

# Deformation of Solids

## TOPIC QUESTIONS (2)

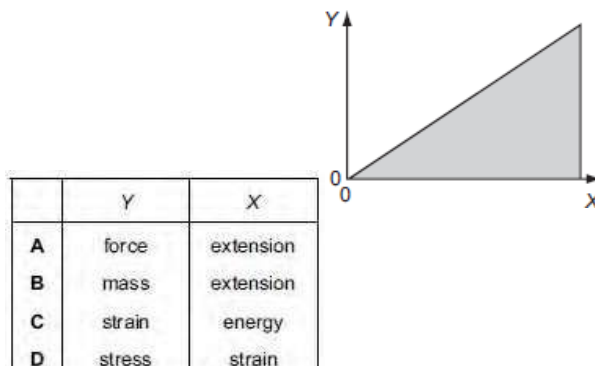
Level	A Level
Subject	Physics
Exam Board	CIE
Paper Type	Multiple Choice

Time Allowed : 1Hour 10Min

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1. 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?



2. Nylon breaks when the stress within it reaches  $1 \times 10^9$  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

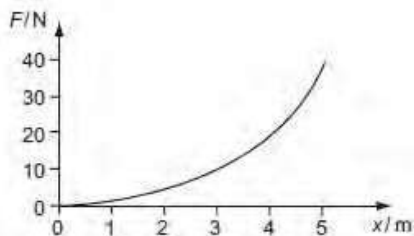
3. Which two substances are normally both crystalline?

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

4. 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 <sup>2</sup>
A	1500	0.25
B	2000	1.0
C	3000	0.56
D	5000	2.3

5. 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

6. When describing the behaviour of a spring, the spring constant is used.

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

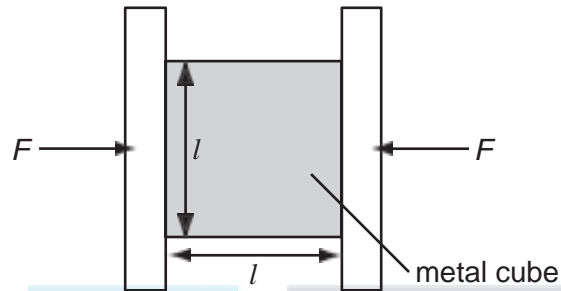
To find the spring constant, which quantities are required?

- A the elastic limit and the loads

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- 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

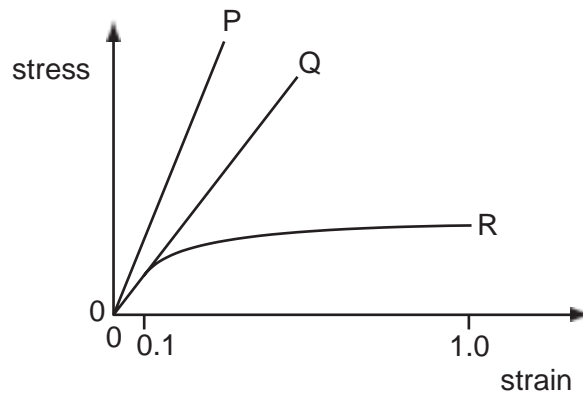
7. A metal cube of side  $l$  is placed in a vice and compressed elastically by two opposing forces  $F$ .



How will  $\Delta l$ , 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  $\Delta l \propto l^2$

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

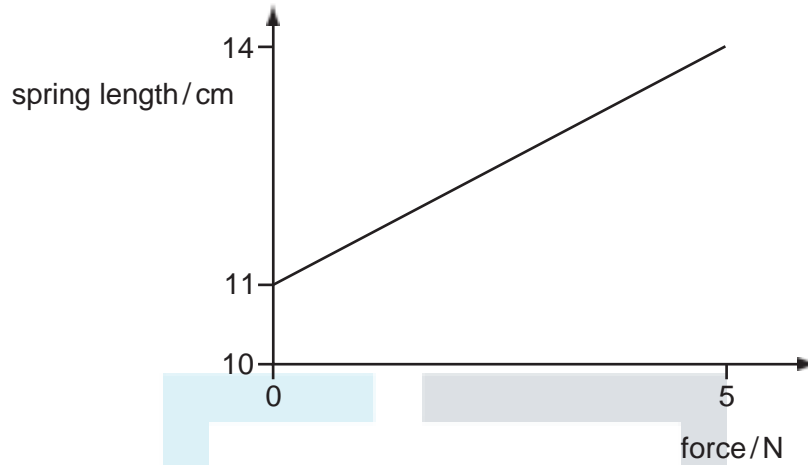


Which statements are correct?

- 1 The extension of P is approximately twice that of Q for the same stress.
- 2 The ratio of the Young modulus for P to that of Q is approximately two.
- 3 For strain less than 0.1, R obeys Hooke's law.

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

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

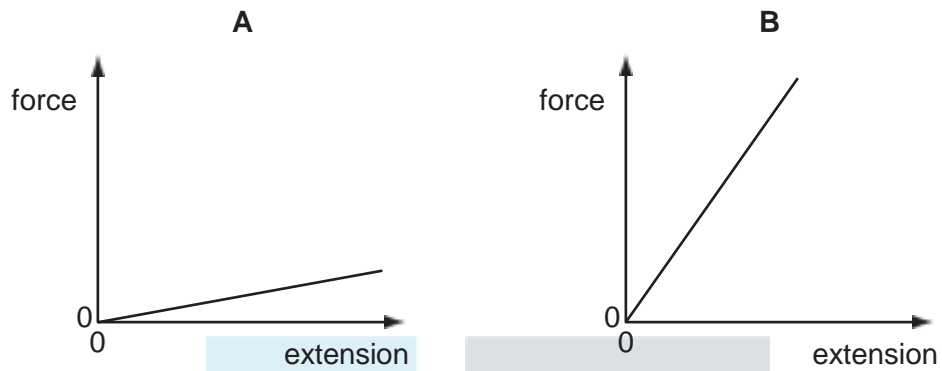


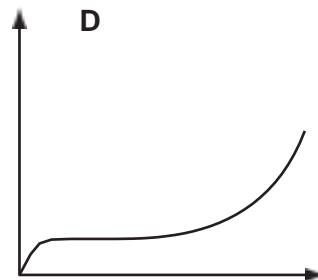
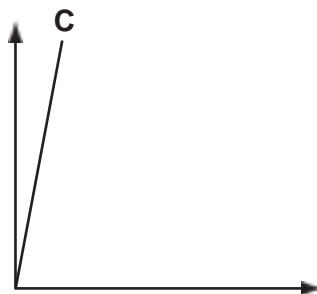
What is the total increase in length produced by a 7 N force, assuming the spring obeys Hooke's law?

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

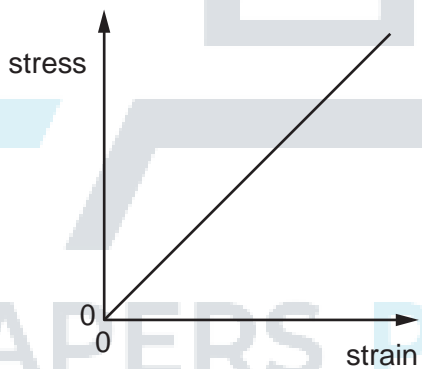
10. The following force-extension graphs are drawn to the same scale.

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



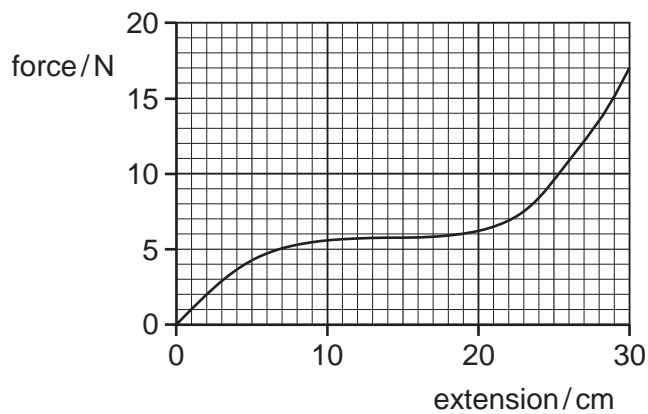


11. The stress-strain graph for a glass rod, up to the point at which it breaks, is shown below.



Which statement about the glass rod is correct?

- A Hooke's law is obeyed for all values of stress up to the breaking point.
  - B The glass is ductile.
  - C The glass shows plastic deformation.
  - D When the cross-sectional area of the rod is doubled, the ultimate tensile stress of the rod is halved.
12. A rubber band is stretched by hanging weights on it and the force-extension graph is plotted from the results.



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

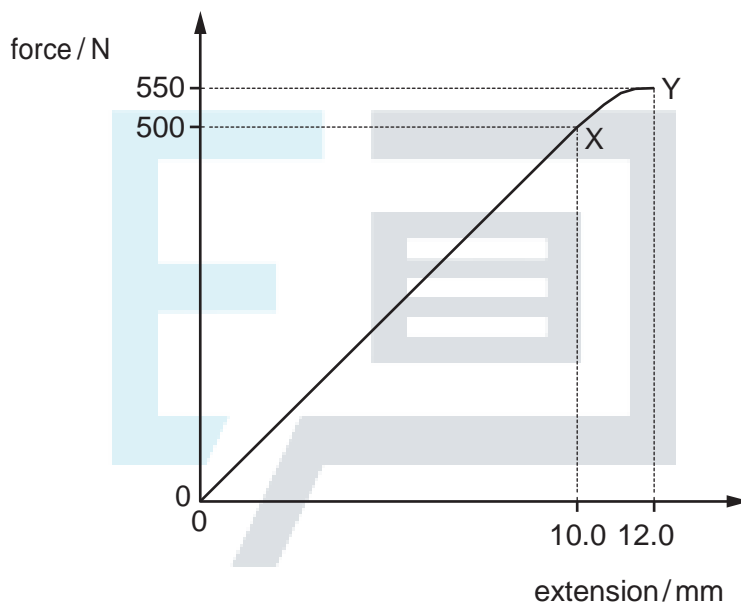
- A 1.8J      B 2.6J      C 5.1J      D 200J



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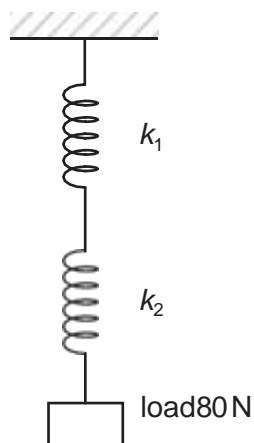
13. What is meant by the ultimate tensile stress of a material?
- A the maximum force that can be applied to a bar of the material before it bends
  - B the maximum inter-atomic force before the atomic bonds of the material break
  - C the maximum stretching force per unit cross-sectional area before the material breaks
  - D the maximum tensile force in a wire of the material before it breaks
14. 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 to 12.0 mm extension?  
Simplify the calculation by treating the curve XY as a straight line.

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

15. Two springs, one with spring constant  $k_1 = 4 \text{ kNm}^{-1}$  and the other with spring constant  $k_2 = 2 \text{ kNm}^{-1}$ , are connected as shown.



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

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

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

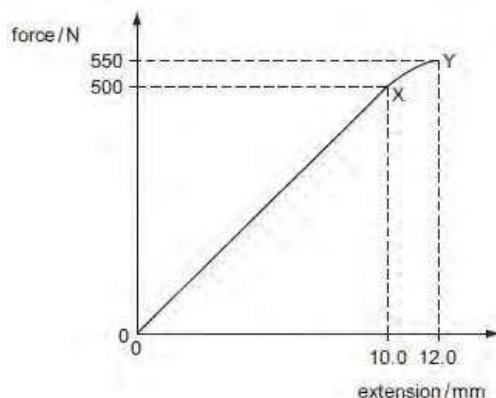
A second wire of the same material, with half the diameter and a quarter of the original length of the first wire, is stretched by the same load. Assuming that Hooke's law is obeyed, what is the extension of this wire?

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

17. 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

18. 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 straightline.

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

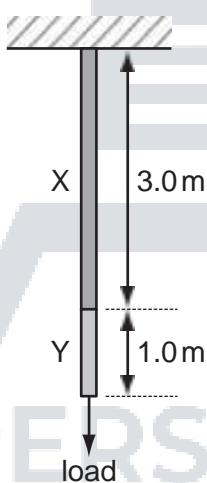
19. What is represented by the gradient of a graph of force (vertical axis) against extension (horizontal axis)?

- A elastic limit      B spring constant  
C stress      D the Young modulus

20. What is the unit of the Young modulus?

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

21. A wire consists of a 3.0 m length of metal X joined to a 1.0 m length of metal Y. 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

22. Which group of materials contains two polymers?

- A copper sand polystyrene
- B glass wood aluminium
- C nylon sugar rubber
- D stone diamond steel

23. Two wires P and Q are made from the same material.

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.

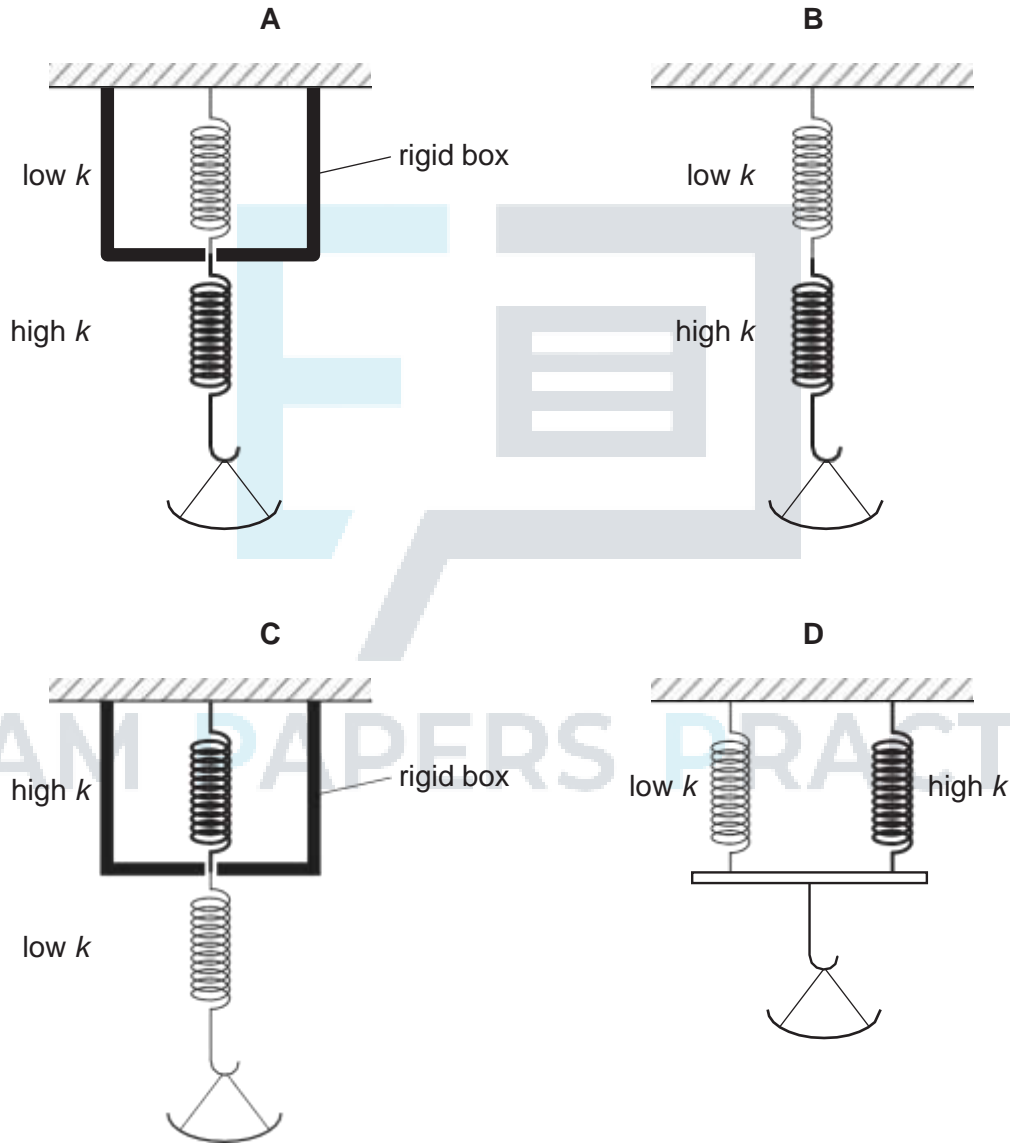
What is the ratio of the extension in P to that in Q?

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

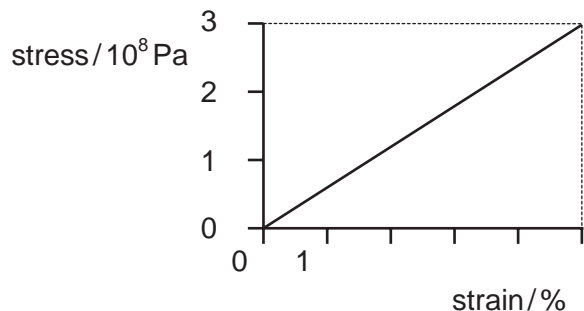
24. To determine the mass of food in a pan, a scale is used that has high sensitivity for small masses but low sensitivity for large masses.

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?



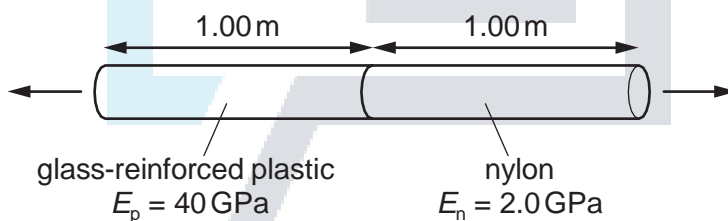
25. In stress-strain experiments on metal wires, the stress axis is often marked in units of  $10^8$  Pa and the strain axis is marked as a percentage. This is shown for a particular wire in the diagram.



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

- A  $6.0 \times 10^7$  Pa    B  $7.5 \times 10^8$  Pa    C  $1.5 \times 10^9$  Pa    D  $6.0 \times 10^9$  Pa

26. A composite rod is made by attaching a glass-reinforced plastic rod and a nylon rod end to end, as shown.



The rods have the same cross-sectional area and each rod is 1.00 m in length. The Young modulus  $E_p$  of the plastic is 40 GPa and the Young modulus  $E_n$  of the nylon is 2.0 GPa.

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

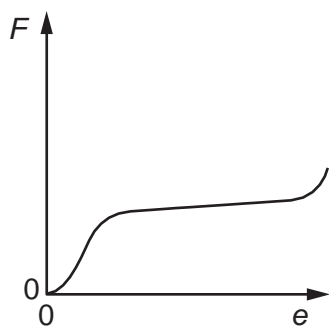
What is the greatest tensile stress that can be applied to the composite rod before it breaks?

- A  $7.1 \times 10^{-14}$  Pa  
 B  $7.1 \times 10^{-2}$  Pa  
 C  $5.7 \times 10^6$  Pa  
 D  $5.7 \times 10^9$  Pa
27. An elastic material with a Young modulus  $E$  is subjected to a tensile stress  $S$ . Hooke's Law is obeyed.

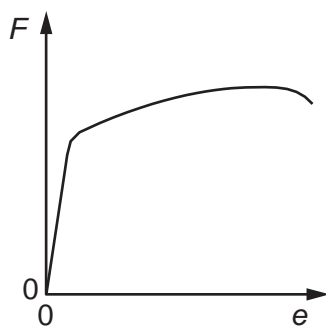
What is the expression for the elastic energy stored per unit volume of the material?

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

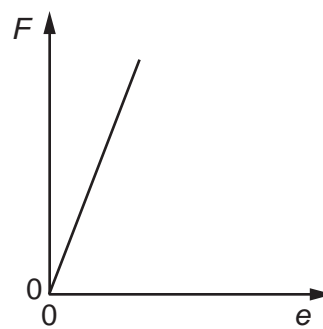
28. Cylindrical samples of steel, glass and rubber are each subjected to a gradually increasing tensile force  $F$ . The extensions  $e$  are measured and graphs are plotted as shown below.



graph X



graph Y



graph Z



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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

29. Which two substances are normally both crystalline?

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

30. Which properties best describe modelling clay?

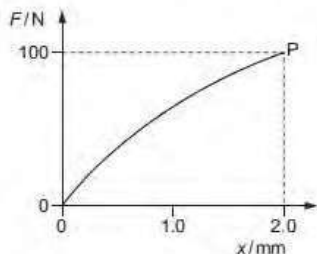
- A brittle and ductile
- B ductile and elastic
- C elastic and plastic
- D plastic and ductile

31. 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

32. 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?

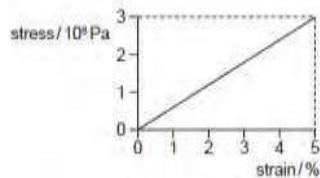
- A 0.09 J      B 0.10 J      C 0.11 J      D 0.20 J

33. A steel string on an electric guitar has the following properties. diameter =  $5.0 \times 10^{-4}$  m Young modulus =  $2.0 \times 10^{11}$  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  $1.3 \times 10^{-2}$  %

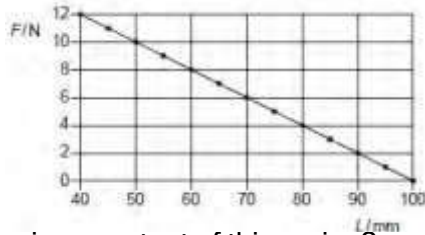
34. In stress-strain experiments on metal wires, the stress axis is often marked in units of  $10^8$  Pa and the strain axis is marked as a percentage. This is shown for a particular wire in the diagram.





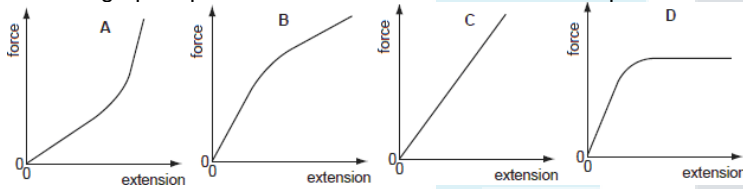
What is the value of the Young modulus for the material of the wire? A  $6.0 \times 10^7 \text{ Pa}$       B  $7.5 \times 10^8 \text{ Pa}$   
 C  $1.5 \times 10^9 \text{ Pa}$       D  $6.0 \times 10^9 \text{ Pa}$

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



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

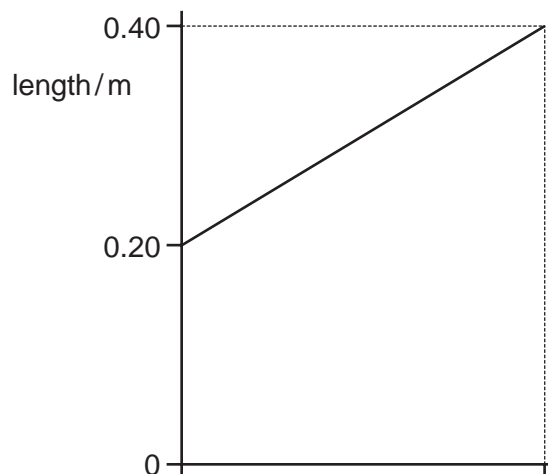
36. Which graph represents the force-extension relationship of a rubber band that is stretched almost to its breaking point?



37. 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.

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



0

force/N 25

What is the maximum strain energy in this deformed rubber cord?

A 2.5J

B 5.0J

C 7.5J

D 10J



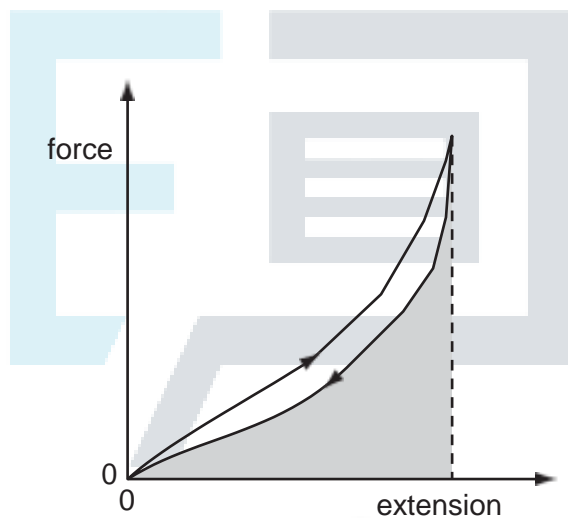
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39. A piece of copper is drawn into a continuous wire.

What behaviour is the copper exhibiting?

- A brittle only
- B elastic only
- C plastic only
- D both brittle and elastic

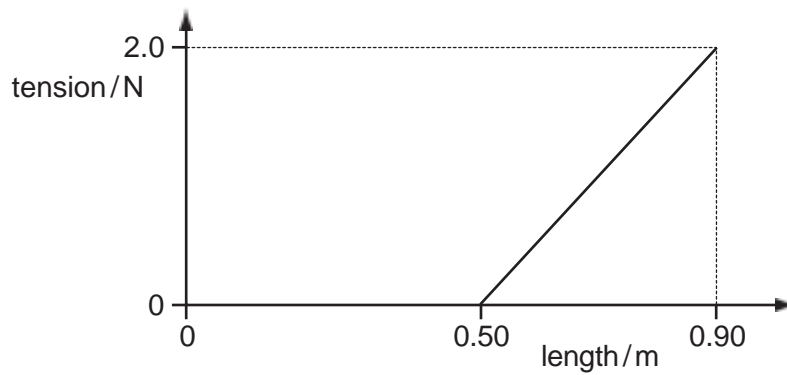
40. The force-extension graph of a particular sample of rubber as a load is applied and then removed is shown.



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

41. 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.



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How much strain energy is stored in the spring?

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

42. 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

43. What is the unit of the Young modulus?

- A  $\text{Nm}^{-1}$       B Nm      C  $\text{Nm}^{-2}$       D  $\text{Nm}^2$

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

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

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

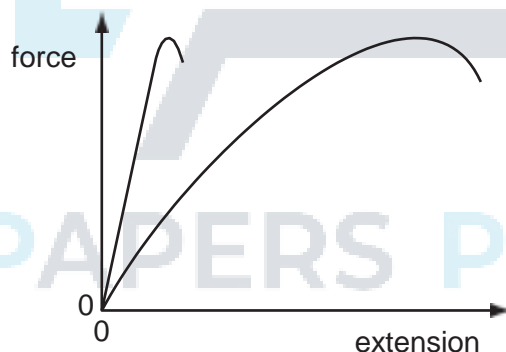
What is the ratio of the extension of the steel to the extension of the brass?

- A 2      B 4      C 8      D 16

45. Which row gives the correct description for the arrangement of atoms in the four types of material?

	atoms have no long-range order	atoms form giant chain-like molecules	atoms have an ordered arrangement in regions, but these ordered regions are at angles to one another	atoms are arranged in an ordered way throughout
<b>A</b>	crystalline	amorphous	polymeric	polycrystalline
<b>B</b>	polycrystalline	crystalline	amorphous	polymeric
<b>C</b>	polymeric	polycrystalline	crystalline	amorphous
<b>D</b>	amorphous	polymeric	polycrystalline	crystalline

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



What describes the behaviour of the materials?

- A Both materials are brittle.
- B Both materials obey Hooke's law.
- C Both materials are plastic.
- D Both materials have the same ultimate tensile stress.

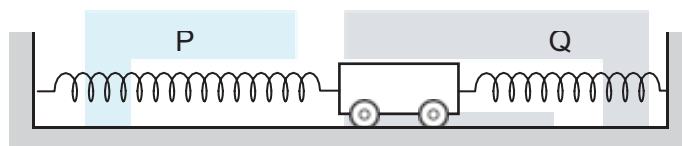
47. Two wires, X and Y, are made from different metals and have different dimensions. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y.

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

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



Each spring has an unstretched length of 0.10 m.

Spring P has spring constant  $60 \text{ N m}^{-1}$ .

Spring Q has spring constant  $120 \text{ N m}^{-1}$ .

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

49. A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm. The lift drops 1 mm when a man of mass 80 kg steps into the lift.

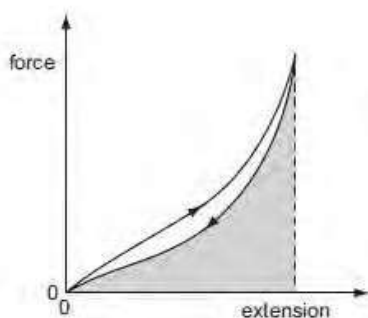
What is the best estimate of the value of the Young modulus of the steel?

- A  $2 \times 10^{10} \text{ N m}^{-2}$   
 B  $4 \times 10^{10} \text{ N m}^{-2}$   
 C  $2 \times 10^{11} \text{ N m}^{-2}$   
 D  $4 \times 10^{11} \text{ N m}^{-2}$

50. 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

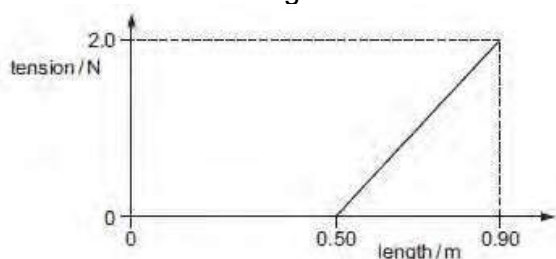
51. The force-extension graph of a particular sample of rubber as a load is applied and then removed is shown.



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

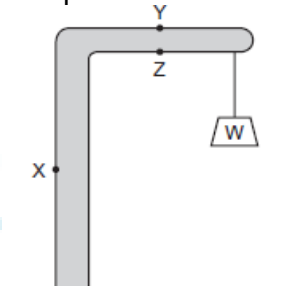
52. A spring of unextended length 0.50 m is stretched by a force of 2.0 N to a new length of 0.90 m. The variation of its length with tension is as shown.



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

53. 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

54. 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



55. A steel string on an electric guitar has the following properties.

$$\text{diameter} = 5.0 \times 10^{-4} \text{ m}$$

$$\text{Young modulus} = 2.0 \times 10^{11} \text{ Pa}$$

$$\text{tension} = 20 \text{ N}$$

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  $1.3 \times 10^{-2}\%$

56. Four materials are formed into rods of the same dimensions.

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

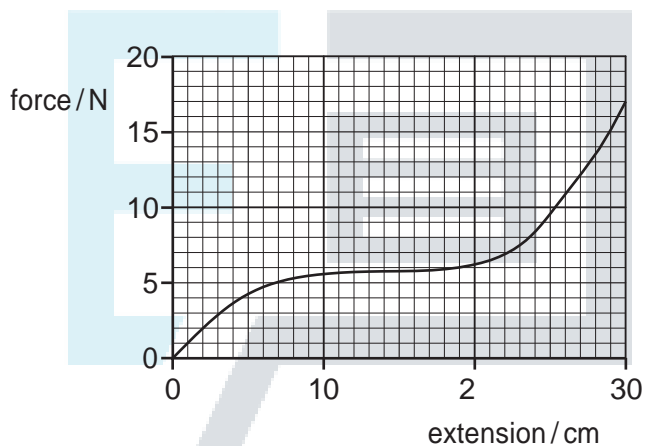
- A the ductile material aluminium
- B the brittle material carbon
- C the brittle material glass
- D the ductile material steel

57. 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.

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  $\frac{4}{1}$

58. 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

59. Which properties best describe modelling clay?

- A brittle and ductile
- B ductile and elastic
- C elastic and plastic
- D plastic and ductile

60. 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?

