6. Deformation of Solids

6.2 Elastic and plastic behaviour

Paper 1

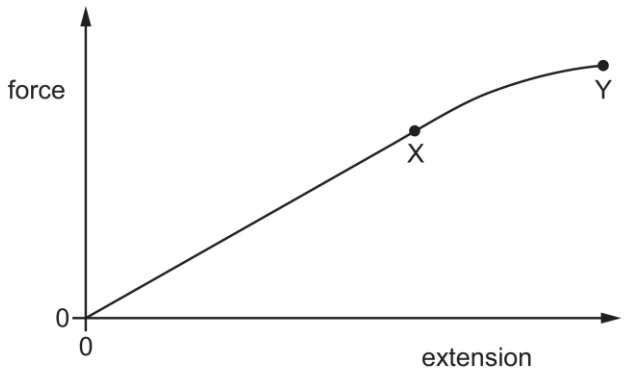
Question Paper

1 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 potential energy stored in the wire?

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

2 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 elastic but **not** plastic

D plastic but **not** elastic

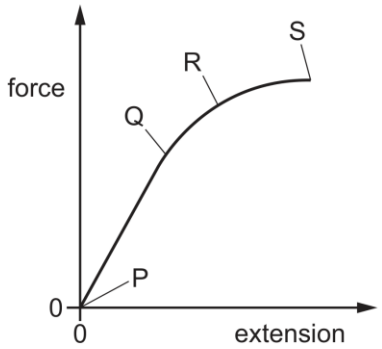
3 A spring of spring constant $30\,\text{N}\,\text{m}^{-1}$ is suspended vertically from its top. The spring obeys Hooke's law. Initially the spring is not compressed and not stretched. A mass of 0.50 kg is attached to the bottom of the spring. The mass is released from rest and falls.

Frictional effects are negligible.

In the motion that follows, what is the maximum extension of the spring?

A 0.017 m **B** 0.033 m **C** 0.16 m **D** 0.33 m

4 A wire is stretched by a gradually increasing force. The force–extension graph for the wire is shown.



Which statement **must** be correct?

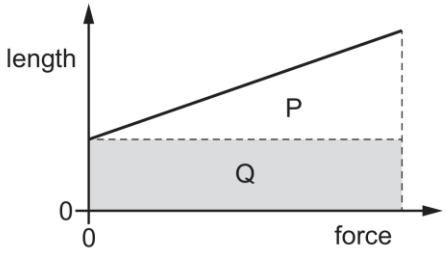
A Point Q is the elastic limit.

B Point R is the limit of proportionality.

C The area under the graph from P to S is the elastic potential energy stored in the wire.

D The area under the graph from P to S is the work done in stretching the wire.

5 The graph shows how the length of a spring varies with the force applied to it. Two areas P and Q are labelled.



Which area represents the work done in stretching the spring?

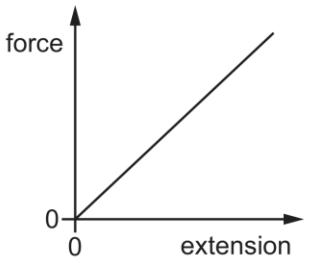
A area P

B area Q

C area P + area Q

D area Q – area P

6 The force–extension graph for a spring is shown.



What represents the work done to extend the spring?

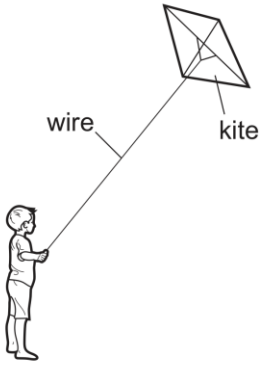
A the area under the graph

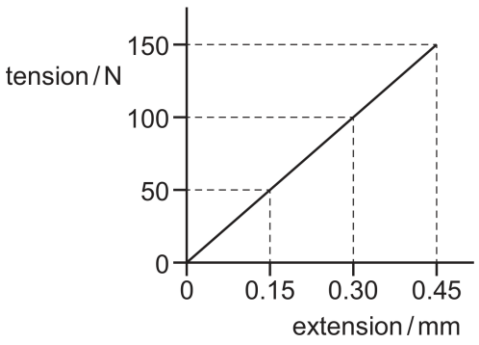
B the gradient of the graph

C the reciprocal of the gradient of the graph

D twice the area under the graph

7 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.



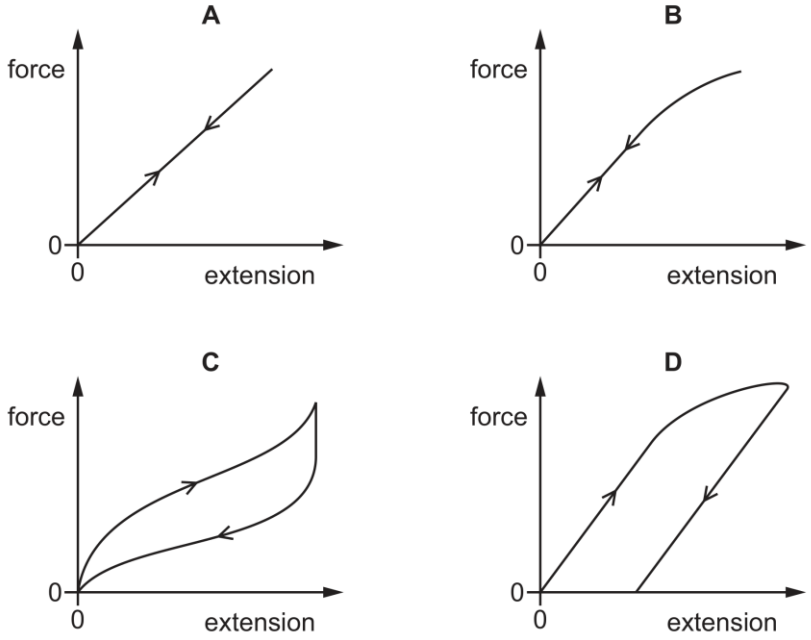


A gust of wind increases the tension from 100 N to 150 N.

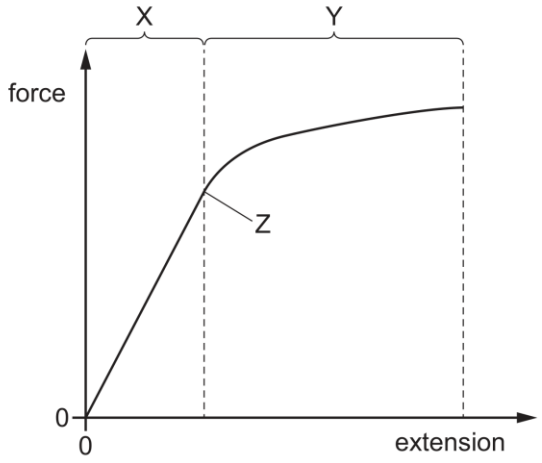
What is the change in the elastic potential energy of the wire caused by the gust of wind?

A 3.8 mJ **B** 19 mJ **C** 34 mJ **D** 38 mJ

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



9 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

10 Which statement about elastic and plastic deformation **must** be correct?

A Elastic deformation and plastic deformation are proportional to the applied force.

B Elastic deformation and plastic deformation cause no change in volume.

C Elastic deformation causes heating of the material but plastic deformation does not.

D Elastic deformation is reversible but plastic deformation is not.

11 A wire is being stretched by a tensile force.

Which statement about the elastic limit **must** be correct?

A The deformation is plastic after the elastic limit has been reached.

B The deformation is plastic until the elastic limit is reached.

C The extension is proportional to the tensile force after the elastic limit has been reached.

D The extension is proportional to the tensile force until the elastic limit is reached.

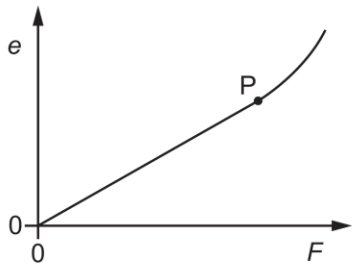
12 An unstretched spring has a length of 2.0 cm.

The spring is then stretched within its limit of proportionality by a tensile force of 1.5 N so that the elastic potential energy stored in the spring is 0.045 J.

What is the stretched length of the spring?

A 3.0 cm **B** 5.0 cm **C** 6.0 cm **D** 8.0 cm

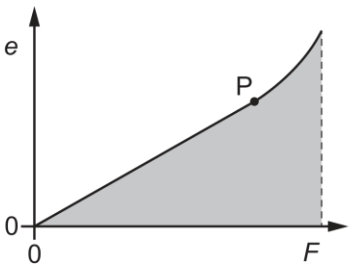
13 Forces are applied to the ends of a rod so that its length increases. The variation with force *F* of the extension *e* of the rod is shown.



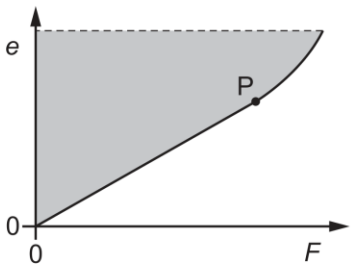
The point P is the elastic limit.

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

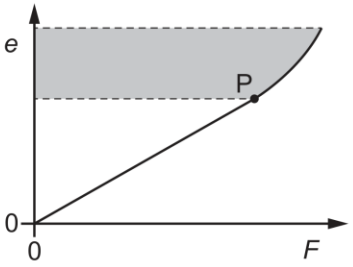
A



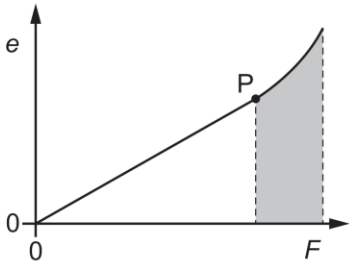
B



C



D



14 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 2*F* that causes an extension 2*x*.

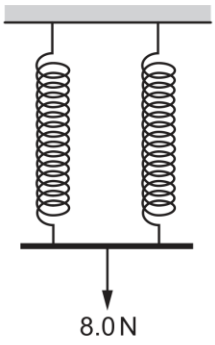
The strings obey Hooke's law.

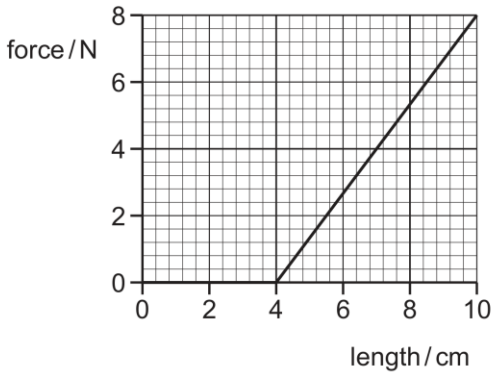
What is the ratio $\frac{\text{strain energy in stretched string X}}{\text{strain energy in stretched string Y}}$?

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

15 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.

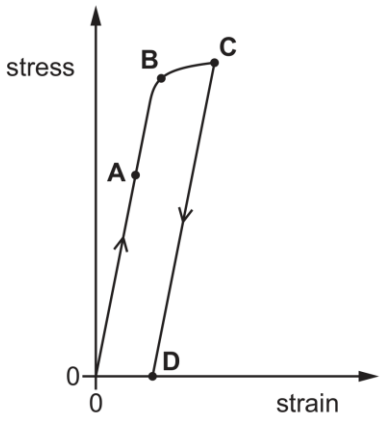
What is the strain energy in **one** of the springs?

A 0.060 J **B** 0.12 J **C** 0.14 J **D** 0.24 J

16 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?



17 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?

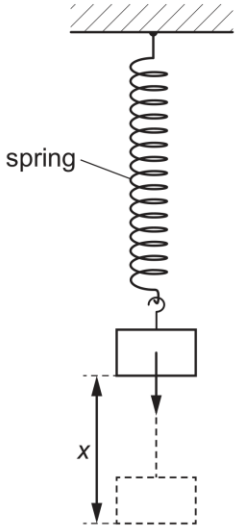
A If the rubber band stretches elastically and plastically, all the work done by the force is converted to thermal energy in the rubber.

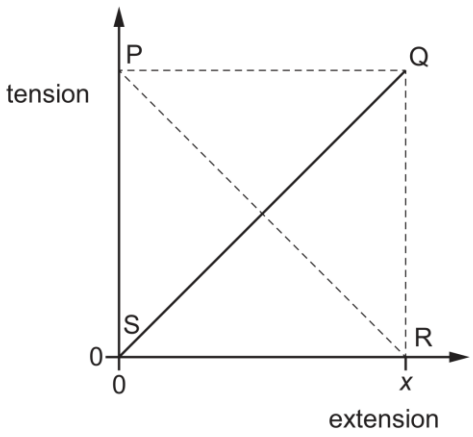
B If the rubber band stretches elastically, it obeys Hooke's law.

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.

18 A spring is attached at one end to a fixed point. A mass is then hung from the other end of the spring. The spring has extension x when the system is in equilibrium.





The variation of the tension in the spring with its extension is shown on the graph.

Which statement is correct?

A Area SPR represents the energy stored in the spring which cannot be recovered.

B Area SPQR represents the energy stored in the spring which can be recovered.

C Area SPQ represents the loss of gravitational potential energy of the mass due to the extension of the spring.

D Area SQR represents the elastic potential energy stored in the spring.

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

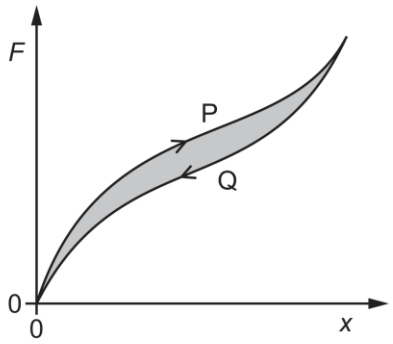
A It always obeys Hooke's law.

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.

20 An unstretched rubber cord is stretched by a force. The force *F* is plotted against the extension *x*. *F* is slowly increased from zero, causing the cord to extend along path P. *F* is then reduced back to zero along path Q.



What is represented by the shaded area?

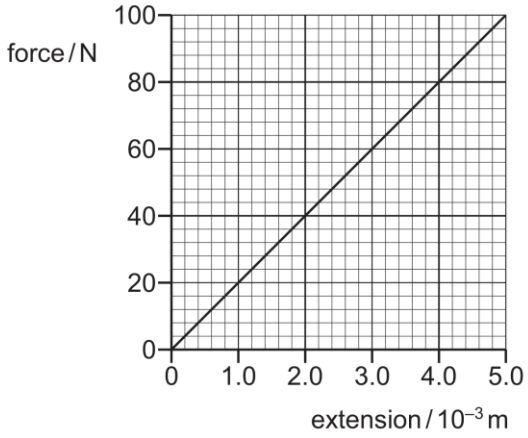
A the elastic energy stored in the rubber cord

B the energy that causes plastic deformation

C the energy dissipated as heat

D the work done to extend the rubber cord

21 The graph shows the force–extension graph for a wire.

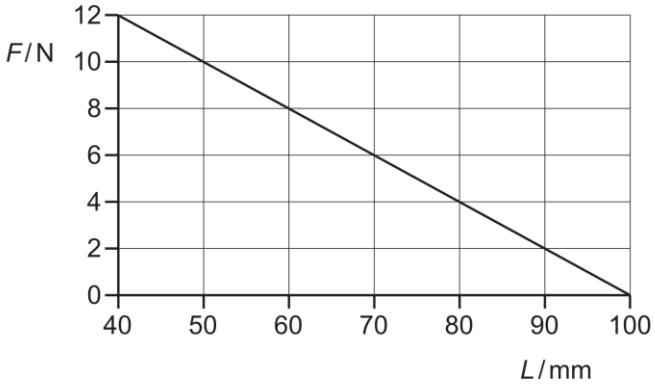


The wire is already extended by a force of 60 N.

How much work is done to increase the extension of the wire by 2.0 mm?

A 0.040 J **B** 0.090 J **C** 0.16 J **D** 0.25 J

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 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.

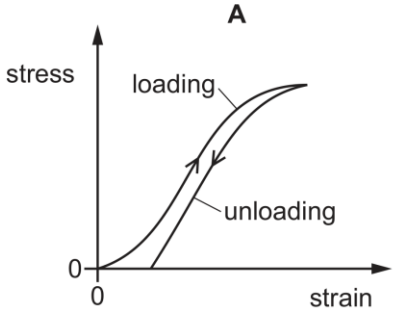
What is the gain in elastic potential energy of wire Y?

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

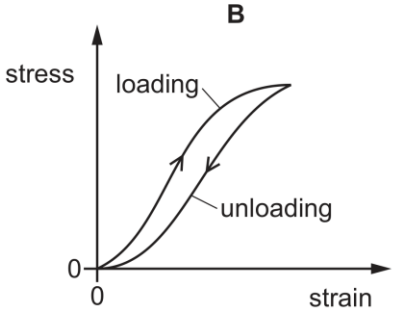
24 The stress-strain graphs for loading and unloading four different materials are shown.

Which material exhibits purely elastic behaviour?

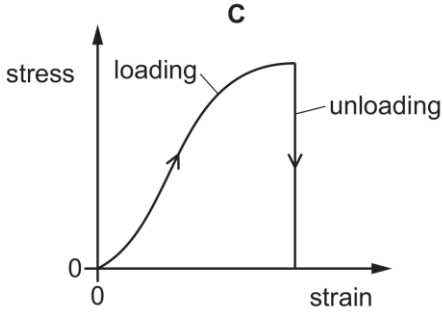
A



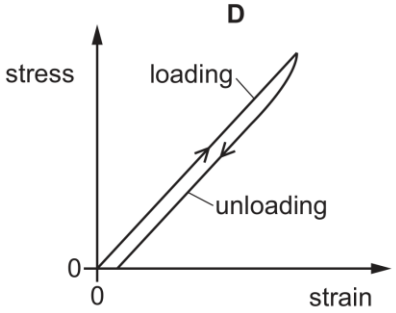
B



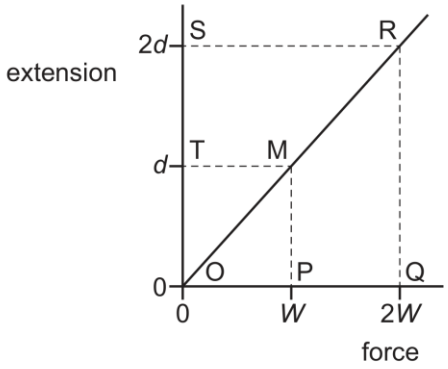
C



D



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

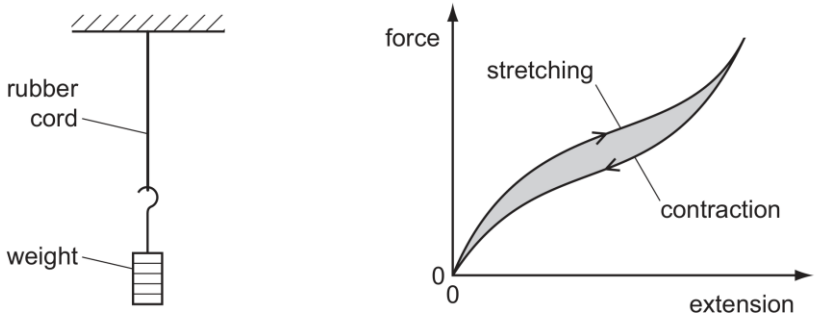


Initially a force W gives an extension d. The force is then increased to $2W$. This increases the extension to $2d$.

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

26 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

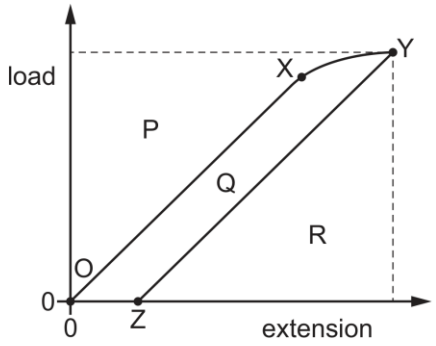
D the work done by the rubber cord during contraction

27 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** $\frac{S^2}{2E}$

28 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