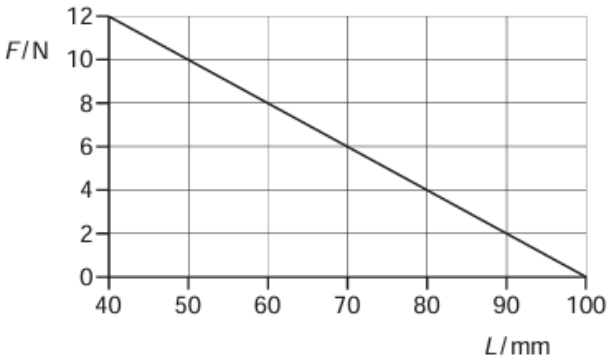
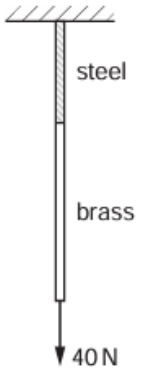
**22** A spring of original length 100 mm is compressed by a force. The graph shows the variation of the compressing force $F$ with the length $L$ of the spring.




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

**23** 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 $2.0 \times 10^{11}$ Pa.

The Young modulus of brass is $1.0 \times 10^{11}$ Pa.

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

The wires obey Hooke's law.

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

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

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

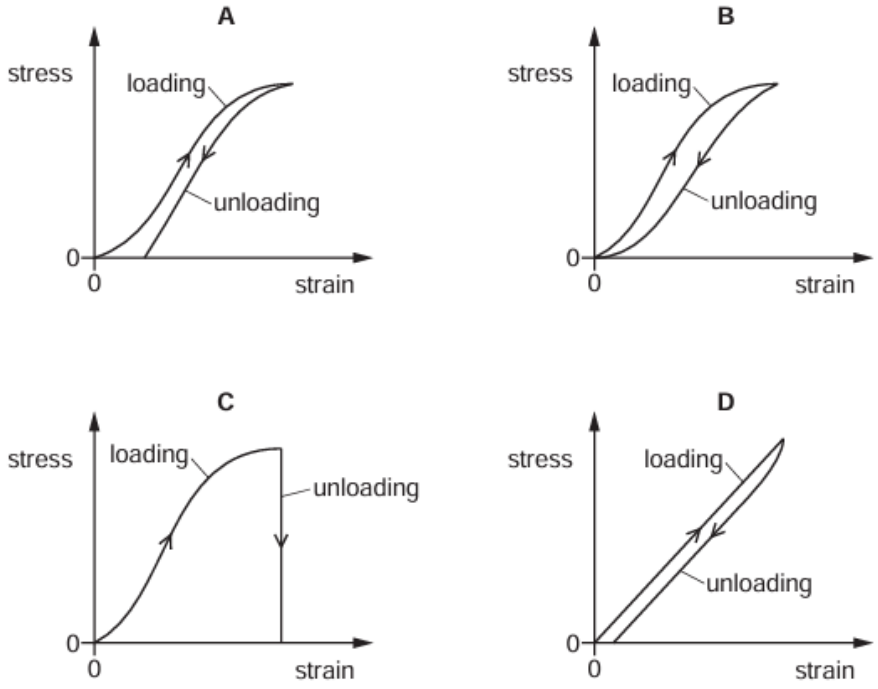
The same force is applied to wire Y of the same material, with the same initial length but twice the diameter of wire X. Both wires obey Hooke's law.

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

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

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

Which material exhibits purely elastic behaviour?




**26** 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** $2.0 \times 10^{8}\,N\,m^{-2}$

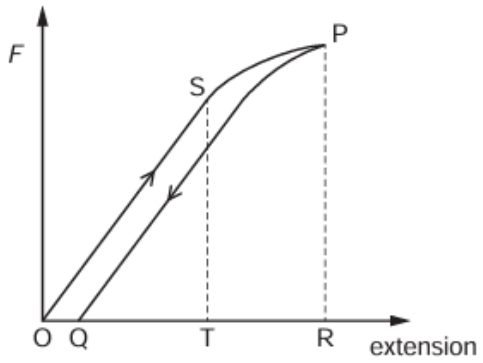
**B** $2.0 \times 10^{11}\,N\,m^{-2}$

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

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

**27** 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.



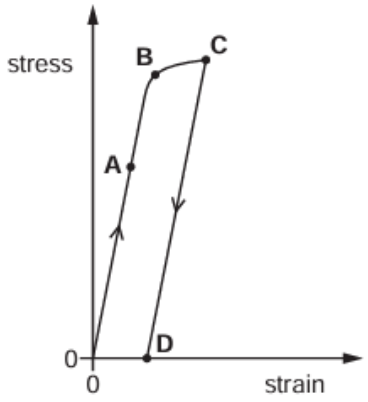

Which area on the graph represents the work done by the wire as it contracts?

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

**28** 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?



**29** 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.

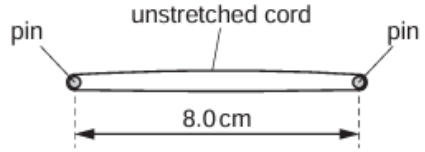
**B** If the rubber band stretches elastically, it obeys Hooke's law.

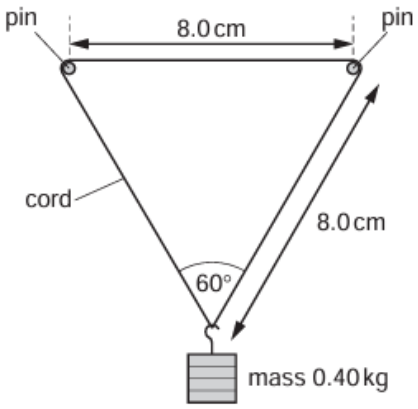
**C** If the rubber band stretches elastically, the gradient of the force–extension graph represents the work done by the force.

**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.

**30** An elastic cord of unstretched total length 16.0 cm and cross-sectional area $2.0 \times 10$ m 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°.

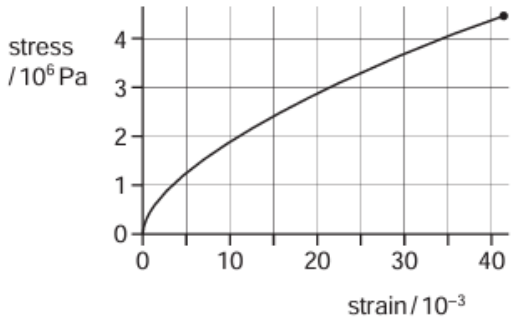



What is the Young modulus of the cord material?

**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

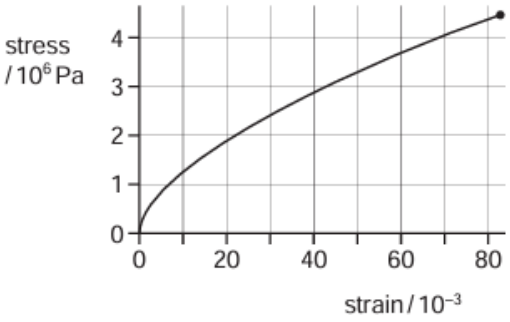
**31** A student is investigating the mechanical properties of a metal. He applies different loads to a long thin wire up to its breaking point, and measures the extension of the wire for each load. He then plots a graph of stress against strain.



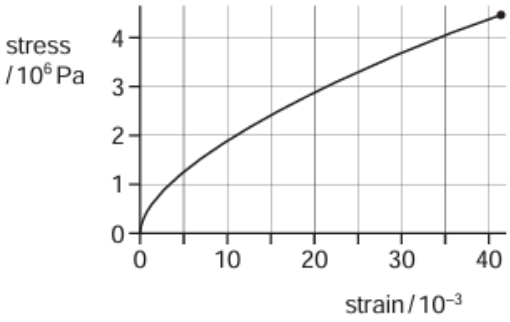

The student repeats the experiment with a wire made from the same metal, with twice the original length and half the diameter.

Which graph is obtained?

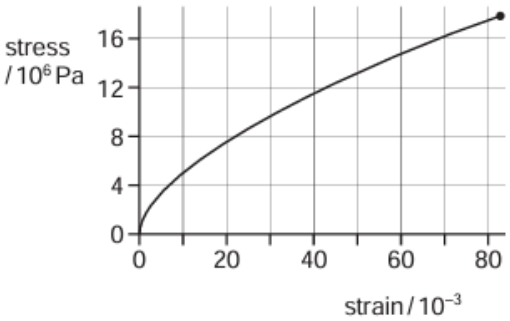
**A**



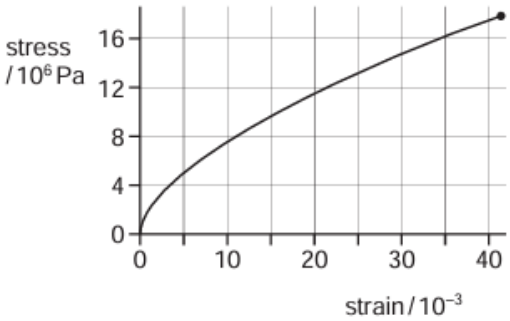

**B**




**C**




**D**



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

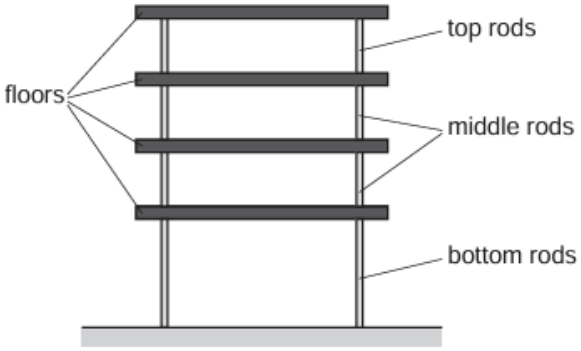
**A** It always obeys Hooke's law.

**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.

**33** 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.

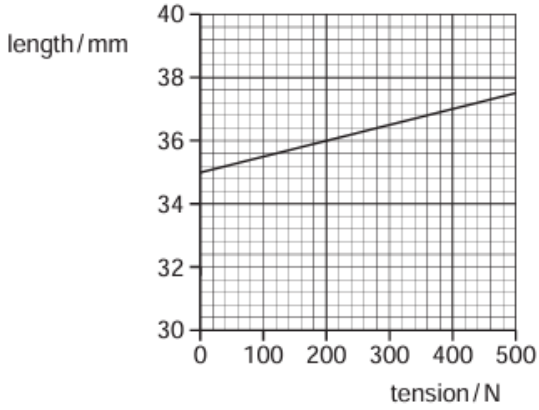
What is the ratio $\frac{\text{diameter of bottom rods}}{\text{diameter of top rods}}$?

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

**9702/13/M/J/20/Q21**

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

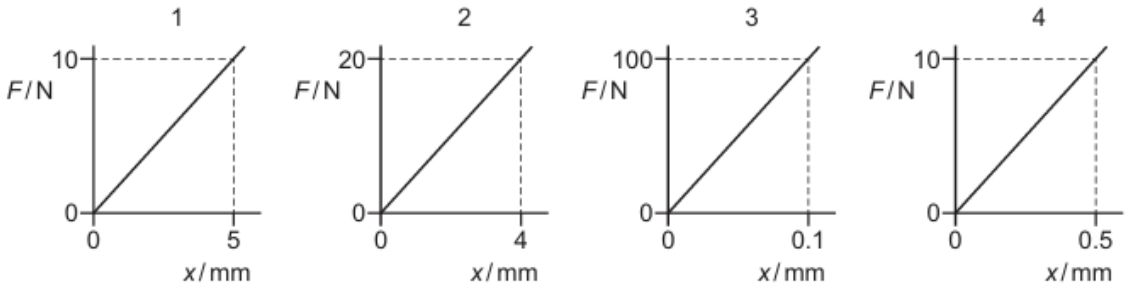
The graph shows the variation with tension of the length of the tendon.




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

**35** 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?

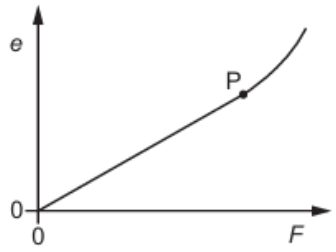
**A** $2 \rightarrow 1 \rightarrow 3 \rightarrow 4$

**B** $3 \rightarrow 4 \rightarrow 2 \rightarrow 1$

**C** $4 \rightarrow 2 \rightarrow 1 \rightarrow 3$

**D** $4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

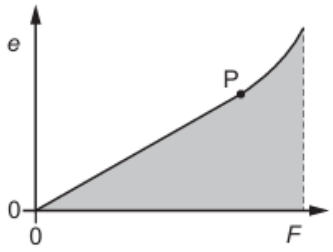
**36** Forces are applied to the ends of a rod so that its length increases. The variation with force $F$ of the extension $e$ of the rod is shown.



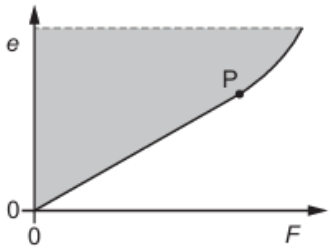

The point P is the elastic limit.

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

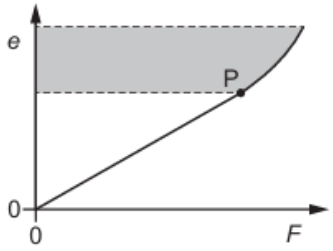
**A**



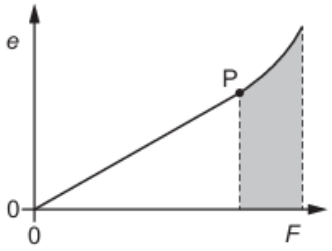

**B**




**C**




**D**




**37** 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

**38** 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 $\frac{\text{strain energy in stretched string X}}{\text{strain energy in stretched string Y}}$?

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

**39** The stress $\sigma$ in a material is given by the equation shown.

$$\sigma = \frac{F}{A}$$

The strain $\varepsilon$ in the same material is given by the equation shown.

$$\varepsilon = \frac{x}{L}$$

Which expression gives the Young modulus of the material?

**A** $\frac{\varepsilon}{\sigma}$ **B** $\frac{Fx}{AL}$ **C** $\frac{\sigma x}{L}$ **D** $\frac{F}{A\varepsilon}$

**40** What is an example of plastic deformation?

**A** A rubber ball is momentarily compressed every time it hits the ground.

**B** A spoon stirring some coffee in a ceramic mug hits its surface and makes a clinking sound.

**C** A toolbox is left on a horizontal plank. When the toolbox is removed, the plank is no longer straight.

**D** The spring in some bathroom weighing scales is compressed by a person standing on the scales.