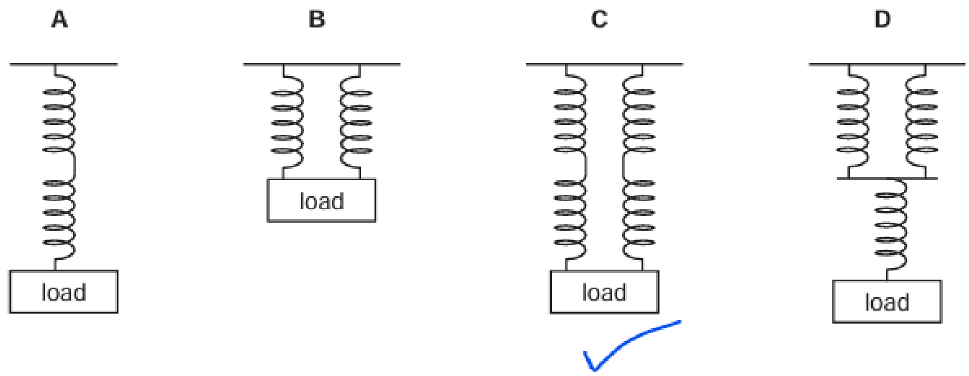
1 A number of identical springs are joined in four arrangements.

Which arrangement has the same spring constant as a single spring?



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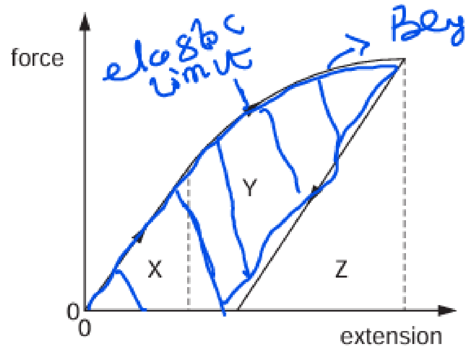
2 A sample of material is stretched by a tensile force to a point beyond its elastic limit. The tensile force is then reduced to zero. The graph of force against extension is shown below.



Beyond elastic limit

x+y

Which area represents the net work done on the sample?

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

3 A spring balance consists of a spring of length 20.0 cm with a hook attached.

When a fish of mass 3.0 kg is suspended from the hook, the new length of the spring is 27.0 cm.

What is the spring constant of the spring?

A $4.2\,N\,m^{-1}$ **B** $43\,N\,m^{-1}$ **C** $110\,N\,m^{-1}$ **D** $420\,N\,m^{-1}$

$L_1 = 20cm$ $L_2 = 27cm$ $m = 3.0kg$ $g = 9.81$

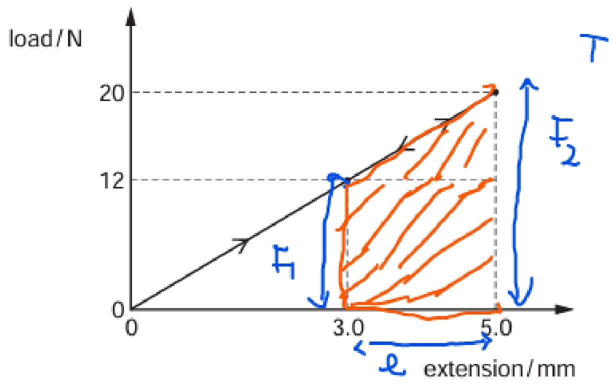
$F = m \times g = 3 \times 9.81 = 29.4$

extension $= L_2 - L_1 = 27 - 20 = 7cm \times 10^{-2}$

$F = Ke$

$K = F/e = \frac{29.4}{7 \times 10^{-2}} = 420\,Nm^{-1}$

4 A metal wire is attached at one end to a fixed point and a load is hung from the other end so that the wire hangs vertically. The load is increased from zero to 20 N. This causes the wire to extend elastically by 5.0 mm. The load is then reduced to 12 N and the extension decreases to 3.0 mm.



How much strain energy is released during the unloading process?

A 0.8×10^{-2} J **B** 1.8×10^{-2} J **C** 2.4×10^{-2} J **D** 3.2×10^{-2} J

The strain energy is the area under the graph during unloading

Strain energy = Area under the graph = Area of trapezium

$A = \frac{1}{2}(F_1 + F_2) \times e = \frac{1}{2} \times (12 + 20) \times 2 \times 10^{-3}$

$0.5 \times 32 \times 0.002 = 3.2 \times 10^{-2}$ J

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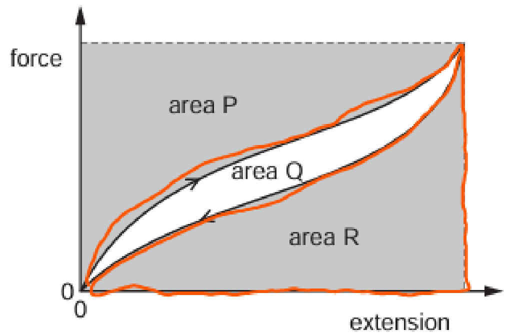
5 The diagram shows the force-extension graph for a sample of material. The sample is stretched and then returns to its original length.



Which area represents the work done to stretch the sample?

A P + Q **B** P only **C** Q + R **D** R only

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6 A metal wire of cross-sectional area $0.20\,mm^2$ hangs vertically from a fixed point. A load of 84 N is then attached to the lower end of the wire. The wire obeys Hooke's law and increases in length by 0.30%.

What is the Young modulus of the metal of the wire?

A $1.4 \times 10^5\,Pa$

B $1.4 \times 10^8\,Pa$

C $1.4 \times 10^9\,Pa$

D $1.4 \times 10^{11}\,Pa$

Young modulus = $\frac{\text{stress}}{\text{strain}}$

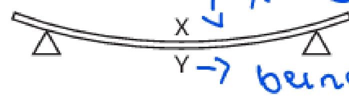
stress = $\frac{\text{Force}}{\text{Area}} = \frac{84}{0.2 \times 10^{-6}} = 4.2 \times 10^8$

strain = Fractional change in length = $\frac{0.3}{100}$

= 0.003

$E = \frac{4.2 \times 10^8}{0.003} = 1.4 \times 10^{11}$ Pa

7 The diagram shows a beam supported on two pivots.



X = compression

being pulled (Tension)

Which statement describes the state of the top surface X and of the bottom surface Y?

A Both X and Y are in compression.

B Both X and Y are in tension.

C X is in compression and Y is in tension.

D X is in tension and Y is in compression.

8 A wire of diameter d and length l hangs vertically from a fixed point. The wire is extended by hanging a mass M on its end. The Young modulus of the wire is E. The acceleration of free fall is g.

Which equation is used to determine the extension x of the wire?

A $x = \dfrac{Ml}{\pi d^2 E}$ **B** $x = \dfrac{Mgl}{\pi d^2 E}$ **C** $x = \dfrac{4Mgl}{\pi d E}$ **D** $x = \dfrac{4Mgl}{\pi d^2 E}$

Young modulus (E) $= \dfrac{\text{Stress}}{\text{Strain}}$, stress $= \dfrac{\text{Force}}{\text{Area}}$

strain $= \dfrac{\text{extension}}{\text{original length}}$

$F = M \times g = mg$

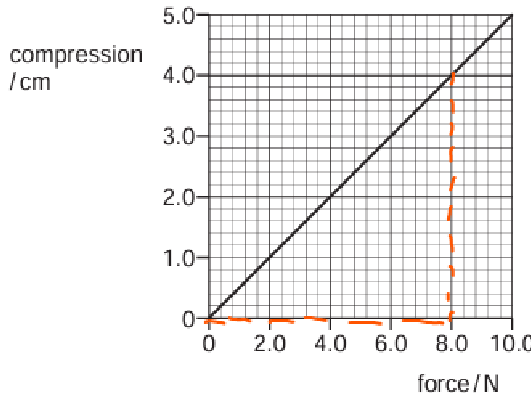
Area $= \pi r^2 = \dfrac{\pi d^2}{4}$

$$E = \frac{\text{stress}}{\text{strain}} = \frac{Mg/\pi d^2/4}{e/l} = E \times \frac{e}{l} = \frac{4Mg}{\pi d^2}$$

$$4Mgl = E e \pi d^2$$

$$e = \frac{4Mgl}{E \pi d^2}$$

9 The variation of the compression of a spring with the force applied to it is shown in the graph.

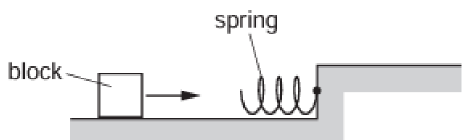


$K.E = \frac{1}{2} F \times e$

$= \frac{1}{2} \times 8 \times 4 \times 10^{-2}$

$= 0.16 J$

A block slides along a horizontal frictionless surface towards the spring, as shown.



The block is brought to rest by the spring. When the spring reaches a compression of 4.0 cm, all of the kinetic energy of the block is transferred to the elastic potential energy of the spring.

What is the kinetic energy of the block when it first makes contact with the spring?

A 0.16 J **B** 0.32 J **C** 16 J **D** 32 J

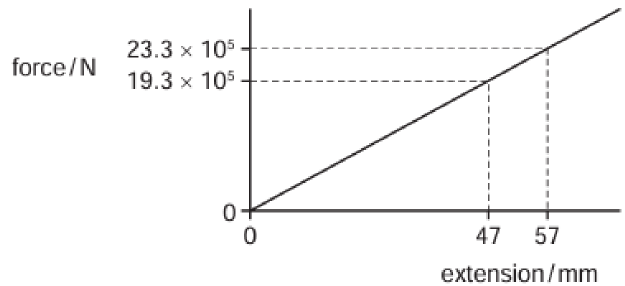
The Kinetic energy = workdone by the spring = Area under the graph

$K.E = \frac{1}{2} F \times e = \frac{1}{2} \times 8 \times 4 \times 10^{-2}$

$= \underline{0.16 J}$

10 A cable on a suspension bridge supports a weight of 19.3×10 N. This weight causes the cable to stretch by 47 mm.

A lorry crossing the bridge then increases the force on the cable to 23.3×10^5 N. The force-extension graph for the cable is shown.



What is the **increase** in strain energy in the cable when the lorry is crossing the bridge?

A 21 kJ **B** 23 kJ **C** 45 kJ **D** 66 kJ

The strain energy = work done when the lorry crosses the bridge

$= \frac{1}{2} \times [23.3 + 19.3] \times 10^5 \times (57 - 47) \times 10^{-3}$

$21.3 \times 10^5 \times 10 \times 10^{-3}$

$= 21.3 \times 10^3$ J $= 21$ kJ

11 What are the units of stress, strain and the Young modulus?

	stress	strain	Young modulus
A	newton	metre	pascal
B	newton	no unit	newton
C	pascal	metre	newton
D	pascal	no unit	pascal

$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{N}{m^2} = Nm^{-2} = \text{pascal}$

$\text{Strain} = \frac{\text{extension (m)}}{\text{original length(m)}}$

strain has no unit

$\text{Young modulus} = \frac{\text{Stress(Pascal)}}{\text{strain (No unit)}}$

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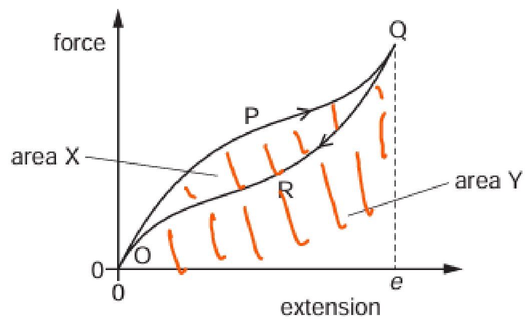
12 A rubber band is stretched and then relaxed to its original length. The diagram shows the force-extension graph for this process.



As the force is increased, the curve follows the path OPQ to extension *e*. As the force is reduced, the curve follows the path QRO to return to zero extension.

The area labelled X is between the curves OPQ and QRO. The area labelled Y is bounded by the curve QRO and the horizontal axis.

Which statement about the process is correct?

A Area X is the energy which heats the band as it is stretched to extension *e*.

B (Area X + area Y) is the minimum energy required to stretch the band to extension *e*.

C Area X is the elastic potential energy stored in the band when it is stretched to extension *e*.

D (Area Y – area X) is the net work done on the band during the process.

13 Two wires with the same Young modulus E and cross-sectional area A, but different lengths L, are subject to different tensile forces F. The extension e of each wire is the same.

The column headings in the table show four different quantities.

Which quantities have the same value and which quantities have different values for the two wires?

	$\frac{FL}{e}$	$\frac{Ae}{L}$	$\frac{E}{FL}$
A	different	different	same
B	different	same	same
C	same	different	different
D	same	different	same

Wire A   Wire B

$E_A = E_B$

$L_A \neq L_B$

$F_A \neq F_B$

$E = \frac{F/A}{e/L} = \frac{FL}{Ae} = E$

from $E = \frac{FL}{Ae}$

E is protional to $\frac{FL}{e}$ = same

from $E = \frac{FL}{Ae}$, $L = \frac{EAe}{F}$

From $E = \frac{FL}{Ae}$, $F = \frac{EAe}{L}$ ∴

F is proportional to $\frac{Ae}{L}$ = same

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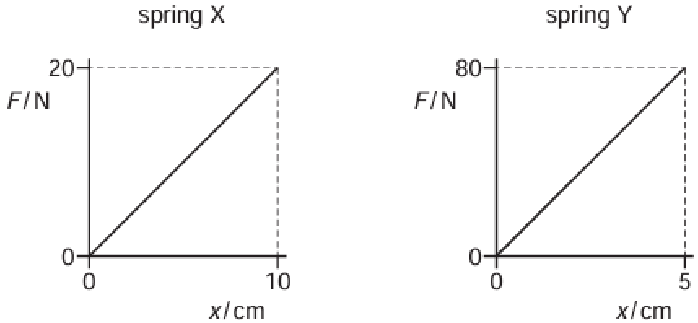
14 Two springs X and Y stretch elastically. The graphs show the variation with extension x of the force F applied to each spring.

$w = \frac{1}{2} Fe$

$= \frac{1}{2} \times 20 \times \cancel{10}$

$100\ J$



$W = \frac{1}{2} Fe$

$\frac{1}{2} \times \overset{40}{80} \times 5$

$W = 200\ J$

Which statement is correct?

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.

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15 The diagram shows the force-extension graph for a steel wire, up to its breaking point.

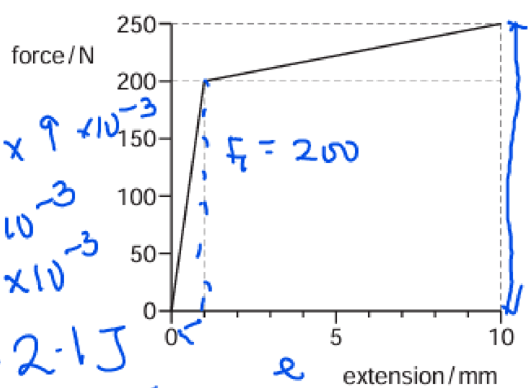
W = Area under the graph

$W = \frac{1}{2}(200 + 250) \times 9 \times 10^{-3}$

$W = \frac{1}{2}(450) \times 9 \times 10^{-3}$

$225 \times 9 \times 10^{-3}$

$225 \times 0.009 \simeq 2.1\ J$

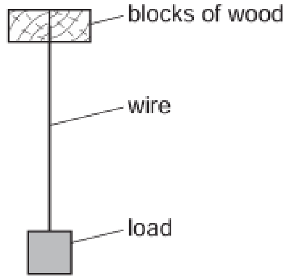


$F_2 = 250$

What is the best estimate of the work done to break the wire?

A 2.1 J **B** 2.3 J **C** 2.4 J **D** 2.5 J

16 The diagram shows a wire of diameter *D* and length *L* that is firmly clamped at one end between two blocks of wood. A load is applied to the wire which extends its length by *x*.



$E = F/A \times L/e$

$EAe = FL$

$e = \frac{FL}{AE}$

A second wire is made of the same material, but of diameter 2*D* and length 3*L*. Both wires obey Hooke's law.

What is the extension of the second wire when the same load is applied?

A $\frac{2}{3}x$ **B** $\frac{3}{4}x$ **C** $\frac{4}{3}x$ **D** $\frac{3}{2}x$

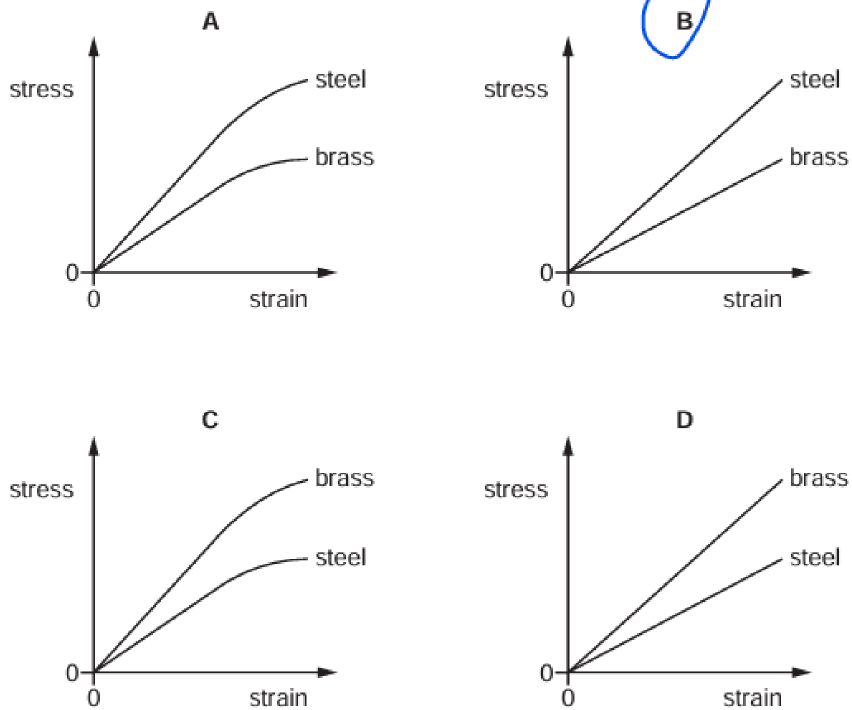
$e = \frac{FL}{AE}$, $A = \frac{\pi D^2}{4}$

$e = \frac{FL}{\frac{\pi D^2}{4}} = \frac{F \times 3L}{\pi \times 2^2} = \frac{3}{4}x$

17 Two wires, one made of brass and the other of steel, are stretched in an experiment. Both wires obey Hooke's law during this experiment.

The Young modulus for brass is less than the Young modulus for steel.

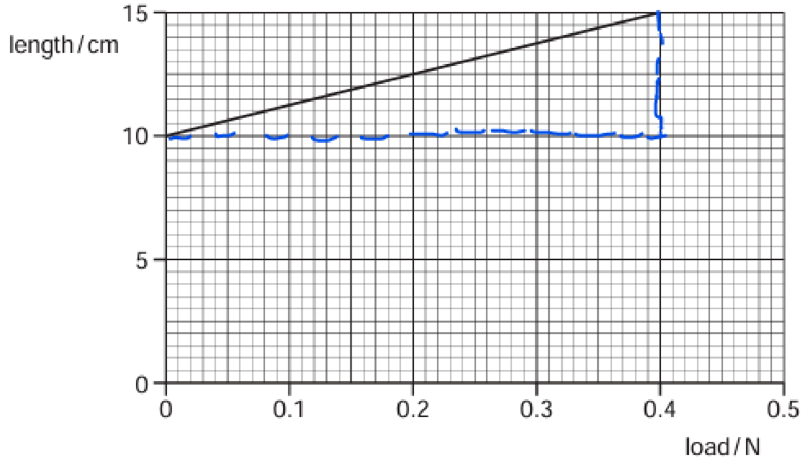
Which graph shows how the stress varies with strain for both wires in this experiment?



The steeper the line the more the young modulus.

The right option is B

19 The graph shows the length of a spring as it is stretched by an increasing load.



What is the spring constant of the spring?

A 0.080 N m^{-1} **B** 0.13 N m^{-1} **C** 2.7 N m^{-1} **D** 8.0 N m^{-1}

$F = Ke$

$K = F/e$ = gradient

The gradient of the graph is the spring constant $= \frac{15cm - 10cm}{0.4N - 0} = \frac{5cm}{0.4N}$

$K = N/m = \frac{5 \times 10^{-2} m}{0.4N} = \frac{0.4}{0.05 m} = 8.0 \ N m^{-1}$

20 Data for a steel wire on an electric guitar are listed.

diameter = 5.0×10^{-4} m

Young modulus = 2.0×10^{11} Pa

tension = 20 N

The wire snaps and contracts elastically. Assume the wire obeys Hooke's law.

By what percentage does the length l of a piece of the wire contract?

A 1.3×10^{-4} % **B** 5.1×10^{-4} % **C** 1.3×10^{-2} % **D** 5.1×10^{-2} %

$$E = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{\text{fractional / percentange change in length}}$$

$$A = \frac{\pi d^2}{4} = \frac{3.14 \times (5.0 \times 10^{-4})^2}{4} = 0.00000019625$$

$$\text{Stress} = \frac{20}{0.00000019625} = 1.02 \times 10^8 \text{ pa}$$

$$E = \frac{\text{stress}}{\text{strain}}, \quad \text{strain} = \frac{\text{stress}}{E} =$$

$$\frac{1.02 \times 10^8}{2.0 \times 10^{11}} = 5.1 \times 10^{-4}$$

convert to % $= 5.1 \times 10^{-4} \times 100$

$= 5.1 \times 10^{-2}$ %