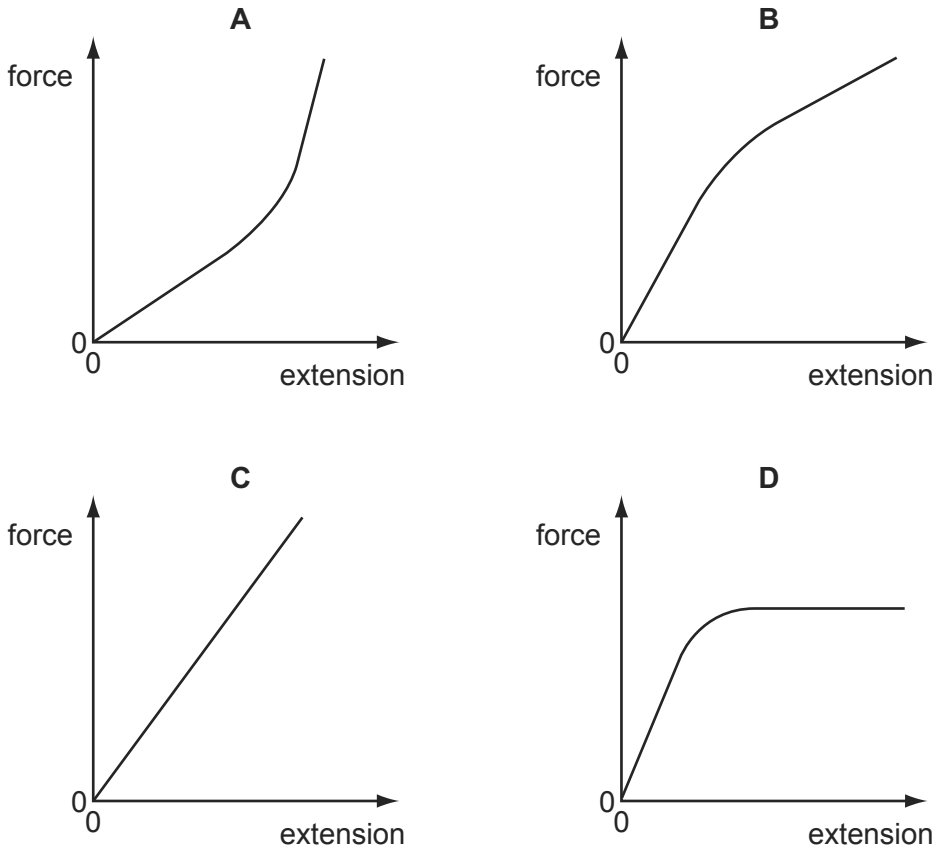
48 A spring is compressed by a force. The graph shows the compressing force F plotted against the length L of the spring. 9702/11/M/J/10/Q20



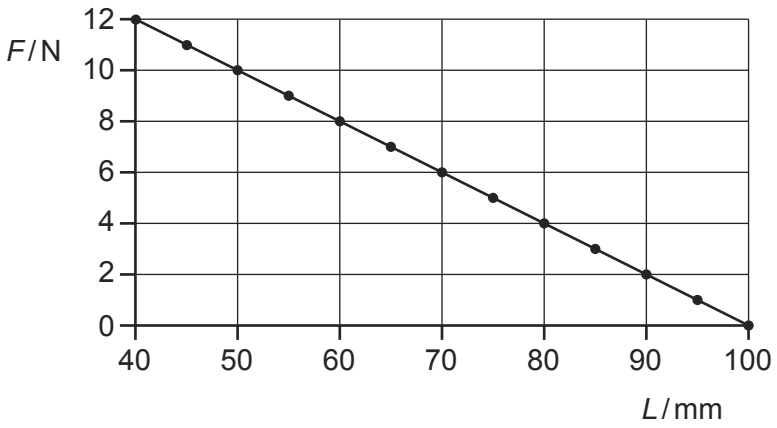
What is the spring constant of this spring?

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

49 Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point? 9702/11/M/J/10/Q21



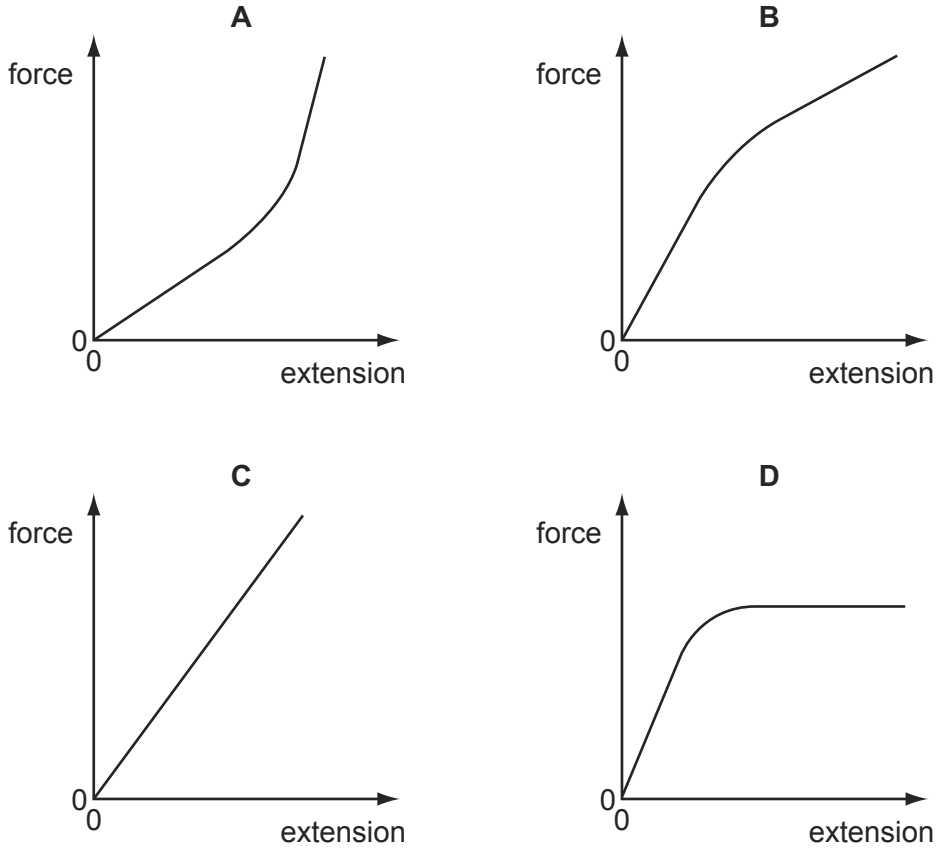
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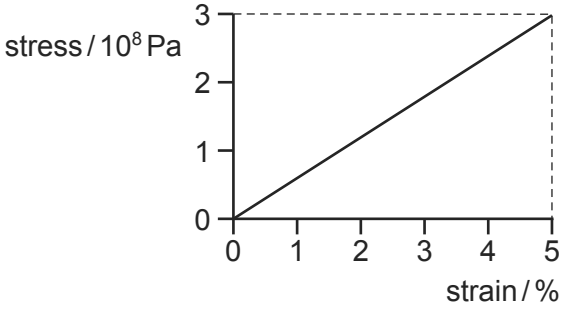
A $0.2\,N\,m^{-1}$ **B** $5\,N\,m^{-1}$ **C** $100\,N\,m^{-1}$ **D** $200\,N\,m^{-1}$

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52 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.

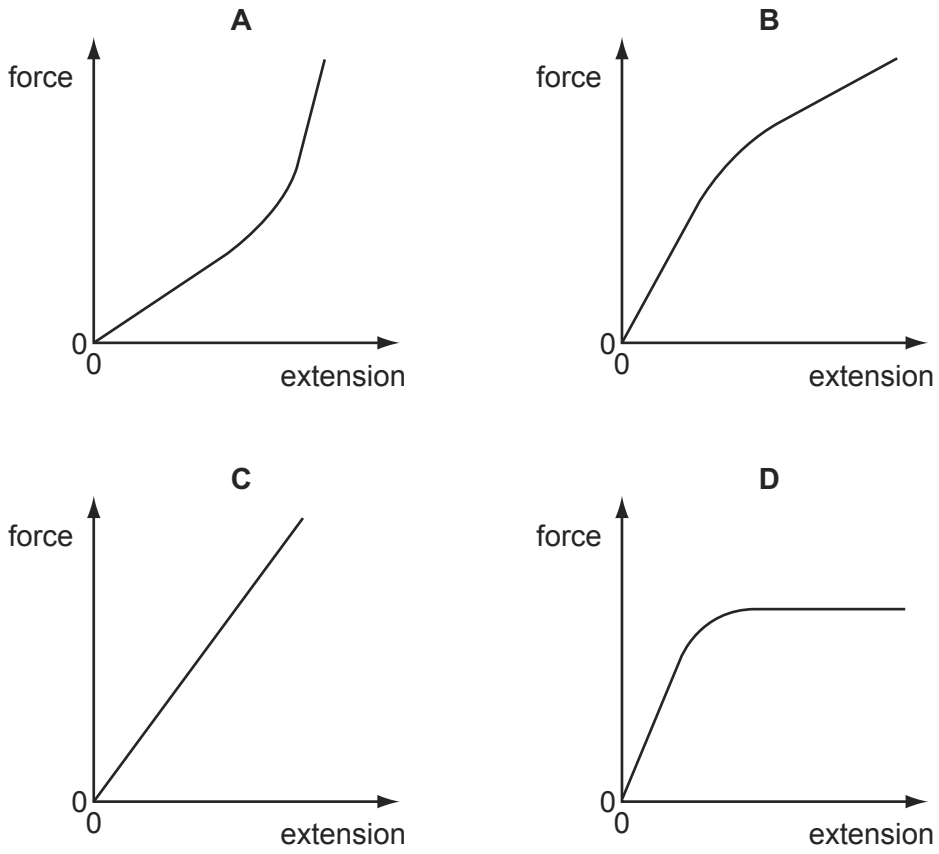
9702/12/M/J/10/Q21



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

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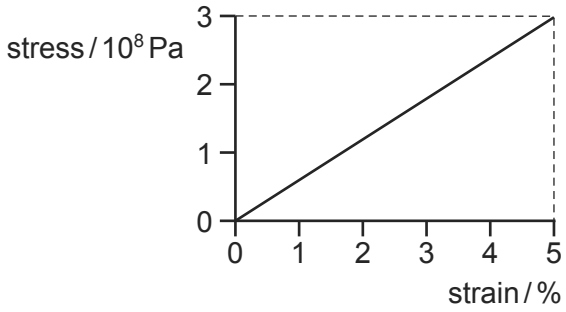


54 In which order of magnitude are the frequencies of electromagnetic waves in the visible spectrum? 9702/12/M/J/11/Q25

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

55 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.

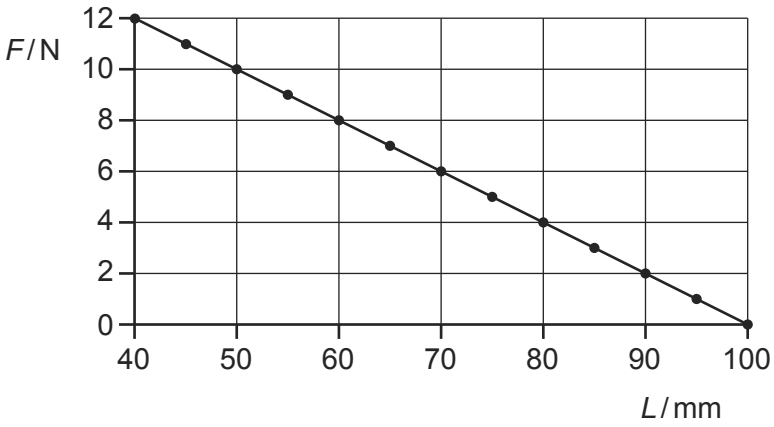
9702/13/M/J/10/Q20



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

56 A spring is compressed by a force. The graph shows the compressing force F plotted against the length L of the spring. 9702/13/M/J/10/Q21



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** $200\,\text{N m}^{-1}$

57 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. 9702/13/M/J/10/Q22

Both a and D are now doubled.

What is the new fringe separation?

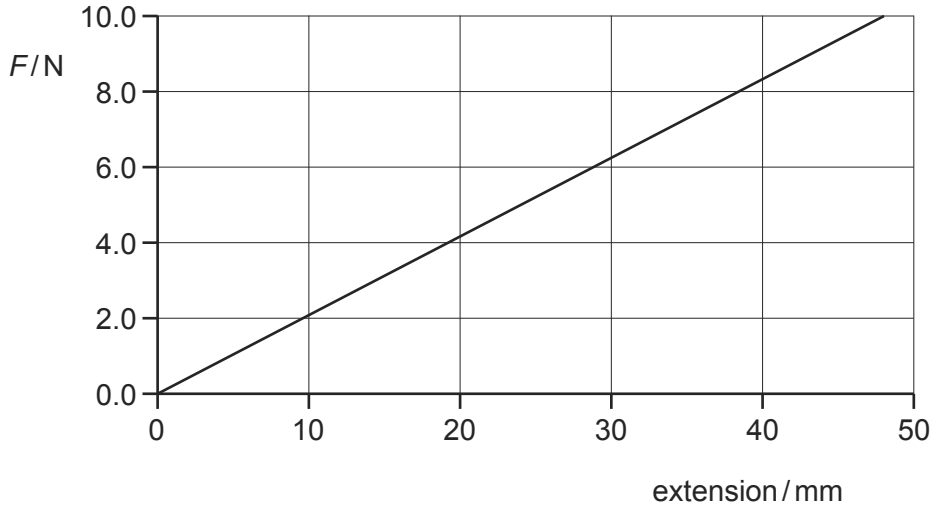
A $\frac{x}{2}$ **B** x **C** $2x$ **D** $4x$

58 The pressure at sea level is approximately 100 000 Pa. The density of sea water is $1030\,\text{kg m}^{-3}$.

What is the approximate pressure 80 m below the surface of the sea? 9702/12/O/N/10/Q20

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

59 The graph shows how force depends on extension for a certain spring. 9702/11/O/N/10/Q21

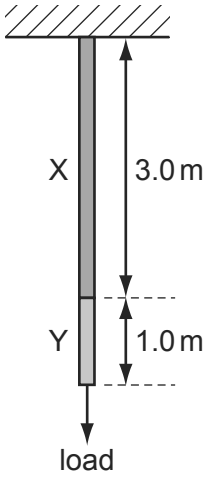


What is the energy stored in the spring when the extension is 30 mm?

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

60 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/Q22

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

61 Two wires P and Q are made from the same material. 9702/12/O/N/10/Q21

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?

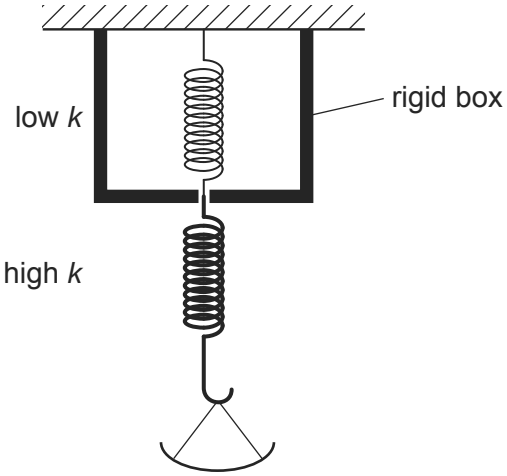
A $\frac{1}{2}$ **B** 1 **C** 2 **D** 4

62 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/Q22

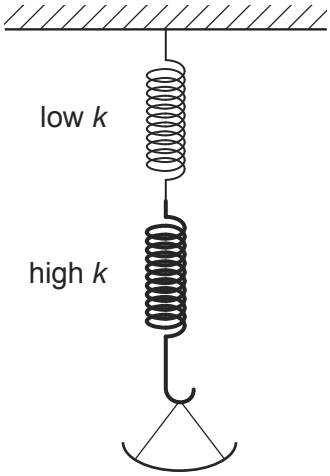
To do this, two springs are used, each with a different spring constant *k*. One of the springs has a low spring constant and the other has a high spring constant.

Which arrangement of springs would be suitable?

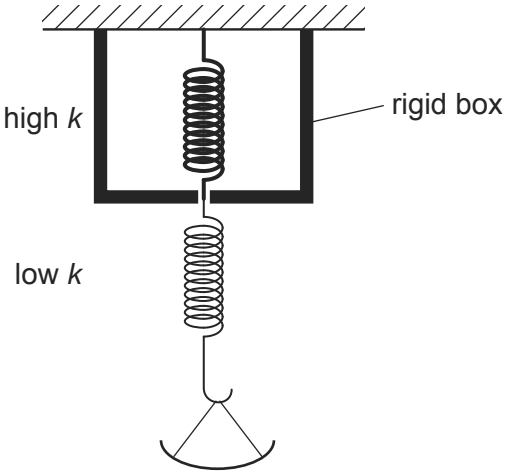
A



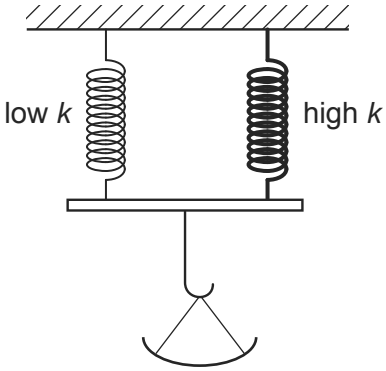
B



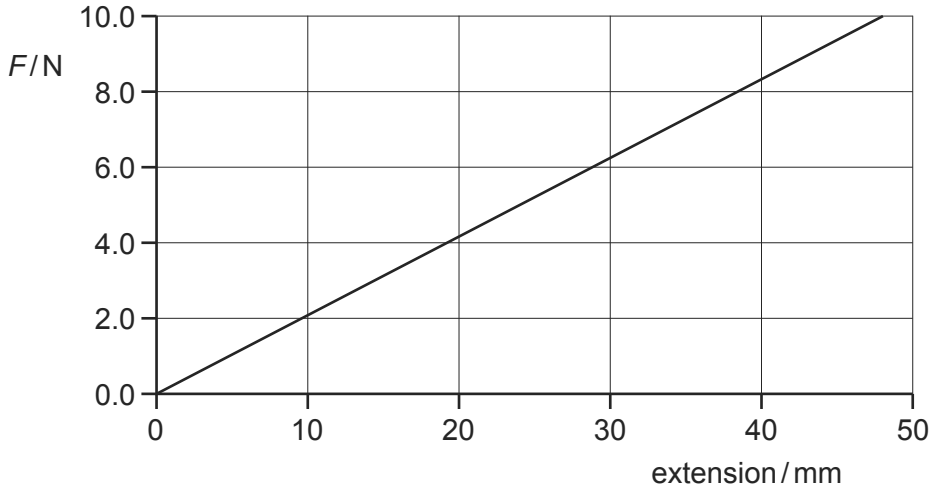
C



D



63 The graph shows how force depends on extension for a certain spring. 9702/13/O/N/10/Q19



What is the energy stored in the spring when the extension is 30 mm?

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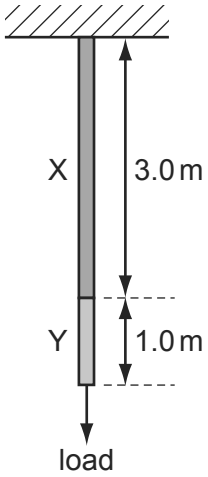
64 The Mariana Trench in the Pacific Ocean has a depth of about 10 km. 9702/13/O/N/10/Q20

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

65 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/Q21

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.

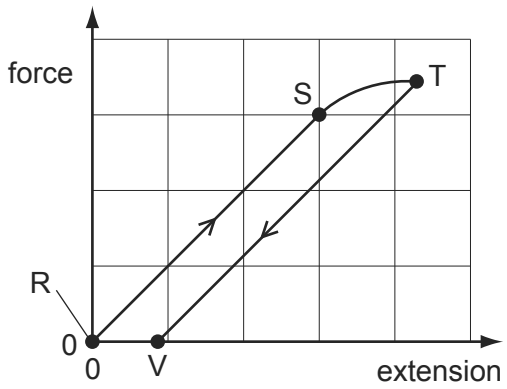
What is the total extension of this second wire?

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

66 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/Q20

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

67 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/Q21

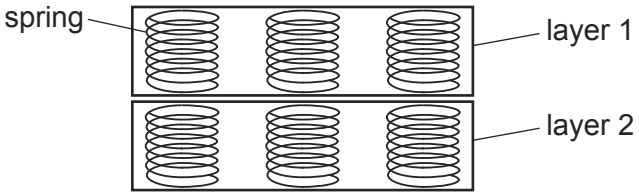
A	mass of stretching load	original length of wire	diameter of wire	extension of wire
B	mass of stretching load	new length of wire	cross-sectional area of wire	diameter of wire
C	mass of wire	original length of wire	cross-sectional area of wire	new length of wire
D	mass of wire	new length of wire	diameter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

68 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/Q23

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

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

69 The diagram shows the structure of part of a mattress. 9702/12/M/J/11/Q24



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

70 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/Q20

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

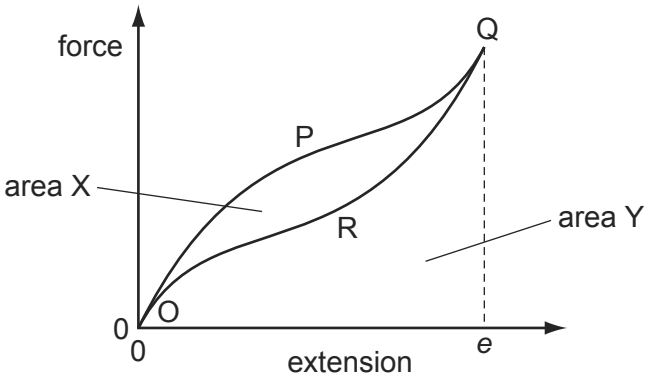
71 The Young modulus of steel is determined using a length of steel wire and is found to have the value *E*. 9702/11/O/N/11/Q23

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** $4E$

72 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/Q24



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.

73 When describing the behaviour of a spring, the spring constant is used. 9702/11/O/N/11/Q25

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

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

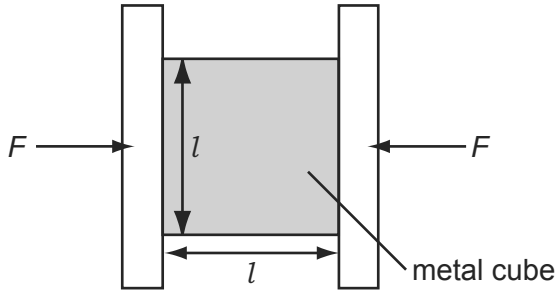
Another experiment is carried out using a wire of the same steel, but of half the length and half the diameter.

What value is obtained for the Young modulus in the second experiment? 9702/13/O/N/11/Q21

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

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

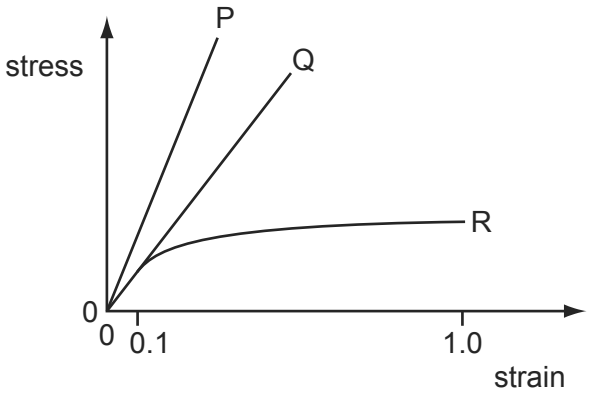
9702/11/O/N/11/Q26



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

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

76 The graph shows the relationship between stress and strain for three wires of the same linear dimensions but made from different materials. 9702/12/O/N/11/Q21



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

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

9702/13/M/J/12/Q22

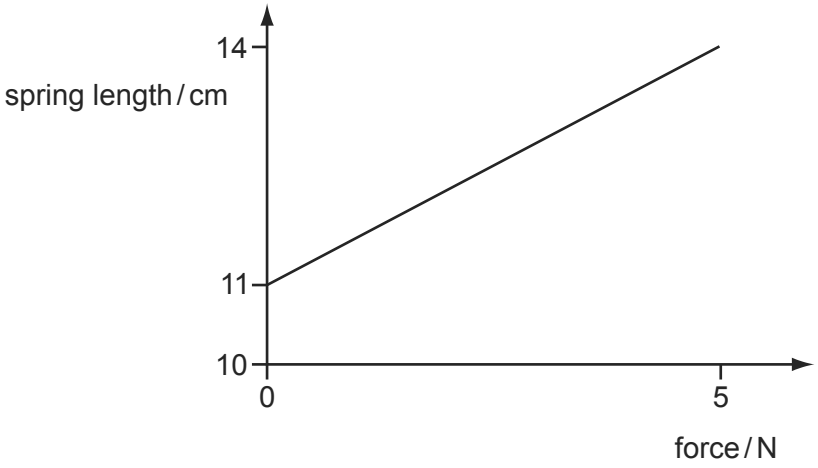
A ductility

B elastic limit

C spring constant

D ultimate tensile stress

78 The graph shows the effect of applying a force of up to 5 N to a spring. 9702/12/O/N/11/Q22



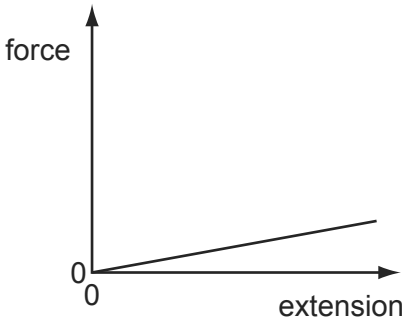
What is the total increase in length produced by a 7 N force, assuming the spring obeys Hooke's law?

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

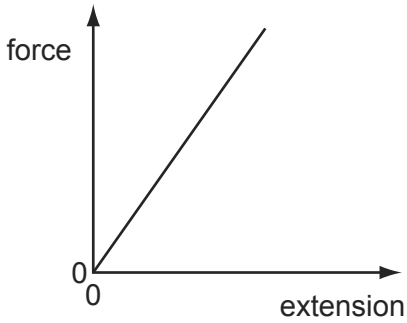
79 The following force-extension graphs are drawn to the same scale. 9702/12/O/N/11/Q23

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

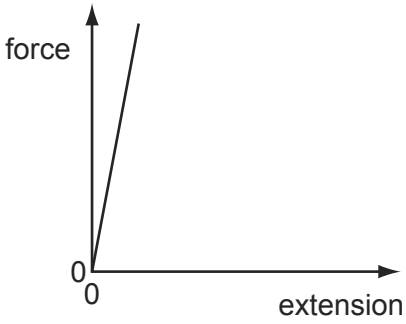
A



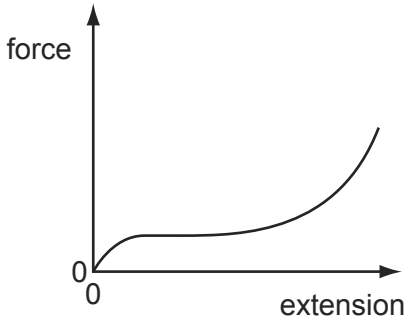
B



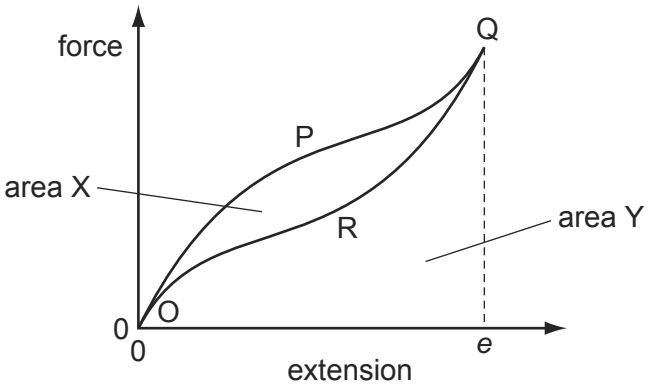
C



D



80 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/Q22



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.

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

81 Which property of a metal wire depends on its Young modulus? 9702/11/M/J/12/Q23

A ductility

B elastic limit

C spring constant

D ultimate tensile stress

82 What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)? 9702/11/M/J/12/Q25

A elastic limit

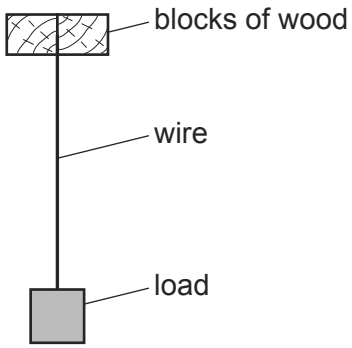
B spring constant

C stress

D Young modulus

83 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.

9702/11/M/J/12/Q24

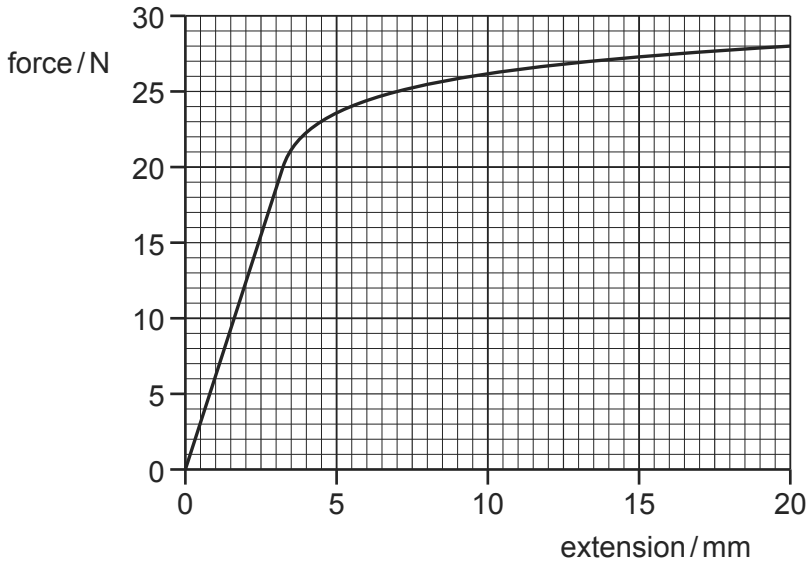


By how much would a wire of the same material, but of diameter $2D$ and length $3L$, extend when the same load is applied?

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

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

9702/12/M/J/12/Q24



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

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

9702/12/M/J/12/Q25

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

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

9702/13/M/J/12/Q20

A elastic limit

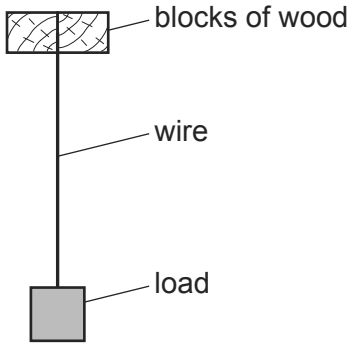
B spring constant

C stress

D Young modulus

87 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.

9702/13/M/J/12/Q21

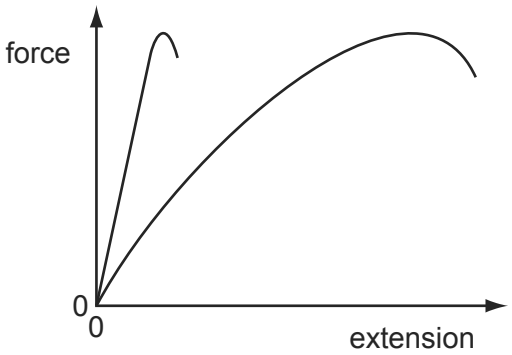


By how much would a wire of the same material, but of diameter $2D$ and length $3L$, extend when the same load is applied?

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

88 The diagram shows the force-extension graphs for two materials, of the same dimensions, loaded to fracture.

9702/12/O/N/12/Q26



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.

89 What leads to the conclusion that the movement of molecules is random? 9702/12/O/N/12/Q25

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

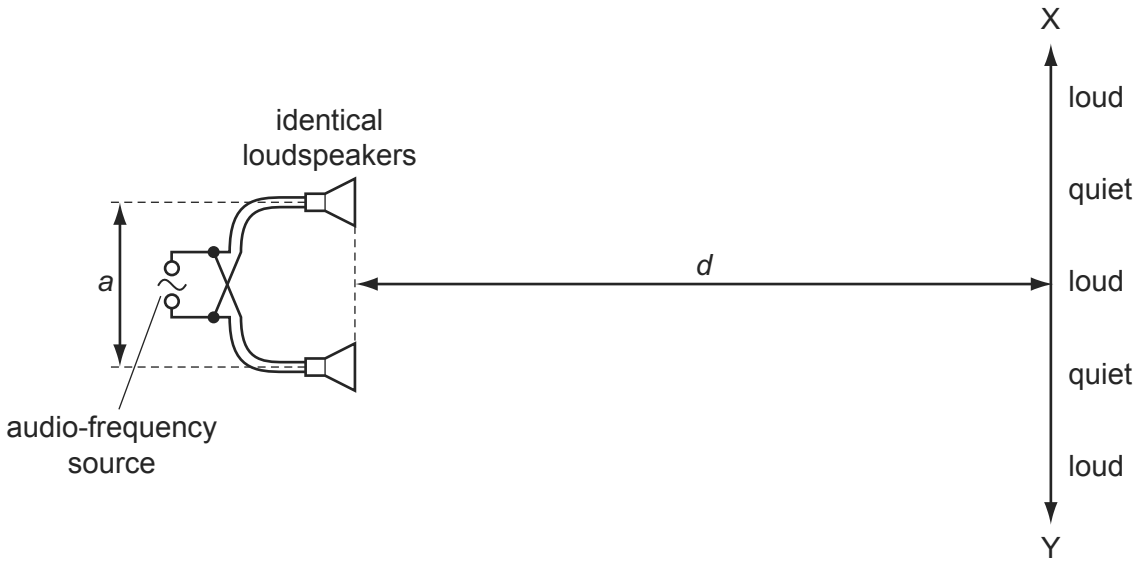
90 Two wires, X and Y, are made from different metals and have different dimensions. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y. 9702/12/O/N/12/Q27

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

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

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

91 The diagram shows two identical loudspeakers driven in phase by a common audio-frequency source. 9702/12/O/N/12/Q28



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?

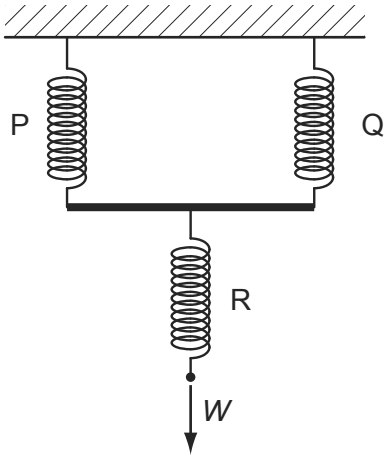
A decreasing the distance *a* between the speakers

B increasing distance *d*

C increasing the frequency of the audio-frequency source

D increasing the power output from the audio-frequency source

92 Three springs are arranged vertically as shown. 9702/11/O/N/12/Q23

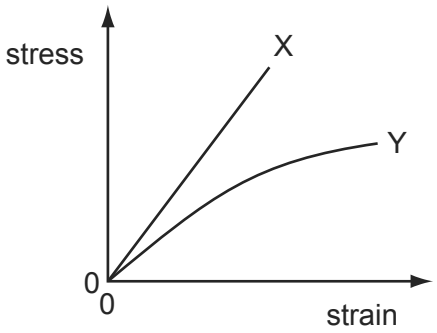


Springs P and Q are identical and have spring constant k. Spring R has spring constant $3k$.

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

A $\frac{5}{6}\frac{W}{k}$ **B** $\frac{4}{3}\frac{W}{k}$ **C** $\frac{7}{2}kW$ **D** $4kW$

93 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. 9702/11/O/N/12/Q24



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.

94 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.

9702/11/O/N/12/Q25

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

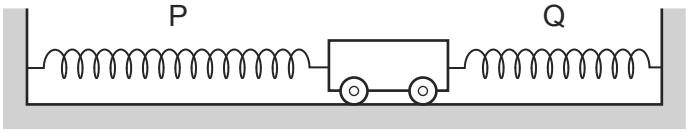
The Young modulus for steel is 2.0×10^{11} Pa and for brass is 1.0×10^{11} Pa.

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

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

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

9702/13/O/N/12/Q24



Each spring has an unstretched length of 0.10 m.

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

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

9702/13/O/N/12/Q25

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 2×10^{10} N m^{-2}

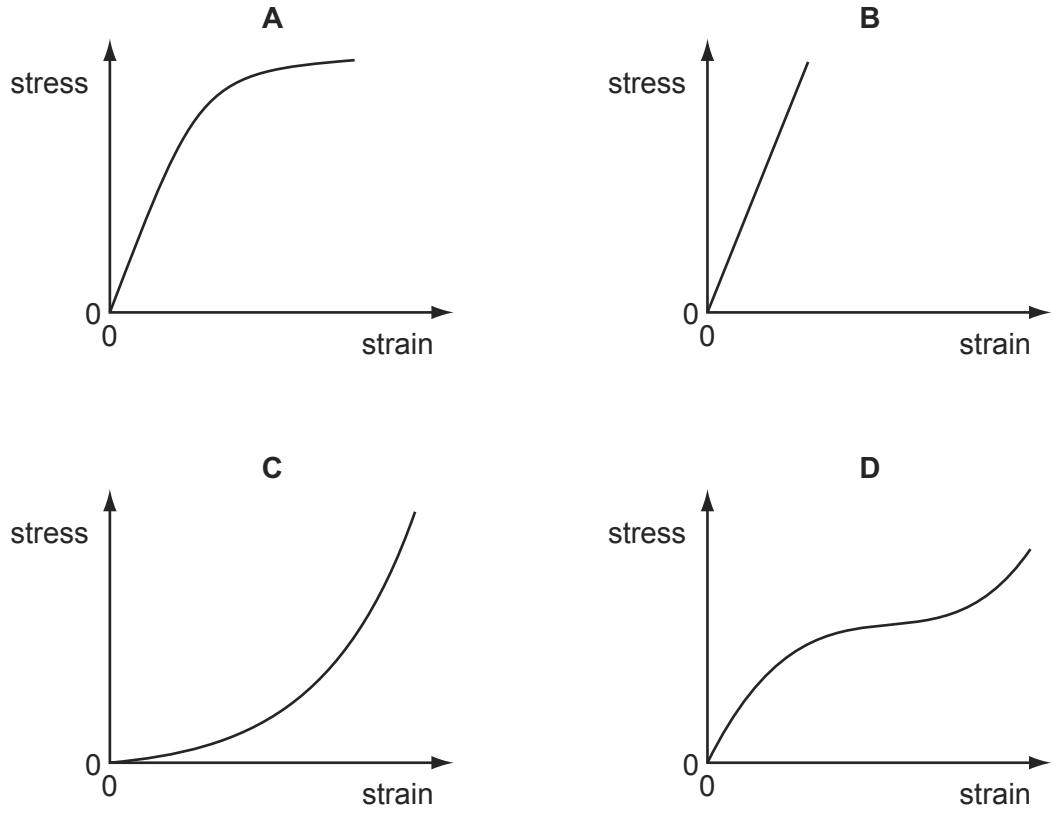
B 4×10^{10} N m^{-2}

C 2×10^{11} N m^{-2}

D 4×10^{11} N m^{-2}

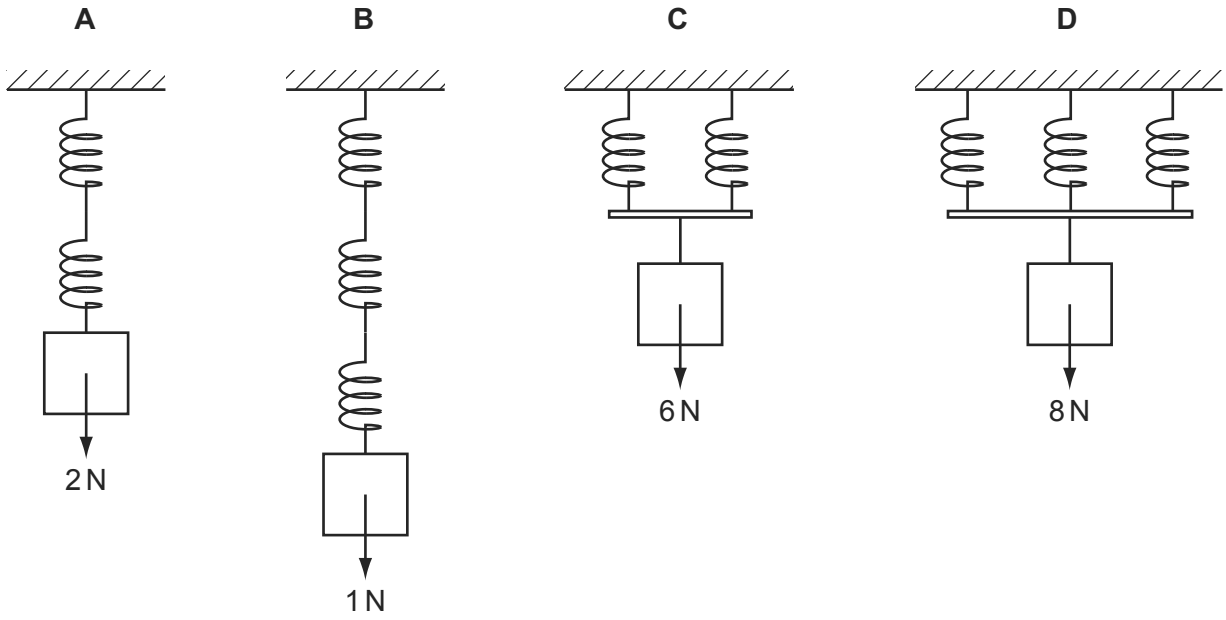
97 The stress-strain graphs for four different materials are shown below. 9702/11/M/J/13/Q22

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



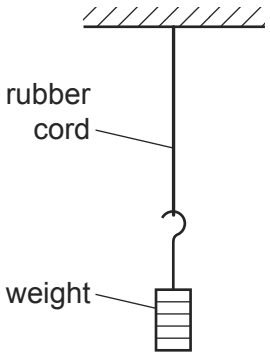
98 A number of identical springs, each having the same spring constant, are joined in four arrangements. A different load is applied to each arrangement. 9702/11/M/J/13/Q23

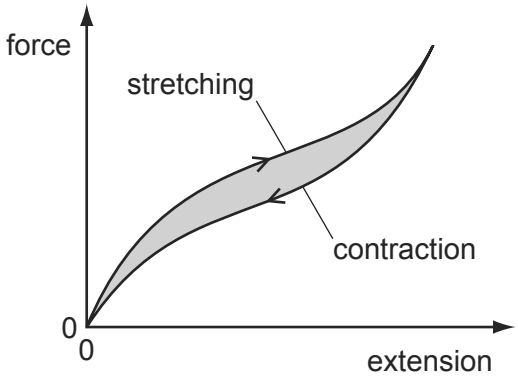
Which arrangement has the largest extension?



99 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.

9702/12/M/J/13/Q22





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

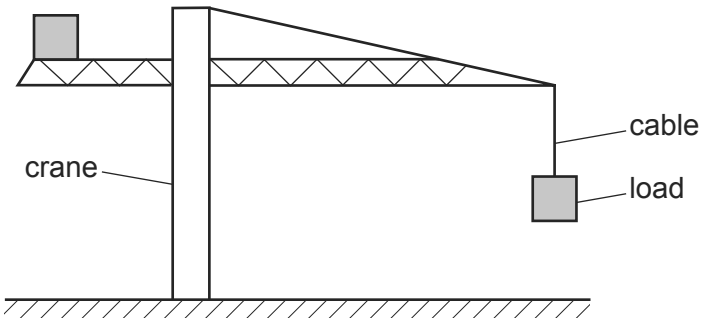
B the amount of thermal energy dissipated in the rubber

C the work done on the rubber cord during stretching

D the work done by the rubber cord during contraction

100 The diagram shows a large crane on a construction site lifting a cube-shaped load.

9702/12/M/J/13/Q23



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 $\frac{\text{stress in the cable on the full-size crane}}{\text{stress in the cable on the model crane}}$?

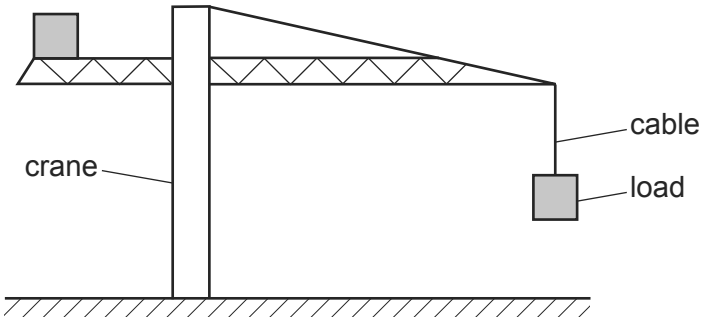
A 10^0 **B** 10^1 **C** 10^2 **D** 10^3

101 What is the unit of the Young modulus?

9702/12/M/J/13/Q21

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

102 The diagram shows a large crane on a construction site lifting a cube-shaped load. 9702/13/M/J/13/Q19



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

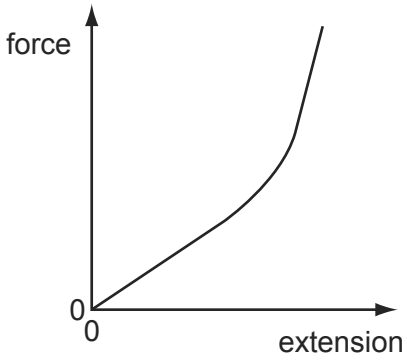
The material used for each part of the model is the same as that in the full-size crane, cable and load. The model is one tenth full-size in all linear dimensions.

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

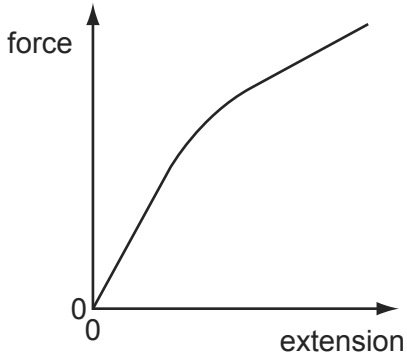
A 10^0 **B** 10^1 **C** 10^2 **D** 10^3

103 Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point? 9702/13/M/J/13/Q20

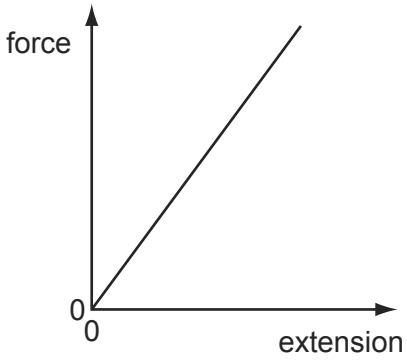
A



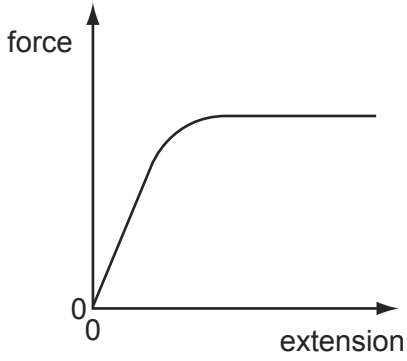
B



C



D



104 A spring is stretched over a range within which elastic deformation occurs. Its spring constant is $3.0\,\text{N}\,\text{cm}^{-1}$. 9702/13/M/J/13/Q21

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

105 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. 9702/13/M/J/13/Q15

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

106 Which properties best describe modelling clay? 9702/11/O/N/13/Q23

A brittle and ductile

B ductile and elastic

C elastic and plastic

D plastic and ductile

107 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. 9702/11/O/N/13/Q24

What was the original length of the spring?

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

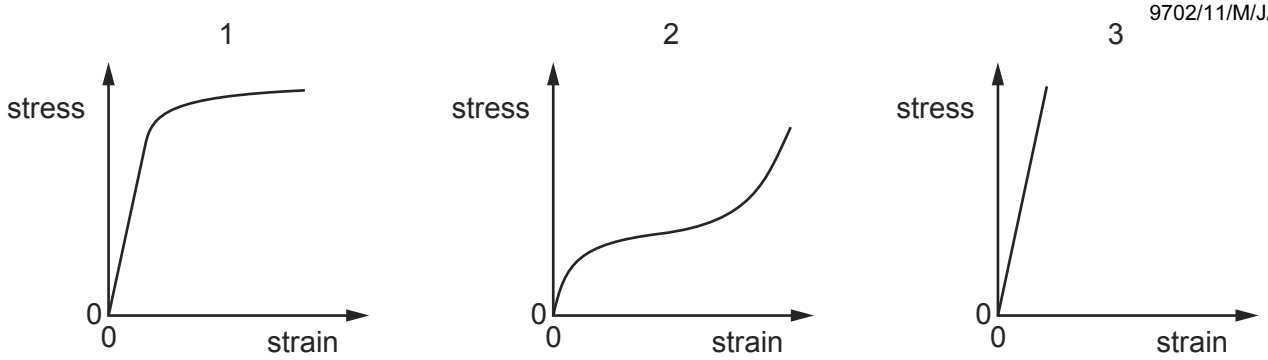
108 A lift is supported by two steel cables each of length 20 m. 9702/13/O/N/13/Q22

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

109 The stress-strain graphs for three different materials are shown, not drawn to the same scales. 9702/11/M/J/14/Q20

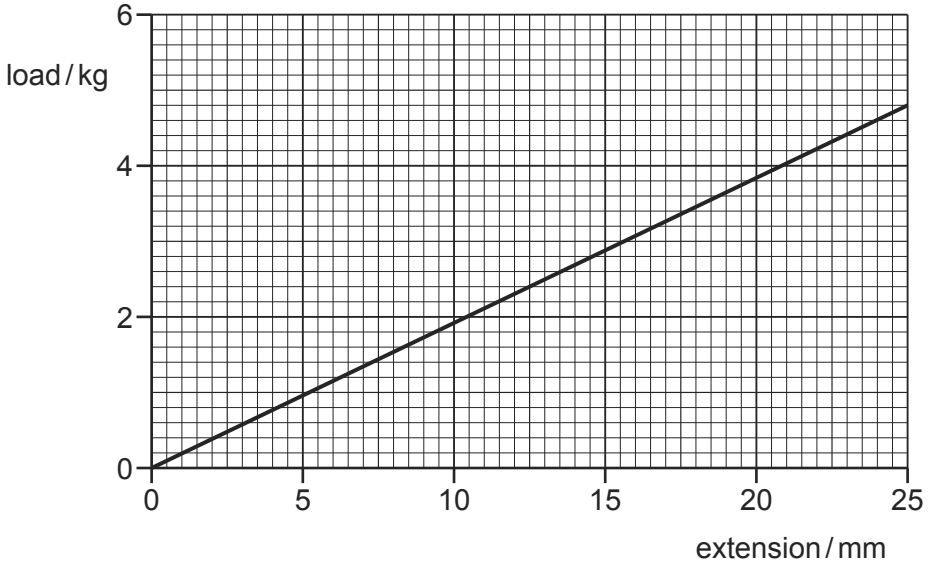


The three materials are copper, rubber and glass.

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

110 The graph is a load-extension graph for a wire undergoing elastic deformation. 9702/11/M/J/14/Q21



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

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

9702/13/O/N/13/Q23

A area under the force-extension graph

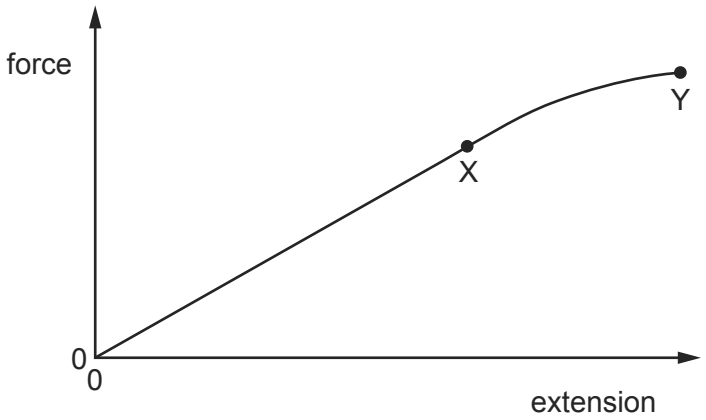
B area under the stress-strain graph

C gradient of the force-extension graph

D gradient of the stress-strain graph

112 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.

9702/12/M/J/14/Q19



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

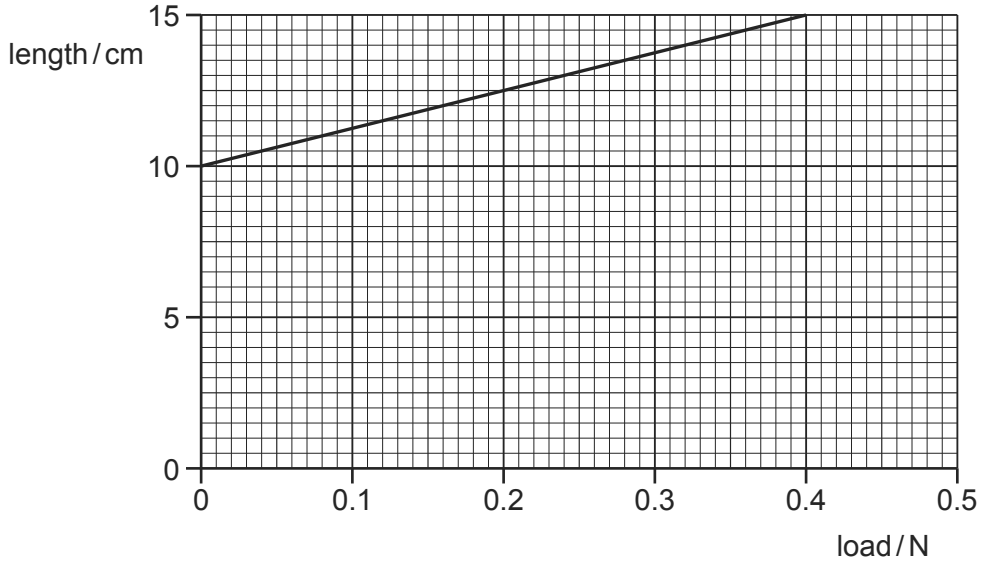
113 An elastic material with a Young modulus E is subjected to a tensile stress S. Hooke's Law is obeyed.

9702/13/M/J/14/Q23

What is the expression for the elastic energy stored per unit volume of the material?

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

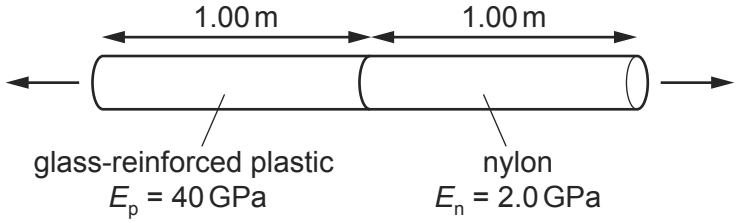
114 The graph shows the length of a spring as it is stretched by an increasing load. 9702/12/M/J/14/Q20



What is the spring constant?

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

115 A composite rod is made by attaching a glass-reinforced plastic rod and a nylon rod end to end, as shown. 9702/12/M/J/14/Q21



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

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

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

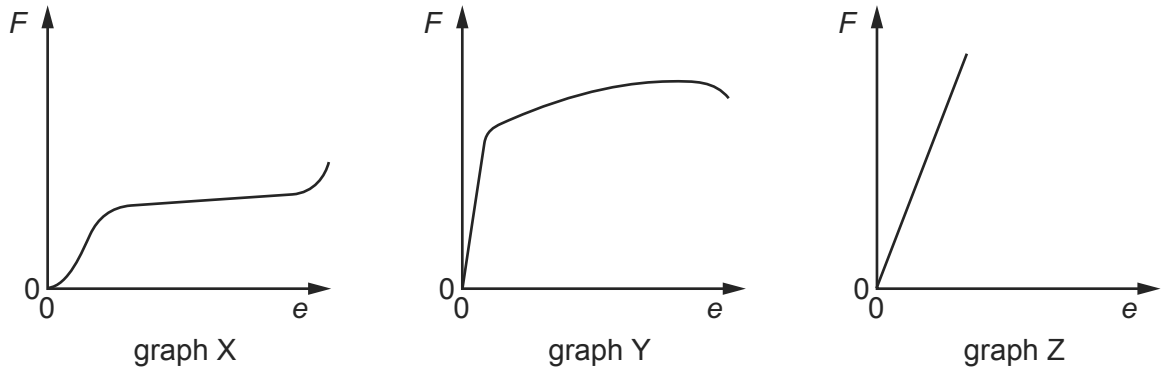
D $5.7 \times 10^{9}\,Pa$

116 The Mariana Trench in the Pacific Ocean has a depth of about 10 km. 9702/13/M/J/14/Q22

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** $10^{8}\,Pa$

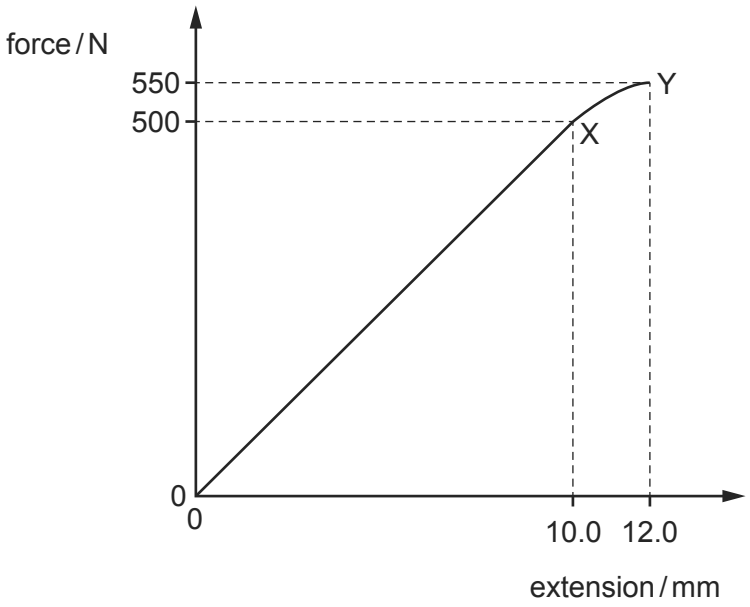
117 Cylindrical samples of steel, glass and rubber are each subjected to a gradually increasing tensile force *F*. The extensions *e* are measured and graphs are plotted as shown below. 9702/13/M/J/14/Q24



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

118 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/Q24



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

119 What is meant by the ultimate tensile stress of a material? 9702/13/O/N/14/Q23

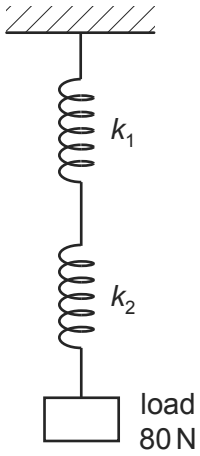
A the maximum force that can be applied to a bar of the material before it bends

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

120 Two springs, one with spring constant $k_1 = 4\,\text{kN}\,\text{m}^{-1}$ and the other with spring constant $k_2 = 2\,\text{kN}\,\text{m}^{-1}$, are connected as shown. 9702/13/O/N/14/Q25

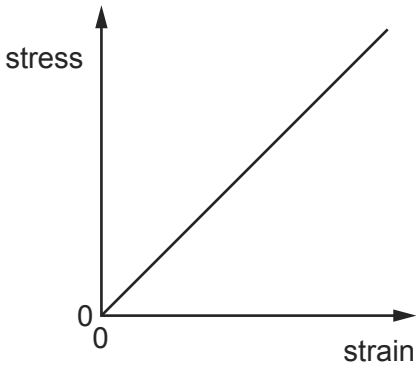


What is the total extension of the springs when supporting a load of 80 N?

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

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

9702/11/O/N/14/Q20



Which statement about the glass rod is correct?

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

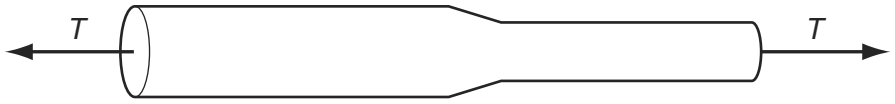
B The glass is ductile.

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.

122 A steel bar of circular cross-section is under tension T, as shown. 9702/13/M/J/15/Q22

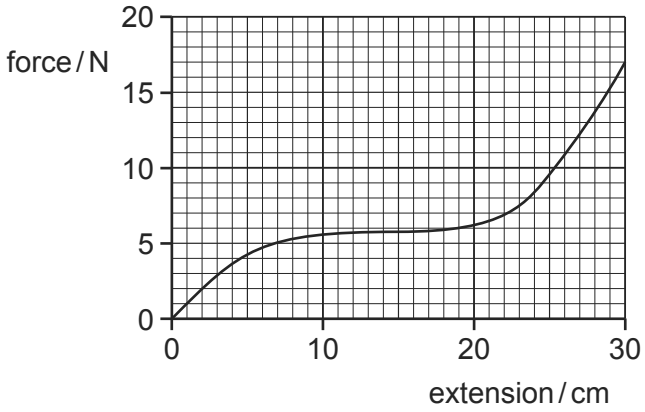
The diameter of the wide portion is double the diameter of the narrow portion.



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

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

123 A rubber band is stretched by hanging weights on it and the force-extension graph is plotted from the results. 9702/11/O/N/14/Q21



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

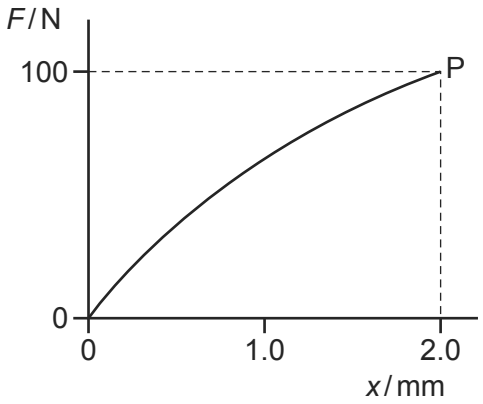
124 To determine the Young modulus of a wire, several measurements are taken. 9702/12/M/J/15/Q21

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

125 The graph shows the non-linear force-extension curve for a wire made from a new composite material.

9702/13/M/J/15/Q23

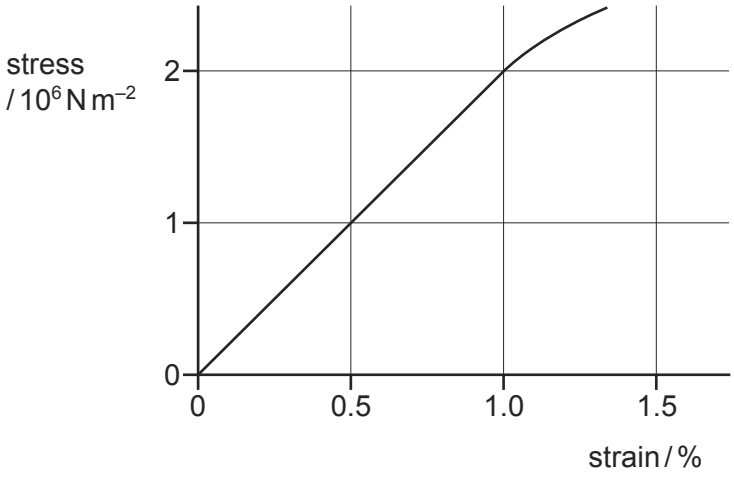


What could be the value of the strain energy stored in the wire when it is stretched elastically to point P?

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

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

9702/13/M/J/15/Q24



What is the Young modulus of bone?

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

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

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

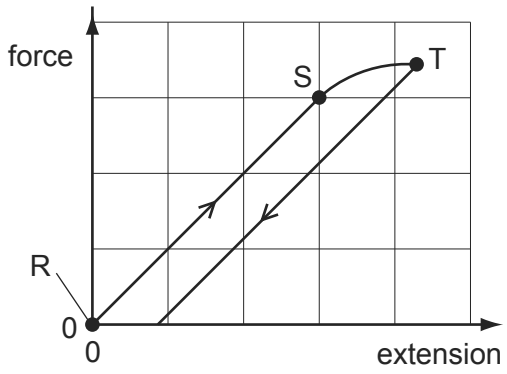
D $2 \times 10^8\,\text{N m}^{-2}$

127 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/Q22

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

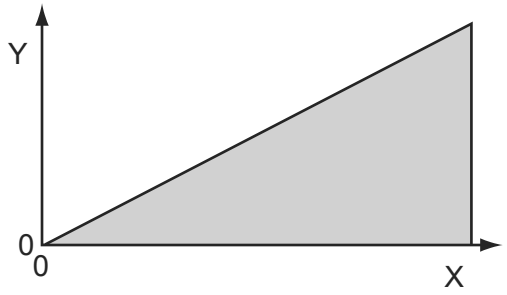
B just beyond point S

C exactly at point S

D exactly at point T

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

9702/11/M/J/15/Q22

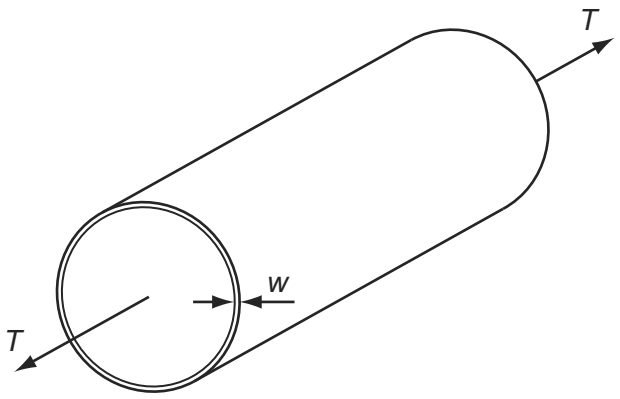


The shaded area represents the total strain energy stored in stretching the wire.

How should the axes be labelled?

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

129 The diagram represents a steel tube with wall thickness w which is small in comparison with the diameter of the tube. 9702/12/M/J/15/Q23

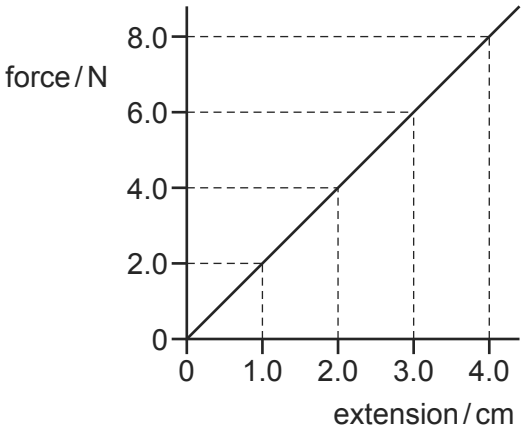


The tube is under tension, caused by a force T, parallel to the axis of the tube. To reduce the stress in the material of the tube, it is proposed to thicken the wall.

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

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

130 The variation with applied force of the extension of a spring is shown in the graph. 9702/11/M/J/15/Q23



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

Q1.

Use

3 **(a)** Fig. 3.1 shows the variation with tensile force of the extension of a copper wire.

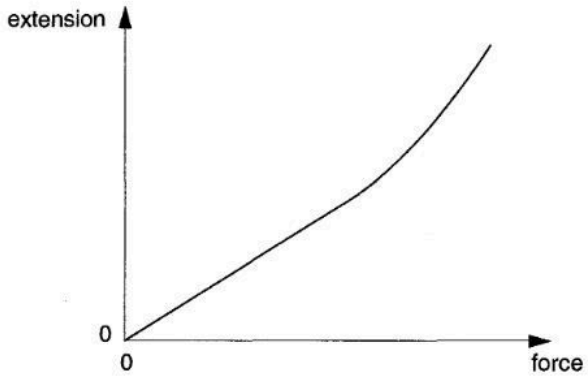


Fig. 3.1

(i) State whether copper is a ductile, brittle or polymeric material.

.....

(ii) **1.** On Fig. 3.1, mark with the letter L the point on the line beyond which Hooke's law does not apply.

2. State how the spring constant for the wire may be obtained from Fig. 3.1.

.....

.....

[3]

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Use

(b) A copper wire is fixed at one end and passes over a pulley. A mass hangs from the free end of the wire, as shown in Fig. 3.2.

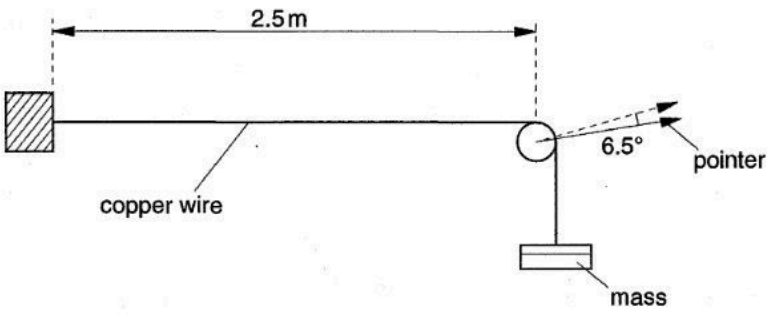


Fig. 3.2

The length of wire between the fixed end and the pulley is 2.5 m. When the mass on the wire is increased by 6.0 kg, a pointer attached to the pulley rotates through an angle of 6.5°. The pulley, of diameter 3.0 cm, is rough so that the wire does not slide over it.

(i) For this increase in mass,

1. show that the wire extends by 0.17 cm,

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2. calculate the increase in strain of the wire.

increase in strain = ...
[4]

(ii) The area of cross-section of the wire is $7.9 \times 10^{-7}\,m^2$. Calculate the increase in stress produced by the increase in load.

increase in stress = ... Pa [3]

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(iii) Use your answers to **(i) 2** and **(ii)** to determine the Young modulus of copper.

Young modulus = ... Pa [2]

(iv) Suggest how you could check that the elastic limit of the wire is not exceeded when the extra load is added.

.....

..... [1]

Q2.

4 A glass fibre of length 0.24 m and area of cross-section $7.9 \times 10^{-7}\,m^2$ is tested until it breaks. The variation with load F of the extension x of the fibre is shown in Fig. 4.1.

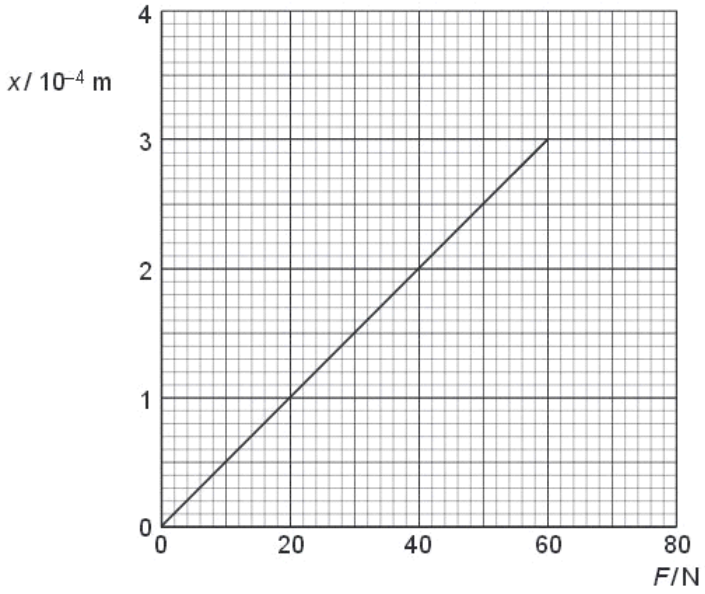


Fig. 4.1

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(a) State whether glass is ductile, brittle or polymeric.

.....[1]

(b) Use Fig. 4.1 to determine, for this sample of glass,

(i) the ultimate tensile stress,

ultimate tensile stress = ... Pa [2]

(ii) the Young modulus,

Young modulus = ... Pa [3]

(iii) the maximum strain energy stored in the fibre before it breaks.

maximum strain energy = ... J [2]

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(c) A hard ball and a soft ball, with equal masses and volumes, are thrown at a glass window. The balls hit the window at the same speed. Suggest why the hard ball is more likely than the soft ball to break the glass window.

.....

.....

.....

.....[3]

Q3.

5 Fig. 5.1 shows the variation with force F of the extension x of a spring as the force is increased to F_3 and then decreased to zero.

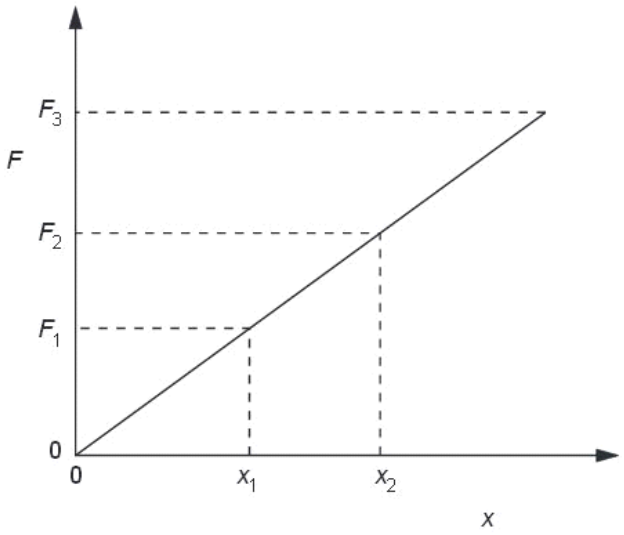


Fig. 5.1

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(a) State, with a reason, whether the spring is undergoing an elastic change.

.....

..... [1]

(b) The extension of the spring is increased from x_1 to x_2.

Show that the work W done in extending the spring is given by

$$W = \tfrac{1}{2}k(x_2^2 - x_1^2),$$

where k is the spring constant.

[3]

(c) A trolley of mass 850 g is held between two fixed points by means of identical springs, as shown in Fig. 5.2.

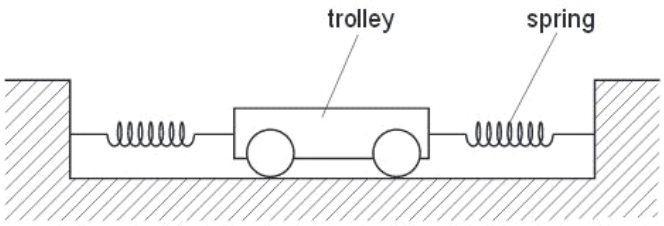


Fig. 5.2

When the trolley is in equilibrium, the springs are each extended by 4.5 cm. Each spring has a spring constant 16 N cm^{-1}.

The trolley is moved a distance of 1.5 cm along the direction of the springs. This causes the extension of one spring to be increased and the extension of the other spring to be decreased. The trolley is then released. The trolley accelerates and reaches its maximum speed at the equilibrium position.

Assuming that the springs obey Hooke's law, use the expression in **(b)** to determine the maximum speed of the trolley.

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speed = ... $m\,s^{-1}$ [4]

Q4.

2 A spring is placed on a flat surface and different weights are placed on it, as shown in Fig. 2.1.

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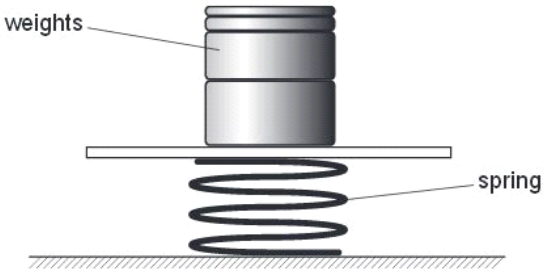


Fig. 2.1

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The variation with weight of the compression of the spring is shown in Fig. 2.2.

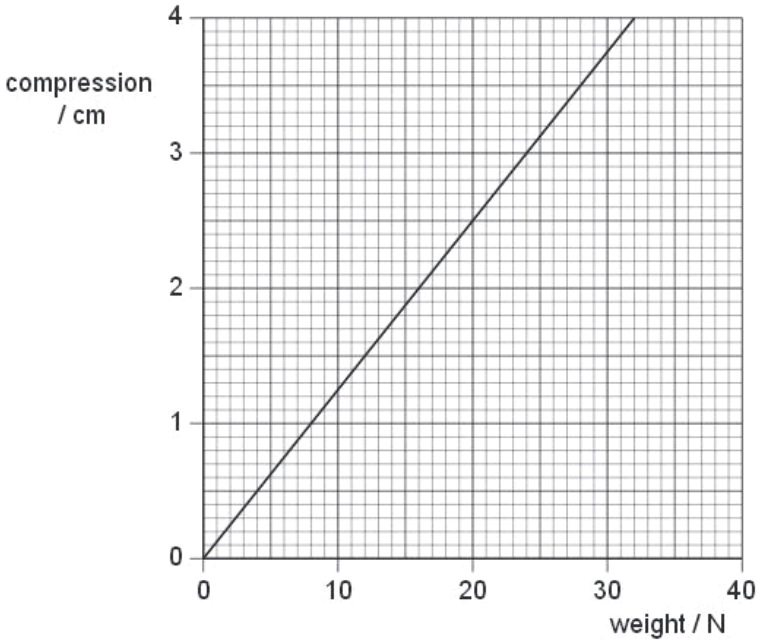


Fig. 2.2

The elastic limit of the spring has not been exceeded.

(a) (i) Determine the spring constant *k* of the spring.

k = ... Nm^{-1} [2]

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(ii) Deduce that the strain energy stored in the spring is 0.49 J for a compression of 3.5 cm.

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[2]

(b) Two trolleys, of masses 800 g and 2400 g, are free to move on a horizontal table. The spring in **(a)** is placed between the trolleys and the trolleys are tied together using thread so that the compression of the spring is 3.5 cm, as shown in Fig. 2.3.

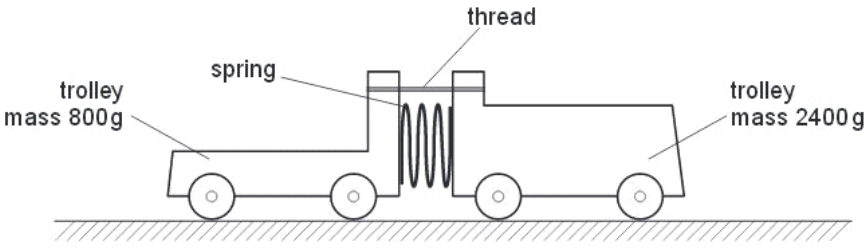


Fig. 2.3

Initially, the trolleys are not moving.
The thread is then cut and the trolleys move apart.

(i) Deduce that the ratio

$$\frac{\text{speed of trolley of mass 800 g}}{\text{speed of trolley of mass 2400 g}}$$

is equal to 3.0.

[2]

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(ii) Use the answers in **(a)(ii)** and **(b)(i)** to calculate the speed of the trolley of mass 800 g.

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speed = ... $m\,s^{-1}$ [3]

Q5.

4 **(a)** **(i)** Define the terms

1. tensile stress,

.....

.....[1]

2. tensile strain,

.....

.....[1]

3. the Young modulus.

.....

.....[1]

(ii) Suggest why the Young modulus is not used to describe the deformation of a liquid or a gas.

.....

.....[1]

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(b) The change ΔV in the volume V of some water when the pressure on the water increases by Δp is given by the expression

$$\Delta p = 2.2 \times 10^9 \frac{\Delta V}{V},$$

where Δp is measured in pascal.
In many applications, water is assumed to be incompressible.
By reference to the expression, justify this assumption.

.....

.....

.....[2]

(c) Normal atmospheric pressure is 1.01×10^5 Pa.

Divers in water of density $1.08 \times 10^3 \text{kg m}^{-3}$ frequently use an approximation that every 10 m increase in depth of water is equivalent to one atmosphere increase in pressure.
Determine the percentage error in this approximation.

error = ... % [3]

Q6.

4 A spring having spring constant k hangs vertically from a fixed point. A load of weight L, when hung from the spring, causes an extension e. The elastic limit of the spring is not exceeded.

(a) State

(i) what is meant by an *elastic deformation*,

.....

.....

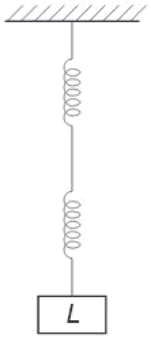
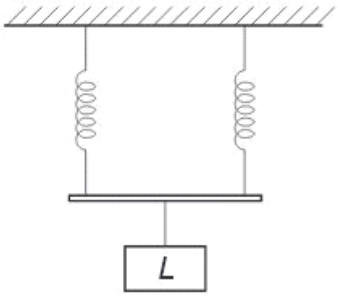
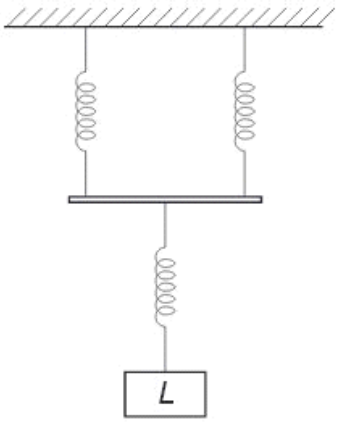
..... [2]

(ii) the relation between k, L and e.

..... [1]

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(b) Some identical springs, each with spring constant k, are arranged as shown in Fig. 4.1.

arrangement	total extension	spring constant of arrangement
	.....	.....
	.....	.....
	.....	.....

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The load on each of the arrangements is L.

For each arrangement in Fig. 4.1, complete the table by determining

(i) the total extension in terms of e,

(ii) the spring constant in terms of k.

[5]

Q7.

3 (a) The variation with extension x of the tension F in a spring is shown in Fig. 3.1.

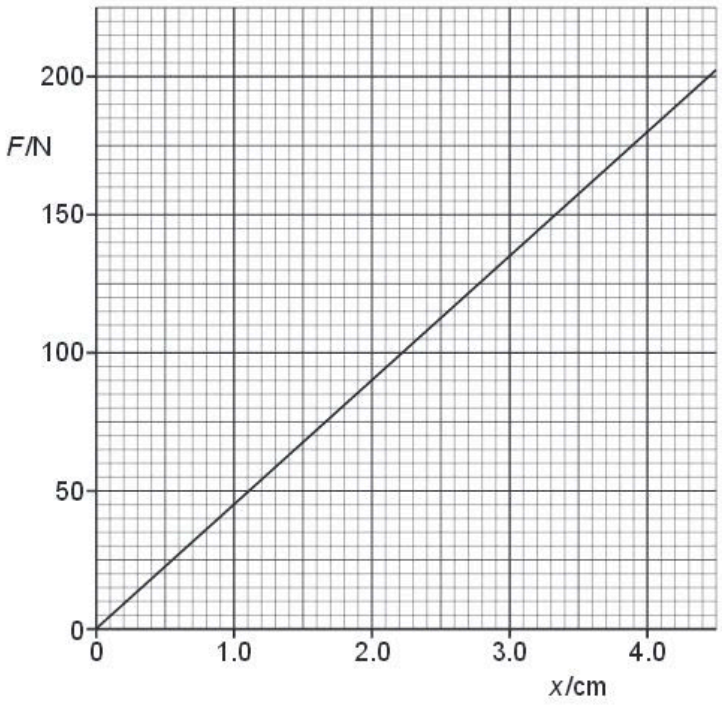


Fig. 3.1

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Use Fig. 3.1 to calculate the energy stored in the spring for an extension of 4.0 cm.
Explain your working.

energy = ... J [3]

(b) The spring in **(a)** is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

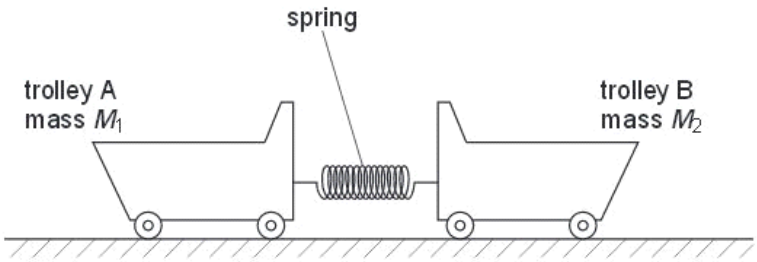


Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

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(i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

.....

.....

.....

.....[2]

(ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2.
Write down

1. an equation, based on momentum, to relate V_1 and V_2,

.....

.....[1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

.....

.....[1]

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(iii) **1.** Show that the kinetic energy E_K of an object of mass m is related to its momentum p by the expression

$$E_K = \frac{p^2}{2m}.$$

[1]

2. Trolley A has a larger mass than trolley B.
Use your answer in **(ii) part 1** to deduce which trolley, A or B, has the larger kinetic energy at the instant when the extension of the spring is zero.

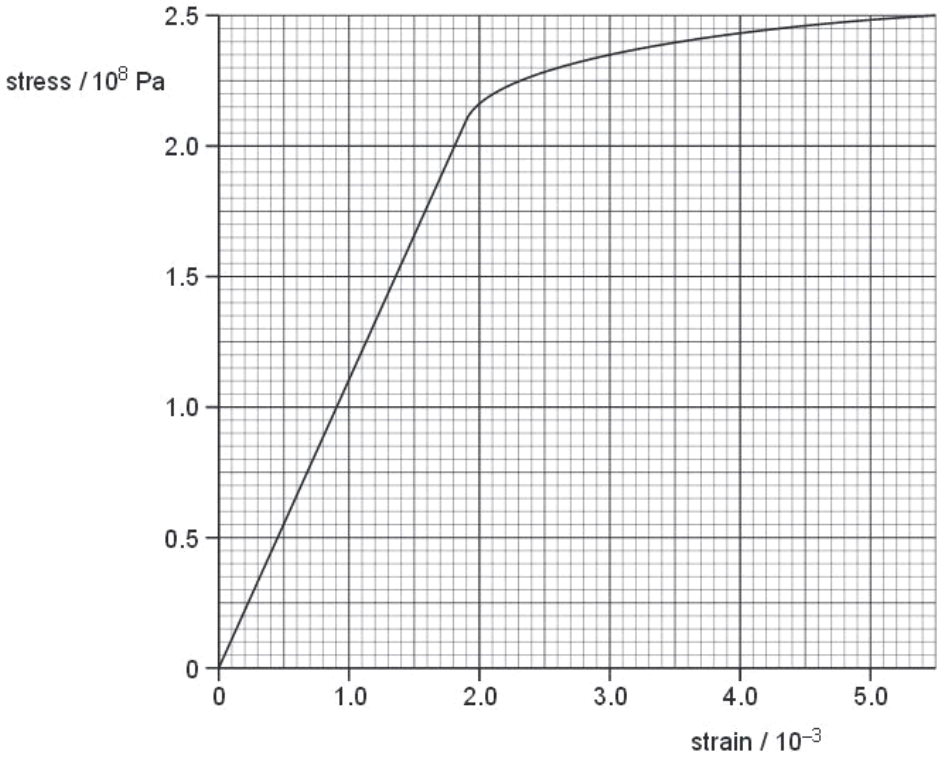
.....

.....[1]

Q8.

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5 **(a)** Tensile forces are applied to opposite ends of a copper rod so that the rod is stretched. The variation with stress of the strain of the rod is shown in Fig. 5.1.



(i) Use Fig. 5.1 to determine the Young modulus of copper.

Young modulus = ... Pa [3]

(ii) On Fig. 5.1, sketch a line to show the variation with stress of the strain of the rod as the stress is reduced from 2.5×10^6 Pa to zero. No further calculations are expected. [1]

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(b) The walls of the tyres on a car are made of a rubber compound.
The variation with stress of the strain of a specimen of this rubber compound is shown in Fig. 5.2.

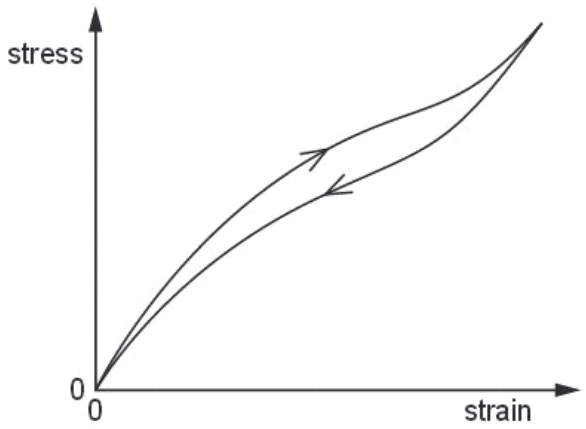


Fig. 5.2

As the car moves, the walls of the tyres bend and straighten continuously.

Use Fig. 5.2 to explain why the walls of the tyres become warm.

.....

.....

.....

.....[3]

Q9.

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4 **(a)** Define, for a wire,

(i) *stress*,

.....

..... [1]

(ii) *strain*.

.....

..... [1]

(b) A wire of length 1.70 m hangs vertically from a fixed point, as shown in Fig. 4.1.

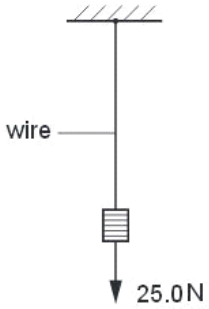


Fig. 4.1

The wire has cross-sectional area $5.74 \times 10^{-8}\,m^2$ and is made of a material that has a Young modulus of 1.60×10^{11} Pa. A load of 25.0 N is hung from the wire.

(i) Calculate the extension of the wire.

extension = ... m [3]

(ii) The same load is hung from a second wire of the same material. This wire is twice the length but the **same volume** as the first wire. State and explain how the extension of the second wire compares with that of the first wire.

.....

.....

..... [3]

Q10.

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4 A student measures the Young modulus of a metal in the form of a wire.

(a) Describe, with the aid of a diagram, the apparatus that could be used.

.....

.....

.....

..... [2]

(b) Describe the method used to obtain the required measurements.

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..... [4]

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(c) Describe how the measurements taken can be used to determine the Young modulus.

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..... **[4]**

Q11.

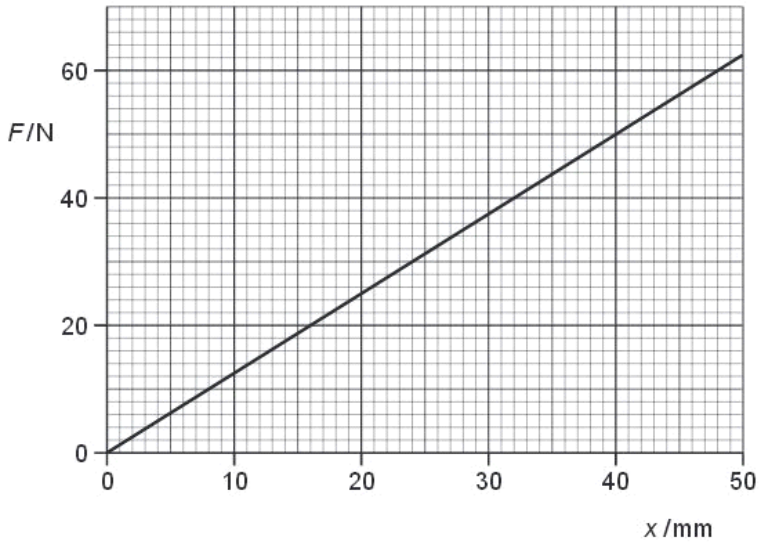
4 **(a)** State Hooke's Law.

Fo
Exami
Us

.....

.....[1]

(b) A spring is compressed by applying a force. The variation with compression x of the force F is shown in Fig. 4.1.



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(i) Calculate the spring constant.

spring constant = ... $N m^{-1}$ [1]

(ii) Show that the work done in compressing the spring by 36 mm is 0.81 J.

[2]

(c) A child's toy uses the spring in **(b)** to shoot a small ball vertically upwards. The ball has a mass of 25 g. The toy is shown in Fig. 4.2.

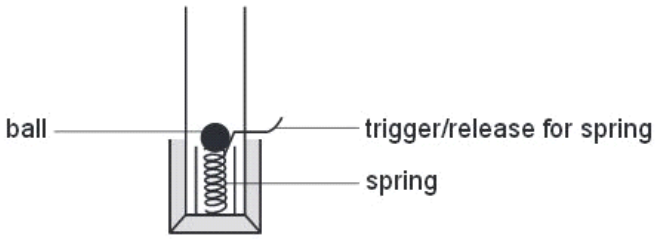


Fig. 4.2

(i) The spring in the toy is compressed by 36 mm. The spring is released.
Assume all the strain energy in the spring is converted to kinetic energy of the ball.
Using the result in **(b)(ii)**, calculate the speed with which the ball leaves the spring.

speed = ... $m s^{-1}$ [2]

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(ii) Determine the compression of the spring required for the ball to leave the spring with twice the speed determined in **(i)**.

compression = ... mm [2]

(iii) Determine the ratio

$$\frac{\text{maximum possible height for compression in (i)}}{\text{maximum possible height for compression in (ii)}}.$$

ratio = ... [2]

Q12.

3 One end of a spring is fixed to a support. A mass is attached to the other end of the spring. The arrangement is shown in Fig. 3.1.

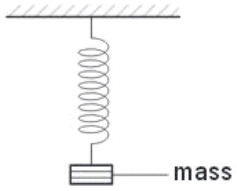


Fig. 3.1

(a) The mass is in equilibrium. Explain, by reference to the forces acting on the mass, what is meant by equilibrium.

.....

.....

.....[2]

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(b) The mass is pulled down and then released at time $t = 0$. The mass oscillates up and down. The variation with t of the displacement of the mass d is shown in Fig. 3.2.

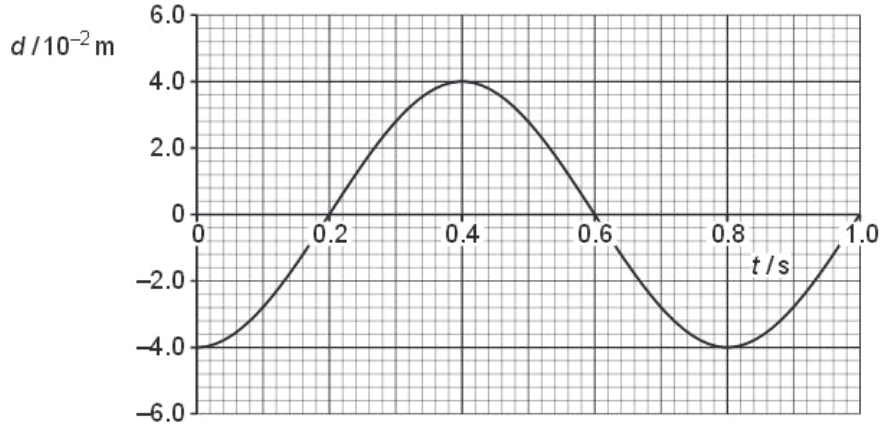


Fig. 3.2

Use Fig. 3.2 to state a time, one in each case, when

(i) the mass is at maximum speed,

time = ... s [1]

(ii) the elastic potential energy stored in the spring is a maximum,

time = ... s [1]

(iii) the mass is in equilibrium.

time = ... s [1]

(c) The arrangement shown in Fig. 3.3 is used to determine the length l of a spring when different masses M are attached to the spring.

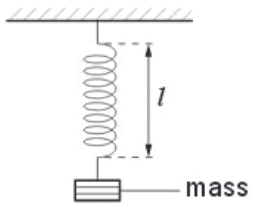


Fig. 3.3

The variation with mass M of l is shown in Fig. 3.4.

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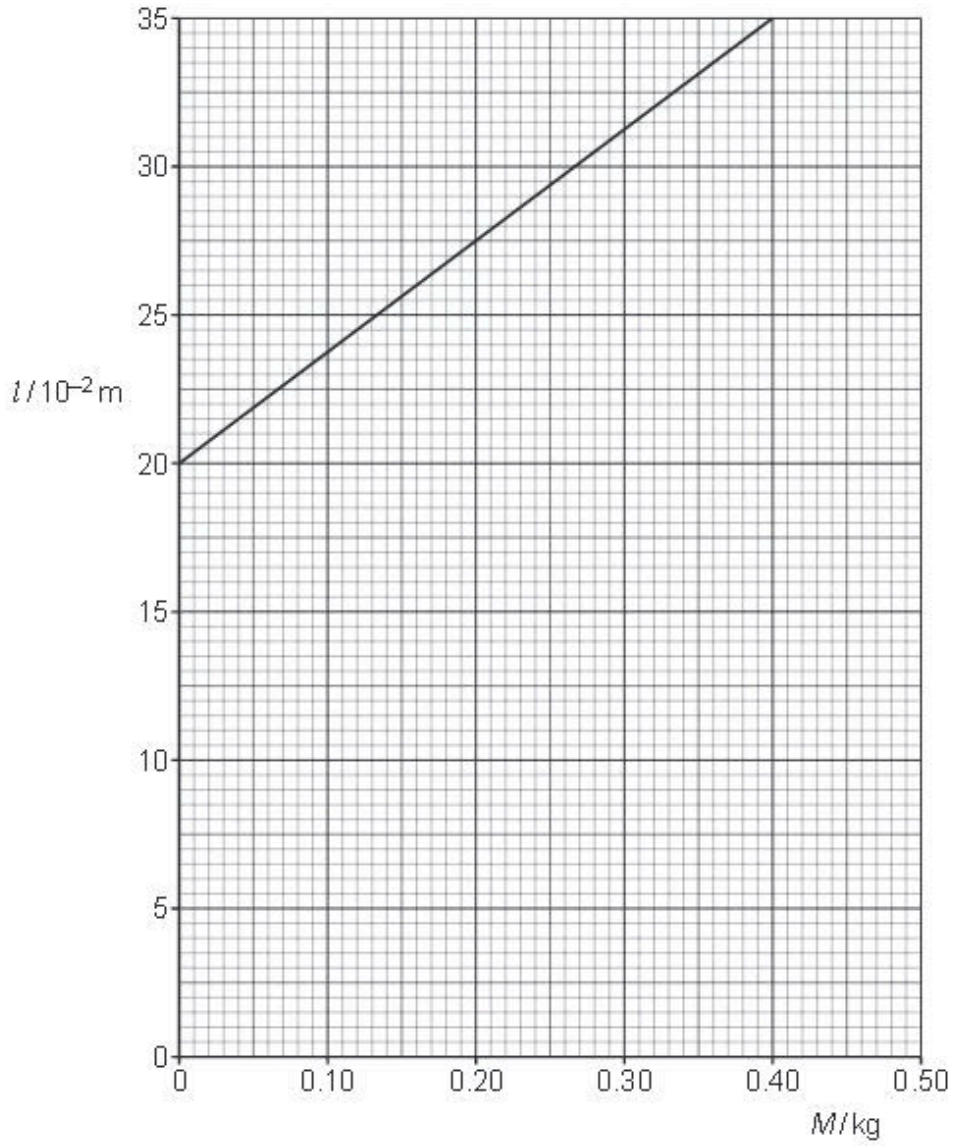


Fig. 3.4

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(i) State and explain whether the spring obeys Hooke's law.

For Examin Use

.....

.....

.....[2]

(ii) Show that the force constant of the spring is 26 N m^{-1}.

[2]

(iii) A mass of 0.40 kg is attached to the spring. Calculate the energy stored in the spring.

energy = ... J [3]

Q13.

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5 **(a)** Define the *Young modulus*.

.....

.....[1]

(b) A load F is suspended from a fixed point by a steel wire. The variation with extension x of F for the wire is shown in Fig. 5.1.

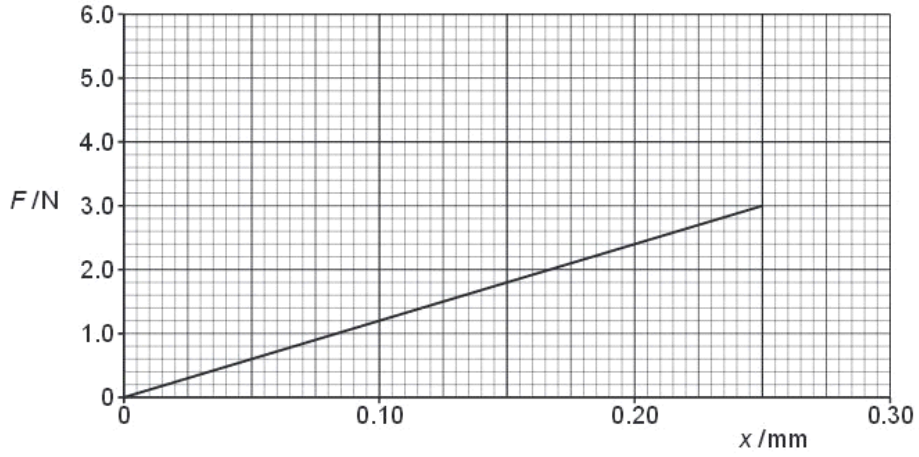


Fig. 5.1

(i) State two quantities, other than the gradient of the graph in Fig. 5.1, that are required in order to determine the Young modulus of steel.

1. .....

2. .....

[1]

(ii) Describe how the quantities you listed in **(i)** may be measured.

.....

.....

.....[2]

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(iii) A load of 3.0 N is applied to the wire. Use Fig. 5.1 to calculate the energy stored in the wire.

energy = ... J [2]

(c) A copper wire has the same original dimensions as the steel wire. The Young modulus for steel is $2.2 \times 10^{11}\,\text{Nm}^{-2}$ and for copper is $1.1 \times 10^{11}\,\text{Nm}^{-2}$.

On Fig. 5.1, sketch the variation with x of F for the copper wire for extensions up to 0.25 mm. The copper wire is not extended beyond its limit of proportionality. [2]

Q14.

1 Energy is stored in a metal wire that is extended elastically.

(a) Explain what is meant by *extended elastically*.

.....

..... [2]

Q15.

4 **(a)** Define

(i) stress,

.....[1]

(ii) strain.

.....[1]

(b) The Young modulus of the metal of a wire is 0.17 TPa. The cross-sectional area of the wire is $0.18\,\text{mm}^2$.

The wire is extended by a force F. This causes the length of the wire to be increased by 0.095 %.

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Calculate

(i) the stress,

stress = ... Pa [4]

(ii) the force *F*.

F = ... N [2]

Q16.

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9 An aluminium wire of length 1.8 m and area of cross-section $1.7 \times 10^{-6}\,m^2$ has one end fixed to a rigid support. A small weight hangs from the free end, as illustrated in Fig. 9.1.

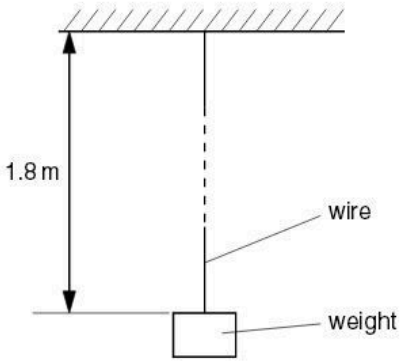


Fig. 9.1

The resistance of the wire is 0.030 Ω and the Young modulus of aluminium is 7.1×10^{10} Pa.

The load on the wire is increased by 25 N.

(a) Calculate

(i) the increase in stress,

increase = ... Pa

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(ii) the change in length of the wire.

change = ... m
[4]

(b) Assuming that the area of cross-section of the wire does not change when the load is increased, determine the change in resistance of the wire.

change = ... Ω [3]

Q17.

5 **(a)** A metal wire has an unstretched length L and area of cross-section A. When the wire supports a load F, the wire extends by an amount ΔL. The wire obeys Hooke's law.

Write down expressions, in terms of L, A, F and ΔL, for

(i) the applied stress,

.....

(ii) the tensile strain in the wire,

.....

(iii) the Young modulus of the material of the wire.

.....
[3]

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(b) A steel wire of uniform cross-sectional area 7.9×10^{-7} m^2 is heated to a temperature of 650 K. It is then clamped between two rigid supports, as shown in Fig. 5.1.

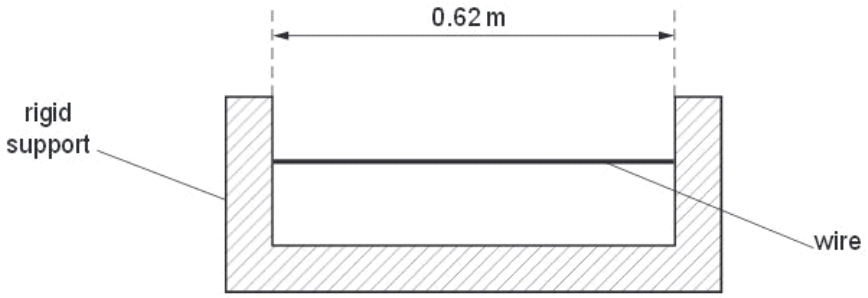


Fig. 5.1

The wire is straight but not under tension and the length between the supports is 0.62 m. The wire is then allowed to cool to 300 K.

When the wire is allowed to contract freely, a 1.00 m length of the wire decreases in length by 0.012 mm for every 1 K decrease in temperature.

(i) Show that the change in length of the wire, if it were allowed to contract as it cools from 650 K to 300 K, would be 2.6 mm.

[2]

(ii) The Young modulus of steel is 2.0×10^{11} Pa. Calculate the tension in the wire at 300 K, assuming that the wire obeys Hooke's law.

tension = ... N [2]

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(iii) The ultimate tensile stress of steel is 250 MPa. Use this information and your answer in **(ii)** to suggest whether the wire will, in practice, break as it cools.

.....

..... [3]

Q18.

6 A straight wire of unstretched length L has an electrical resistance R. When it is stretched by a force F, the wire extends by an amount ΔL and the resistance increases by ΔR. The area of cross-section A of the wire may be assumed to remain constant.

Fi
Exam
Ut

(a) **(i)** State the relation between R, L, A and the resistivity ρ of the material of the wire.

.....

..... [1]

(ii) Show that the fractional change in resistance $\frac{\Delta R}{R}$ is equal to the strain in the wire.

[2]

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(b) A steel wire has area of cross-section $1.20 \times 10^{-7}\ m^2$ and a resistance of $4.17\ \Omega$.

The Young modulus of steel is 2.10×10^{11} Pa.

The tension in the wire is increased from zero to 72.0 N. The wire obeys Hooke's law at these values of tension.

Determine the strain in the wire and hence its change in resistance. Express your answer to an appropriate number of significant figures.

change = ... Ω [5]

Q19.

Use

4 A sample of material in the form of a cylindrical rod has length *L* and uniform area of cross-section *A*. The rod undergoes an increasing tensile stress until it breaks.
Fig. 4.1 shows the variation with stress of the strain in the rod.

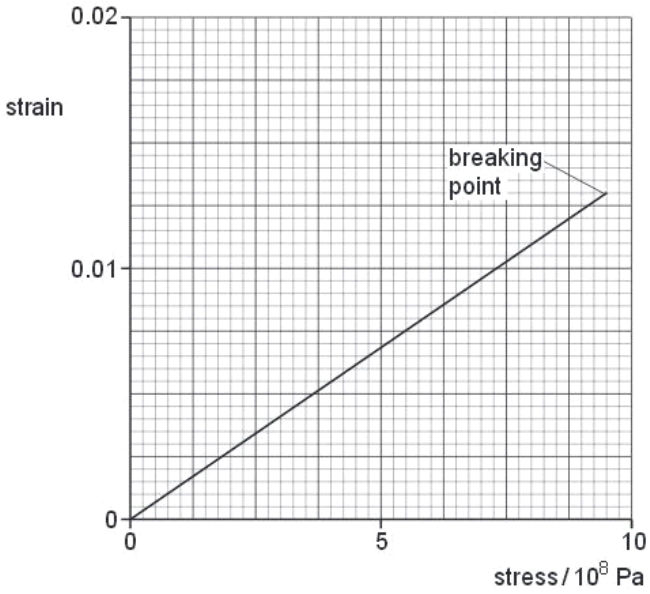


Fig. 4.1

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(a) State whether the material of the rod is ductile, brittle or polymeric.

..... [1]

(b) Determine the Young modulus of the material of the rod.

Young modulus = ... Pa [2]

(c) A second cylindrical rod of the same material has a spherical bubble in it, as illustrated in Fig. 4.2.

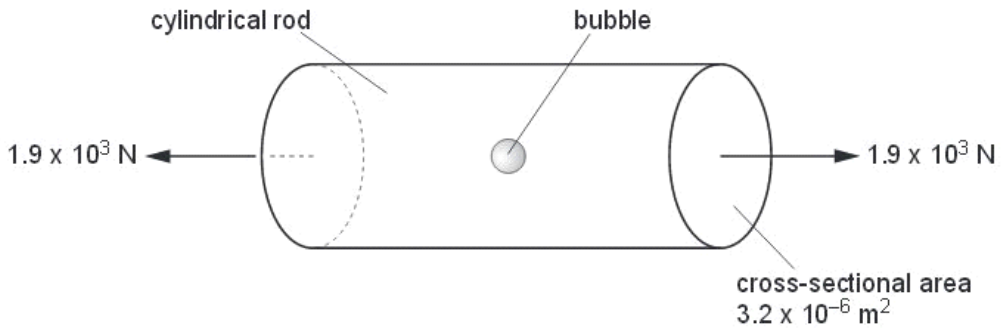


Fig. 4.2

The rod has an area of cross-section of $3.2 \times 10^{-6}\,m^2$ and is stretched by forces of magnitude $1.9 \times 10^3\,N$.
By reference to Fig. 4.1, calculate the maximum area of cross-section of the bubble such that the rod does not break.

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area = ... m^2 [3]

(d) A straight rod of the same material is bent as shown in Fig. 4.3.



Fig. 4.3

Suggest why a thin rod can bend more than a thick rod without breaking.

.....

.....

..... [2]

Q20.

4 A uniform wire has length *L* and area of cross-section *A*.
The wire is fixed at one end so that it hangs vertically with a load attached to its free end, as shown in Fig. 4.1.

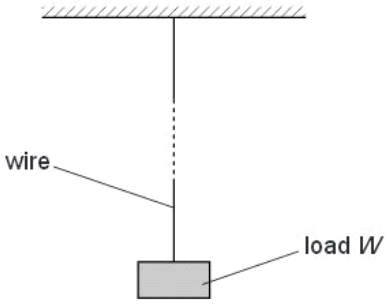


Fig. 4.1

When the load of magnitude *W* is attached to the wire, it extends by an amount *e*. The elastic limit of the wire is not exceeded.

The material of the wire has resistivity ρ.

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(a) **(i)** Explain what is meant by extends *elastically*.

.....

.....

..... [2]

(ii) Write down expressions, in terms of L, A, W, ρ and e for

1. the resistance R of the unstretched wire,

R = ... [1]

2. the Young modulus E of the wire.

E = ... [1]

(b) A steel wire has resistance 0.44 Ω. Steel has resistivity $9.2 \times 10^{-8}\,\Omega\,m$.

A load of 34 N hung from the end of the wire causes an extension of 7.7×10^{-4} m.

Using your answers in **(a)(ii)**, calculate the Young modulus E of steel.

For Examiner Use

E = ... Pa [3]

Q21.

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4 **(a)** Explain what is meant by *strain energy* (*elastic potential energy*).

.....

.....

..... [2]

(b) A spring that obeys Hooke's law has a spring constant k.

Show that the energy E stored in the spring when it has been extended elastically by an amount x is given by

$$E = \tfrac{1}{2}kx^2.$$

[3]

(c) A light spring of unextended length 14.2 cm is suspended vertically from a fixed point, as illustrated in Fig. 4.1.

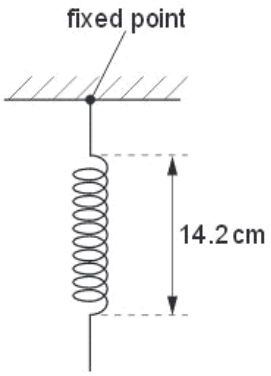


Fig. 4.1

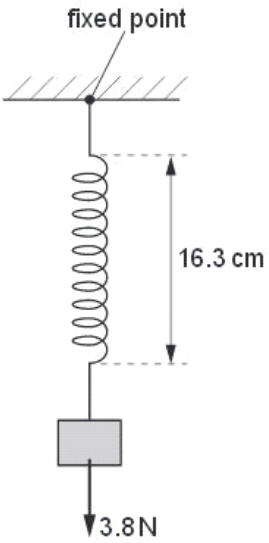


Fig. 4.2

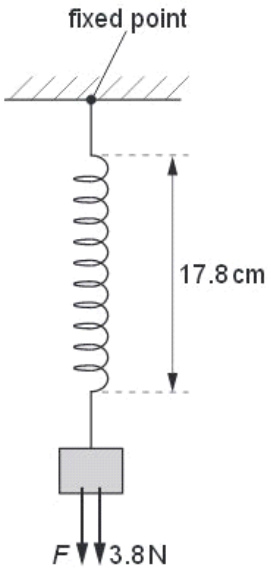


Fig. 4.3

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A mass of weight 3.8 N is hung from the end of the spring, as shown in Fig. 4.2. The length of the spring is now 16.3 cm.

An additional force F then extends the spring so that its length becomes 17.8 cm, as shown in Fig. 4.3.

The spring obeys Hooke's law and the elastic limit of the spring is not exceeded.

(i) Show that the spring constant of the spring is 1.8 N cm^{-1}.

[1]

(ii) For the extension of the spring from a length of 16.3 cm to a length of 17.8 cm,

1. calculate the change in the gravitational potential energy of the mass on the spring,

change in energy = ... J [2]

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2. show that the change in elastic potential energy of the spring is 0.077 J,

[1]

3. determine the work done by the force *F*.

work done = ... J [1]

Q22.

4 (a) A uniform wire has length *L* and constant area of cross-section *A*.
The material of the wire has Young modulus *E* and resistivity ρ.
A tension *F* in the wire causes its length to increase by ΔL.

For Examiner Use

For this wire, state expressions, in terms of *L*, *A*, *F*, ΔL and ρ for

(i) the stress σ,

..... [1]

(ii) the strain ε,

..... [1]

(iii) the Young modulus *E*,

..... [1]

(iv) the resistance *R*.

..... [1]

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(b) One end of a metal wire of length 2.6 m and constant area of cross-section $3.8 \times 10^{-7}\,m^2$ is attached to a fixed point, as shown in Fig. 4.1.

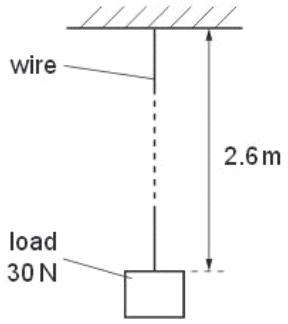


Fig. 4.1

The Young modulus of the material of the wire is 7.0×10^{10} Pa and its resistivity is $2.6 \times 10^{-8}\,\Omega\,m$.
A load of 30 N is attached to the lower end of the wire. Assume that the area of cross-section of the wire does not change.
For this load of 30 N,

(i) show that the extension of the wire is 2.9 mm,

[1]

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(ii) calculate the change in resistance of the wire.

change = ... Ω [2]

(c) The resistance of the wire changes with the applied load.
Comment on the suggestion that this change of resistance could be used to measure the magnitude of the load on the wire.

.....

.....

..... [2]

Q23.

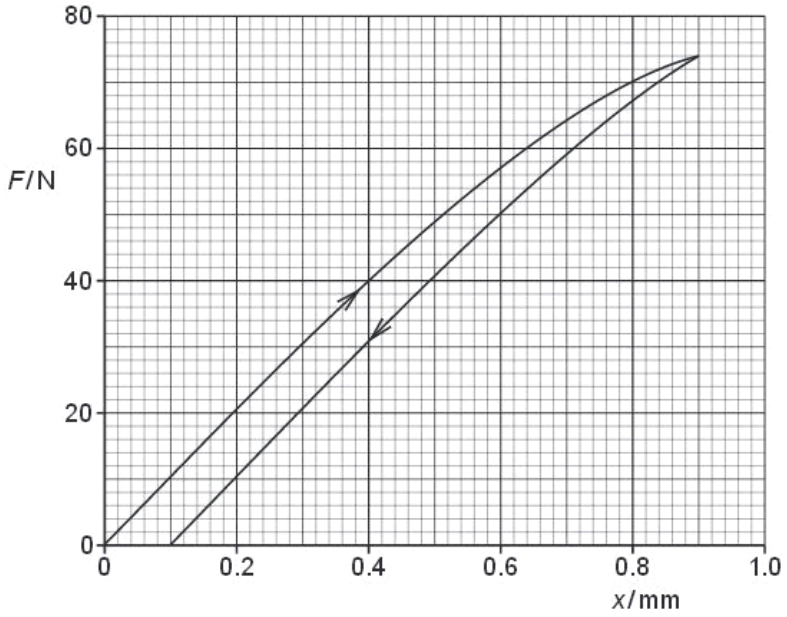
4 **(a)** A metal wire has spring constant k. Forces are applied to the ends of the wire to extend it within the limit of Hooke's law.
Show that, for an extension x, the strain energy E stored in the wire is given by

$$E = \frac{1}{2}kx^2.$$

[4]

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(b) The wire in **(a)** is now extended beyond its elastic limit. The forces causing the extension are then removed.
The variation with extension x of the tension F in the wire is shown in Fig. 4.1.



Energy E_S is expended to cause a permanent extension of the wire.

(i) On Fig. 4.1, shade the area that represents the energy E_S. [1]

(ii) Use Fig. 4.1 to calculate the energy E_S.

E_S = ... mJ [3]

(iii) Suggest the change in the structure of the wire that is caused by the energy E_S.

.....

.....[1]

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Q24.

5 A spring hangs vertically from a fixed point and a mass of 94 g is suspended from the spring, stretching the spring as shown in Fig. 5.1.

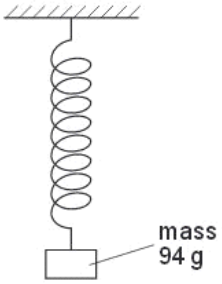


Fig. 5.1

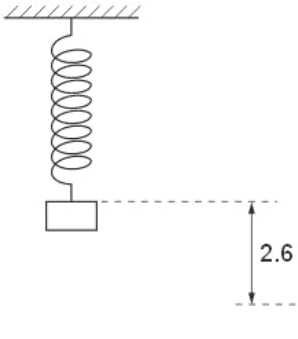


Fig. 5.2 Fig. 5.3

The mass is raised vertically so that the length of the spring is its unextended length. This is illustrated in Fig. 5.2.

The mass is then released. The mass moves through a vertical distance of 2.6 cm before temporarily coming to rest. This position is illustrated in Fig. 5.3.

(a) State which diagram, Fig. 5.1, Fig. 5.2 or Fig. 5.3, illustrates the position of the mass such that

(i) the mass has maximum gravitational potential energy,

..... [1]

(ii) the spring has maximum strain energy.

..... [1]

(b) Briefly describe the variation of the kinetic energy of the mass as the mass falls from its highest position (Fig. 5.2) to its lowest position (Fig. 5.3).

.....

..... [1]

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(c) The strain energy E stored in the spring is given by the expression

$$E = \frac{1}{2}kx^2$$

where k is the spring constant and x is the extension of the spring.

For the mass moving between the positions shown in Fig. 5.2 and Fig. 5.3,

(i) calculate the change in the gravitational potential energy of the mass,

change = ... J [2]

(ii) determine the extension of the spring at which the strain energy is half its maximum value.

extension = ... cm [3]

Q25.

6 **(a)** State Hooke's law.

.....

..... [1]

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(b) The variation with extension x of the force F for a spring A is shown in Fig. 6.1.

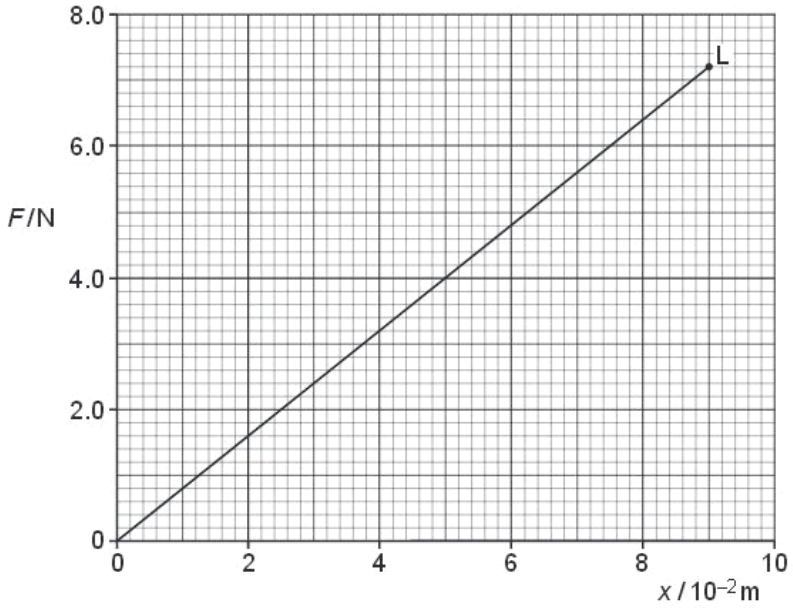


Fig. 6.1

The point L on the graph is the elastic limit of the spring.

(i) Describe the meaning of *elastic limit*.

.....

.....

..... [1]

(ii) Calculate the spring constant k_A for spring A.

k_A = ... Nm^{-1} [1]

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(iii) Calculate the work done in extending the spring with a force of 6.4 N.

For Examiner's Use

work done = ... J [2]

(c) A second spring B of spring constant $2k_A$ is now joined to spring A, as shown in Fig. 6.2.

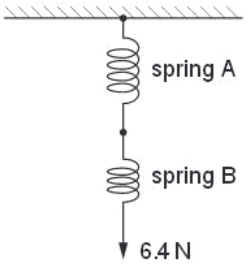


Fig. 6.2

A force of 6.4 N extends the combination of springs.

For the combination of springs, calculate

(i) the total extension,

extension = ... m [1]

(ii) the spring constant.

spring constant = ... Nm^{-1} [1]

Q26.

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3 **(a)** Define

(i) *stress*,

.....

.....[1]

(ii) *strain*.

.....

.....[1]

(b) Explain the term *elastic limit*.

.....

.....[1]

(c) Explain the term *ultimate tensile stress*.

.....

.....

.....[2]

(d) **(i)** A **ductile** material in the form of a wire is stretched up to its breaking point. On Fig. 3.1, sketch the variation with extension x of the stretching force F.



Fig. 3.1

[2]

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(ii) On Fig. 3.2, sketch the variation with x of F for a **brittle** material up to its breaking point.



Fig. 3.2

[1]

(e) **(i)** Explain the features of the graphs in **(d)** that show the characteristics of ductile and brittle materials.

.....

.....

.....

.....

.....[2]

(ii) The force F is removed from the materials in **(d)** just before the breaking point is reached. Describe the subsequent change in the extension for

1. the ductile material,

.....

.....[1]

2. the brittle material.

.....

.....[1]

Q27.

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5 **(a)** Explain what is meant by *plastic deformation*.

.....

..... [1]

(b) A copper wire of uniform cross-sectional area $1.54 \times 10^{-6}\,m^2$ and length 1.75 m has a breaking stress of 2.20×10^{8} Pa. The Young modulus of copper is 1.20×10^{11} Pa.

(i) Calculate the breaking force of the wire.

breaking force = ... N [2]

(ii) A stress of 9.0×10^{7} Pa is applied to the wire. Calculate the extension.

extension = ... m [2]

(c) Explain why it is not appropriate to use the Young modulus to determine the extension when the breaking force is applied.

.....

..... [1]

Q28.

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6 **(a)** State Hooke's law.

For Examiner Use

.....

.....[1]

(b) A spring is attached to a support and hangs vertically, as shown in Fig. 6.1. An object M of mass 0.41 kg is attached to the lower end of the spring. The spring extends until M is at rest at R.

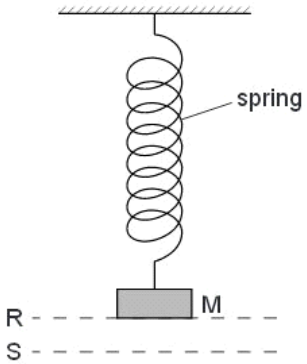


Fig. 6.1

The spring constant of the spring is 25 $N m^{-1}$. Show that the extension of the spring is about 0.16 m.

[2]

(c) The object M in Fig. 6.1 is pulled down a further 0.060 m to S and is then released. For M, just as it is released,

(i) state the forces acting on M,

.....[1]

(ii) calculate the acceleration of M.

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

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(d) Describe and explain the energy changes from the time the object M in Fig. 6.1 is released to the time it first returns to R.

Ex

.....

.....

.....

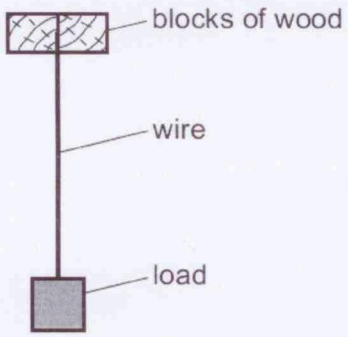
.....[2]

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Deformation of solids - 2018

1. 9702/11/M/J/18/No.18

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 extends its length by x.



A second wire is made of the same material, but of diameter $2D$ and length $3L$. Both wires obey Hooke's law.

What is the extension of the second wire when the same load is applied?

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

(1) $E = \frac{FL}{Ax}$. $= \frac{FL}{\pi \times (\frac{D}{2})^2 \times x}$. $= \frac{4FL}{\pi D^2 x}$

$x = \frac{4FL}{\pi D^2 E}$

(2) $E = \frac{3FL}{\pi (\frac{2D}{2})^2 x_2}$ $= \frac{3FL}{\pi D^2 x_2}$

$x_2 = \frac{3FL}{\pi D^2 E}$

Let $\frac{FL}{\pi D^2 E} = m$.

So $x = 4m$, $m = \frac{x}{4}$.

$x_2 = 3m$

$= 3 \times \frac{x}{4}$

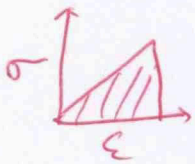
$= \frac{3}{4}x$

2. 9702/12/M/J/18/No.20

An elastic material with 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 $\frac{E}{2S^2}$ B $\frac{2E}{S^2}$ C $\frac{S^2}{E}$ D $\frac{S^2}{2E}$



Area under graph $= \frac{1}{2}\sigma \times \varepsilon$.

$= \frac{1}{2} \frac{F}{A} \times \frac{x}{L} = \frac{Fx}{2AL}$.

$= \frac{\text{work done}}{2 \text{volume}}$.

work done = elastic energy stored.

So find expression that gives $\frac{Fx}{2AL}$.

Try D

$S^2 = \frac{F^2}{A^2}$, $E = \frac{FL}{Ax}$.

$\frac{S^2}{2E} = \frac{F^2}{A^2} \div 2\frac{FL}{Ax}$

$= \frac{F^2}{A^2} \times \frac{Ax}{2FL}$

$= \frac{Fx}{2AL}$.

1

3. 9702/11/M/J/18/No.19

Two wires, one made of brass and the other of steel, are stretched in an experiment. Both wires obey Hooke's law during this experiment.

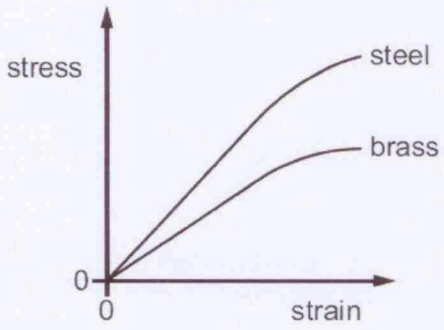
The Young modulus for brass is less than the Young modulus for steel.

$E_{Brass} < E_{steel}$

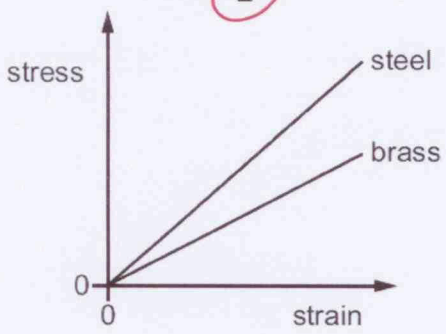
So steel has a steeper gradient in $\sigma - \varepsilon$ graph.

Which graph shows how the stress varies with strain for both wires in this experiment?

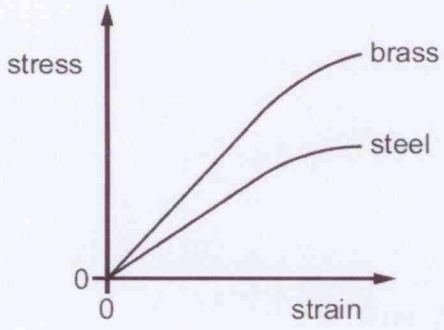
A



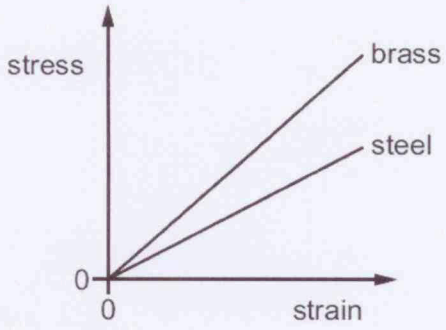
B ✓



C



D



4. 9702/13/M/J/18/No.18

Data for a steel wire on an electric guitar are listed.

diameter = 5.0×10^{-4} m

Young modulus = 2.0×10^{11} Pa

tension = 20 N

$x = \frac{FL}{AE}$

$= \frac{20 \times L}{\pi \times \left(\frac{5.0 \times 10^{-4}}{2}\right)^2 \times 2 \times 10^{11}}$

$x = 0.00051 L$

The wire snaps and contracts elastically. Assume the wire obeys Hooke's law.

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

$\frac{x}{L} = 0.00051$

$\frac{x}{L}\% = 0.00051 \times 100$

$= 0.051\%$

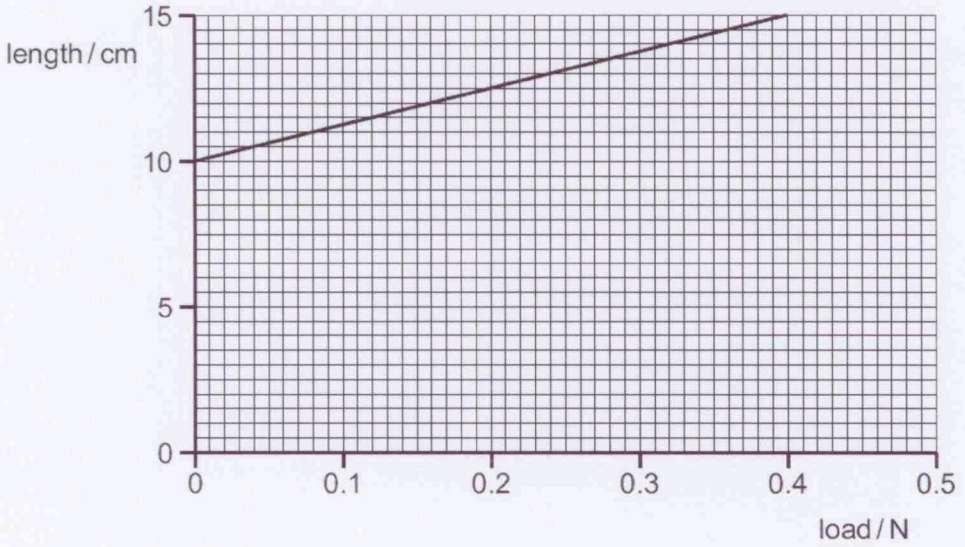
$= 5.1 \times 10^{-2}\%$

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

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5. 9702/12/M/J/18/No.21

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



What is the spring constant of the spring?

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

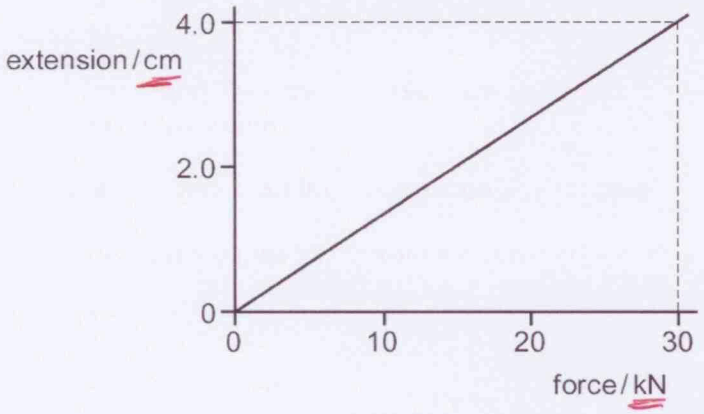
$k = \frac{F}{\Delta x}$ = gradient

$= \frac{0.4 - 0}{0.15 - 0.1} = \frac{0.4}{0.05}$

$= 8.0\ N\,m^{-1}$

6. 9702/13/M/J/18/No.19

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



$E = \frac{1}{2} F x$

$= \frac{1}{2} \times 30000 \times 0.04$

$= 600\ J$

- change force from kN to N by multiplying by 1000
- change cm to m.

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

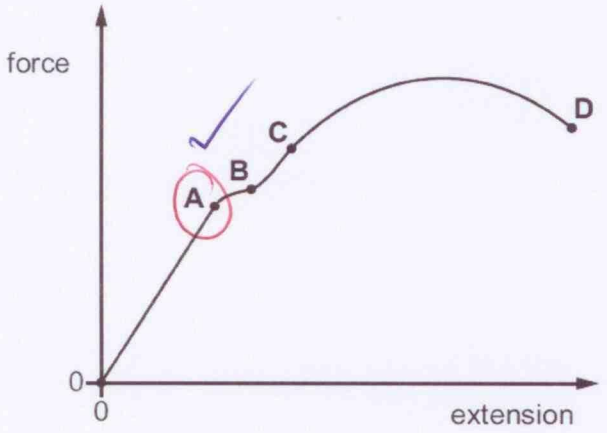
A 60 J **B** 120 J **C** 600 J **D** 1200 J

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7. 9702/12/F/M /18/No.19

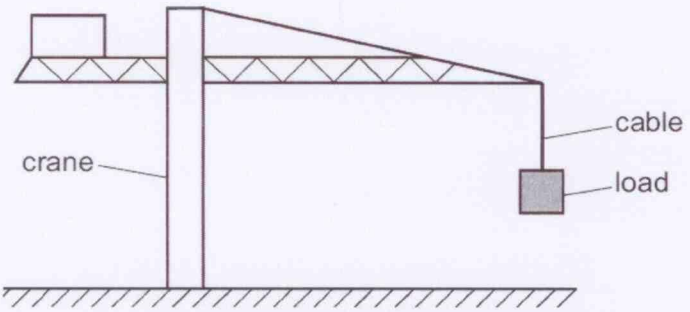
The force-extension graph of a metal wire is shown.

At which point on the graph does the metal wire stop obeying Hooke's law?



8. 9702/12/F/M /18/No.20

The diagram shows a large crane on a construction site lifting a cube-shaped load at a constant speed.



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 $\frac{\text{stress in the cable on the full-size crane}}{\text{stress in the cable on the model crane}}$?

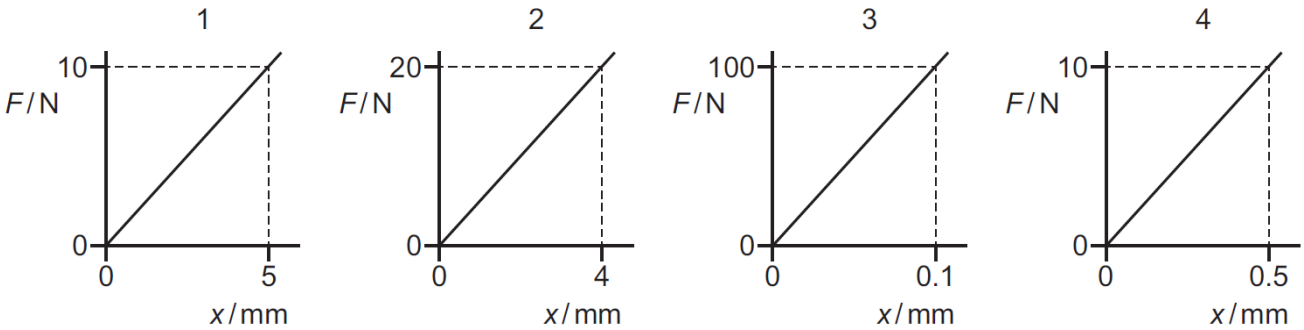
A 0.1 B 1 C 10 D 100

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Deformation of Solid – 2021 AS

1. June/2021/Paper_11/No.19

The spring constants of four springs are determined by plotting the following graphs of force F against extension x.



Which order of the graphs shows **decreasing** spring constants?

A 2 → 1 → 3 → 4

B 3 → 4 → 2 → 1

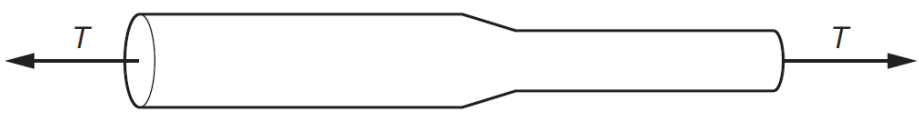
C 4 → 2 → 1 → 3

D 4 → 3 → 2 → 1

2. June/2021/Paper_12/No.19

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.



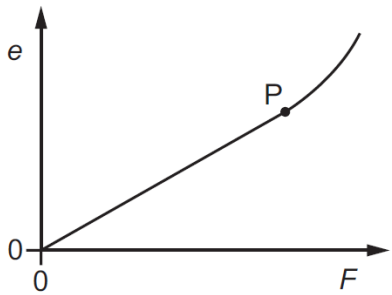
What is the value of $\frac{\text{stress in the wide portion}}{\text{stress in the narrow portion}}$?

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

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3. June/2021/Paper_11/No.20

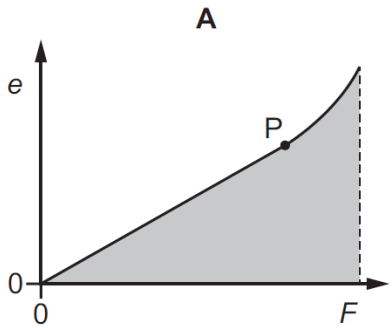
Forces are applied to the ends of a rod so that its length increases. The variation with force F of the extension e of the rod is shown.



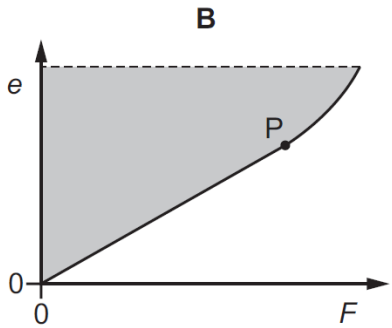
The point P is the elastic limit.

Which shaded area represents the work done during the plastic deformation of the rod?

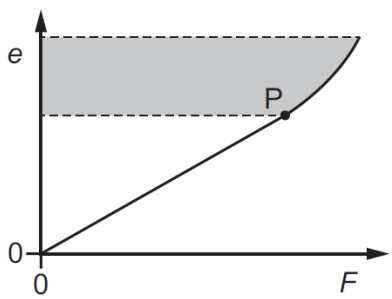
A



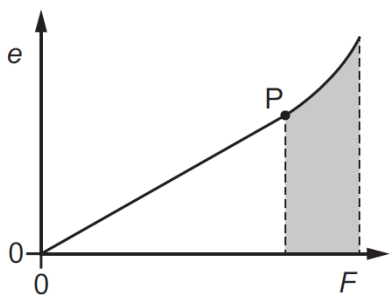
B



C



D



4. June/2021/Paper_12/No.20

Two guitar strings are stretched by tensile forces.

String X is stretched by a tensile force F that causes an extension x.

String Y is stretched by a tensile force $2F$ that causes an extension $2x$.

The strings obey Hooke's law.

What is the ratio $\dfrac{\text{strain energy in stretched string X}}{\text{strain energy in stretched string Y}}$?

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

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5. Nov/2021/Paper_11/No.19

A metal wire, of cross-sectional area A and unstretched length l, is subjected to stress σ. As a result it has strain ε.

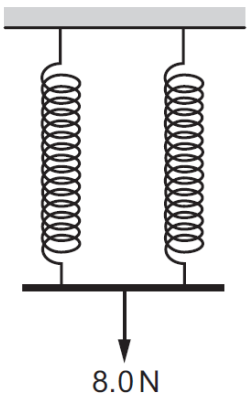
Which expression gives the Young modulus of the metal?

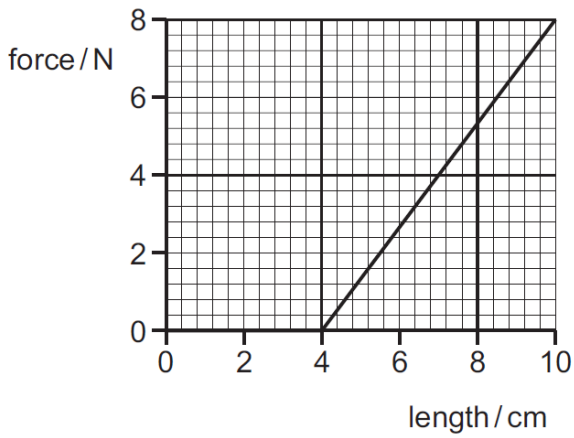
A $\frac{\varepsilon}{\sigma}$ **B** $\frac{\varepsilon A}{\sigma l}$ **C** $\frac{\sigma}{\varepsilon}$ **D** $\frac{\sigma l}{\varepsilon A}$

6. Nov/2021/Paper_11/No.20

Two identical springs are connected in parallel.

A weight of 8.0 N is hung from the combination, as shown.





The graph shows the variation with length of the force applied to **one** of the springs.

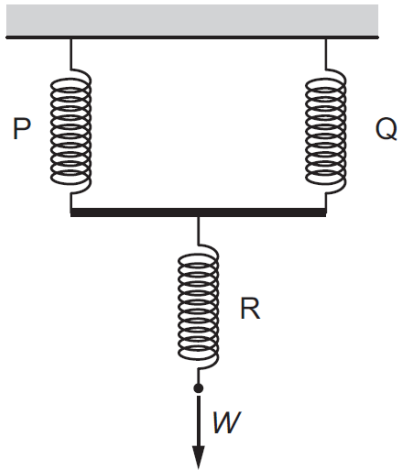
What is the strain energy in **one** of the springs?

A 0.060 J **B** 0.12 J **C** 0.14 J **D** 0.24 J

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7. Nov/2021/Paper_12/No.21

Three springs are arranged vertically as shown.



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

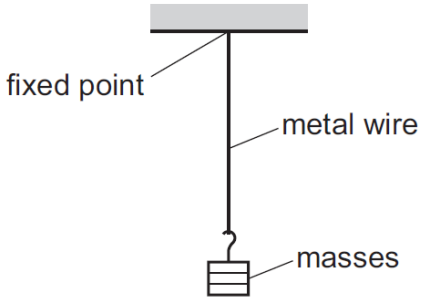
What is the increase in the overall length of the arrangement when a force W is applied as shown?

A $\frac{5}{6}\frac{W}{k}$ **B** $\frac{4}{3}\frac{W}{k}$ **C** $\frac{7}{2}kW$ **D** $4kW$

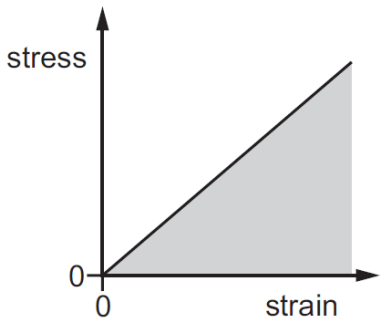
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8. Nov/2021/Paper_12/No.22

A length of metal wire is attached to a fixed point and hangs vertically. Masses are then suspended from the wire. Assume that the cross-sectional area of the wire remains constant.



A stress–strain graph for the wire is plotted, as shown.



What is represented by the shaded area under the graph?

A strain energy in the wire

B $\dfrac{\text{strain energy in the wire}}{\text{cross-sectional area of the wire}}$

C $\dfrac{\text{strain energy in the wire}}{\text{original length of the wire}}$

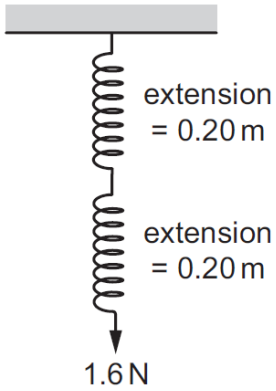
D $\dfrac{\text{strain energy in the wire}}{\text{original volume of the wire}}$

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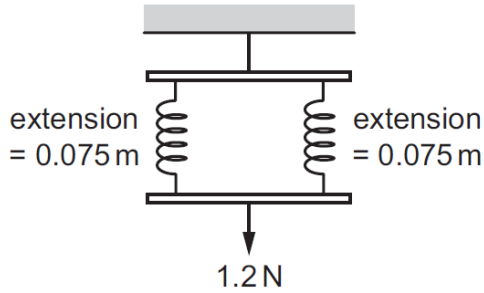
9. Nov/2021/Paper_13/No.20

Which spring combination has an overall spring constant of $8.0\,\text{N}\,\text{m}^{-1}$?

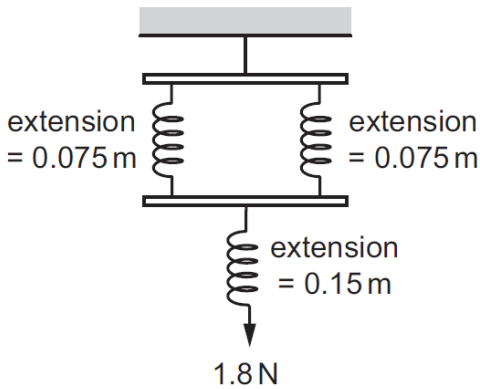
A



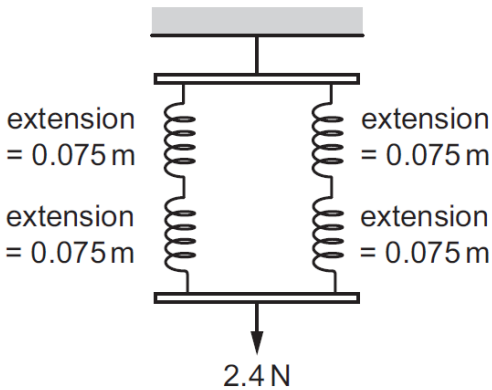
B



C



D



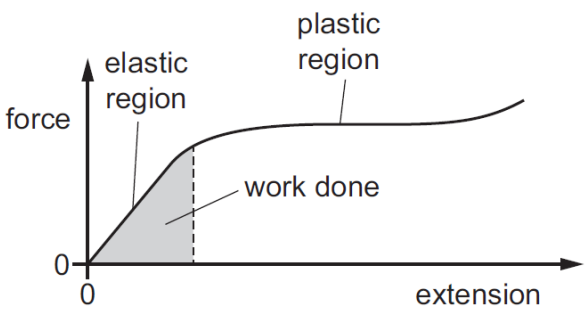
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10. Nov/2021/Paper_13/No.21

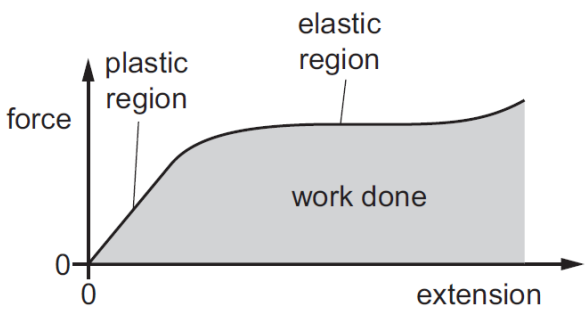
A metal wire is stretched to breaking point and the force–extension graph is plotted.

Which graph is correctly labelled with the elastic region, the plastic region and the area representing the work done to stretch the wire until it breaks?

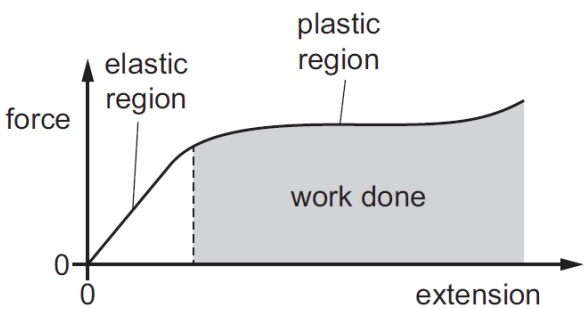
A



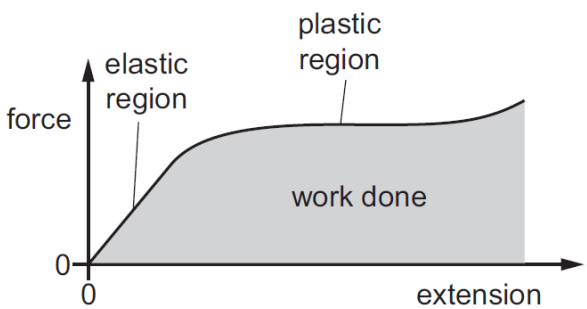
B



C



D



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Deformation of Solid – 2021 AS

1. Nov/2021/Paper_21/No.3

(a) A uniform metal bar, initially unstretched, has sides of length *w*, *x* and *y*, as shown in Fig. 3.1.

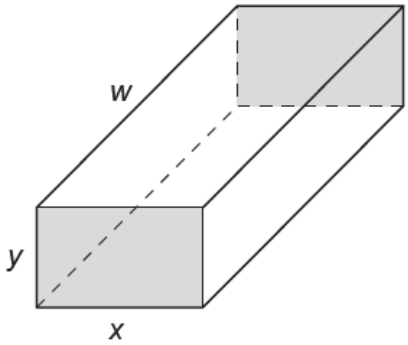


Fig. 3.1

The bar is now stretched by a tensile force *F* applied to the shaded ends. The changes in the lengths *x* and *y* are negligible. The bar now has sides of length *x*, *y* and *z*, as shown in Fig. 3.2.

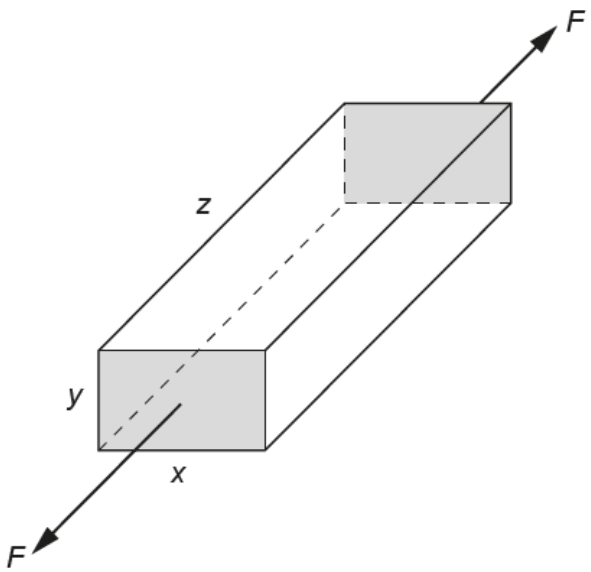


Fig. 3.2

Determine expressions, in terms of some or all of *F*, *w*, *x*, *y* and *z*, for:

(i) the stress σ applied to the bar by the tensile force

σ = ... [1]

(ii) the strain ε in the bar due to the tensile force

ε = ... [1]

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(iii) the Young modulus E of the metal from which the bar is made.

E = ... [2]

(b) A copper wire is stretched by a tensile force that gradually increases from 0 to 280 N. The variation with extension of the tensile force is shown in Fig. 3.3.

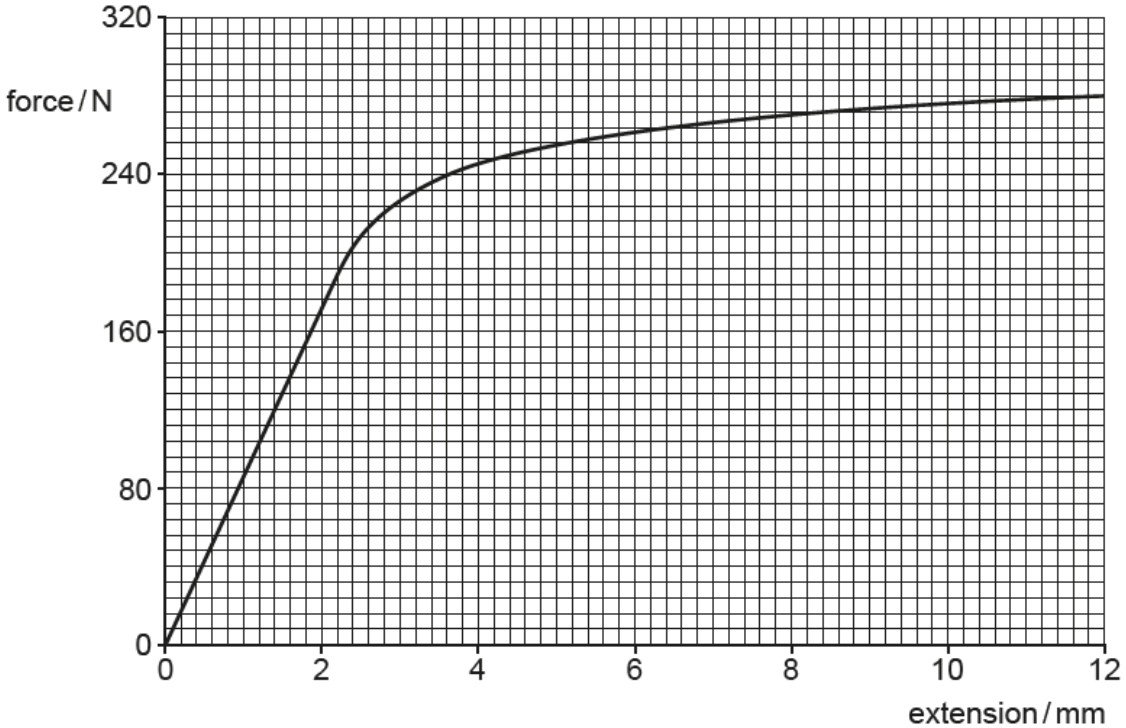


Fig. 3.3

(i) State the maximum extension of the wire for which it obeys Hooke's law.

extension = ... mm [1]

(ii) Use Fig. 3.3 to determine the strain energy in the wire when the tensile force is 120 N.

strain energy = ... J [3]

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(iii) Explain why the work done in stretching the wire to an extension of 12 mm is not equal to the energy recovered when the tensile force is removed.

.....

.....

..... [2]

[Total: 10]

2. March/2021/Paper_22/No.3

A spring is extended by a force. The variation with extension x of the force F is shown in Fig. 3.1.

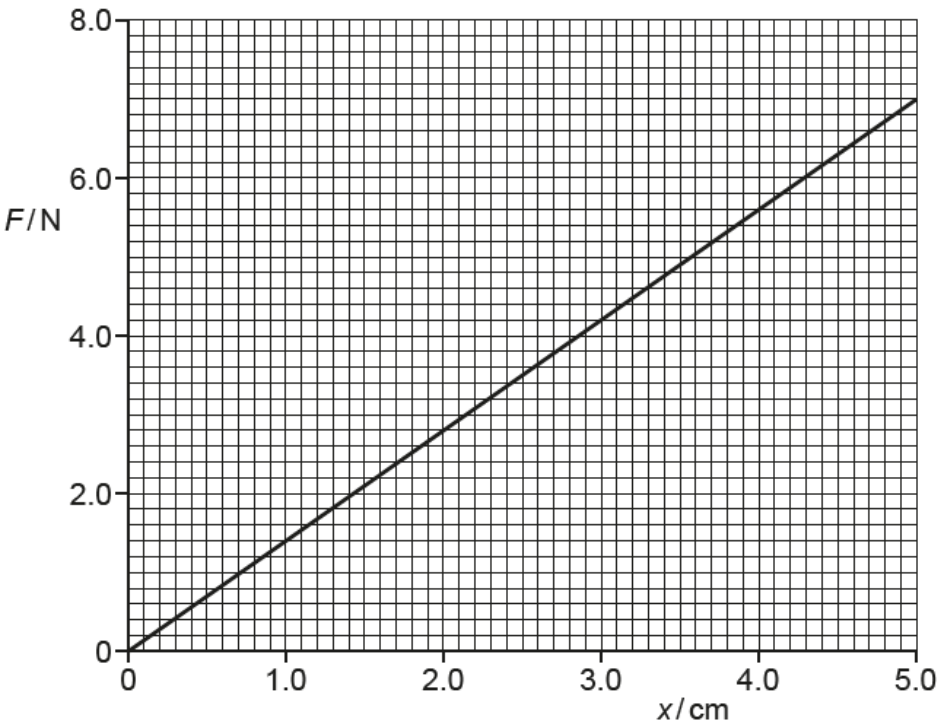


Fig. 3.1

(a) State the name of the law that relates the force and extension of the spring shown in Fig. 3.1.

..... [1]

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(b) Determine:

(i) the spring constant, in $N\,m^{-1}$, of the spring

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

(ii) the strain energy (elastic potential energy) in the spring when the extension is 4.0 cm.

strain energy = ... J [2]

(c) One end of the spring is attached to a fixed point. A cylinder that is submerged in a liquid is now suspended from the other end of the spring, as shown in Fig. 3.2.

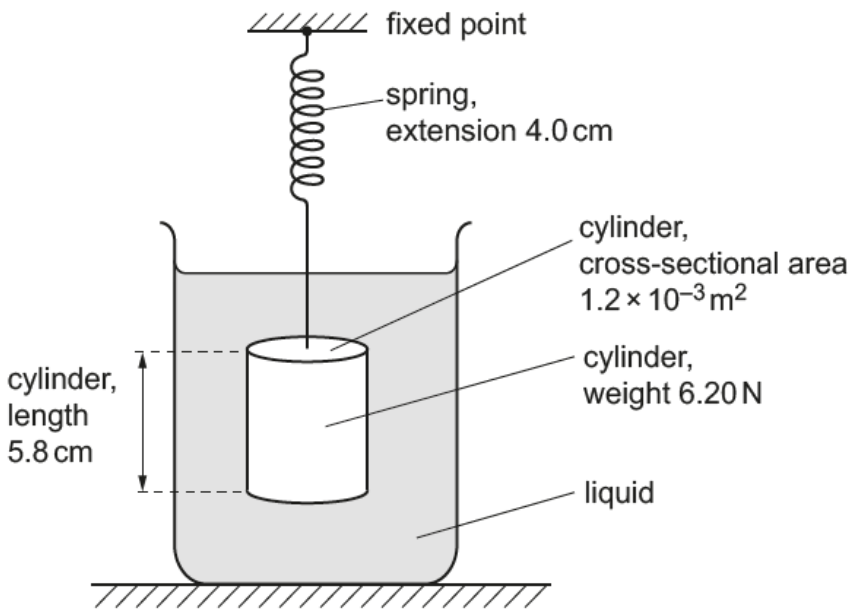


Fig. 3.2

The cylinder has length 5.8 cm, cross-sectional area $1.2 \times 10^{-3}\,m^2$ and weight 6.20 N. The cylinder is in equilibrium when the extension of the spring is 4.0 cm.

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(i) Show that the upthrust acting on the cylinder is 0.60 N.

[1]

(ii) Calculate the difference in pressure between the bottom face and the top face of the cylinder.

difference in pressure = ... Pa [2]

(iii) Calculate the density of the liquid.

density = ... $kg\,m^{-3}$ [2]

(d) The liquid in **(c)** is replaced by another liquid of greater density.

State the effect, if any, of this change on:

(i) the upthrust acting on the cylinder

..... [1]

(ii) the extension of the spring.

..... [1]

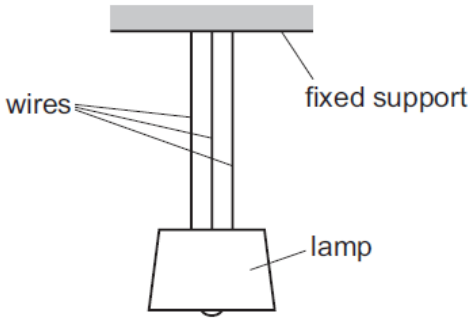
[Total: 12]

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Deformation of Solid – 2023 June AS Physics 9702

1. June/2023/Paper_ 9702/11/No.18

A lamp is suspended in equilibrium from a fixed support by three long identical wires.



The weight of the lamp causes each wire to have an extension of 0.40 cm. The height *h* of the lamp above the floor is measured.

The middle wire suddenly breaks and the lamp falls a small distance as the extensions of the remaining two wires increase. The wires obey Hooke's law.

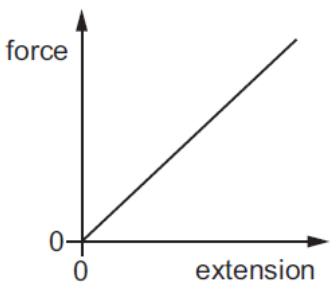
When the lamp is in equilibrium, the height *h* of the lamp above the floor is measured again.

What is the difference between the two values of *h*?

A 0.20 cm **B** 0.27 cm **C** 0.40 cm **D** 0.60 cm

2. June/2023/Paper_ 9702/11/No.19

The force–extension graph for a spring is shown.



What represents the work done to extend the spring?

A the area under the graph

B the gradient of the graph

C the reciprocal of the gradient of the graph

D twice the area under the graph

3. June/2023/Paper_ 9702/12/No.18

What is meant by the spring constant of a spring?

A extension per unit force

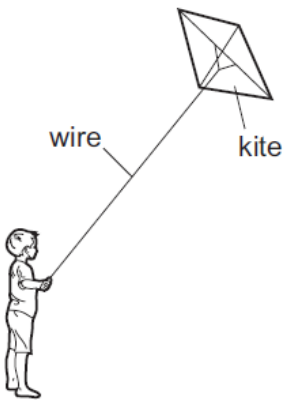
B $\frac{1}{2} \times$ force $\times$ extension

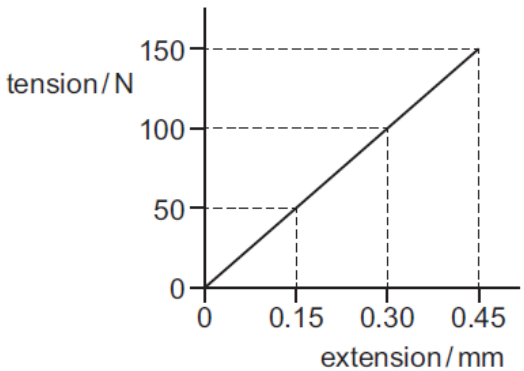
C force $\times$ extension

D force per unit extension

4. June/2023/Paper_ 9702/12/No.19

A child holds a thin metal wire that is attached to a kite. The graph shows how the extension of the wire varies with its tension.





A gust of wind increases the tension from 100 N to 150 N.

What is the change in the elastic potential energy of the wire caused by the gust of wind?

A 3.8 mJ **B** 19 mJ **C** 34 mJ **D** 38 mJ

5. June/2023/Paper_ 9702/13/No.18

A metal wire has length 5.2 m and diameter 1.0 mm. The metal has Young modulus 360 GPa.

The wire is fixed at one end and a force is applied to the other end. The force extends the wire by 7.2 mm. The wire obeys Hooke's law.

What is the force applied to the wire?

A 1.2×10^2 N

B 3.9×10^2 N

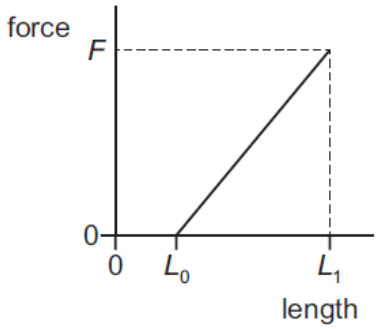
C 5.0×10^2 N

D 1.6×10^3 N

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6. June/2023/Paper_ 9702/13/No.19

The graph shows how the length of a spring varies with the force applied to it.



The spring has unstretched length L_0. When a force F is applied, the spring has length L_1.

What is the work done in stretching the spring to length L_1?

A $\frac{1}{2}FL_1$ **B** $\frac{1}{2}F(L_1 - L_0)$ **C** FL_1 **D** $F(L_1 - L_0)$

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7. June/2023/Paper_ 9702/22/No.4

A spring is suspended from a fixed point at one end. The spring is extended by a vertical force applied to the other end. The variation of the applied force F with the length L of the spring is shown in Fig. 4.1.

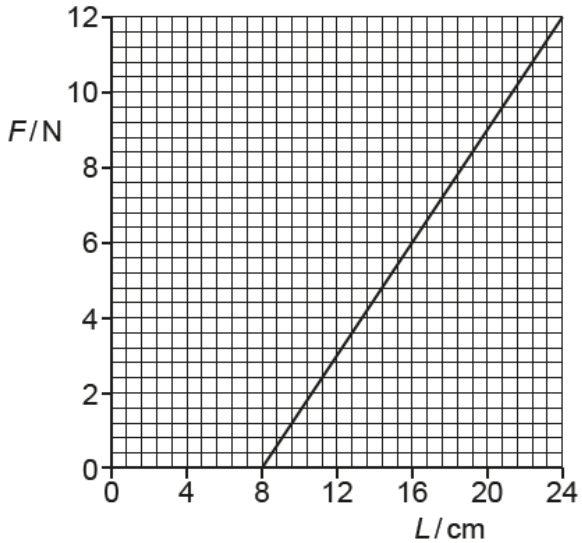


Fig. 4.1

For the spring:

(a) state the name of the law that gives the relationship between the force and the extension

..... [1]

(b) determine the spring constant, in $N\,m^{-1}$

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

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(c) determine the elastic potential energy when $F = 6.0\,\text{N}$.

elastic potential energy = ... J [2]

[Total: 5]

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8. June/2023/Paper_ 9702/23/No.6

(a) Define the Young modulus.

.....

..... [1]

(b) A uniform wire is suspended from a fixed support. Masses are added to the other end of the wire, as shown in Fig. 6.1.

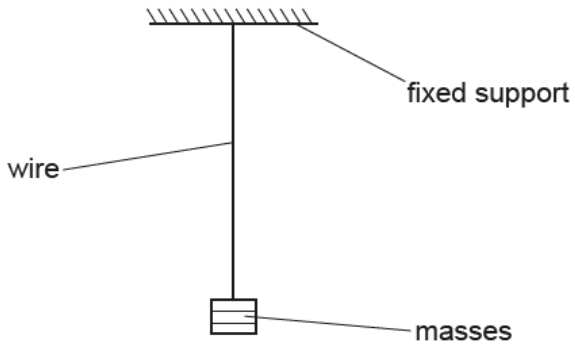


Fig. 6.1 (not to scale)

The variation of the length l of the wire with the force F applied to the wire by the masses is shown in Fig. 6.2.

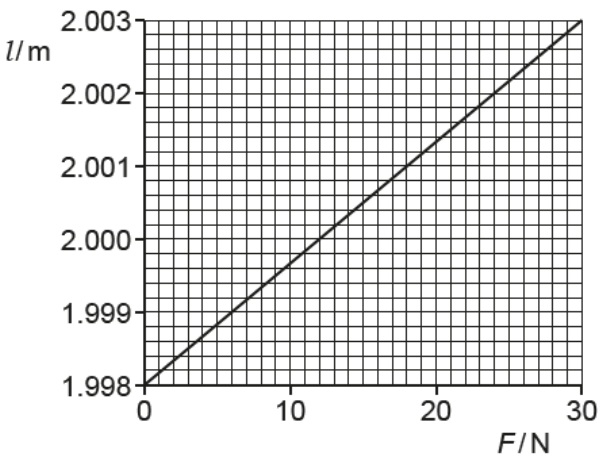


Fig. 6.2

The cross-sectional area of the wire is 0.95 mm^2.

(i) Determine the unstretched length of the wire.

unstretched length = ... m [1]

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(ii) For an applied force F of 30 N, determine:

- the stress in the wire

stress = ... Pa

- the strain of the wire.

strain = ...
[3]

[Total: 5]

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9. March/2023/Paper_ 9702/12/No.18

A spring has an unstretched length of 4.50 cm. The spring is fixed at one end and a force of 35.0 N is applied to the other end so that the spring extends.

The spring obeys Hooke's law and has a spring constant of 420 $N\,m^{-1}$.

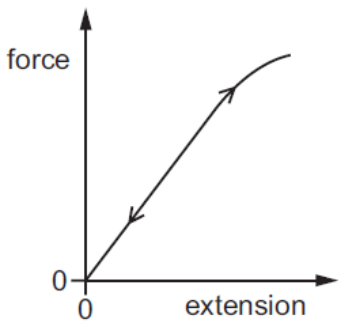
What is the strain of the extended spring?

A 0.019 **B** 0.083 **C** 1.85 **D** 2.67

10. March/2023/Paper_ 9702/12/No.19

A wire is fixed at one end and extended by a force that is applied to the other end. The force is slowly increased from zero and then slowly decreased back to zero.

The force–extension graph for the wire is shown.



The graph line for the wire being loaded is the same as the graph line for the wire being unloaded.

Which statement describes the deformation of the wire?

A It is both elastic and plastic.

B It is elastic only.

C It is neither elastic nor plastic.

D It is plastic only.

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11. March/2023/Paper_ 9702/22/No.2a (i)

A motor uses a wire to raise a block, as illustrated in Fig. 2.1.

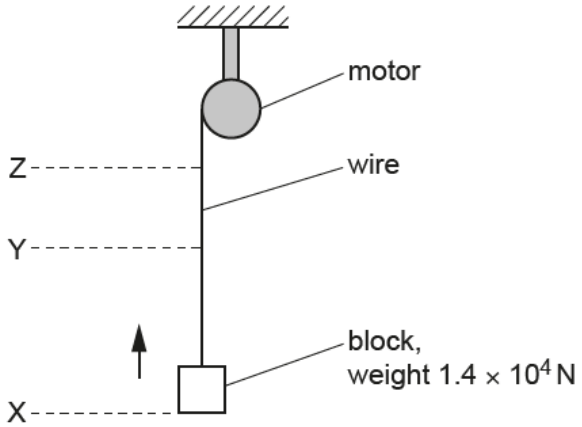


Fig. 2.1 (not to scale)

The base of the block takes a time of 0.49 s to move vertically upwards from level X to level Y at a constant speed of 0.64 m s^{-1}. During this time the wire has a strain of 0.0012. The wire is made of metal of Young modulus 2.2 × 10^{11} Pa and has a uniform cross-section.

The block has a weight of 1.4 × 10^4 N. Assume that the weight of the wire is negligible.

(a) Calculate:

(i) the cross-sectional area *A* of the wire

A = ... m^2 [2]

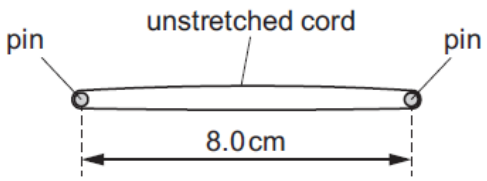
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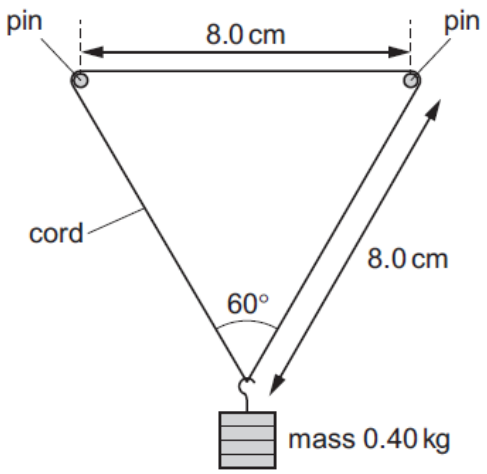
Deformation of Solid – 2023 Nov AS Physics 9702

1. Nov/2023/Paper_ 9702/11/No.18

An elastic cord of unstretched total length 16.0 cm and cross-sectional area $2.0 \times 10^{-6}\,m^2$ is held horizontally by two smooth pins a distance 8.0 cm apart.

The cord obeys Hooke's law. A load of mass 0.40 kg is suspended centrally on the cord. The angle between the two sides of the cord supporting the load is 60°.



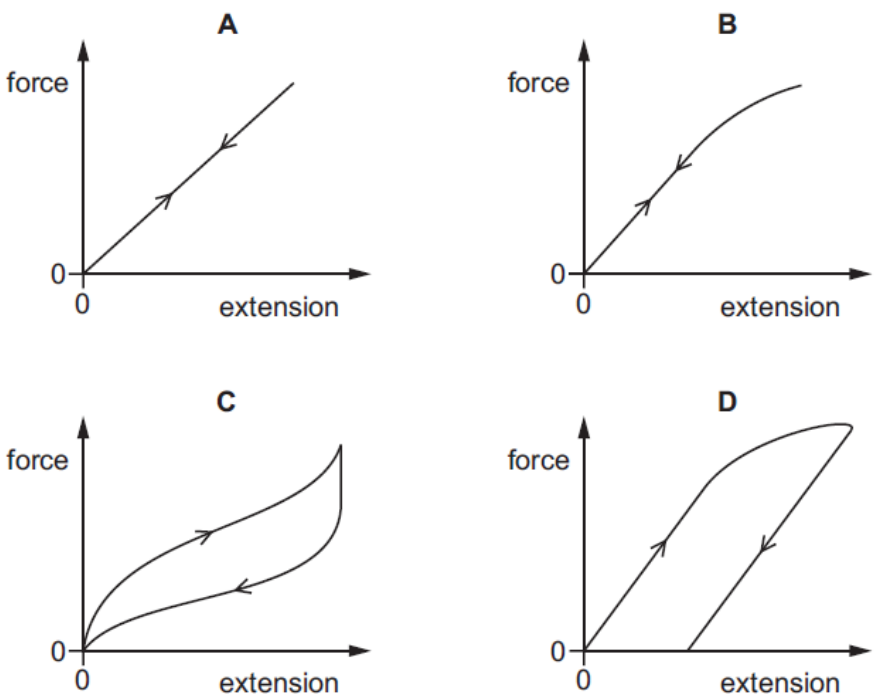


What is the Young modulus of the cord material?

A $5.7 \times 10^5\,Pa$ **B** $1.1 \times 10^6\,Pa$ **C** $2.3 \times 10^6\,Pa$ **D** $3.9 \times 10^6\,Pa$

2. Nov/2023/Paper_ 9702/11/No.19

Which force–extension graph shows plastic deformation of a sample of material?

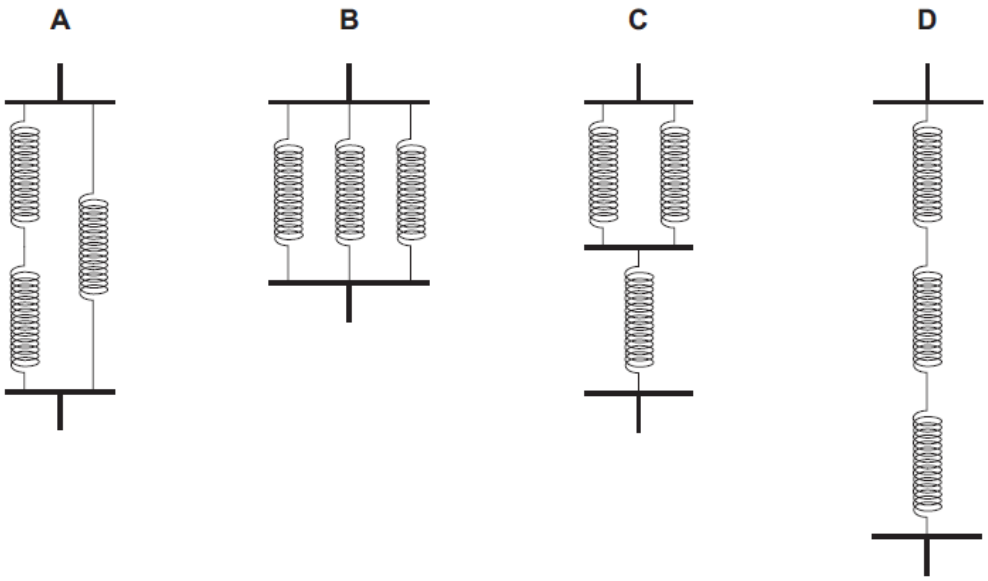


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3. Nov/2023/Paper_ 9702/12/No.18

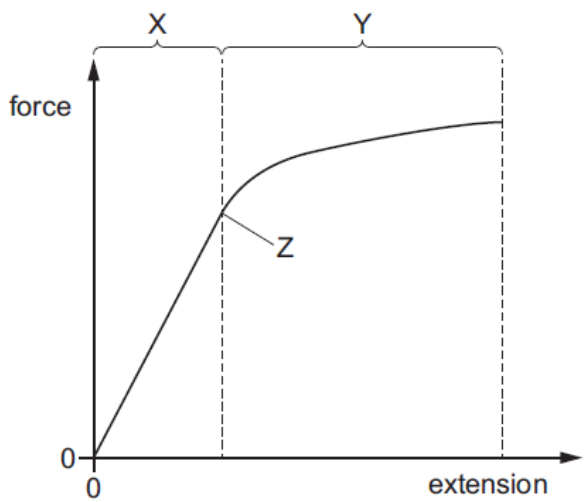
Three identical springs, each with the same spring constant, are connected together in four different arrangements, as shown.

Which arrangement has the largest combined spring constant?



4. Nov/2023/Paper_ 9702/12/No.19

The force–extension graph for a wire is shown.



Which row could identify the labels X, Y and Z?

	limit of proportionality	region of elastic deformation	region of plastic deformation
A	X	Y	Z
B	Z	Y	X
C	Y	Z	X
D	Z	X	Y

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5. Nov/2023/Paper_ 9702/13/No.18

A copper wire of diameter 1.6 mm is stretched within its limit of proportionality by a tensile force of 430 N.

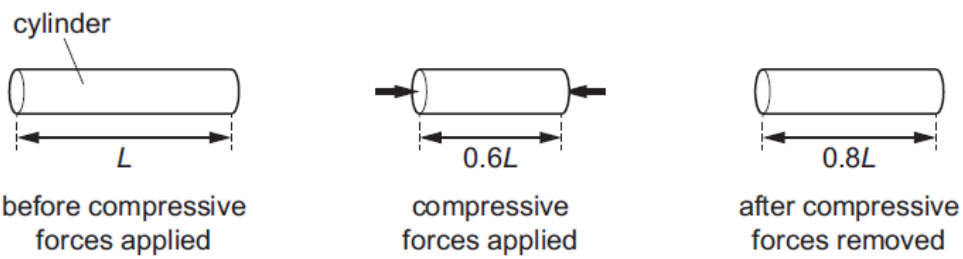
The Young modulus of copper is 130 GPa.

What is the strain in the wire?

A 4.1×10^{-4} **B** 1.3×10^{-3} **C** 1.6×10^{-3} **D** 5.2×10^{-3}

6. Nov/2023/Paper_ 9702/13/No.19

Compressive forces are applied normally to the end faces of a cylinder of initial length L. The cylinder is compressed by the forces so that its length decreases to $0.6L$. After the compressive forces are removed, the cylinder's length increases to $0.8L$.



before compressive forces applied | compressive forces applied | after compressive forces removed

What describes the deformation of the cylinder when its length was $0.6L$?

A both elastic and plastic

B elastic only

C plastic only

D neither elastic nor plastic

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7. Nov/2023/Paper_ 9702/21/No.2(c)

A hot-air balloon floats just above the ground. The balloon is stationary and is held in place by a vertical rope, as shown in Fig. 2.1.

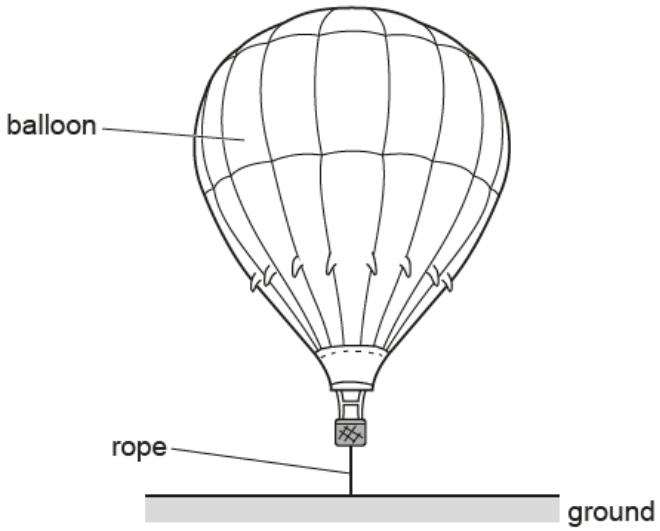


Fig. 2.1

The balloon has a weight W of 3.39×10^4 N. The tension T in the rope is 4.00×10^2 N.
Upthrust U acts on the balloon.
The density of the surrounding air is $1.23\,\text{kg}\,\text{m}^{-3}$.

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(c) Before the balloon is released, the rope holding the balloon has a strain of 2.4×10^{-5}. The rope has an unstretched length of 2.5 m. The rope obeys Hooke's law.

(i) Show that the extension of the rope is 6.0×10^{-5} m.

[1]

(ii) Calculate the elastic potential energy E_P of the rope.

E_P = ... J [2]

(iii) The rope holding the balloon is replaced with a new one of the same original length and cross-sectional area. The tension is unchanged and the new rope also obeys Hooke's law.

The new rope is made from a material of a lower Young modulus.

State and explain the effect of the lower Young modulus on the elastic potential energy of the rope.

.....

.....

..... [2]

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8. Nov/2023/Paper_ 9702/22/No.3

A vertical rod is fixed to the horizontal surface of a table, as shown in Fig. 3.1.

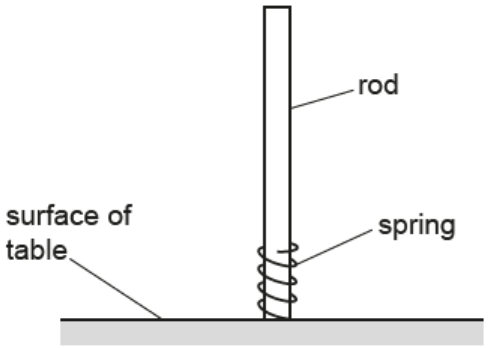


Fig. 3.1 (not to scale)

A spring of mass 7.5 g is able to slide along the full length of the rod.

The spring is first pushed against the surface of the table so that it has an initial compression of 2.1 cm. The spring is then suddenly released so that it leaves the surface of the table with a kinetic energy of 0.048 J and then moves up the rod.

Assume that the spring obeys Hooke's law and that the initial elastic potential energy of the compressed spring is equal to the kinetic energy of the spring as it leaves the surface of the table. Air resistance is negligible.

(a) By using the initial elastic potential energy of the compressed spring, calculate its spring constant.

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

(b) Calculate the speed of the spring as it leaves the surface of the table.

speed = ... $m\,s^{-1}$ [2]

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(c) The spring rises to its maximum height up the rod from the surface of the table. This causes the gravitational potential energy of the spring to increase by 0.039 J.

(i) Calculate, for this movement of the spring, the increase in height of the spring after leaving the surface of the table.

increase in height = ... m [2]

(ii) Calculate the average frictional force exerted by the rod on the spring as it rises.

average frictional force = ... N [2]

(d) The rod is replaced by another rod that exerts negligible frictional force on the moving spring. The initial compression x of the spring is now varied in order to vary the maximum increase in height Δh of the spring after leaving the surface of the table. Assume that the spring obeys Hooke's law for all compressions.

On Fig. 3.2, sketch a graph to show the variation with x of Δh. Numerical values are not required.

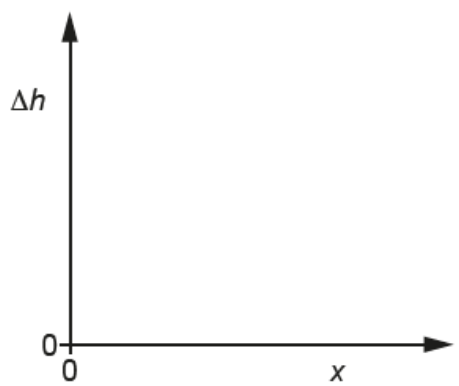


Fig. 3.2

[2]

[Total: 10]

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9. Nov/2023/Paper_ 9702/23/No.4

Fig. 4.1 shows the variation with extension x of the tensile force F for two wires, G and H, made from the same material.

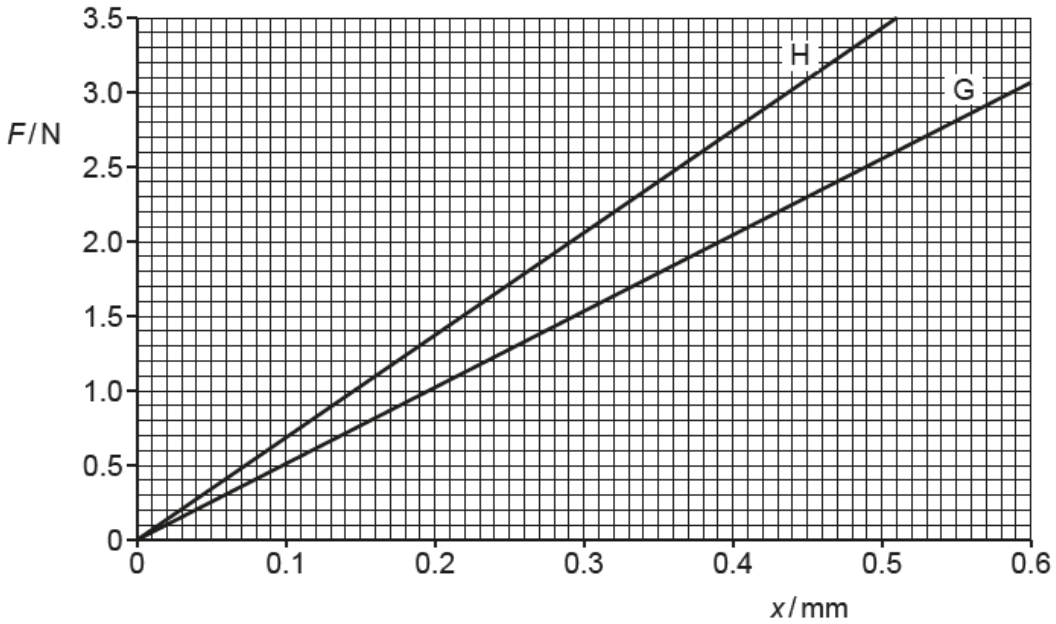


Fig. 4.1

The elastic limit has not been exceeded for G or H.

(a) For the lines in Fig. 4.1:

(i) state what is represented by the gradient

..... [1]

(ii) explain why the area under the line represents the elastic potential energy of the wire.

.....

.....

.....

..... [2]

(b) Wires G and H are joined together end-to-end to form a composite wire of negligible weight. The composite wire hangs vertically from a fixed support.

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A block of weight of 2.0 N is attached to the end of the wire, as shown in Fig. 4.2.

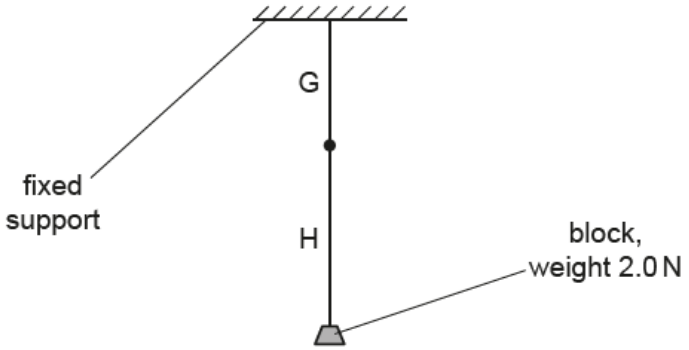


Fig. 4.2

(i) Use Fig. 4.1 to determine:

- the extension x_G of wire G

x_G = ... mm

- the extension x_H of wire H.

x_H = ... mm
[1]

(ii) Calculate the total elastic potential energy E_P of the composite wire due to the weight of the block.

E_P = ... J [2]

(iii) The original length of wire G is L and the original length of wire H is $1.5L$.

Calculate the ratio

$$\frac{\text{cross-sectional area of wire G}}{\text{cross-sectional area of wire H}}.$$

ratio = ... [3]

[Total: 9]

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