## Pages 217–219 Exam practice questions

**1** A

**2** C

**3** C

**4** C

**5** D

**6** C

**7** A

**8** B

**9** A

**10** D

**11** C

**12** Ultimate tensile stress is the stress at which the sample breaks.

Stress = force / area

= 840 N/ ($1.3 \times 10^{-5}$ m$^2$)

= $6.46 \times 10^7$ Pa [1]

**13 a)** Density = mass / volume

volume = $6.3 \times 10^{-3}$ m$^3$

density = 2063.5 kg m$^{-3}$

**b)** stress = force / area

maximum stress will occur for smallest area

stress = (13 kg × 9.81 N kg$^{-1}$) / (0.3 m × 0.035 m)

= $1.2 \times 10^4$ Pa

**14 a)** Strain = extension / original length

= 4

**b)** stress = force / cross-sectional area

cross-sectional area = 30 N/ $14 \times 10^6$ m$^2$

= $2.1 \times 10^{-6}$ m$^2$

**15 a)** The deformation is elastic because the wire returns to its original length when unloaded.

**b)** 1 mark each for method to measure length, extension and one safety point. Additional mark for one other point.

Original length is measured with a ruler.

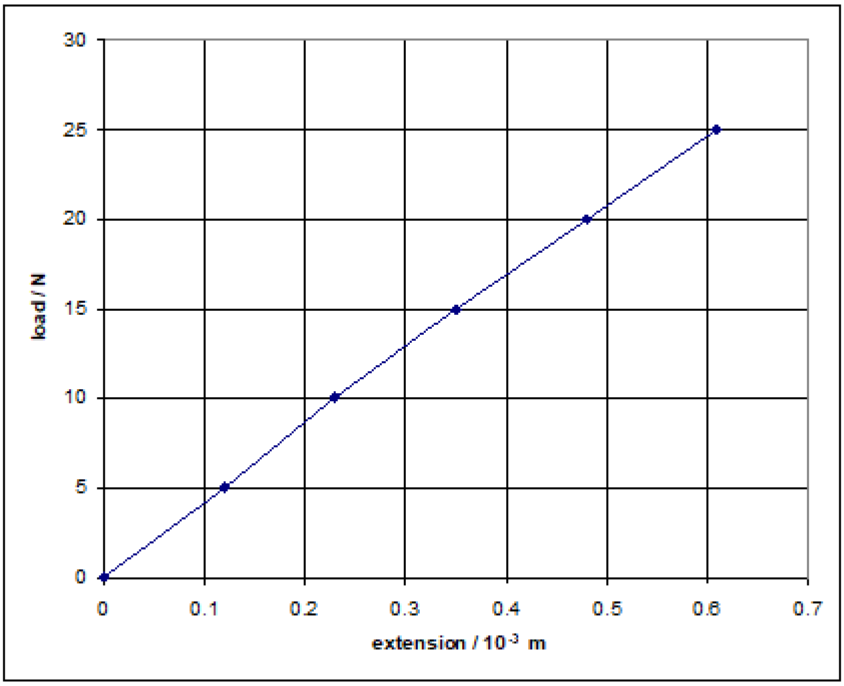
Extension may be measured by marker attached to wire and a scale.

Extension may also be measured using a Vernier scale fixed to a reference wire hung next to the sample wire.

Safety goggles must be worn when measuring extension in case of the wire breaking.

Cushioning should be placed under the weights to prevent damage to floor or feet in case of the wire breaking.

**c)**




Gradient = $4.16 \times 10^4$ N $m^{-1}$

Spring constant = $4.16 \times 10^4$ N $m^{-1}$

**d)** Diameter of the wire to calculate the cross-sectional area.

**16 a)** $\rho = m/V$

mass = 90 kg

**b)** Stress = $F / A$

$= (500 + 450 + 90)\ \text{kg} \times 9.81\ \text{N m}^{-1} / \pi\,(0.01\ \text{m})^2$

$= 3.3 \times 10^7$ Pa

This is approximately 30 MPa.

**17 a)**

- Elastic band suspended from fixed point.
- Fix a ruler close, and parallel, to the band.
- Unstretched length measured. Ensure that band is straight to reduce measurement error (small pointer attached to bottom of band could be used to aid reading).
- 100 g mass hanger added and new length measured.
- Masses continue to be added in regular increments and length measured each time.
- To measure unloading, the masses are removed – again in regular increments – and the length measured once each mass has been removed.

**b)** This will increase the likelihood of incorrect readings as random errors will be less obvious.

**c)** No.

- Hooke's law states that force is proportional to extension and will give a straight line graph.
- The elastic band does not have a straight line force–extension graph so doesn't show Hooke's law behaviour.

**d)** The amount of energy dissipated is the difference in area between the loading and unloading graph.

The student could count the number of squares between the loading and unloading lines.

Each small square on the graph is equivalent to $2 \times 10^{-3}$ J.

She should then multiply the number of small squares by this value to obtain an estimate of the energy dissipated.

**e)** The elastic band would become warm.

**18 a)** Strain is a ratio of extension to original length. Ratios do not have units.

**b)** The copper obeys Hooke's law. The extension is proportional to the force applied.

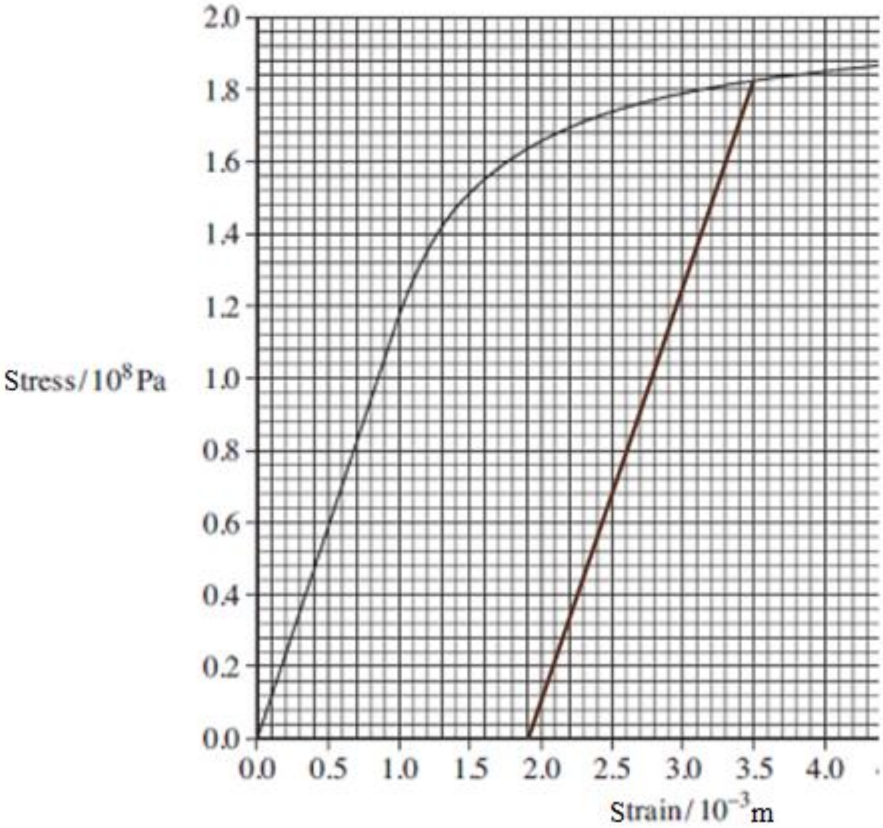
**c)** $190 \times 10^{6}$ Pa (190 MPa or $1.9 \times 10^{8}$ Pa)

**d)** Young modulus = stress / strain

At strain of $1.0 \times 10^{-3}$ the stress is $118 \times 10^{6}$ Pa

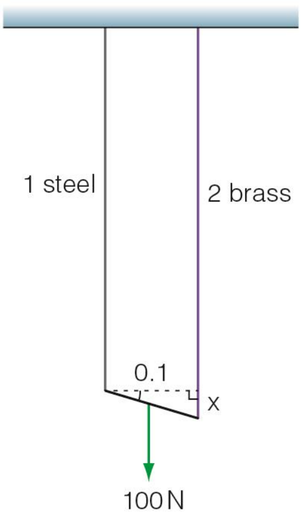
Young modulus = $1.18 \times 10^{11}$ Pa

**e)** At strain of $3.5 \times 10^{-3}$ wire has passed its elastic limit and is exhibiting plastic behaviour. When the load is removed, the wire does not return to its original length and has been permanently stretched as shown in the diagram.




## Page 220 Stretch and challenge questions

**19 a)** The diagram shows the extension of the wires when the 100 N force is applied.




tan $\theta$ = opp / adj

tan 1 = $x$ / 0.1

difference in extensions = $1.7 \times 10^{-3}$ m

**b)** Each wire will be subject to half of the applied force.

Young modulus = stress / strain

$\Delta l = F\,l / EA$

Area = $\pi r^2 = 5 \times 10^{-7}$ m$^2$

$\Delta l$ = (50 N × 2.0 m) / ($2 \times 10^{11}$ N m$^{-2}$) ($5 \times 10^{-7}$ m$^2$)

$\Delta l = 1 \times 10^{-3}$ m

**c)** Difference in extension of steel and brass wire is $1.7 \times 10^{-3}$ m. So brass wire will have extended this amount + the amount that the steel wire extended.

Total extension of brass wire = $2.7 \times 10^{-3}$m

Young modulus = stress / strain

Young modulus brass= $1.0 \times 10^{11}$ Nm$^{-2}$

**d)** Elastic strain energy = ½ $F\,\Delta l$

= ½ × 50 × 1.0 × $10^{-3}$

= 0.025 J

**20** The initial energy of the ball will be equal to the energy stored in the spring.

The final energy of the ball will be KE + GPE. These two will be equal as there are no energy loses in the system.

Elastic strain energy = ½ $k\,x^2$

Gravitational potential energy = $mgh$

Using trigonometry to calculate the gain in height of the ball:

sin (8.5) = $h$ / 0.05

$h$ = 0.05 sin(8.5)

GPE = 0.1 × 9.8 × 0.05 sin8.5

GPE = $7.24 \times 10^{-3}$J

½ $kx^2$ = ½ $mv^2$ + GPE

$k = 2(½\, mv^2 + \text{GPE})/x^2$

$k$ = 24.3 Nm$^{-1}$

**21** The spider silk is not as strong as steel. The breaking strength of steel is twice that of the silk.

However, the young modulus of spider silk is lower than that of steel.

Young modulus = stress / strain

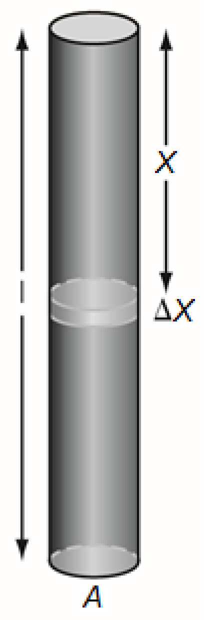
For a particular value of stress (e.g. the weight of a fly), the strain of the silk will be 20 times greater than that of the steel. This means that a silk rope will stretch much more than a steel rope.

The energy which can be stored (or absorbed) by each rope is given by:

elastic strain energy per unit volume = ½ (stress × strain).

If we consider two ropes of the same dimensions, then spider silk is able to absorb much more energy from the moving train due to its greater ability to stretch and so will be more useful to the spider when trying to catch the fly.

**22**




The stress due to a length *x* is:

$$= \frac{F}{A}$$
$$= \frac{\rho A x g}{A}$$
$$= \rho x g$$

The extension, $\Delta e$, due to the stress in a section $\Delta x$ is calculated from:

Young modulus = stress / strain

$$= \frac{\rho x g}{\Delta e / \Delta x}$$

$$= \frac{\rho x g \Delta x}{\Delta e}$$

therefore $\Delta e = \frac{\rho x g \Delta x}{E}$

so total extension $\frac{\rho g}{E} \int_0^l x dx$

$$= \frac{\rho g l^2}{2E}$$

Alternatively, we could say:

the average stress is $\frac{\rho g l}{2}$

so:

$$\frac{\Delta e}{l} = \frac{\rho g l}{2E}$$
$$\Delta e = \frac{\rho g l^2}{2E}$$