

Deformation of Solids

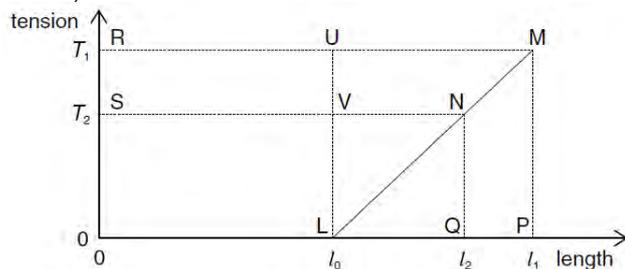
May 02

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

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

2. A wire is stretched by 8 mm when a load of 60 N is applied. What will be the extension of a wire of the same material having four times the cross-sectional area and twice the original length, when the same load is applied?
A 2 mm **B** 4 mm **C** 8 mm **D** 16 mm

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).

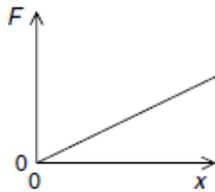


Which area of the graph represents the work done by the spring during this reduction in length?

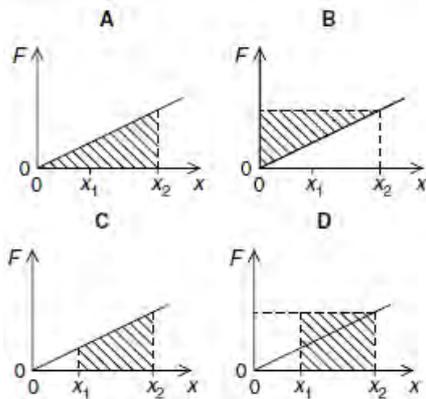
- A** MLP **B** MNQP **C** MNSR **D** MPLU

Nov 02

4. The variation of the extension x of a spring with applied force F is shown.



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

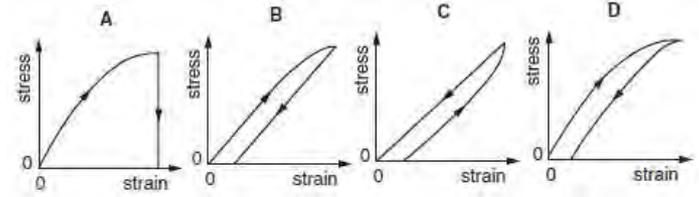


5. Two springs P and Q both obey Hooke's law. They have spring constants $2k$ and k respectively. The springs are stretched, separately, by a force that is gradually increased from zero up to a certain maximum value, the same for each spring. The work done in stretching spring P is W_P , and the work done in stretching spring Q is W_Q . How is W_P related to W_Q ?

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

June 03

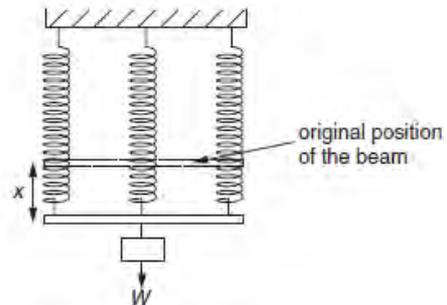
6. A suspended copper wire is gradually loaded until it is stretched just beyond the elastic limit, and it is then gradually unloaded. Which graph (with arrows indicating the sequence) best illustrates the variation of the tensile stress with longitudinal strain?



7. What is the ultimate tensile stress of a material?

- 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 .



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?

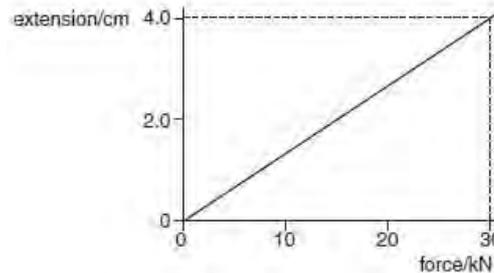
- A** $3x/2$ **B** $4x/3$ **C** $2x$ **D** $3x$

Nov 03

9. What is the Young modulus of a metal?

- 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.



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

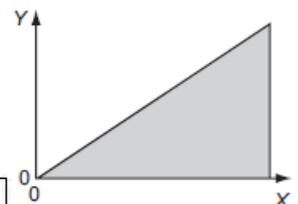
- A** 60 J **B** 120 J **C** 600 J **D** 1200 J

June 04

11. 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 |

12. Nylon breaks when the stress within it reaches 1×10^9 Pa. 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

Nov 04

13. Which two substances are normally both crystalline?

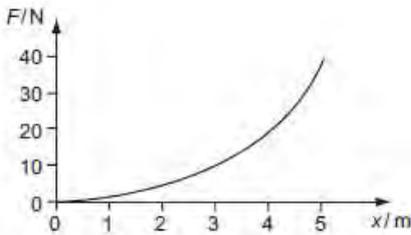
- A copper and diamond B copper and glass
C diamond and glass D diamond and rubber

14. The table shows a load applied to four wires and the cross-sectional area of each.

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 |

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

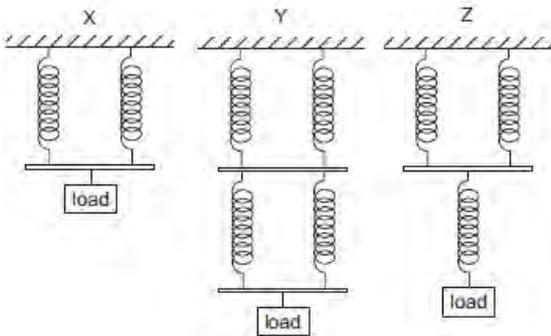


The energy stored in the rubber for an extension of 5 m is

- A less than 100 J. B 100 J.
C between 100 J and 200 J. D more than 200 J

June 05

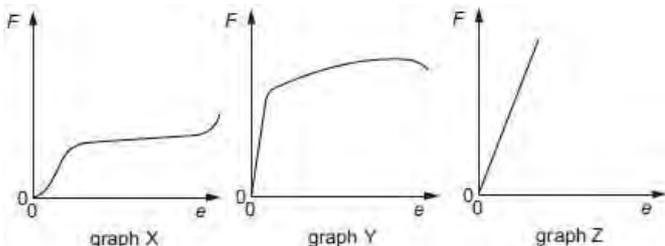
16. A number of similar springs, each having the same spring constant, are joined in three arrangements X, Y and Z. The same load is applied to each.



What is the order of increasing extension for these arrangements?

| | smallest | → | largest |
|----------|----------|---|---------|
| A | X | Y | Z |
| B | Z | X | Y |
| C | Z | Y | X |
| D | Y | X | Z |

17. 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.



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 |

18. Two steel wires P and Q have lengths l and $2l$ respectively, and cross-sectional areas A and $A/2$ respectively. Both wires obey Hooke's law.

What is the ratio $\frac{\text{tension in P}}{\text{tension in Q}}$

when both wires are stretched to the same extension?

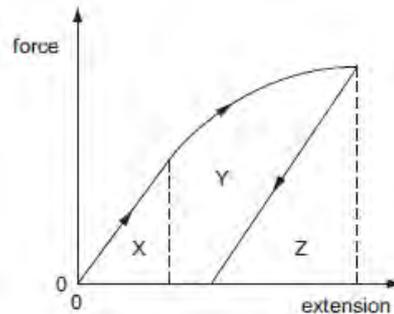
- A** $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{4}{1}$

Nov 05

19. When white sugar granules are heated, they melt. When the melt is cooled quickly, a brittle solid form of toffee is produced. How does the structure of the sugar change?

- A amorphous to polymeric B crystalline to amorphous
C crystalline to polymeric D polymeric to amorphous

20. A ductile material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below.



Which area represents the net work done on the sample?

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

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

A second wire of the same material, with half the diameter and a quarter of the original length of the first wire, is stretched by the same load. Assuming that Hooke's law is obeyed, what is the extension of this wire?

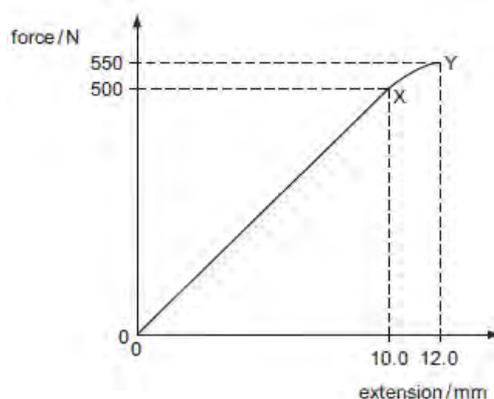
- A 1 mm B 4 mm C 8 mm D 16 mm

June 06

22. In describing the behaviour of a spring, the spring constant is used. Different loads are used to extend the spring by different amounts. To find the spring constant, which quantities are required?

- A the elastic limit and the loads
B the elastic limit, extensions and the length of the spring
C the loads and the extensions of the spring
D the loads and the length of the spring

23. The graph shows the behaviour of a sample of a metal when it is stretched until it starts to undergo plastic deformation.



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

Nov 06

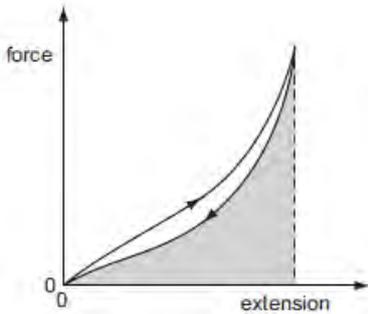
24. What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)?
 A elastic limit B spring constant
 C stress D the Young modulus

25. What is the unit of the Young modulus?
 A N m^{-1} B N m C N m^{-2} D N m^2

June 07

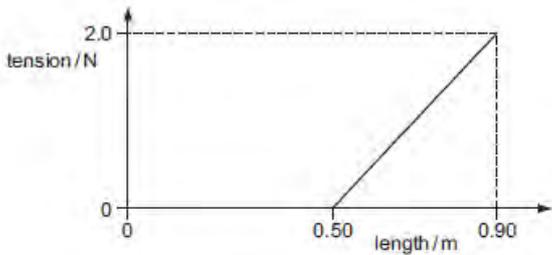
26. A piece of copper is drawn into a continuous wire. What behaviour is the copper exhibiting?
 A brittle only B elastic only
 C plastic only D both brittle and elastic

27. The force-extension graph of a particular sample of rubber as a load is applied and then removed is shown.



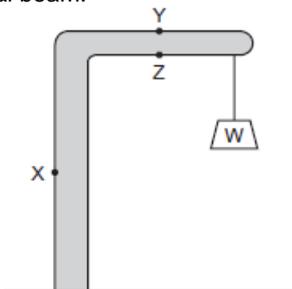
- What does the shaded area represent?
 A the energy transformed into heat during the complete cycle
 B the recoverable elastic potential energy stored at maximum extension
 C the work done on the sample while loading
 D the work done on the sample while unloading

28. 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.



- 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

29. A simple crane consists of a rigid vertical pillar supporting a horizontal beam.

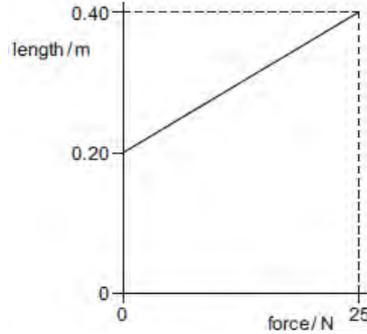


- A weight W is lifted by a rope at the end of the beam. What are the forces at points X, Y and Z due to the weight W?
- | | force at X | force at Y | force at Z |
|---|-------------|-------------|-------------|
| A | tension | compression | tension |
| B | tension | tension | compression |
| C | compression | tension | compression |
| D | compression | compression | compression |

Nov. 07

30. What is plastic deformation?
 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.

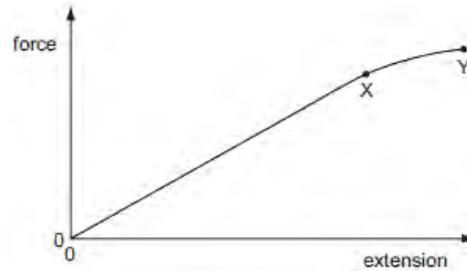
31. The graph shows how the length of a particular rubber cord varies as force is applied.



- 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

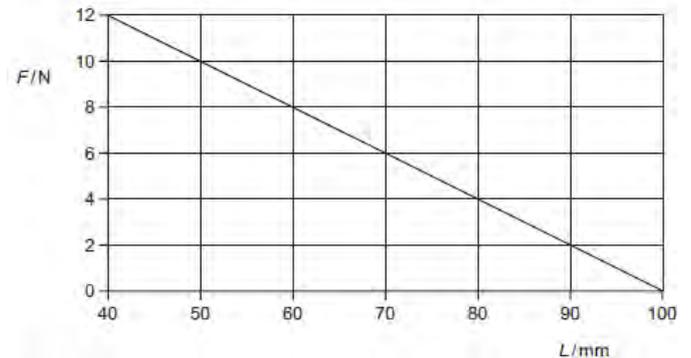
June 08

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.



- 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.



- 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

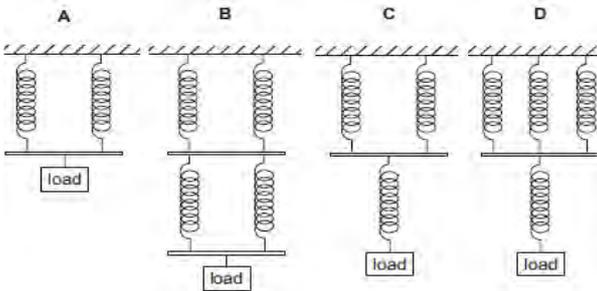
34. The Young modulus of steel is determined using a length of steel wire and is found to have the value E. Another experiment is carried out using a wire of the same steel, but of twice the length and half the diameter. What value is obtained for the Young modulus in the second experiment?

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

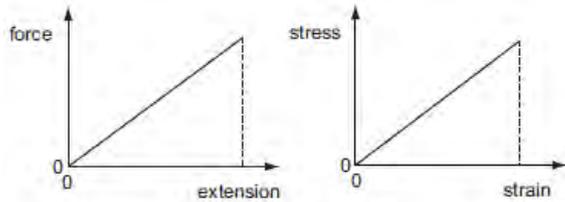
Nov 08

35. Which properties best describe modelling clay?
 A brittle and ductile B ductile and elastic
 C elastic and plastic D plastic and ductile

36. 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?



37. The graphs show how force varies with extension and stress varies with strain for the loading of a metal wire.



- 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.

38. 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

June 09

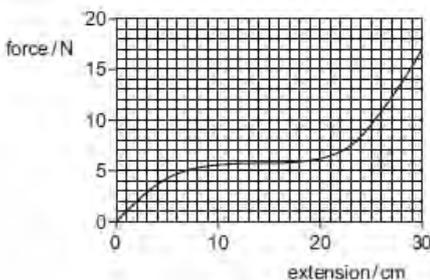
39. Four materials are formed into rods of the same dimensions. At room temperature, which can sustain the largest plastic deformation?
 A the ductile material aluminium
 B the brittle material carbon
 C the brittle material glass
 D the ductile material steel

40. Two steel wires P and Q have lengths l and $2l$ respectively, and cross-sectional areas A and $A/2$ respectively. Both wires obey Hooke's law.

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 $\frac{4}{1}$

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

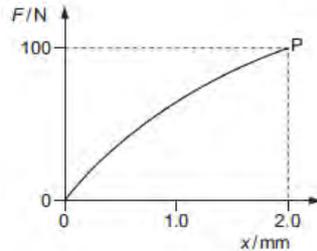


What is the best estimate of the strain energy stored in the rubber band when it is extended 30 cm?
 A 2.0 J B 2.6 J C 5.1 J D 200 J

Nov 09

42. Which row best defines elastic and plastic behaviour of a material?
 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 and size

43. 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 to point P?

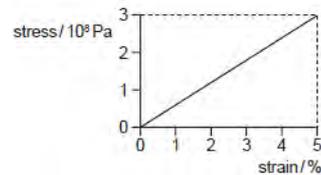
- A 0.09 J B 0.10 J C 0.11 J D 0.20 J

44. A steel string on an electric guitar has the following properties. 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 $5.1 \times 10^{-4} \%$ B $5.1 \times 10^{-2} \%$ C $1.3 \times 10^{-4} \%$ D $1.3 \times 10^{-2} \%$

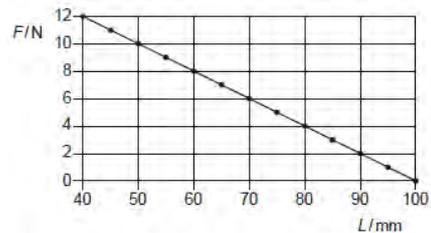
June 10

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



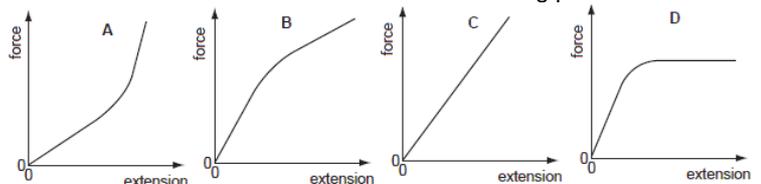
What is the value of the Young modulus for the material of the wire?
 A 6.0×10^7 Pa B 7.5×10^8 Pa C 1.5×10^9 Pa D 6.0×10^9 Pa

46. A spring is compressed by a force. The graph shows the compressing force F plotted against the length L of the spring.



What is the spring constant of this spring?
 A 0.2 N m^{-1} B 5 N m^{-1} C 100 N m^{-1} D 200 N m^{-1}

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



Answers

| | | | | | |
|-----|------|------|------|------|------|
| 1 c | 9 d | 17 d | 25 c | 33 a | 41 a |
| 2 b | 10 c | 18 d | 26 c | 34 c | 42 d |
| 3 b | 11 a | 19 b | 27 b | 35 d | 43 c |
| 4 c | 12 c | 20 b | 28 a | 36 c | 44 b |
| 5 b | 13 a | 21 c | 29 b | 37 c | 45 d |
| 6 b | 14 a | 22 c | 30 b | 38 c | 46 d |
| 7 b | 15 a | 23 b | 31 a | 39 a | 47 d |
| 8 d | 16 a | 24 b | 32 c | 40 d | |