

SUR HW One

40 min
40 marks

1. Steel can be classified as a strong material. This is because
- A it is difficult to deform
 - B it has a large ultimate tensile stress value
 - C it has a large Young modulus value
 - D it breaks shortly after its proportional limit

(Total 1 mark)

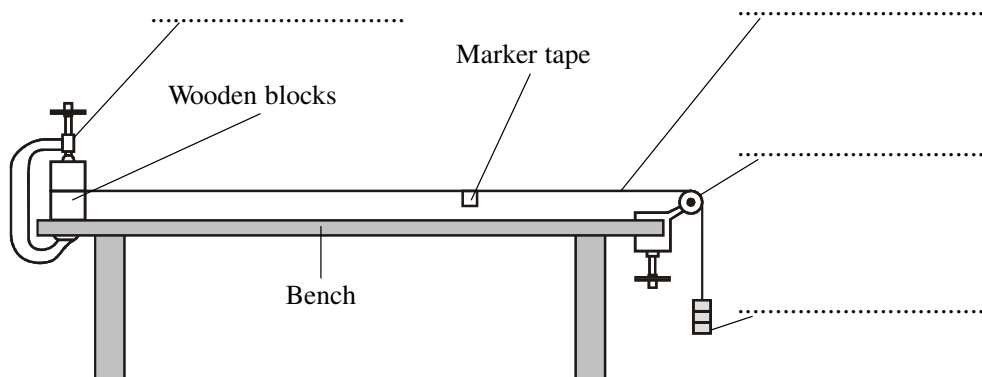
2. Complete the gaps in the following paragraph by selecting appropriate words from the following list.

compressive density energy force mass stiff tensile tough

Increasingly, drinks containers are made out of polymers rather than glass. A container made from a polymer such as polythene has several advantages over a glass container. Polythene has low, and so the of the container is kept low. Polythene is also and so can absorb a large amount of before breaking. Glass is only strong under forces but polythene is also strong under forces.

(Total 3 marks)

3. A student uses the following apparatus to determine the Young modulus of copper.



- (i) The diagram above has four labels missing. Add these labels to the diagram. (2)

- (ii) On the diagram show accurately the length l of the copper wire that should be considered. Suggest an appropriate length for l .

..... (2)

(iii) The student wishes to plot a stress-strain graph for the copper wire.

What two additional pieces of apparatus would be required to determine values for stress and strain?

1

2

(2)

(Total 6 marks)

4. For many years surgeons have used metal implants to repair broken bones and joints. It is important to understand how the properties of the implant materials compare with bone so that comfortable and long-lasting repairs can be made.

One important property of the implant material is its stiffness. How is stiffness calculated?

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(1)

Explain the difference between *stiffness* and the *Young modulus*.

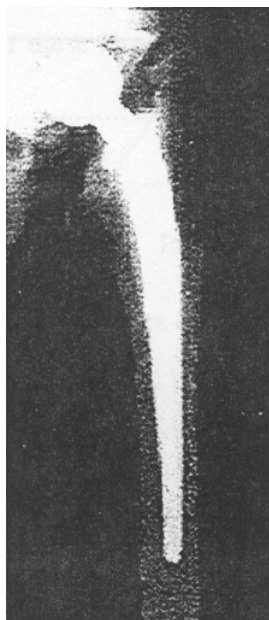
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(2)

The picture shows an X-ray of a hip joint after surgery to replace the weakened joint with an implant



A woman needs a hip replacement operation. Calculate the stress in the bone just below her hip when she is standing still.

Assume that the mass supported by this hip is 30 kg and that the bone just below her hip is of circular cross-section with radius = 2.0×10^{-2} m.

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(3)

A manufacturer of hip replacements is considering using a new polymer of Young modulus 2×10^9 Pa. Explain whether this is a suitable material for hip replacements.

The Young modulus of bone is 1×10^{10} Pa.

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(2)
(Total 8 marks)

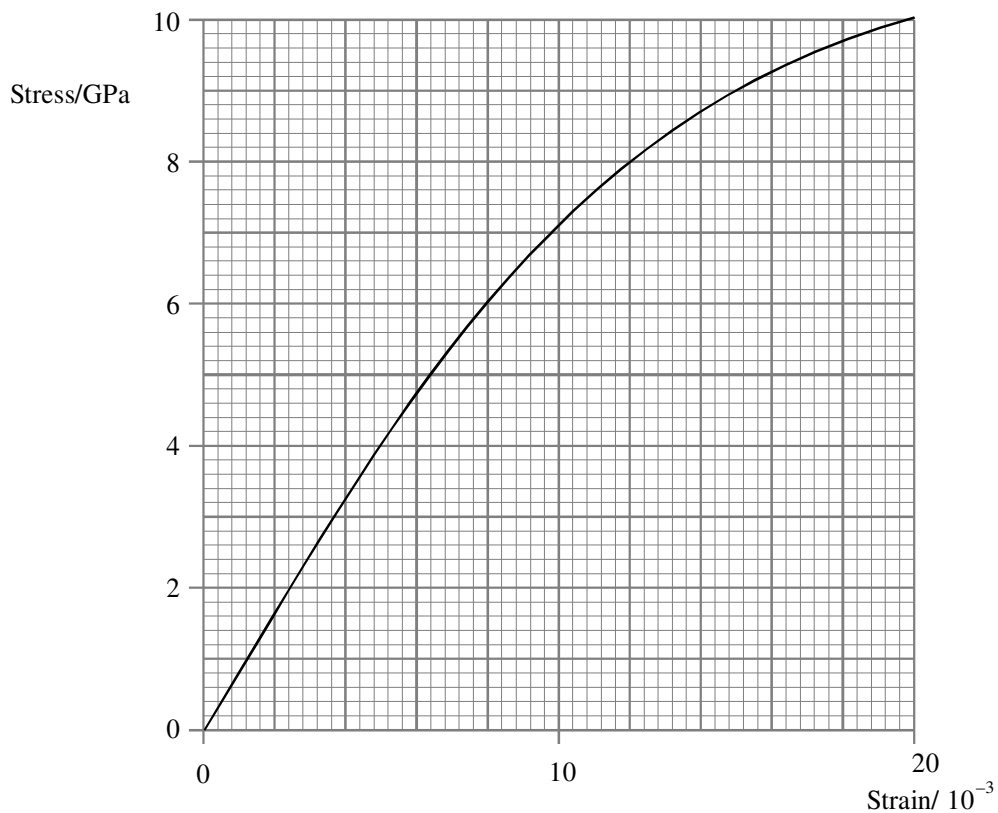
5. This question is about the design of a car seat belt. The seat belt has to restrain a passenger when the car is involved in an accident.

Use definitions of stress and strain to show that $stress \times strain$ has the same units as *energy stored per unit volume of seat belt*.

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(3)

The graph shows how stress varies with strain for the seat belt material.



Use the graph to show that the energy stored per unit volume of seat belt material when the strain is 20×10^{-3} is about $1 \times 10^8 \text{ Jm}^{-3}$.

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(3)

The car is travelling at 20 m s^{-1} carrying a 60 kg passenger who is wearing a seat belt.

(i) Show that the kinetic energy of the passenger is $12\,000 \text{ J}$.

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(1)

- (ii) Calculate the volume of seat belt material which would be required to stop the passenger when the car stops suddenly.

Assume that the maximum strain in the seat belt is 20×10^{-3} .

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Volume =

(2)

- (iii) Use your answer to part (ii) to suggest a suitable width and thickness of seat belt for this situation, assuming its length is 2.0 m.

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(2)

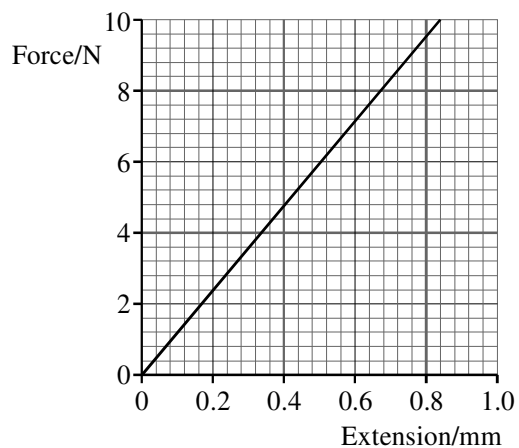
(Total 11 marks)

6. Calculate the stress in a steel wire of length 2.6 m and cross-sectional area $1.5 \times 10^{-7} \text{ m}^2$ when it is subjected to a tensile force of 8.0 N.

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(2)

Part of a force-extension graph for such a steel wire is shown below.



Use the graph to find the extension of the wire for an applied force of 8.0 N.

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Show that the corresponding strain in the wire is approximately 3×10^{-4} .

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Hence determine the Young modulus for steel.

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Young modulus =

(4)

Calculate the work done in stretching the wire by 0.4 mm.

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Work done =

(3)

A second wire is made of the same steel. It has the same cross-sectional area but twice the length.

On the same axes draw the force-extension graph for this wire.

(2)

(Total 11 marks)