AQA

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

Level 3 Technical Level
DESIGN ENGINEERING
MECHATRONIC ENGINEERING

Unit 3 Mathematics for Engineers

Friday 18 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	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	

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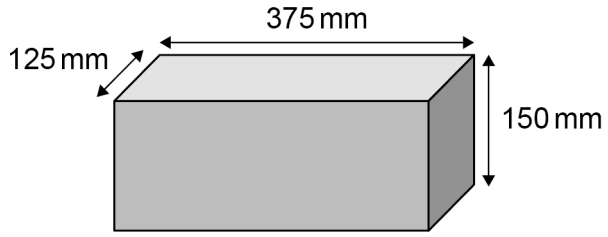
Section A

Answer **all** questions in this section.

Total for this section: 50 marks

0 1 An engineering company has received an order to manufacture 250 containers as shown in **Figure 1**

Figure 1



Each container is manufactured from six sheets of stainless steel.

0 1 . 1 Calculate the surface area needed to manufacture the batch of 250 containers.

Give your answer to the nearest whole number in m^2

[7 marks]

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0 1 . 2 It takes a CNC welding machine 3 minutes 42 seconds to weld each container together.

Calculate how much it will cost to weld the whole batch if the company charges £150 per hour for the use of the machine.

[3 marks]

10

Turn over for the next question

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0 2 A round steel bar is loaded in tension as shown in **Figure 2**

Figure 2

0 2 . 1 The bar has the following dimensions:

- 15 mm diameter
- 1 m original length
- 200 GPa Young's modulus
- Applied tensile load 25 kN

Calculate the change in length of the bar.

Answer in millimetres to 1 significant figure.

[10 marks]

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0 2 . 2 Use the formula method to solve the following quadratic equation:

$$x^2 + 6x + 8 = 0$$

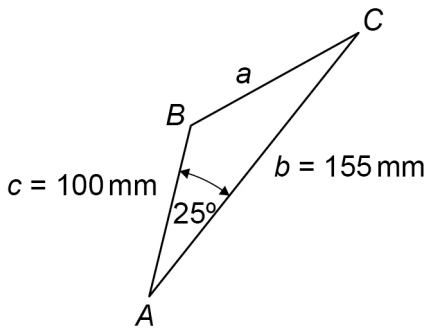
[3 marks]

13

Turn over for the next question

0 3 A metal template needs to be manufactured, as shown in **Figure 3**

Figure 3



Not drawn to scale

Calculate the length of side *a*.

Answer to the nearest millimetre.

[5 marks]

5

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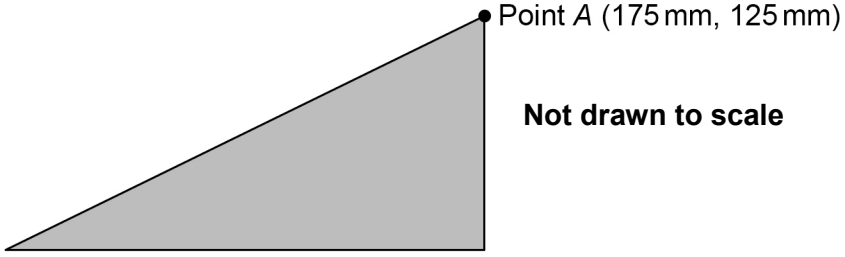
0 4 A CNC programmer needs to determine the position of point A in polar coordinates shown in **Figure 4**

Figure 4



Convert the Cartesian coordinates into polar coordinates.

[5 marks]

5

Turn over for the next question

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0 5 **Table 1** shows the tightening torque (Nm) of a series of bolts on a machine tool.

Table 1

10.5	10.6	10.5	10.4	10.6
10.4	10.5	10.6	10.5	10.5

0 5 . 1 Calculate the mean torque value (Nm) of the data set.

[2 marks]

0 5 . 2 Calculate the median torque value (Nm) of the data set.

[4 marks]

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0 5 . 3 Explain how statistics can help the engineering industry in their quality assurance methods/procedures.

Give **two** examples in your answer.

[4 marks]

10

Turn over for the next question

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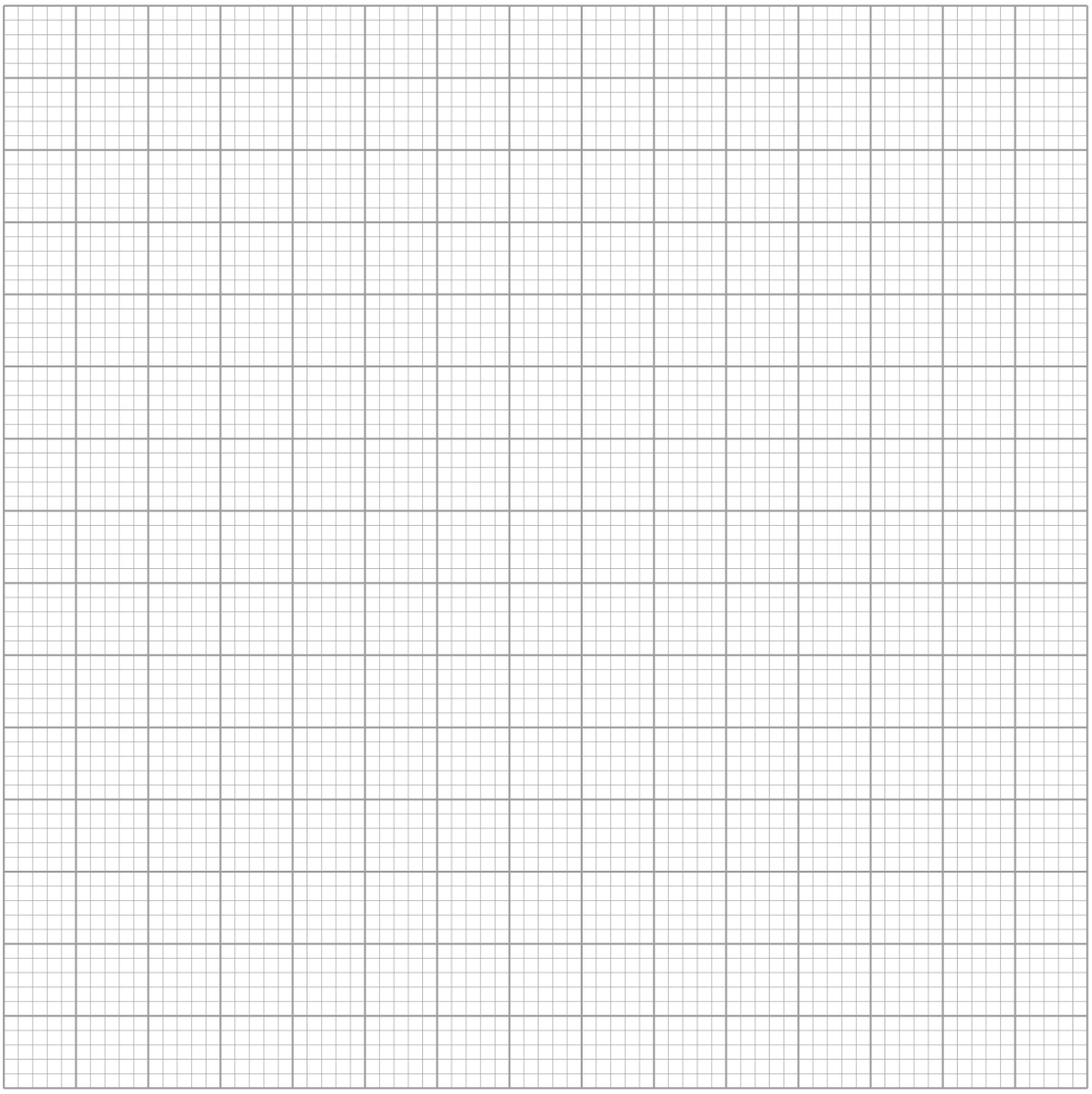
0 6 The data, contained in **Table 2**, is wear rate values taken from a turbine's bearing measured over a period of time.

Table 2

Wear rate – microns	5	10	15	20	25	28	31	33	35	36
Time – seconds	0–1000	1000–2000	2000–3000	3000–4000	4000–5000	5000–6000	6000–7000	7000–8000	8000–9000	9000–10 000

0 6 . 1 Plot a graph of the data set wear rate against time.

[3 marks]



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0 6 . 2 Explain what is happening to the wear rate between 0 and 5000 seconds.

[2 marks]

0 6 . 3 Explain what is happening to the wear rate between 5000 and 10 000 seconds.

[2 marks]

7

Turn over for Section B

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Section B

Answer **all** questions in this section.

Total for this section: 30 marks

0 7 A circular steel shaft is shown in **Figure 5**

Figure 5

Not drawn to scale

It has the following dimensions:

- Diameter = 35 mm
- Mass = 13 200 g
- Density = 7800 kg m^{-3}

Calculate the length of the shaft to the nearest millimetre.

[10 marks]

10

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0 8 In a pressurised hydraulic system, an engineer uses the following equations:

$$26 = 7p_1 - 2p_2$$
$$29 = 6p_1 + 5p_2$$

0 8 . 1 Calculate the values of the **two** pressures, p_1 and p_2

[7 marks]

0 8 . 2 The pressure in a hydraulic system is 1.25 MN m^{-2}

Calculate the force if the area is 0.126 m^2 to 4 significant figures.

You **must** show all of your working and include the correct units.

[3 marks]

10

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0 9 The velocity, v, of a robot, t seconds after changing a tool is $(2t^2 + 5)\text{ms}^{-1}$

0 9 . 1 By the use of integration, calculate the distance that the robot has travelled between $t = 0$ to $t = 4$ seconds.

Answer to 2 significant figures.

[7 marks]

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0 9 . 2 Explain what this area represents by showing how you got to this solution.

[3 marks]

10

END OF QUESTIONS

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