Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Applied Science SC05

Unit 5 Choosing and Using Materials

Thursday 16 May 2013 9.00 am to 10.30 am

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

Time allowed
- 1 hour 30 minutes

A

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 The properties of materials are important in determining their use.

1 (a) Give the meaning of the terms *brittle* and *ductile*.

Brittle.....

.....

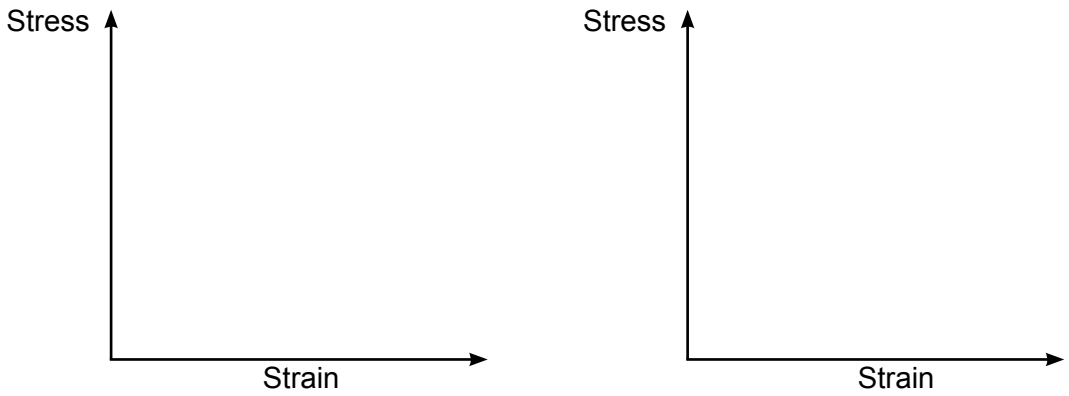
Ductile.....

.....

(2 marks)

1 (b) Complete the stress–strain graphs in **Figure 1** to show the behaviour of brittle and ductile materials.

Figure 1



Brittle material

Ductile material

(2 marks)

1 (c) Give **one** example of a ductile material and a situation where its ductile behaviour is desirable.

Ductile material.....

Situation.....

.....

.....

(2 marks)

1 (d) A physics book gives this definition:

'A material that shows a large plastic deformation under compression'.

This is the definition for **one** of the following properties.

Circle the correct property.

Tough **Hard** **Malleable** **Stiff** **Ductile**

(1 mark)

1 (e) (i) Define the ultimate tensile strength of a material.

.....

.....

(1 mark)

1 (e) (ii) Suggest why an engineer designing a suspension bridge should know the ultimate tensile strength values for all the materials he works with.

.....

.....

(1 mark)

1 (f) Describe the arrangement of atoms in:

1 (f) (i) an amorphous material .....

.....

(1 mark)

1 (f) (ii) a crystalline material .....

.....

(1 mark)

11

Turn over for the next question

2 A technician tested materials used for the strings of badminton racquets.
He measured the extension of the strings when different forces were applied to them.
Figure 2 shows the apparatus he used.

Figure 2

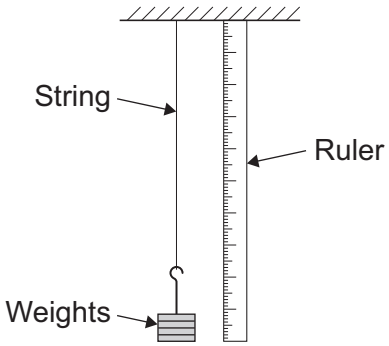


Table 1 shows the results the technician obtained for one of the strings.

Table 1

Force (N)	0	4	8	12	16	20
Extension (mm)	0.0	0.7	1.4		2.8	4.6

2 (a) What was the extension when the force was 12 N?

Extension = ... mm *(1 mark)*

2 (b) (i) Give the range of force where it is certain that the string obeys Hooke's law.

.....

(1 mark)

2 (b) (ii) Give a reason for your answer to part (b)(i).

.....

.....

(1 mark)

2 (c) What would be the effect on the length of the string in **Figure 2** if the force is removed after:

2 (c) (i) an extension of 1.2 mm is reached?

.....

.....

(1 mark)

2 (c) (ii) an extension of 4.6 mm is reached?

.....

.....

(1 mark)

2 (d) Explain your answers to parts (c)(i) and (c)(ii).

.....

.....

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.....

(2 marks)

7

Turn over for the next question

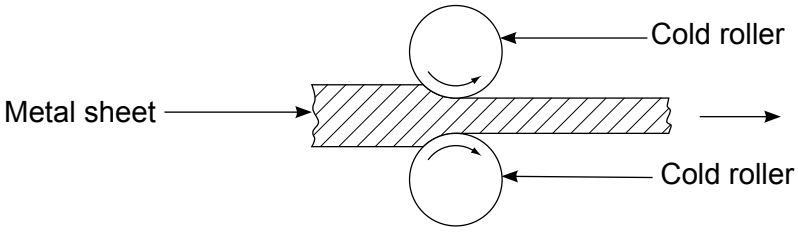
3 **Read the following article about drinks cans and use the information and your own knowledge to answer the questions that follow.**

Drinks cans

The drinks can industry produces nearly 5 billion cans every year. These cans are made from either low-strength steel or aluminium alloy.

The metal reaches the factory in sheets. The sheets are cold rolled to reduce their thickness. **Figure 3** shows the cold rolling process.

Figure 3



Cold rolling introduces unwanted stresses and strains into the metal. Therefore heat treatment (annealing) is required before shaping can take place. After heat treatment the metal sheets are more ductile.

The first stage of the shaping process is to cut discs out of the metal sheets. Each disc is then formed into a cup about 8 cm in diameter. Each cup is then rammed through a tungsten carbide ring to make a hollow cylinder. The bottom of the can is also shaped at this time.

Once shaped and formed, the insides of the cans are coated with a thin layer of plastic. The cans are then filled with their drink before the top of each can is crimped on.

3 (a) Some drinks cans are made from aluminium alloy.
What is an alloy?

.....

.....

(1 mark)

3 (b) Suggest **one** reason for using aluminium alloy instead of pure aluminium.

.....

.....

(1 mark)

3 (c) The metal sheets undergo an annealing process.
Describe how this process is carried out.

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.....

(2 marks)

3 (d) After annealing, the metal sheets are more ductile.
Why do makers of drinks cans prefer to use a metal that is ductile?

.....

.....

(1 mark)

3 (e) Suggest **one** reason why the insides of the cans are coated with a thin layer of plastic.

.....

.....

(1 mark)

3 (f) Manufacturers of drinks cans always want to find ways to reduce their manufacturing costs.

3 (f) (i) How does cold rolling reduce the manufacturing cost of the cans?

.....

.....

(1 mark)

3 (f) (ii) Suggest how the cost of heat treatment might be reduced.

.....

.....

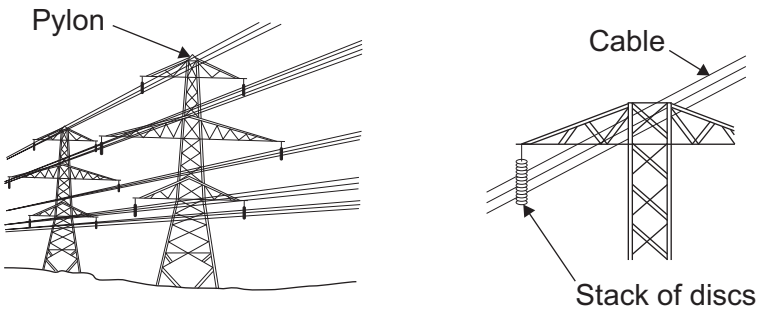
(1 mark)

8

Turn over for the next question

4 Electricity pylons support long electrical cables. The cables hang from the pylons. Stacks of discs prevent the current from passing to the pylons from the cables.

Figure 4



4 (a) (i) The material used for the discs needs a combination of properties.
Suggest **two** properties the material should have.

Property 1 .....

.....

Property 2 .....

.....

(2 marks)

4 (a) (ii) The materials used to make the pylons and the cables belong to the class of materials called metals.
Suggest the class of material that would be most suitable for the stack of discs.

.....

(1 mark)

4 (b) The cables are made from an inner core of steel, which is then clad with aluminium, as shown in **Figure 5**.

Figure 5

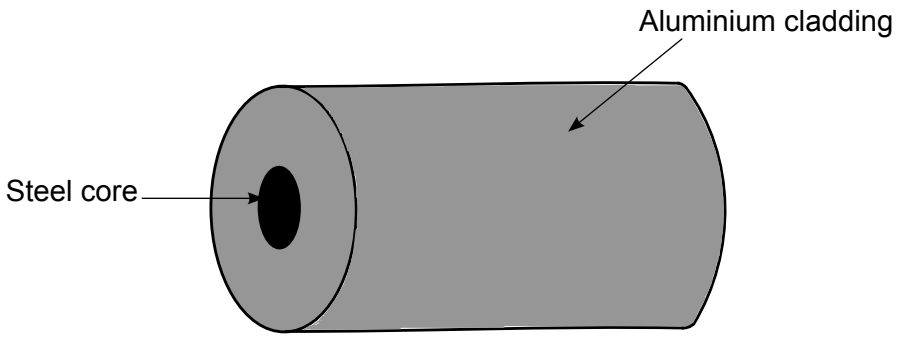


Table 2 shows some properties of aluminium and steel.

Table 2

Material	Density (kg m^{-3})	Tensile strength (MN m^{-2})	Electrical conductivity (S)	Cost per tonne (£)
Aluminium	2700	100	3700	1500
Steel	7800	2500	1000	500

4 (b) (i) What three measurements of a sample of steel must an engineer take in order to calculate the electrical conductivity of steel?

1 .....

2 .....

3 .....

(3 marks)

4 (b) (ii) Use data from **Table 2** to explain the following:

The cable is not made entirely from aluminium.

.....

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.....

.....

The cable is not made entirely from steel.

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(4 marks)

Question 4 continues on the next page

4 (c) The cables should have a high electrical conductance.
Electrical conductance is calculated using the formula below:

$$\text{conductance} = \frac{\text{current}}{\text{voltage}}$$

Describe how you would determine the electrical conductance of a metal wire in a school laboratory.
You should include the measurements that need to be made, and the instruments you would use to make these measurements.

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Extra space (if needed) .....

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(8 marks)

18

5 A metallurgist investigates the thermal expansivity of samples of copper alloy. **Table 3** shows her results.

Table 3

Sample	% increase in length caused by 200 °C temperature rise				
	1st attempt	2nd attempt	3rd attempt	4th attempt	Mean
A	0.39	0.42	0.42	0.45	0.42
B	0.49	0.48	0.49	0.50	0.49
C	0.44	0.43	0.44	0.46	
D	0.40	0.41	0.43	0.44	

5 (a) (i) Which sample, **A**, **B**, **C** or **D**, gave the most reliable results?

Sample .....

(1 mark)

5 (a) (ii) Explain your answer to part (a)(i).

.....

.....

(1 mark)

5 (b) (i) Calculate the mean values for samples **C** and **D**.

Sample **C** = ...

Sample **D** = ...

(1 mark)

5 (b) (ii) Use the mean values of samples **A**, **B**, **C** and **D** to decide which **two** samples are most likely to be of the same type of alloy.

Samples ..... and .....

(1 mark)

Question 5 continues on the next page

5 (c) A more accurate method of comparing the thermal expansivity of materials is to look at their coefficients of linear expansion.

The coefficient of linear expansion is calculated using the formula below:

$$\text{coefficient of linear expansion} = \frac{\text{increase in length}}{\text{original length} \times \text{temperature change}}$$

A surveyor uses a steel measuring tape that is exactly 50 m long at a temperature of 20 °C.

Calculate the length of the tape on a very hot summer day when the temperature is 30 °C. (The coefficient of linear expansion of steel is 1.2×10^{-5} °C^{-1})

Give the correct unit in your answer.

.....

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Length = ...

(4 marks)

5 (d) The properties of a metal may change when it is heated.

Put **one** tick in each row of **Table 4** to show what happens to the mass, volume and density of a metal when it is heated.

Table 4

	Increases	**Decreases**	**Does not change**
Mass			
Volume			
Density			

(2 marks)

5 (e) A sample of metal has a mass of 3400 kg and a volume of 0.42 m^3.

Calculate the density of the metal.

Give the correct unit in your answer.

.....

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Density = ...

(3 marks)

5 (f) Large structures are often made of steel-reinforced concrete.
Suggest why large temperature changes could reduce the lifetime of these structures.

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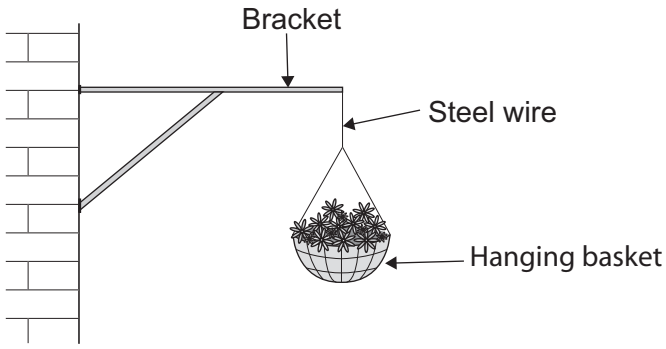
(2 marks)

15

Turn over for the next question

6 A manufacturer of hanging baskets needs to provide a steel wire to be used to suspend the basket from a bracket. **Figure 6** shows the arrangement.

Figure 6



The manufacturer tests different steel wires before deciding which one to use.
One of the properties being considered is the *stiffness* of the wires.

6 (a) Define the term stiffness.

.....

.....

(1 mark)

6 (b) **Table 5** shows the results of the tests on one of the steel wires.

Table 5

Stress (MN m^{-2})	0	6	8	11	15	17	21
Strain $\times$ 10^{-5}	0	4.3	5.7	7.9	10.7	12.1	15.0

6 (b) (i) Define the term stress.

.....

.....

(1 mark)

6 (b) (ii) Define the term strain.

.....

.....

(1 mark)

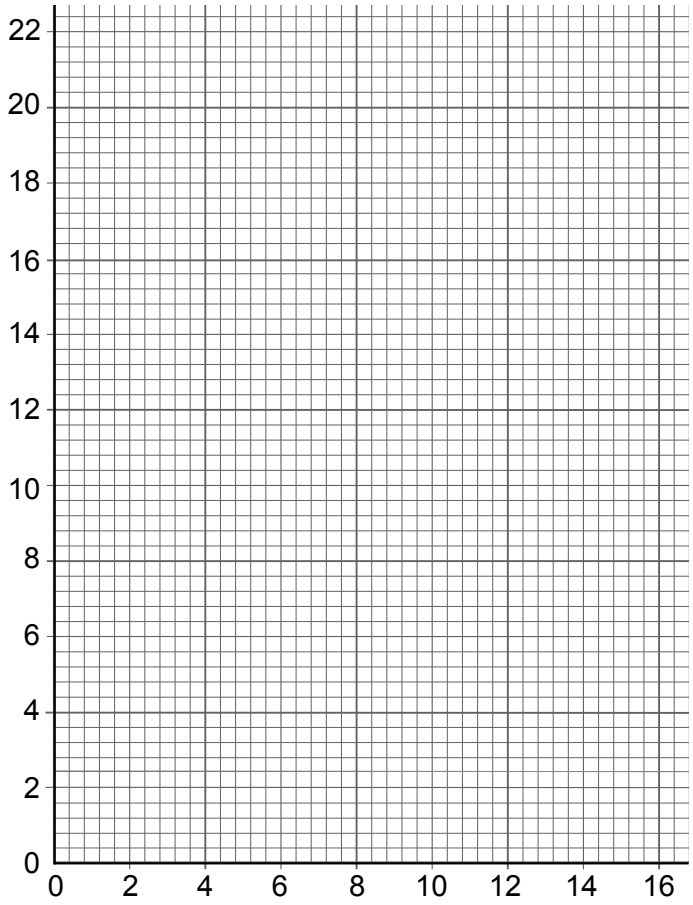
6 (b) (iii) Explain why there is no unit for strain.

.....

.....

(1 mark)

6 (c) (i) Plot the data from **Table 5** onto the grid provided.
Add the correct labels to the axes and draw a line of best fit.



(3 marks)

6 (c) (ii) Use your graph to find the strain when the stress is 14 MN m^{-2}.

.....

(1 mark)

Question 6 continues on the next page

6 (c) (iii) Calculate the Young modulus of the steel used to make the wire.
Give the correct unit in your answer.

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.....

Young modulus = ...

(3 marks)

6 (c) (iv) Draw another line on your graph on page 15 to show the result that would be obtained if a less stiff wire was used.
Label this line **S**.

(2 marks)

6 (d) Apart from stiffness, give **two** other physical properties that the manufacturer should consider when choosing a wire.

1 .....

2 .....

(2 marks)

15

7 Bricks can be made from mud and straw. This type of brick is a composite material.

- Dried mud has high compressive strength, but low tensile strength.
- Straw has low compressive strength, but high tensile strength.

Describe another example of a composite material.

In your answer:

- name the composite material
- name the material for the matrix (eg mud in the above example) and the material for the fibres (eg straw in the above example)
- state the useful properties of each material
- state the drawbacks of each material
- explain why the composite is better than either material alone
- give **one** use for the composite material you have named.

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(6 marks)

END OF QUESTIONS

6

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