Past-paper walk-through

Elastic and plastic behaviour ▪ 6.2

eXercise

Questions in this set

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Question 20

9702/11 N25 ▪ Q20 ▪ 1 mark

A spring is fixed at one end. The length L of the spring is increased by applying a tensile force F to the other end.

The graph shows the variation of L with F.

What is the elastic potential energy of the spring when F is 6.0 N? **[1]**

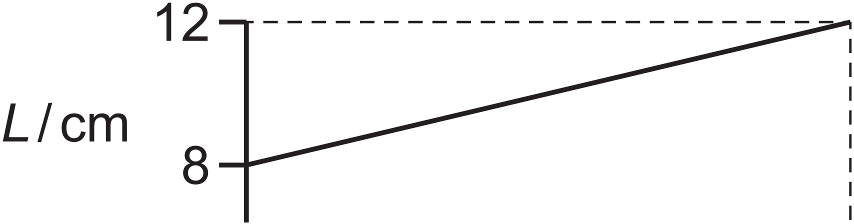
A 0.12 J

B 0.24 J

C 0.36 J

D 0.60 J

Question 20



Solution 20

- **A** 0.12 J ✓
- **B** 0.24 J
- **C** 0.36 J
- **D** 0.60 J

Why

- The graph plots *length*: at $F = 0$ the spring is already 8 cm long.
- At $F = 6.0$ N it is 12 cm, so the extension is 4 cm $= 0.040$ m.
- $E = \frac{1}{2}Fx = \frac{1}{2}(6.0)(0.040) = 0.12$ J; using the whole 12 cm gives C.

Question 23

9702/11 N25 ▪ Q23 ▪ 1 mark

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? **[1]**

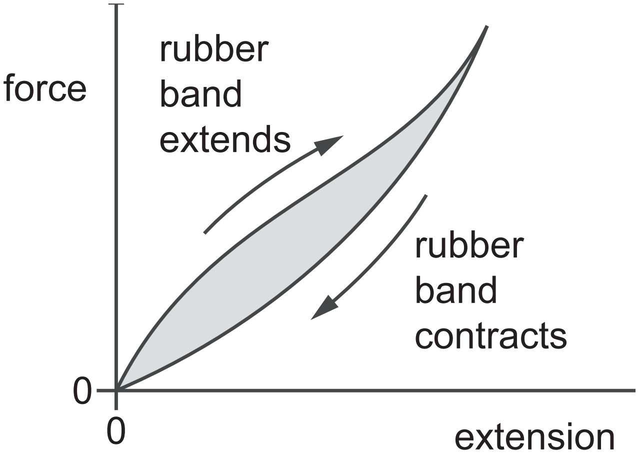
A The rubber band does \textbf{not} return to its original length when the force is decreased to zero.

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.

Question 23



force
rubber band extends
rubber band contracts
0
0
extension

Solution 23

A The rubber band does \textbf{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.

Why

- Rubber shows hysteresis, so the unloading curve lies below the loading curve.
- Both curves still begin and end at the origin, so the band does return to its original length – it stays elastic.
- The curves are not straight, so Hooke's law is not obeyed, and the area between them is energy lost as heat.

Question 23

9702/12 N25 ▪ Q23 ▪ 1 mark

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

What is the elastic potential energy of the spring when the extension is 4.0 cm? **[1]**

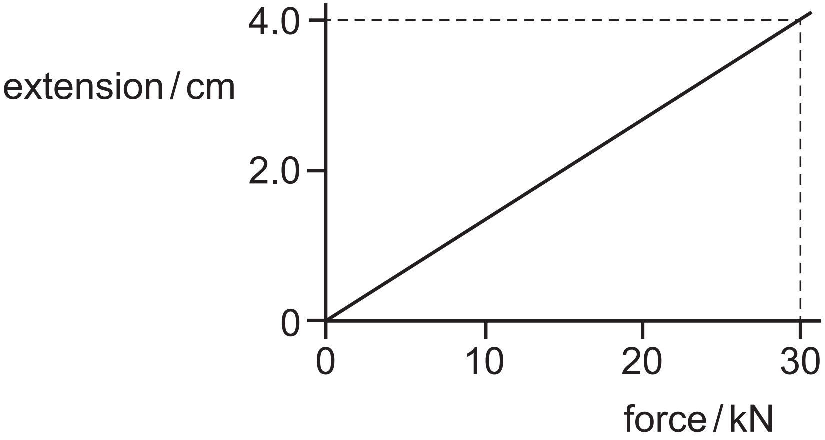
A 60 J

B 120 J

C 600 J

D 1200 J

Question 23



Solution 23

A 60 J

B 120 J

C 600 J ✓

D 1200 J

Why

- Read the force at an extension of 4.0 cm from the graph: 30 kN.
- The energy stored is the area under the line, $\frac{1}{2}Fx$.
- $\frac{1}{2}(30 \times 10^3)(0.040) = 600$ J; D omits the factor of one half.

Question 21

9702/14 N25 ▪ Q21 ▪ 1 mark

The graph shows the variation in extension with force for a sample of rubber.
The top line shows the variation in extension as a force is applied.
The bottom line shows the variation in extension as the force is removed.
What is represented by the area between the two lines? **[1]**

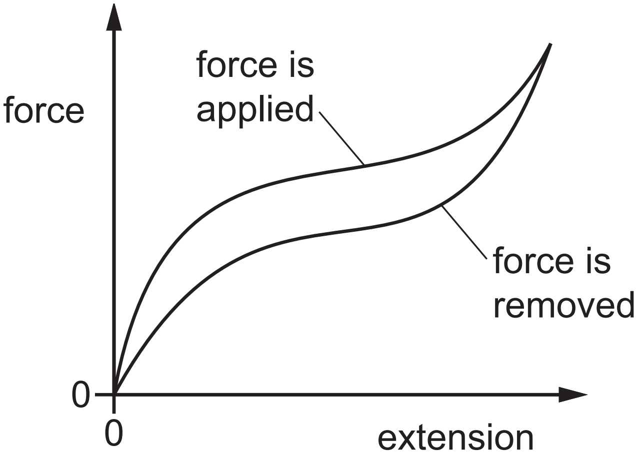
A the work done as the force is applied

B the work done as the force is applied minus the work done as the force is removed

C the work done as the force is removed

D the work done as the force is removed plus the work done as the force is applied

Question 21



Solution 21

A the work done as the force is applied

B the work done as the force is applied minus the work done as the force is removed ✓

C the work done as the force is removed

D the work done as the force is removed plus the work done as the force is applied

Why

- The area under the loading line is the work done stretching the rubber.
- The area under the unloading line is the work the rubber gives back.
- The area between them is the difference – energy dissipated as heat in the rubber.

Question 22

9702/12 J25 ▪ Q22 ▪ 1 mark

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? **[1]**

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

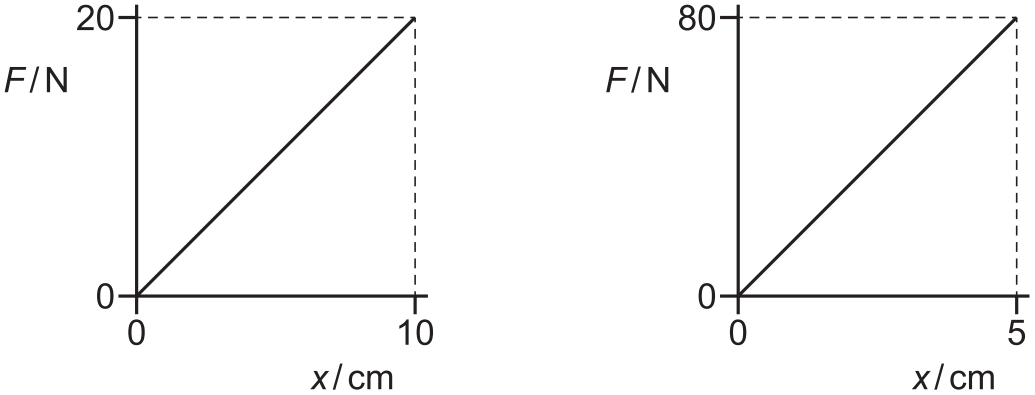
B When each spring is given the same extension, the energy stored in Y is 8 times the energy stored in X.

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

Question 22

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

Question 22



Solution 22

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.

Why

- From the graphs $k_X = 20/0.10 = 200$ N m^{-1} and $k_Y = 80/0.05 = 1600$ N m^{-1}.
- So Y is eight times as stiff as X.
- At the same extension $E = \frac{1}{2}kx^2$, so Y stores eight times the energy.

Question 23

9702/12 J25 ▪ Q23 ▪ 1 mark

Which phrase describes the strain at the elastic limit on a stress–strain graph? **[1]**

A the maximum strain below which Hooke's law is obeyed

B the maximum strain below which the deformation is plastic

C the minimum strain above which Hooke's law is obeyed

D the minimum strain above which the deformation is plastic

Solution 23

A the maximum strain below which Hooke's law is obeyed

B the maximum strain below which the deformation is plastic

C the minimum strain above which Hooke's law is obeyed

D the minimum strain above which the deformation is plastic ✓

Why

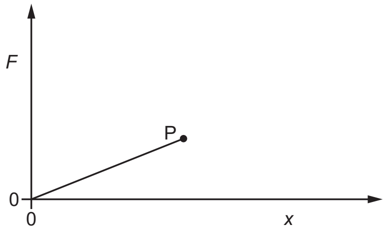
- Beyond the elastic limit the material no longer returns to its original shape.
- So the elastic limit is the smallest strain at which the deformation becomes plastic.
- A describes the limit of proportionality, where Hooke's law stops holding – a different point.

Question 23

9702/13 J25 ▪ Q23 ▪ 1 mark

23 A wire of length L is stretched to determine its limit of proportionality.

The graph shows the variation of the extension x with the force F applied to the wire.

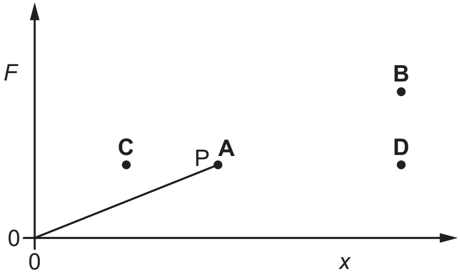


The limit of proportionality is shown by point P on the graph.

Question 23

The experiment is repeated with another wire of length $2L$ but of the same material and same diameter as the first wire.

Which point on the graph shows the limit of proportionality for the new wire?



Solution 23

Answer: **D**

Why

- The limit of proportionality is set by the *stress*, so the force at which it occurs is unchanged.
- A wire of twice the length stretches twice as far for the same force, since $x = FL/AE$.
- So the new point sits at the same height on the force axis but at double the extension.

Question 18

9702/14 J25 ▪ Q18 ▪ 1 mark

18 A spring of unstretched length 0.10 m is suspended vertically from a support.

A weight of 2.0 N is attached to the bottom of the spring and its length increases to 0.15 m.

An additional weight of 4.0 N is then added to the bottom of the spring.

The spring obeys Hooke's law.

How much extra elastic potential energy is stored in the spring due to the addition of the 4.0 N weight?

A 0.067 J **B** 0.13 J **C** 0.20 J **D** 0.40 J

Solution 18

Answer: **D**

Why

- The first 2.0 N produces 0.05 m of extension, so $k = 2.0/0.05 = 40$ N m^{-1}.
- With the full 6.0 N the extension is $6.0/40 = 0.15$ m.
- The extra energy is $\frac{1}{2}(40)(0.15^2 - 0.05^2) = 0.45 - 0.05 = 0.40$ J.

Question 19

9702/12 M25 ▪ Q19 ▪ 1 mark

19 A wire is extended by a tensile force so that its deformation is elastic.

What is meant by elastic deformation?

A The extension of the wire is proportional to the tensile force.

B The extension of the wire is **not** proportional to the tensile force.

C When the tensile force is removed, the wire does **not** return to its original length.

D When the tensile force is removed, the wire returns to its original length.

Solution 19

Answer: **D**

Why

- Elastic deformation means the wire returns to its original length once the force is removed.
- Proportionality is Hooke's law – a stricter and separate condition.
- C describes plastic deformation, which is the opposite case.