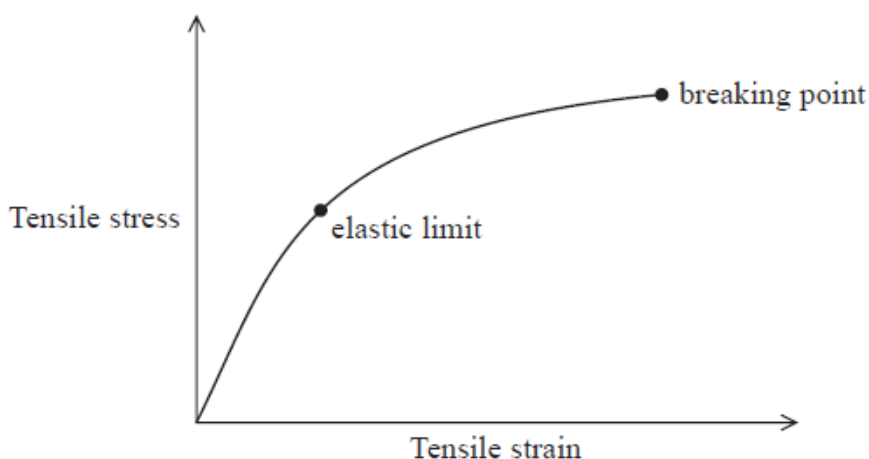


Questions

Q1.

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?

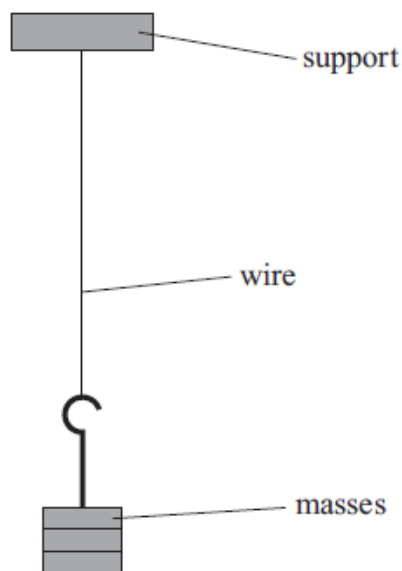
- ☐ A the area under the line up to the breaking point
- ☐ B the area under the line up to the elastic limit
- ☐ C the gradient of the tangent to the line at the origin
- ☐ D the stress divided by the strain at the breaking point

(Total for question = 1 mark)

Q2.

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 attached one end of a wire to a support. The student added masses to the other end of the wire, as shown. The student measured the corresponding extension for each added mass.



The wire broke when the extension was small.

The student replaced the wire with a second wire made of the same material.

The second wire had a larger extension before breaking.

Which of the following produced this result?

- ☒ **A** The second wire had a greater diameter.
- ☒ **B** The second wire had a longer length.
- ☒ **C** The second wire had a smaller diameter.
- ☒ **D** The second wire had a shorter length.

(Total for question = 1 mark)

Q3.

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)

Q4.

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 $3.97 \times 10^{-7} \text{ m}^2$.

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.

(3)

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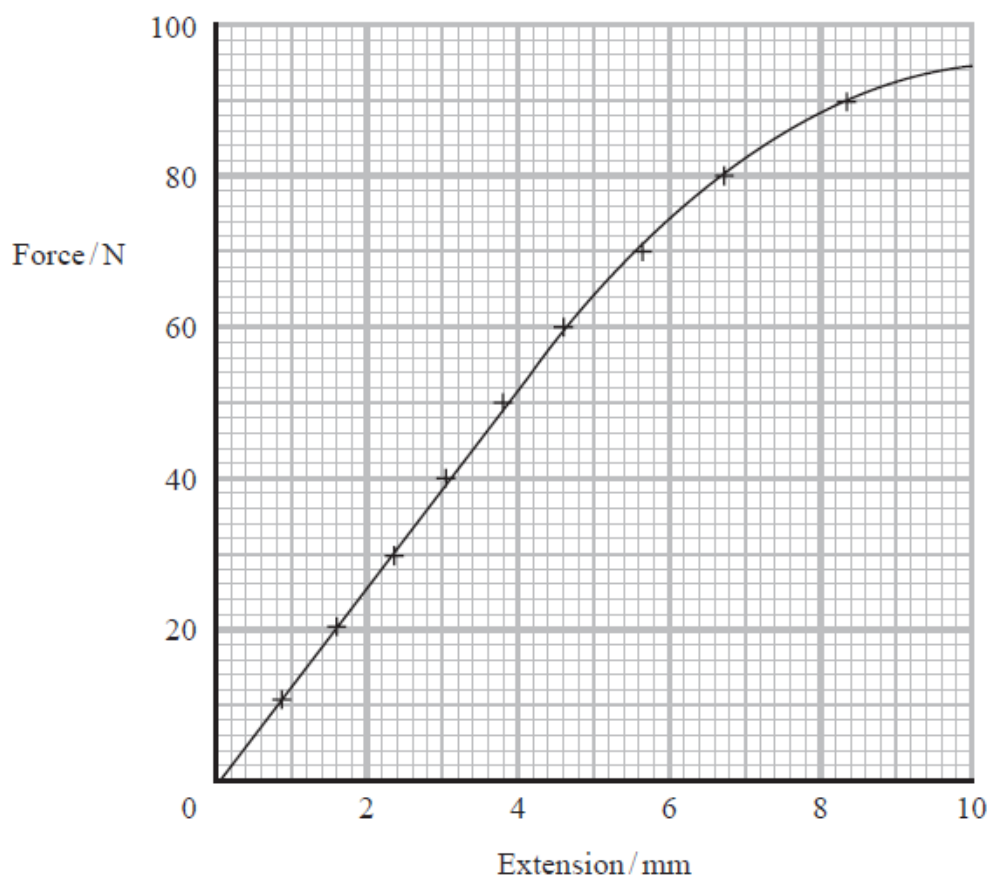
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(b) The student added slotted masses to the wire and determined the corresponding extensions. The student plotted a graph of force against extension, as shown.



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

(2)

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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.

(2)

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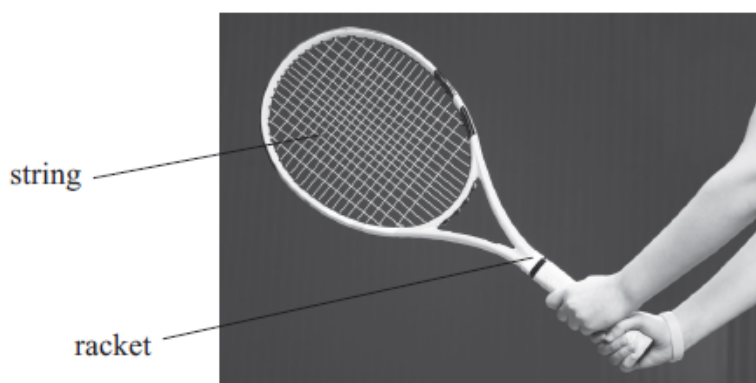
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Young modulus =

(Total for question = 7 marks)

Q5.

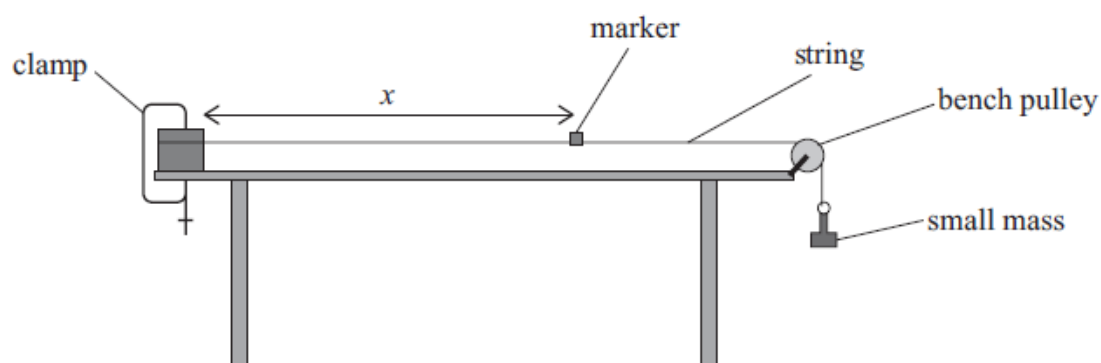
The photograph shows a tennis racket.



(Source: © Diy13/Getty Images)

A student determined the Young modulus of the material of the string from a tennis racket.

She used the apparatus shown below.



The student determined the cross-sectional area of the string. She measured the original length x of the string between the clamp and the marker.

She increased the tension in the string and measured the new length of the string between the clamp and the marker. She used her results to calculate the Young modulus of the string.

(a) State why the student should suspend a small mass from the string before measuring x .

(1)

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(b) Explain how the student could decrease the percentage uncertainty in the value of x .

Material	Young modulus / GPa
gut	6.0
nylon	5.0
polyester	0.92

The string used by the student had a cross-sectional area of $1.2 \times 10^{-6} \text{ m}^2$.
The initial length of the string was 1.6 m.

Deduce which material the string was made from.

[illegible]

(Total for question = 8 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 Δx was measured. This was repeated for increasing masses.

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

(1)

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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.

Diameter/mm	0.230	0.235	0.230	0.240
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(i) Determine the cross-sectional area of the sample of wire used.

(3)

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Cross-sectional area =

(ii) The student plotted a graph of m against Δx . 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

(3)

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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.

(2)

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(Total for question = 9 marks)

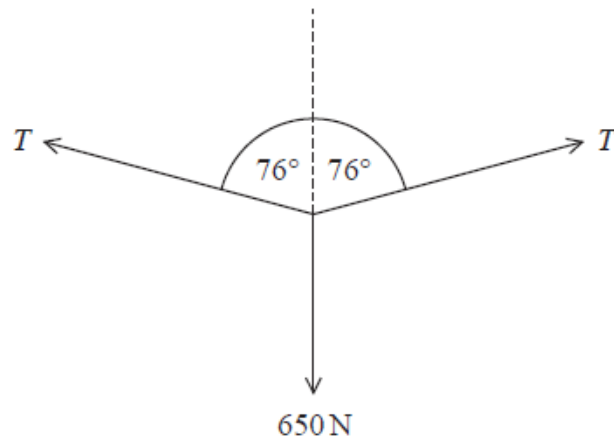
Q7.

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 1.3×10^3 N.

(3)

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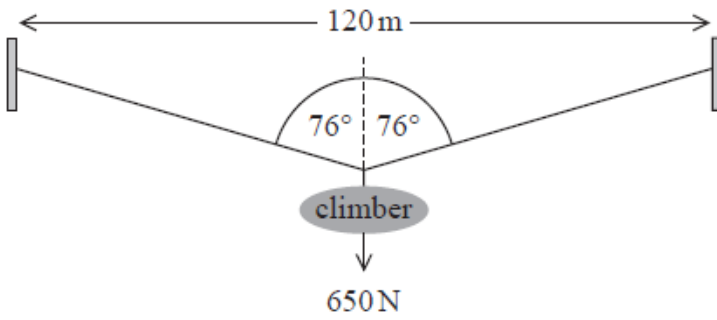
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(b) The rope has an unstretched length of 120 m as shown below.



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

You may ignore the weight of the rope.

(3)

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Strain =

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

Determine the Young modulus of the rope material.

(3)

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Young modulus =

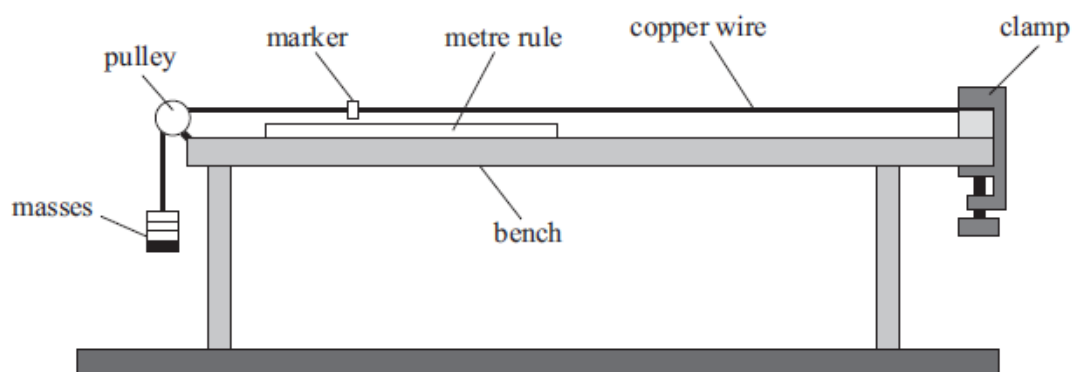
(Total for question = 9 marks)

Q8.

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

*(a) The student clamped one end of a copper wire to the bench. The wire passed over a pulley and masses were added to the other end of the wire.

A metre rule was fixed to the bench and a marker fixed to the wire, as shown.



The student measured the diameter of the copper wire.

Describe the other measurements that need to be made using this apparatus and how they will be used to determine the Young modulus of copper.

You should define the meanings of any symbols you use.

(6)

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(b) Another student attaches a weight of 5.0 N to a copper wire of diameter 0.56 mm.

Calculate the extension of the wire.

length of wire = 2.5 m

Young modulus of copper = 1.1×10^{11} Pa

(4)

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Extension =

(Total for question = 10 marks)

Q9.

A student determined the Young modulus of a material in the form of a wire.

(a) The student used a micrometer to measure the diameter of the wire.

Describe how the student should

- check that the wire is uniform
- check that the wire has a circular cross-section.

(2)

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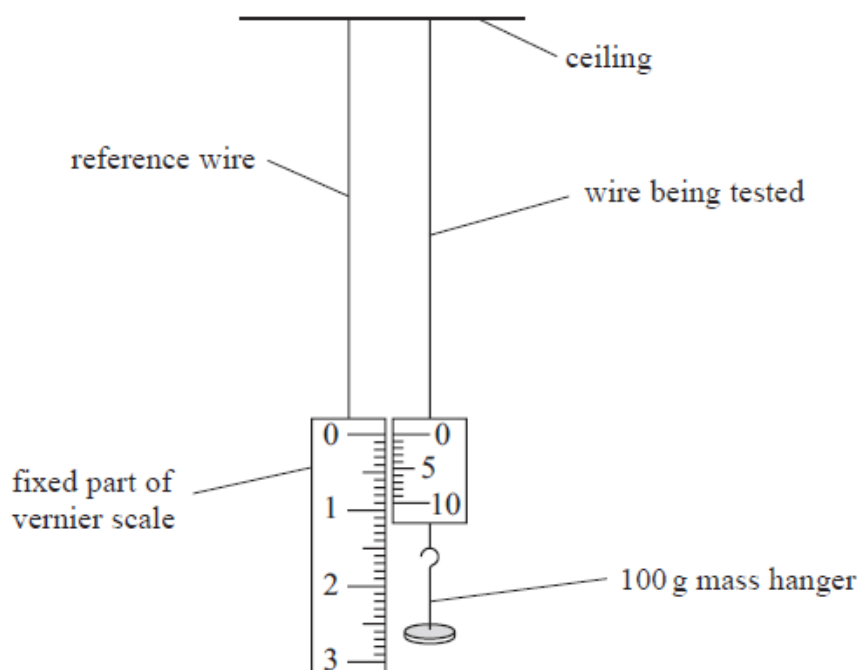
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(b) The student hung a reference wire and the wire being tested from the ceiling.

At the lower end of the reference wire he positioned the fixed part of a vernier scale.

The student attached a 100 g mass hanger to the wire being tested. The initial reading on the vernier scale was 0.0 mm, as shown.

He added masses to the mass hanger and measured the corresponding extension Δx of the wire using the vernier scale.



(i) The student kept his feet away from the apparatus so that the masses could not fall on his feet.

Explain one other safety precaution.

(2)

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(ii) Each time the student added more mass, Δx increased by a few mm.

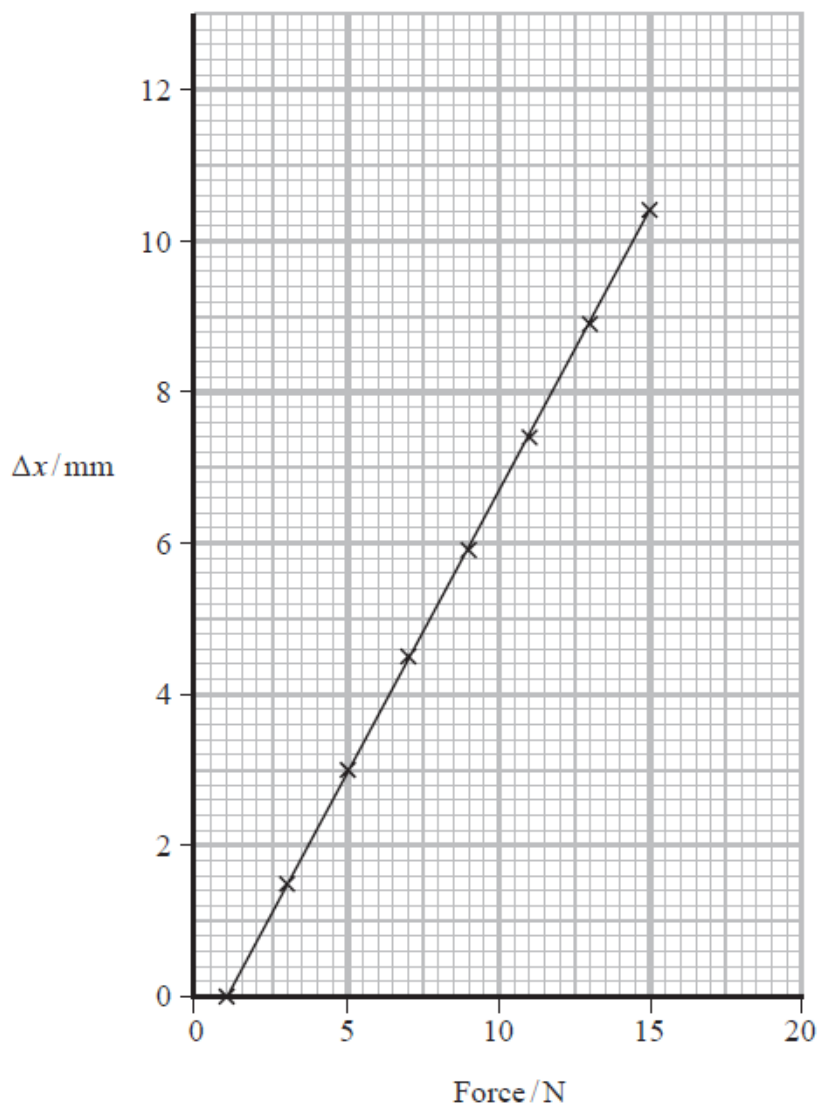
Explain why he should measure Δx using a vernier scale, instead of a metre rule.

(2)

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(c) For each mass added, the student determined the force on the wire. The student plotted the graph shown.



The table gives the Young modulus for some materials.

Material	Young modulus / GPa
Aluminium	68
Brass	106
Steel	200

Deduce which material the wire was made from.

original length of wire = 1.80 m

diameter of wire = 0.17 mm

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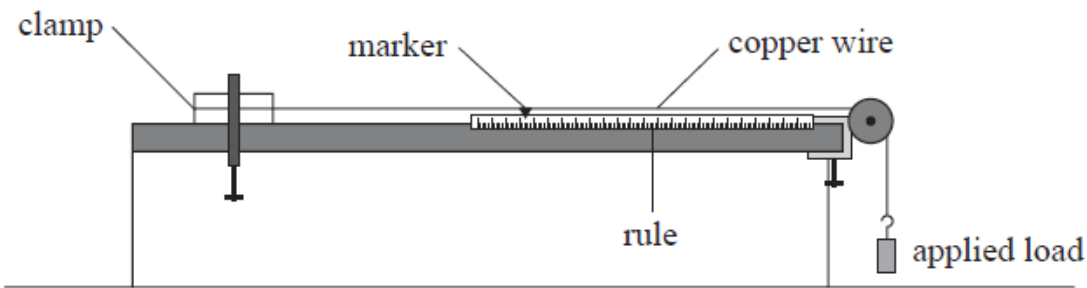
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(Total for question = 11 marks)

Q10.

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.

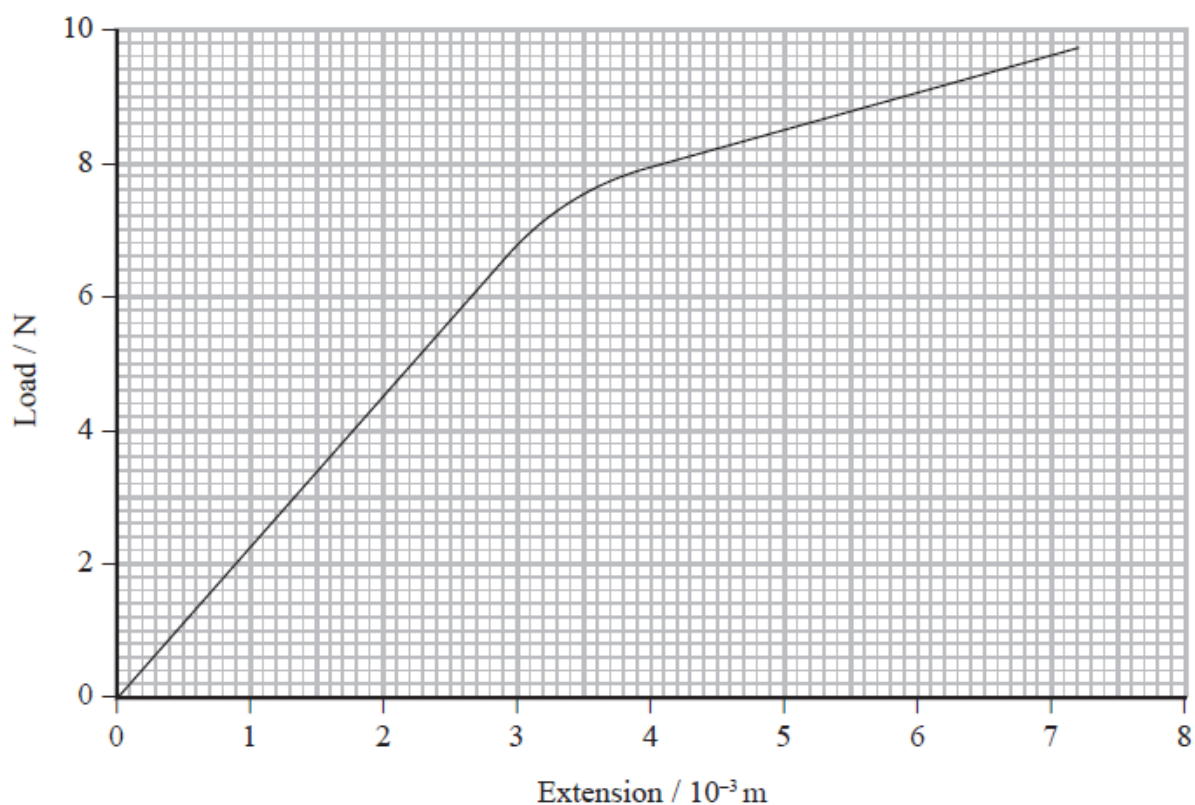
(3)

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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 = 2.3×10^{-4} m

(4)

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Young modulus of copper =

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

(6)

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(Total for question = 13 marks)

Q11.

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

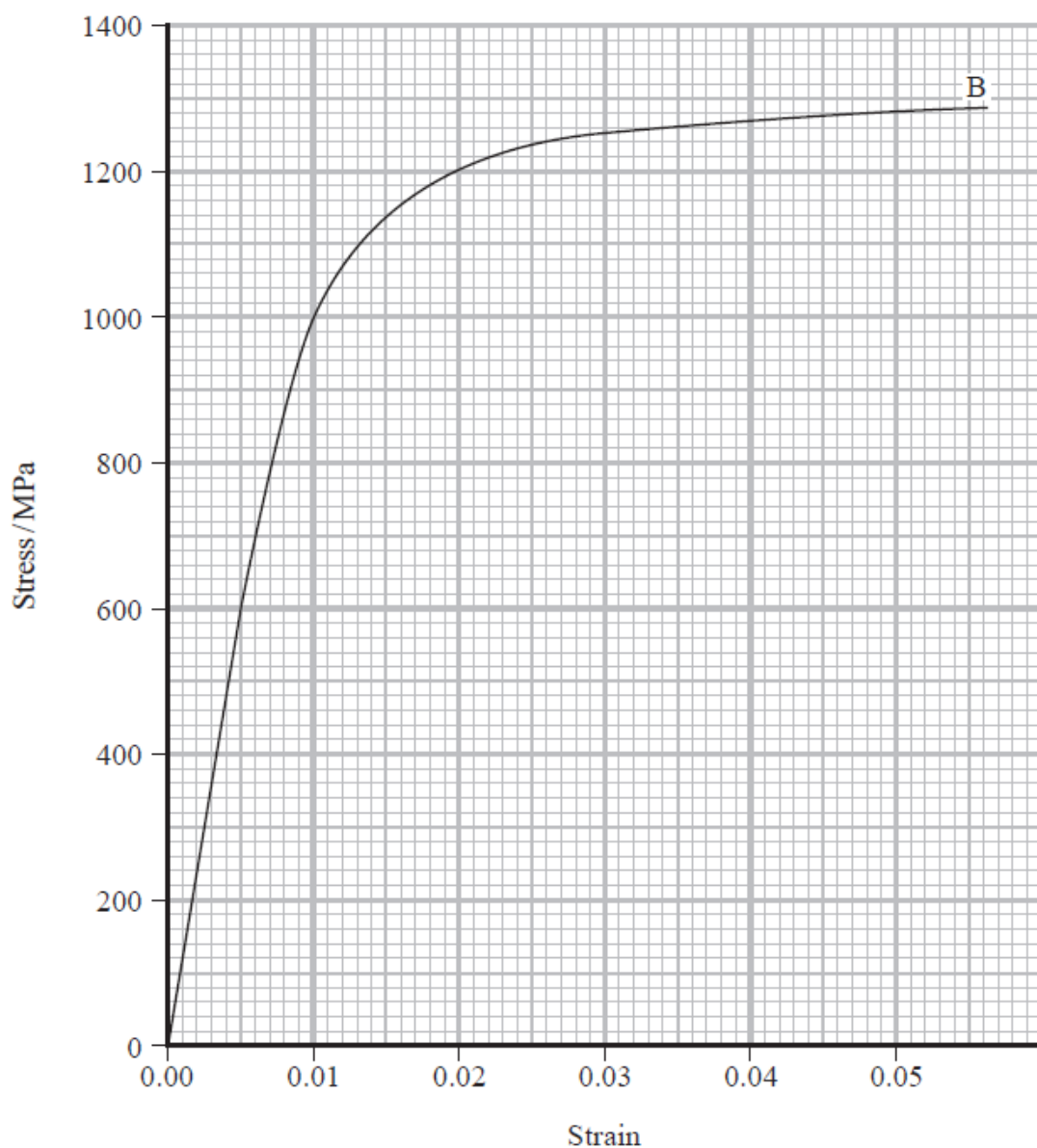
The sample had an original length of 40.0 cm and diameter of 5.05 mm.

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

(1)

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



(i) Determine the Young modulus of the sample.

(3)

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Young modulus =

(ii) The sample broke at point B.

Determine the force required to break the sample.

(4)

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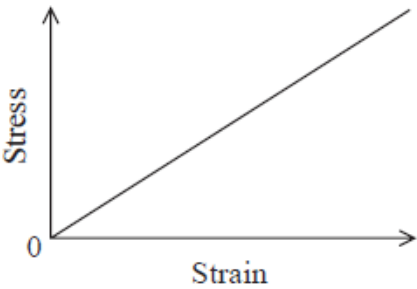
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Force =

(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.

(3)

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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.

(4)

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Work =

(Total for question = 15 marks)