# Questions

Q1.

A student carried out an experiment to determine the Young modulus of constantan.

The student had a constantan wire with cross-sectional area $A$ of $3.97 \times 10^{-7}$ m$^2$.

The unstretched length $x$ of the wire was 4.00 m.

(a) The student had enough slotted masses to apply a weight of up to 150 N to the wire.



The breaking stress for constantan is about 420 MPa.

Deduce whether the wire could support a weight of 150 N.

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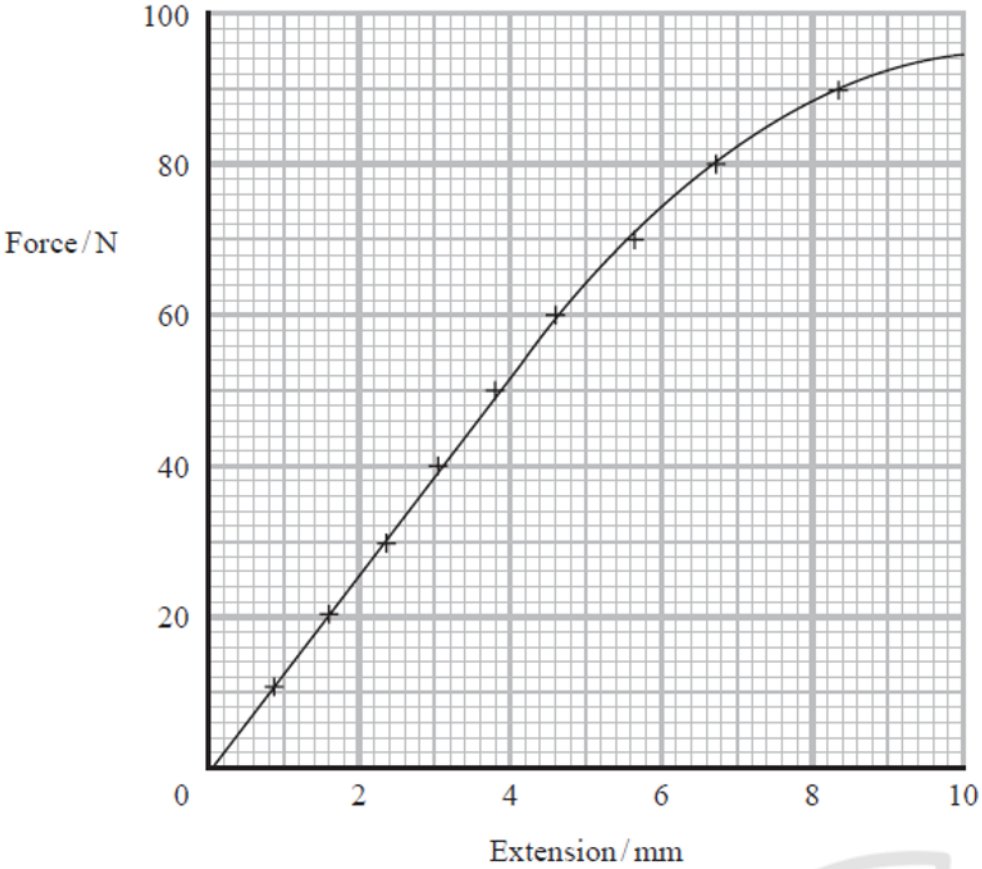
(b) The student added slotted masses to the wire and determined the corresponding extensions. The student plotted a graph of force against extension, as shown.






(i) Show that the stiffness of the wire is about $1.3 \times 10^4$ N m$^{-1}$.

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(ii) The relationship between the stiffness $k$ of the wire and the Young modulus $E$ is given by

$$k = \frac{EA}{x}$$

where $x$ is the unstretched length of the wire and $A$ is the cross-sectional area of the wire.

Determine a value for the Young modulus of constantan using the student's data.



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Young modulus = .....

**(Total for question = 7 marks)**

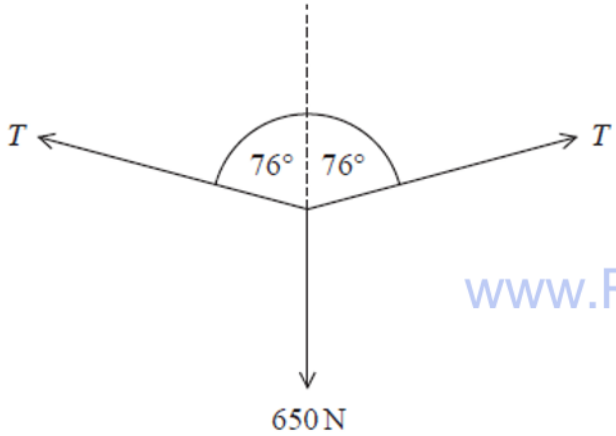
Q2.

The Tyrolean traverse is a technique for crossing a deep valley. The photograph shows a climber crossing a river using this technique. The climber moves along a rope suspended from the bank on either side of the river.



(Source: © Folio Images/Alamy Stock Photo)

(a) The free-body force diagram for the climber is shown below. The weight of the climber is 650 N.






Show that the tension $T$ in the rope is about $1.3 \times 10^3$ N.

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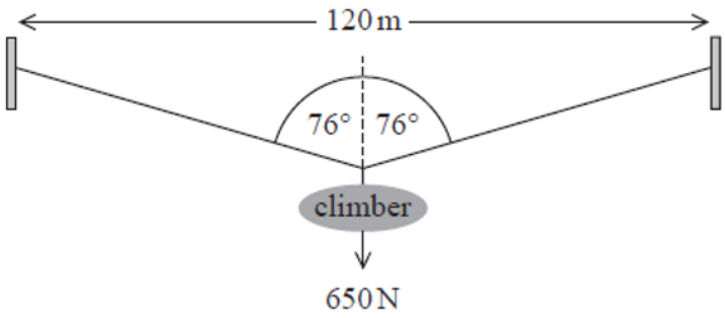
(b) The rope has an unstretched length of 120 m as shown below.






(i) Determine the strain in the rope while it is supporting the weight of the climber.

You may ignore the weight of the rope.

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Strain = .....

(ii) The rope has a cross-sectional area of $3.14 \times 10^{-4}$ $m^2$.

Determine the Young modulus of the rope material.



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Young modulus = .....

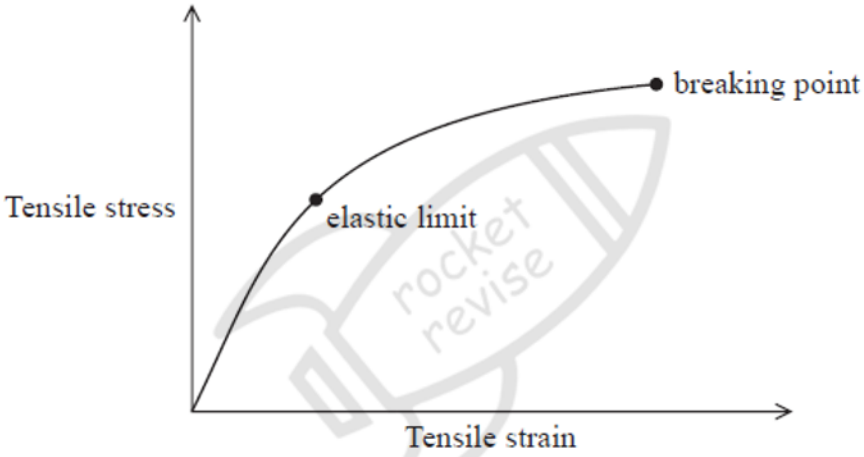
**(Total for question = 9 marks)**

Q3.

**Answer the question with a cross in the box you think is correct (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).**



The graph shows the relationship between tensile stress and tensile strain for a material.




Which of the following gives the Young modulus of the material?

☒ **A** the area under the line up to the breaking point

☒ **B** the area under the line up to the elastic limit

☒ **C** the gradient of the tangent to the line at the origin

☒ **D** the stress divided by the strain at the breaking point



**(Total for question = 1 mark)**

Q4.

**Answer the question with a cross in the box you think is correct ☒. If you change your**

**mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

A student carries out an experiment to determine the Young modulus of copper.

The student adds known masses to a copper wire and measures the corresponding extensions of the wire.

Which other quantities should the student measure directly?

☒ **A** diameter and mass of the wire

☒ **B** diameter and original length of the wire

☒ **C** radius and mass of the wire

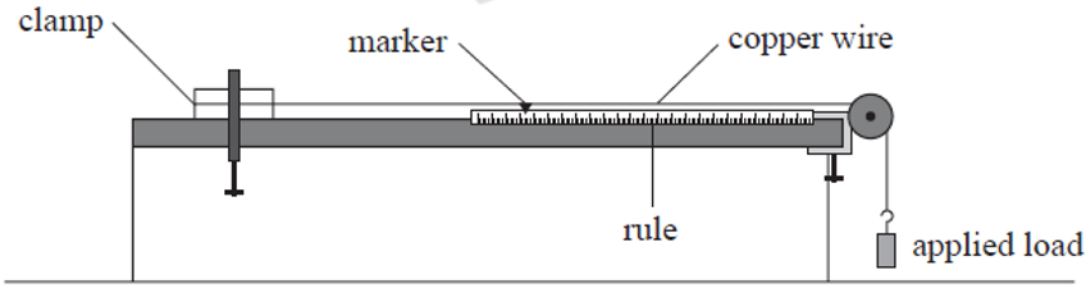
☒ **D** radius and original length of the wire



**(Total for question = 1 mark)**

Q5.

A student carried out an experiment to determine the Young modulus of copper. She used the apparatus below to observe the position of a marker as a copper wire extended under increasing applied loads.




(a) Describe how the diameter of the wire should have been determined.



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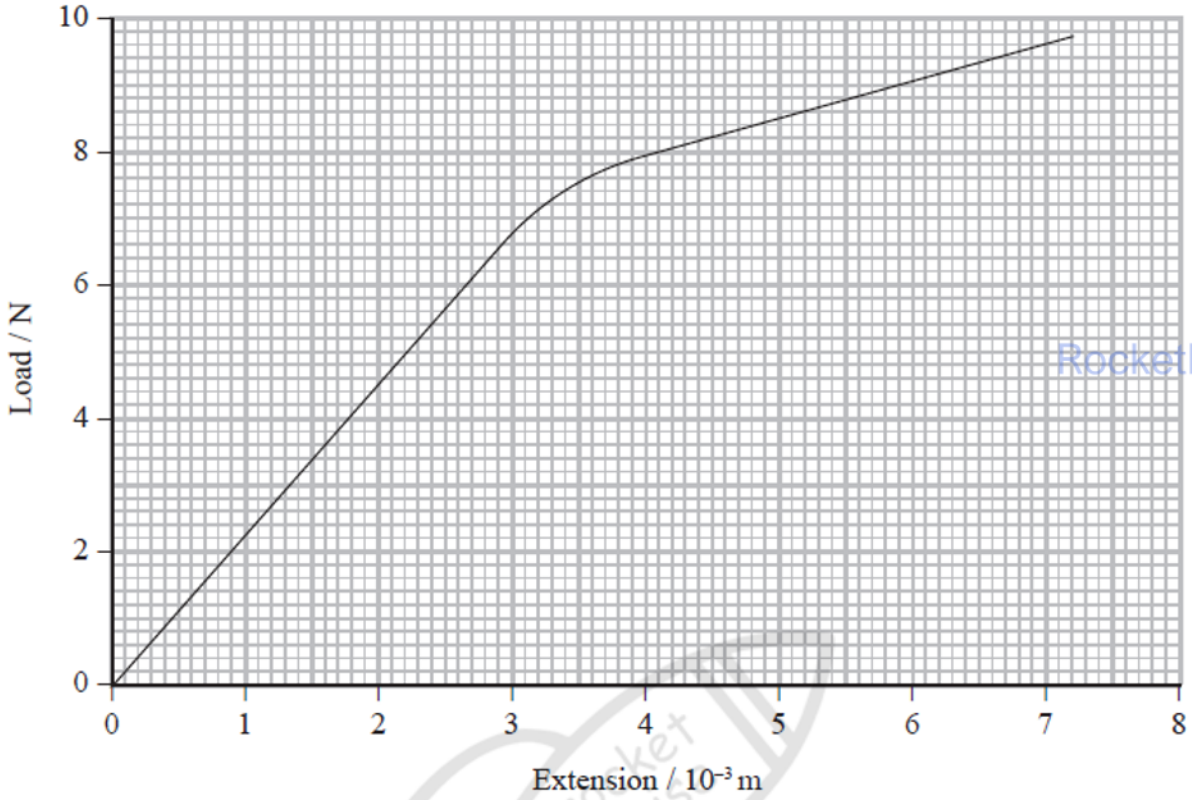
(b) The student calculated the extension of the copper wire for each applied load. She then plotted a graph of load against extension.






Determine a value for the Young modulus of copper.

original length of copper wire = 2.4 m
diameter of copper wire = $2.3 \times 10^{-4}$ m

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Young modulus of copper = .....

(c) Explain why the sample of wire used in this experiment should be long and thin.

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**(Total for question = 13 marks)**

Q6.

A student carried out an experiment to determine the Young modulus of copper.

She added a mass *m* to the free end of a sample of copper in the form of a long thin wire and the corresponding extension Δ *x* was measured. This was repeated for increasing masses.

(a) State the meaning of the term Young modulus.



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(b) The student repeated the measurement of the diameter of the wire at different positions and orientations of the wire. She obtained the following results.

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| Diameter / mm | 0.230 | 0.235 | 0.230 | 0.240 |

(i) Determine the cross-sectional area of the sample of wire used.

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Cross-sectional area = .....



(ii) The student plotted a graph of $m$ against $\Delta x$. She measured the gradient and obtained a value of 195 kg $m^{-1}$.

Determine the Young modulus of the copper.

length of sample of copper used = 3.50 m

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Young modulus = .....

(iii) The experiment was repeated by another student, using a 2.00 m length of the copper wire.

Suggest how the values obtained for the gradient and hence the Young modulus will differ between the students.



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**(Total for question = 9 marks)**

Q7.

A steadily increasing tensile force was applied to a sample of a titanium alloy.

The sample had an original length of 40.0 cm and diameter of 5.05 mm.

(a) State a suitable measuring instrument to measure the diameter of the sample.



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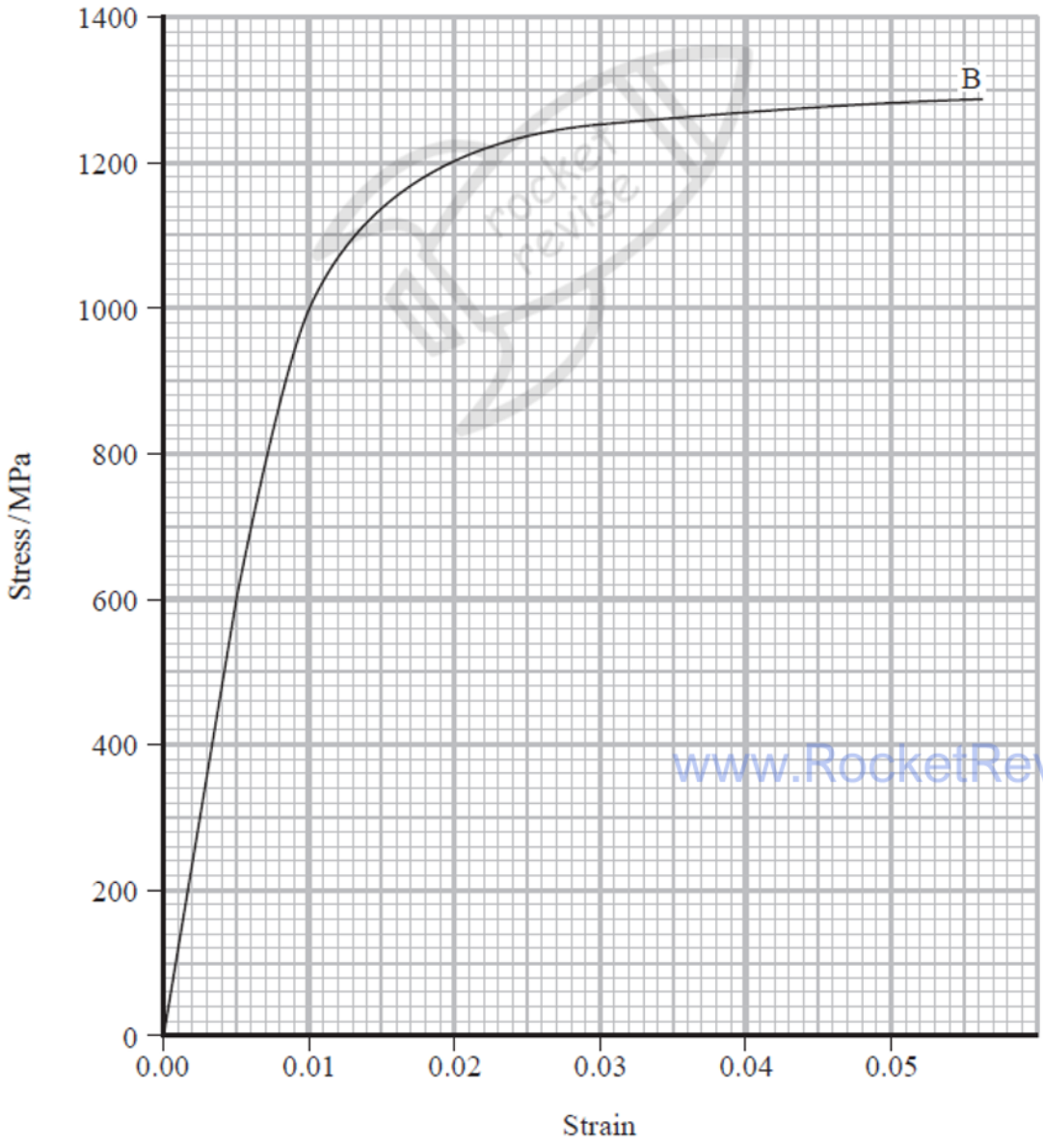
(b) The graph shows how stress varied with strain for the sample.






(i) Determine the Young modulus of the sample.

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Young modulus = .....

(ii) The sample broke at point B.



Determine the force required to break the sample.

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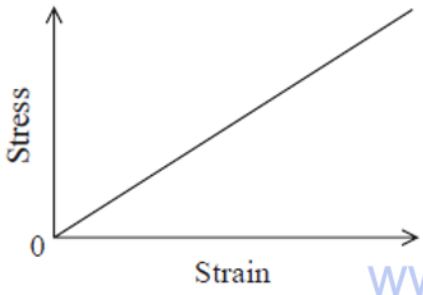
Force = .....

(iii) The graph below shows a linear section of the stress-strain graph for the sample.






Show that the area under this graph represents the work done per unit volume in stretching the sample.

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(iv) The area under any stress-strain graph represents the work done per unit volume.

Estimate the amount of work required to break the titanium alloy sample.

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Work = .....

**(Total for question = 15 marks)**