Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2012

Applied Science SC05

Unit 5 Choosing and Using Materials

Friday 18 May 2012 1.30 pm to 3.00 pm

For this paper you must have:
- a pencil
- a ruler
- a calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show the working of your calculations.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.
- You are expected to use a calculator where appropriate.

Answer **all** questions in the spaces provided.

1 Manufacturers must decide which material to use when making a particular item.

Table 1 shows information about four different materials.

Table 1

Material	Conductor or insulator of heat	Other properties
Iron	Conductor	Melts at 1535°C Very strong Rusts Medium cost
Copper	Conductor	Melts at 1083°C Strong Does not rust High cost
Ceramic fibre	Insulator	Very high melting point Made from strong fibres Heat resistant High cost
Expanded polystyrene	Insulator	Melts easily Not strong Burns easily Low cost

1 (a) One manufacturer makes mats to protect laboratory benches from hot Bunsen burners.

1 (a) (i) Using information from **Table 1**, name the most effective material for making the mats.

.....

(1 mark)

1 (a) (ii) Give **one** reason for your choice of material.

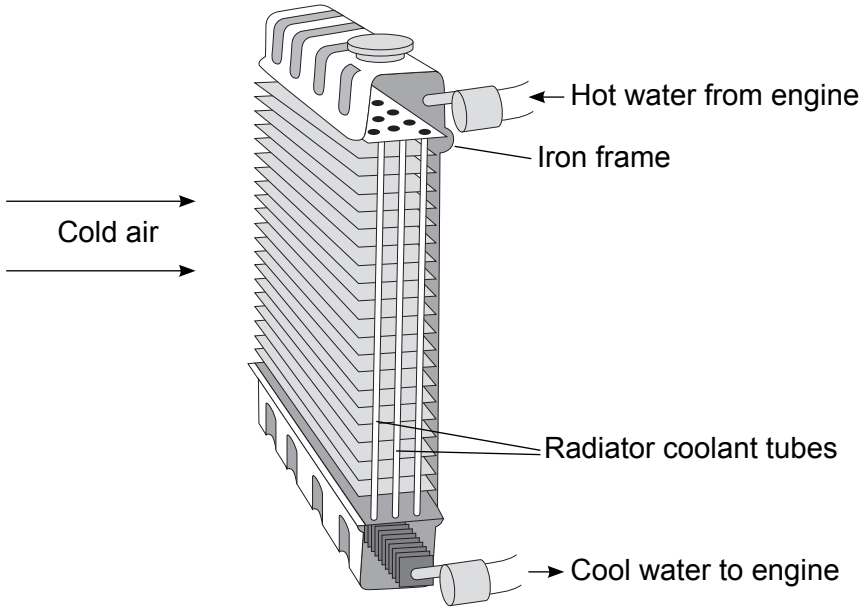
.....

.....

(1 mark)

1 (b) Another manufacturer makes car radiators as shown in **Figure 1**.
Hot water from the engine flows through the radiator coolant tubes.
Cold air flows through the radiator, cooling the water.

Figure 1



1 (b) (i) Using information from **Table 1**, name the most effective material for making the radiator coolant tubes.

.....

(1 mark)

1 (b) (ii) Give **one** reason for your choice of material.

.....

.....

(1 mark)

Question 1 continues on the next page

1 (c) Iron and copper are metals.
Metals are malleable, ductile and good conductors of electricity.

1 (c) (i) Define *malleable.*

.....

.....

(1 mark)

1 (c) (ii) Define *ductile.*

.....

.....

(1 mark)

1 (c) (iii) Explain, in terms of their structure, why metals are good conductors of electricity.

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.....

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(2 marks)

1 (d) The metal tungsten is described as 'not easy to scratch or dent'.
Tungsten is best described as:

Hard ☐

Plastic ☐

Stiff ☐

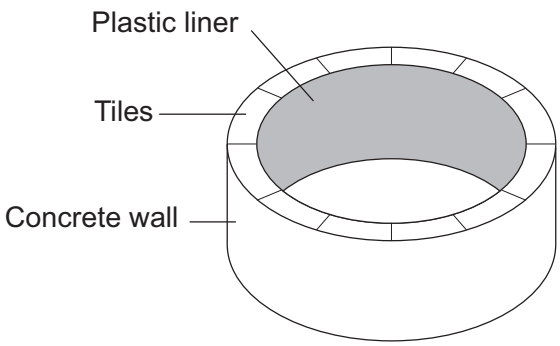
Tough ☐

Tick the box next to the correct answer. *(1 mark)*

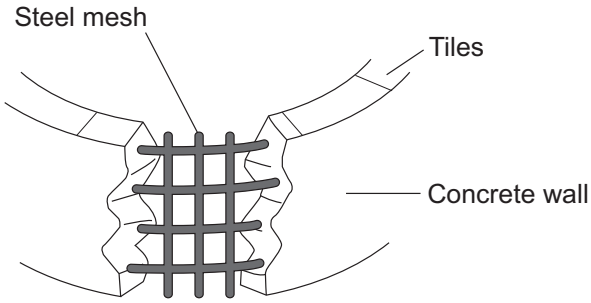
9

2 A garden designer draws the diagrams in **Figure 2** to show the materials she will need to use to make a raised garden pond.

Figure 2



Raised garden pond



Cross section of concrete wall

2 (a) From the diagrams in **Figure 2**, name the part of the pond that is made from:

2 (a) (i) a ceramic material

.....

(1 mark)

2 (a) (ii) a polymer

.....

(1 mark)

2 (a) (iii) a composite material.

.....

(1 mark)

2 (b) Why is steel mesh put into the concrete wall?

.....

.....

(1 mark)

Question 2 continues on the next page

2 (c) Steel is an alloy made from iron.

2 (c) (i) What is meant by the term *alloy*?

.....

.....

(1 mark)

2 (c) (ii) Steel is harder than pure iron. Explain why.
You may use diagrams to help your answer.

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(3 marks)

2 (d) The company that makes the plastic liner for the pond also makes plastics for other uses. **Table 2** shows information about some of the plastics they make.

Table 2

Plastic	Softening temperature	Is it biodegradable?	Is it flammable?	Other properties
A	160°C	No	Yes	Not affected by sunlight
B	130°C	Yes	Yes	Very flexible
C	Does not soften at high temperatures	No	No	High density

2 (d) (i) What is meant by the term *biodegradable*?

.....

.....

(1 mark)

2 (d) (ii) Write down **one** problem that non-biodegradable plastics cause.

.....

.....

(1 mark)

2 (d) (iii) Plastic **A** is the best plastic to use to make a pond liner.
Use information from **Table 2** to write down the **two** best reasons why.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

Question 2 continues on the next page

2 (d) (iv) The company also makes plastic coatings for engines. The coatings are sprayed onto the engines to stop rusting.
Use information from **Table 2** on page 7 to decide which plastic, **A**, **B** or **C**, is the best choice for making an engine coating. Explain your answer.

Plastic .....

Explanation .....

.....

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.....

.....

.....

(3 marks)

15

3 (a) Describe the behaviour of a wire that obeys Hooke's law.

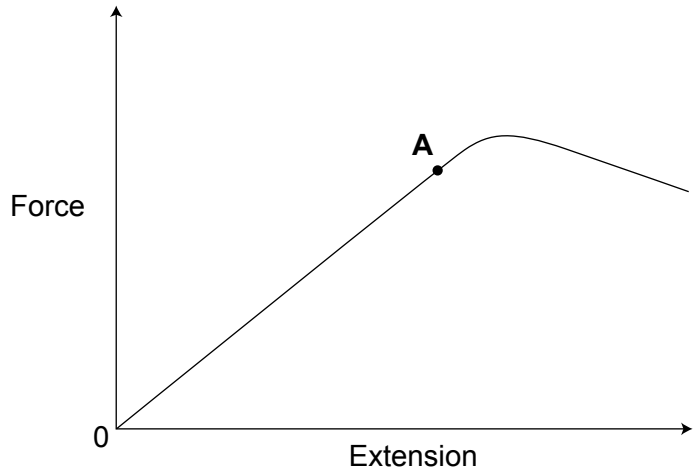
.....

.....

(1 mark)

3 (b) **Figure 3** shows the graph of force against extension for a material.

Figure 3



3 (b) (i) On the graph in **Figure 3**, draw an arrow labelled **E** to a point at which the material is undergoing elastic deformation. *(1 mark)*

3 (b) (ii) On the graph in **Figure 3**, draw an arrow labelled **P** to a point at which the material is undergoing plastic deformation. *(1 mark)*

3 (b) (iii) What name is given to point **A** on the graph in **Figure 3**?

.....

(1 mark)

3 (c) Give the meaning of the terms:

3 (c) (i) *elastic deformation*

.....

.....

(1 mark)

3 (c) (ii) *plastic deformation.*

.....

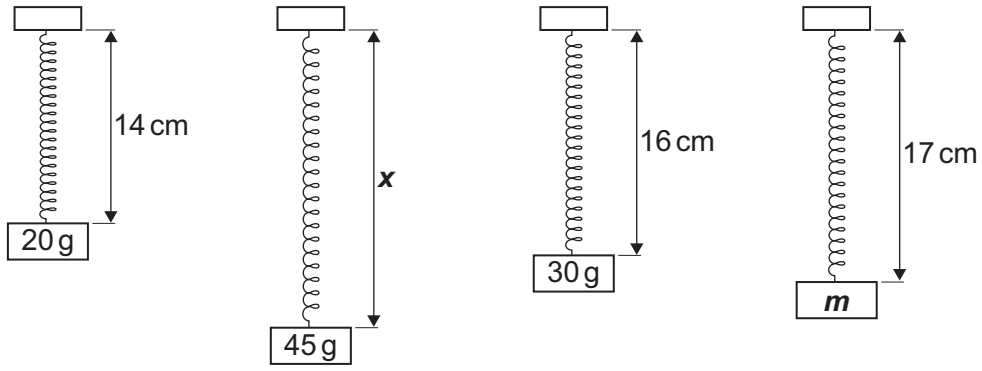
.....

(1 mark)

Turn over ▶

3 (d) **Figure 4** shows four drawings, not to scale, of a spring that obeys Hooke's law.

Figure 4



3 (d) (i) Calculate length ***x***.

.....

length = ...cm
(1 mark)

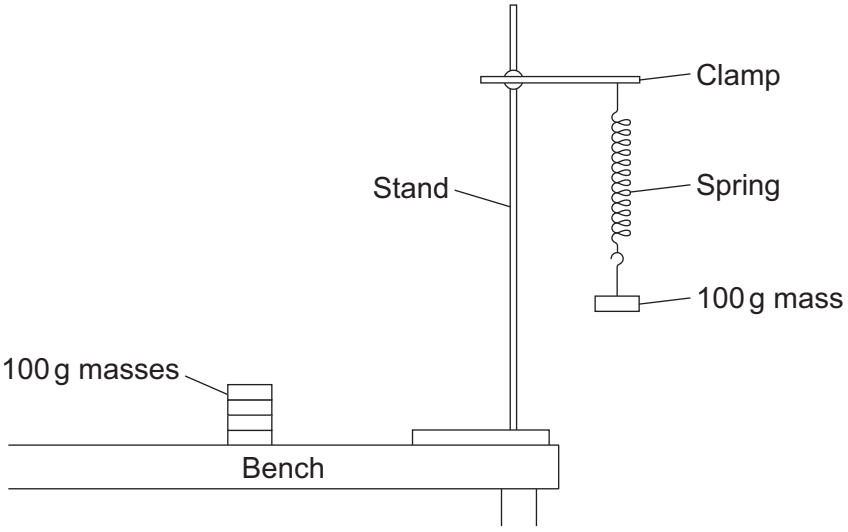
3 (d) (ii) Calculate mass ***m***.

.....

mass =.....g
(1 mark)

3 (e) A student is asked to find the mass of a rock sample using a steel spring, a set of 100 g masses and a metre rule.
He sets up the arrangement shown in **Figure 5**.

Figure 5



3 (e) (i) Describe how you would use this arrangement to find the mass of the rock sample. State the measurements you would make and explain how you would use these measurements to find the mass of the rock sample.

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(7 marks)

Question 3 continues on the next page

3 (e) (ii) State **two** modifications you could make to the arrangement shown in **Figure 5** on page 10 to make it more stable.

Modification 1.....

.....

Modification 2.....

.....

(2 marks)

3 (f) The student found the mass of the rock sample to be 355 g.
The density of the rock is 3.69×10^3 kg m^{-3}.
Calculate the volume of the rock sample.
Give the correct unit in your answer.

.....

.....

.....

.....

.....

Volume =.....

(3 marks)

20

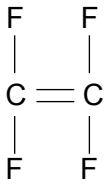
Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

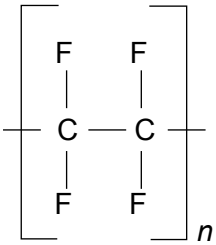
4 **Read the following article about polymers and clothing.**
Use the information and your own knowledge to answer the questions that follow.

Polymers and clothing

Clothing can be made waterproof by using a synthetic fibre (e.g. nylon) with a PTFE coating. PTFE is poly(tetrafluoroethene). This is a polymer formed from the monomer tetrafluoroethene.
These polymer and monomer structures are shown below.

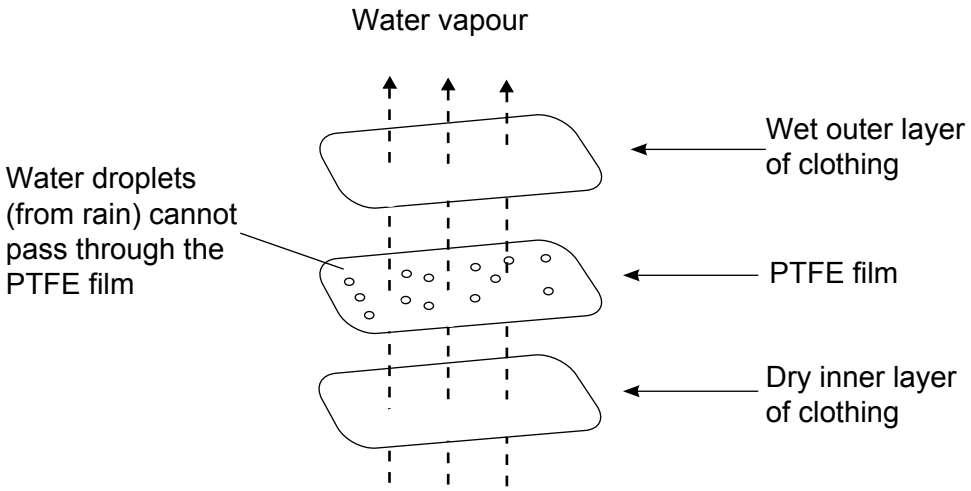


Tetrafluoroethene



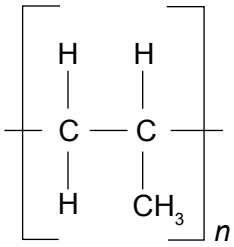
Poly(tetrafluoroethene)

The coated clothing has a thin film of PTFE, which has a large number of very small holes. There are over 1 billion holes per square centimetre. The holes are too small to let liquid water pass through, which makes the PTFE film waterproof. However, the holes are big enough to let water vapour through, which makes the clothing 'breathable'.



This type of material is called Gore-Tex® and it is ideal for making outdoor clothing.

To make outdoor clothing that is both waterproof and warm it is necessary to combine Gore-Tex® material with another material called Thinsulate® insulation. Thinsulate® insulation is a synthetic material partly made from very thin fibres of the polymer poly(propene). The structure of this polymer is shown below.



Poly(propene)

The poly(propene) fibres are spun and woven into a thin layer. The poly(propene) layer is very good at trapping air, which makes it a good insulator of heat. The trapped air keeps the wearer of the clothing warm and the holes between the fibres make the layer 'breathable'. The fibres are also good at reflecting infrared radiation, which also keeps the wearer warm.

Lycra® is a type of material that is ideal for sportswear. Lycra® is made by combining two different polymers in alternating layers. One polymer is hard and crystalline, the other is elastic. Lycra® combines the properties of elasticity with being durable.

4 (a) Give the meaning of the following terms used in the article.

Synthetic .....

.....

Polymer .....

.....

Crystalline .....

.....

Durable .....

.....

(4 marks)

4 (b) Gore-Tex® and Thinsulate® insulation are both 'breathable' materials. What does this mean?

.....

.....

(1 mark)

Question 4 continues on the next page

Turn over ▶

4 (c) (i) What is the name of the monomer from which the material Thinsulate® insulation is made?

.....

(1 mark)

4 (c) (ii) Draw the structure of a molecule of this monomer.

(1 mark)

4 (d) (i) What type of chemical bonding is present in the polymer PTFE?

.....

(1 mark)

4 (d) (ii) Describe this type of bonding.

.....

.....

(1 mark)

4 (e) What part of the structure of a tetrafluoroethene molecule allows it to be polymerised?

.....

.....

(1 mark)

4 (f) State **two** ways in which clothing made from the material Thinsulate® insulation keeps the wearer warm.

1 .....

.....

2 .....

.....

(2 marks)

12

5 Modern materials have improved many products.

The use of modern materials can:
- make a product stronger
- make a product safer
- make a product easier to use
- reduce the weight of a product.

Examples of modern materials are:
- carbon fibre
- nylon
- polycarbonate
- Kevlar®
- GRP (fibreglass)
- aluminium alloys
- Teflon® (PTFE).

Complete **Table 3** by suggesting an example of a product that uses one of the above modern materials to bring about each of the improvements shown.
For each product name the modern material used.

Table 3

Improvement	Product	Name of modern material
Increased strength		
Increased safety		
Easier to use		
Reduced weight		

(8 marks)

8

Turn over for the next question

6 A lift manufacturer is testing different steel cables before deciding which one to use. The cable must have the correct stiffness and have enough tensile strength to be able to support the required load.

6 (a) Define the terms:

6 (a) (i) *stiffness* .....

.....

(1 mark)

6 (a) (ii) *tensile strength* .....

.....

(1 mark)

6 (b) The results of the tests on one of the steel cables are shown in **Table 4**.

Table 4

Stress × 10^7 (N m^{-2})	0	0.9	1.8	2.9	4.0	4.7	5.2	5.4	5.5
Strain × 10^{-3}	0	1.0	2.0	3.2	4.4	5.2	6.4	7.2	8.0

6 (b) (i) Define *stress*.....

.....

(1 mark)

6 (b) (ii) Define *strain*.....

.....

(1 mark)

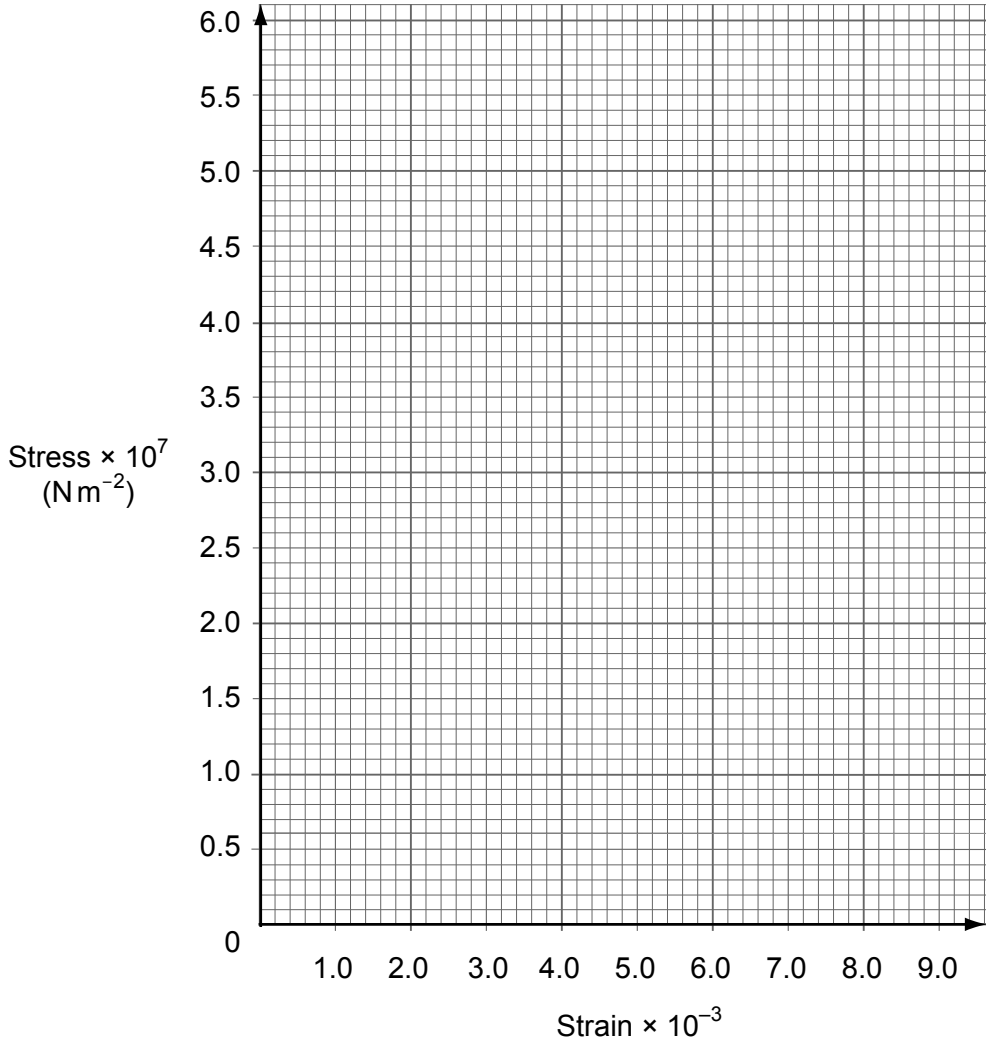
6 (b) (iii) Explain why there is no unit for strain.

.....

.....

(1 mark)

6 (b) (iv) Plot the data from **Table 4** onto the grid.
Draw a line of best fit.



(2 marks)

6 (b) (v) Using your graph, or an alternative method, calculate the Young modulus for steel.
Give the correct unit in your answer.

.....

.....

.....

.....

.....

Young modulus =.....

(3 marks)

Question 6 continues on the next page

Turn over ▶

6 (c) The lift manufacturer does not want the strain in the cable to exceed 4.0×10^{-3}. The maximum load the lift can carry is 6.5 kN. Use your graph on page 19 to calculate the minimum cross-sectional area of the cable. Give the correct unit in your answer.

.....

.....

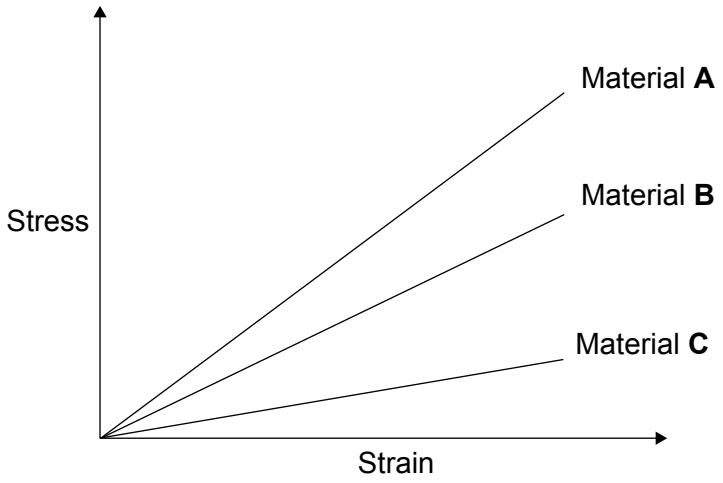
.....

Minimum cross-sectional area =.....

(3 marks)

6 (d) **Figure 6** shows the stress against strain graphs for three different materials, **A**, **B** and **C**.

Figure 6



Which material **A**, **B** or **C** is the least stiff? Explain your answer.

Material .....

Explanation .....

.....

(2 marks)

6 (e) Other than stiffness and tensile strength, write down **one** other physical property of the cable that the lift manufacturer should consider when choosing the material to make it from.

.....

(1 mark)

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END OF QUESTIONS