Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

Level 3 Technical Level
DESIGN ENGINEERING
MECHATRONIC ENGINEERING

Unit 1 Materials Technology and Science

Wednesday 16 January 2019 Afternoon Time allowed: 1 hour 45 minutes

Materials
For this paper you must have:
- pens
- pencils
- simple drawing instruments
- a scientific calculator (non-programmable)
- the formula sheet, which is provided as an insert inside this paper.

Instructions
- Use black ink or black ball-point pen. Use pencil only for drawing.
- 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 answer book. Cross through any work you do not want to be marked.
- Answer to 3 significant figures unless otherwise instructed.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80. There are 50 marks for **Section A** and 30 marks for **Section B**.
- Both sections should be attempted.

Advice
- Do not spend too long on one question.
- Read all questions thoroughly before starting your answer.
- Show all working in the spaces provided.

For Examiner's Use	
Question	Mark
1–10	
11	
12	
13	
14	
15	
16	
17	
TOTAL	

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Section A

Answer **all** questions in this section.

Total for this section: 50 marks

Tick (✓) the box next to the correct answer for questions **01** to **10**.

0 1 What are the units of compressive strength?

[1 mark]

A kg m^2 ☐

B kg m^{-3} ☐

C N m^{-2} ☐

D N m ☐

0 2 Identify which **one** of the following is a thermosetting polymer.

[1 mark]

A Acrylic ☐

B Polycarbonate ☐

C Polyethylene ☐

D Urea formaldehyde ☐

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0 3 Identify which of the following best describes a dislocation in a metal.

[1 mark]

A A line defect. ☐

B A buckling stress. ☐

C A normalising effect. ☐

D A physical property. ☐

0 4 Identify the unit of electrical capacitance.

[1 mark]

A Ampere ☐

B Farad ☐

C Henry ☐

D Ohm ☐

Turn over for the next question

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0 5 Which class of materials are generally the best heat conductors?

[1 mark]

A Ceramics ☐

B Composites ☐

C Metals ☐

D Polymers ☐

0 6 Name the property that is represented by the linear gradient on a stress-strain graph.

[1 mark]

A Plastic deformation ☐

B Tensile strength ☐

C Yield point ☐

D Young's modulus ☐

0 7 Identify the material that a lathe cutting tool would generally be manufactured from.

[1 mark]

A High carbon steel ☐

B Low carbon steel ☐

C Medium carbon steel ☐

D Stainless steel ☐

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0 8 What effect would annealing have on an aluminium alloy?

[1 mark]

A Harden it

B Strengthen it

C Soften it

D Normalise it

0 9 Which of the following is the unit of frequency?

[1 mark]

A Amplitude

B Hertz

C Period

D Phase

1 0 What is the unit of gravitational force?

[1 mark]

A Joule

B Kelvin

C Newton

D Watt

10

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1 1 . 1 Complete **Table 1** by entering the material class and typical use.

The top row has been completed for you as an example.

[6 marks]

Table 1

Material	Class	Typical use
Brass	Non-ferrous metal	Ornaments, bullet cartridges, bells, plumbing application, door knobs, electrical applications etc.
High impact polystyrene (HIPS)		
Cast iron		
Silicon carbide		

1 1 . 2 **Figure 1** shows a wheelbarrow suitable for use by adults.

Figure 1

State **two** materials that Component **A** is commonly manufactured from.

[2 marks]

Material 1 _____

_____

Material 2 _____

_____

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1 1 . 3 Give **two** reasons why these materials can be used.

[2 marks]

Reason 1 _____

_____

Reason 2 _____

_____

10

Turn over for the next question

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1 2 . 1 Explain briefly what is meant by an alkane structure.

Give an example of **one** in your answer.

[3 marks]

Explanation _____

_____

_____

_____

Example _____

_____

1 2 . 2 Explain what is meant by crosslinking in polymers and how it affects the property of the material.

[7 marks]

_____

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1 3 . 1 Explain the function of an electronic transistor.

[5 marks]

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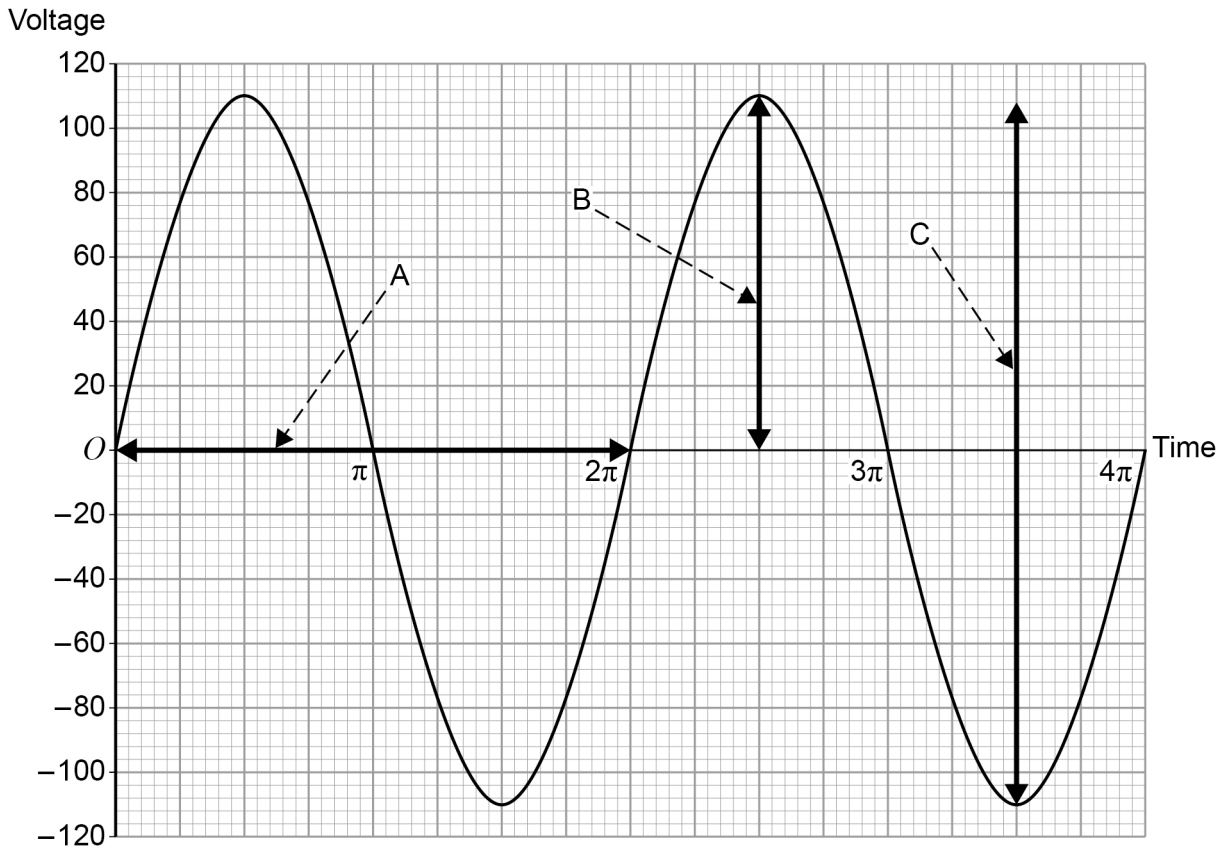
1 3 . 2

Figure 2



Give the correct terms for the properties of the waveform indicated by **A**, **B** and **C** on **Figure 2**

[3 marks]

Point A _____

Point B _____

Point C _____

1 3 . 3 Give **two** engineering examples of where sine waveforms can be found.

[2 marks]

Example 1 _____

_____

Example 2 _____

_____

10

Turn over ►

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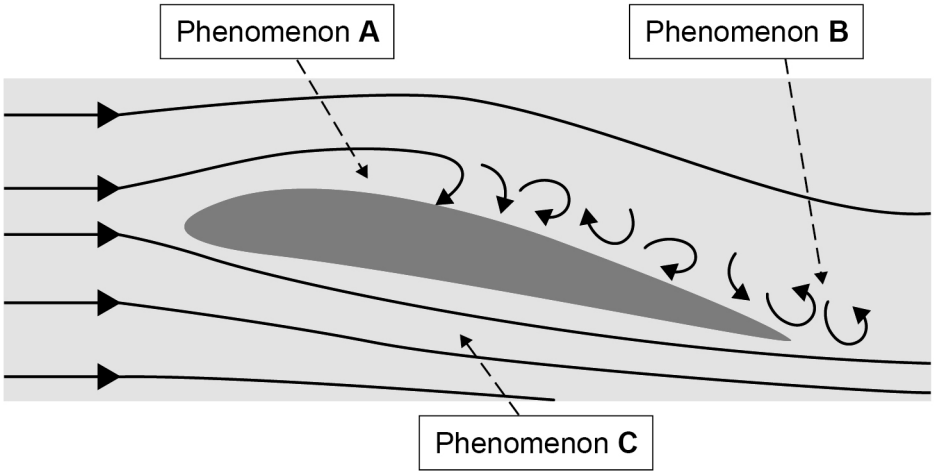
1 4 **Figure 3** shows the cross section of an aircraft's wing in flight.

Figure 3



1 4 . 1 Identify the **three** phenomena listed in **Figure 3**

[3 marks]

Phenomenon **A** _____

_____

Phenomenon **B** _____

_____

Phenomenon **C** _____

_____

1 4 . 2 Explain what is meant by the stagnation point in a two-dimensional fluid flow system.

[2 marks]

_____

_____

_____

_____

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1 4 . 3 Describe how to calculate the efficiency of a simple machine.

[3 marks]

1 4 . 4 Briefly explain what is meant by friction in a mechanical power transmission system.

[2 marks]

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Turn over for the next question

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Section B

Answer **all** questions in this section.

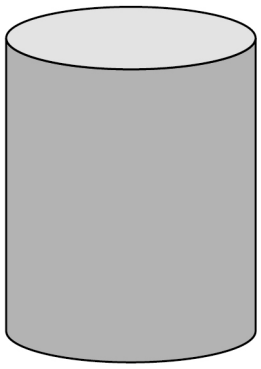
Total for this section: 30 marks

1 5 An engineer is designing a compressed gas storage cylinder – **Figure 4**.

The dimensions of the cylinder are:

Diameter = 1.2 m
Height = 1.75 m

Figure 4



1 5 . 1 Calculate the volume of the cylinder.

Give your answer to 3 decimal places using the correct engineering units.

[4 marks]

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1 5 . 2 The engineer needs to know the mass of air that the cylinder will contain under certain operating parameters.

Use the characteristic gas equation and the volume calculated in question **15.1** to calculate the mass of air.

$pV = mRT$ where:

$p = 1.25$ MPa
$R = 287.05\ J\ kg^{-1}\ K^{-1}$
$T = 75\ °C$
m = mass

[6 marks]

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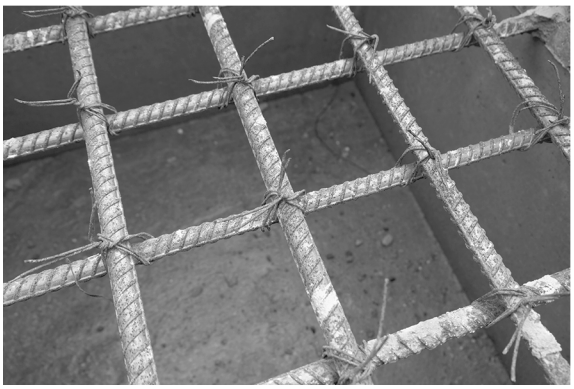
1 6 A tie-bar is to be used in a construction project.

This is shown in **Figure 5**

Figure 5



The following data applies:

Young's Modulus, $E = 200$ GNm^{-2}
Length = 2.0 m
Diameter = 20.0 mm
Load, $F = 50\,000$ N applying tension across the axis of the tie-bar

1 6 . 1 Calculate the tensile stress in the tie-bar to 3 significant figures.

[5 marks]

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1 6 . 2 Calculate the extension in the tie-bar in millimetres to 1 decimal place.

[5 marks]

10

Turn over for the next question

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1 7 . 1 Explain the process of corrosion in metals.

[3 marks]

1 7 . 2 Explain how different metals, used together, can inhibit corrosion.

[2 marks]

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1 7 . 3 Give **five** benefits of corrosion protection.

[5 marks]

10

END OF QUESTIONS

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