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 19 January 2018 Afternoon Time allowed: 1 hour 45 minutes

Materials
For this paper you must have:
- pens
- pencils
- simple drawing instruments
- scientific calculator (non-programmable)
- formula sheet.

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.

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	
Examiner's Initials	
Question	Mark
1	
2	
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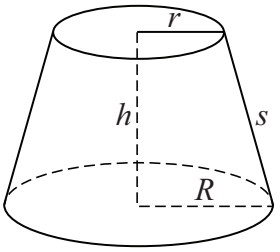
4	
5	
6	
7	
8	
9	
TOTAL	

Section A

Answer **all** questions in this section.

0 1 An engineering company is fabricating 100 buckets. An example of one is shown in **Figure 1**.

Figure 1



Small diameter is 200 mm
Large diameter is 280 mm
Vertical height, *h* is 275 mm.
$Volume = \frac{1}{3}\pi h(R^2 + Rr + r^2)$

0 1 . 1 Determine the volume of **one** bucket in m^3. Show your answer in engineering notation.

[4 marks]

Volume in m^3 _____

Do not write outside the box

0 1 . 2 Determine the surface area of the steel necessary to manufacture the 100 buckets. Your answer must be in standard SI units and in engineering notation.

Surface area = $\pi s(R + r) + \pi r^2$

[7 marks]

11

Turn over for the next question

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0 2 The definition of a logarithm is as follows

If $a^p = q$ then $p = log_a 9$

The laws of logarithms below are used in engineering applications.

$log(A \times B) = logA + logB$

$log(A/B) = logA - logB$

$logA^n = nlogA$

Using the logarithm laws, or otherwise, find the value of the following:

0 2 . 1 $log_3 9$ **[2 marks]**

0 2 . 2 $log_{16} 8$ **[3 marks]**

0 2 . 3 $log_3 \frac{1}{81}$ **[3 marks]**

Do not write outside the box

0 2 . 4 The velocity of a mechanism is given by:

$$log\,(v - 1) + log(v + 1) = 2log(v + 2)$$

Determine the value of v.

[5 marks]

13

Turn over for the next question

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0 3 This question is about degrees and radians.

0 3 . 1 Express 150° in radians as a fraction multiple of π: **[2 marks]**

0 3 . 2 Express 37.5° in radians as a fraction multiple of π: **[2 marks]**

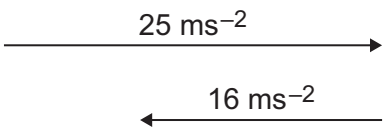
0 3 . 3 Express $\frac{3\pi}{4}$ radians in degrees: **[2 marks]**

0 3 . 4 Express $\frac{5\pi}{2}$ radians in degrees: **[2 marks]**

8

0 4 Determine the resultant vector of the two acceleration vectors in **Figure 2**.

Figure 2



[2 marks]

2

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0 5 The resistance values of 20 electrical resistors (Ω) are shown in **Table 1**.

Table 1

99.0	100.0	100.0	102.0	97.0	98.0	99.0	101.0	97.0	99.0
102.0	101.0	98.0	99.0	100.0	101.0	99.0	97.0	99.0	100.0

0 5 . 1 Determine the mean resistance of the sample.

[2 marks]

0 5 . 2 Determine the standard deviation of the sample.

[4 marks]

0 5 . 3 Determine the modal value of the sample.

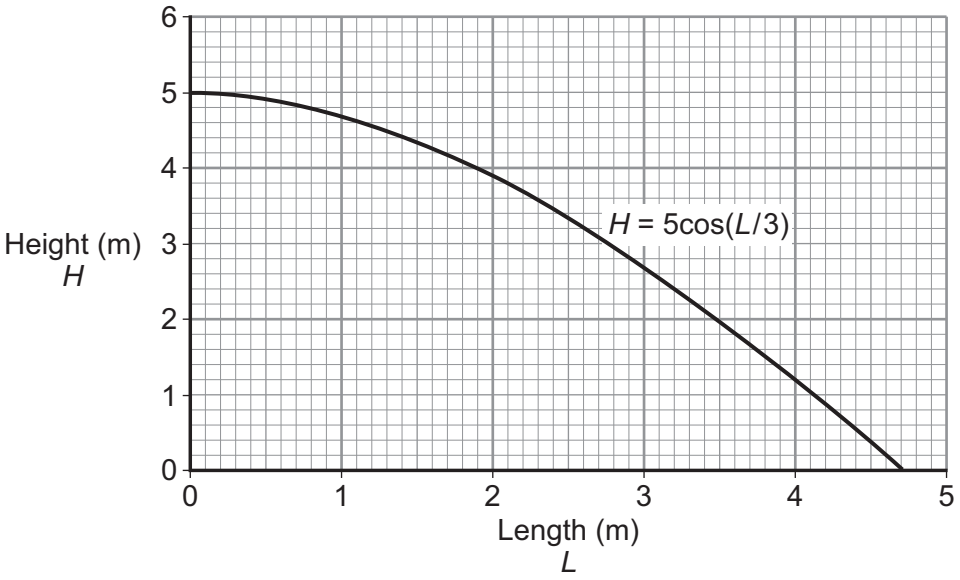
[2 marks]

8

0 6 A manufacturing company needs to fabricate a component.

The component is a flat object with boundaries given by the graph and axes in **Figure 3**.

Figure 3



Using the process of integration, determine the component's area between the limits of 0 to 4.712 for L.

Your answer must include the correct units and be rounded to the nearest integer.

[8 marks]

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8

Turn over for Section B

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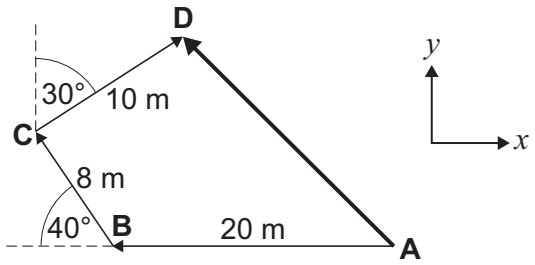
Section B

Answer **all** questions in this section.

0 7 The movement of an automated stacking robot is shown in **Figure 4**.

Figure 4



Determine the value of the resultant position vector **AD**.

[10 marks]

10

0 8 The weights of 50 cast components are recorded to the nearest 0.1 N and results are shown in **Table 2**.

Table 2

8.0	8.6	8.2	7.5	8.0	9.1	8.5	7.6	8.2	7.8
8.3	7.1	8.1	8.3	8.7	7.8	8.7	8.5	8.4	8.5
7.7	8.4	7.9	8.8	7.2	8.1	7.8	8.2	7.7	7.5
8.1	7.4	8.8	8.0	8.4	8.5	8.1	7.3	9.0	8.6
7.4	8.2	8.4	7.7	8.3	8.2	7.9	8.5	7.9	8.0

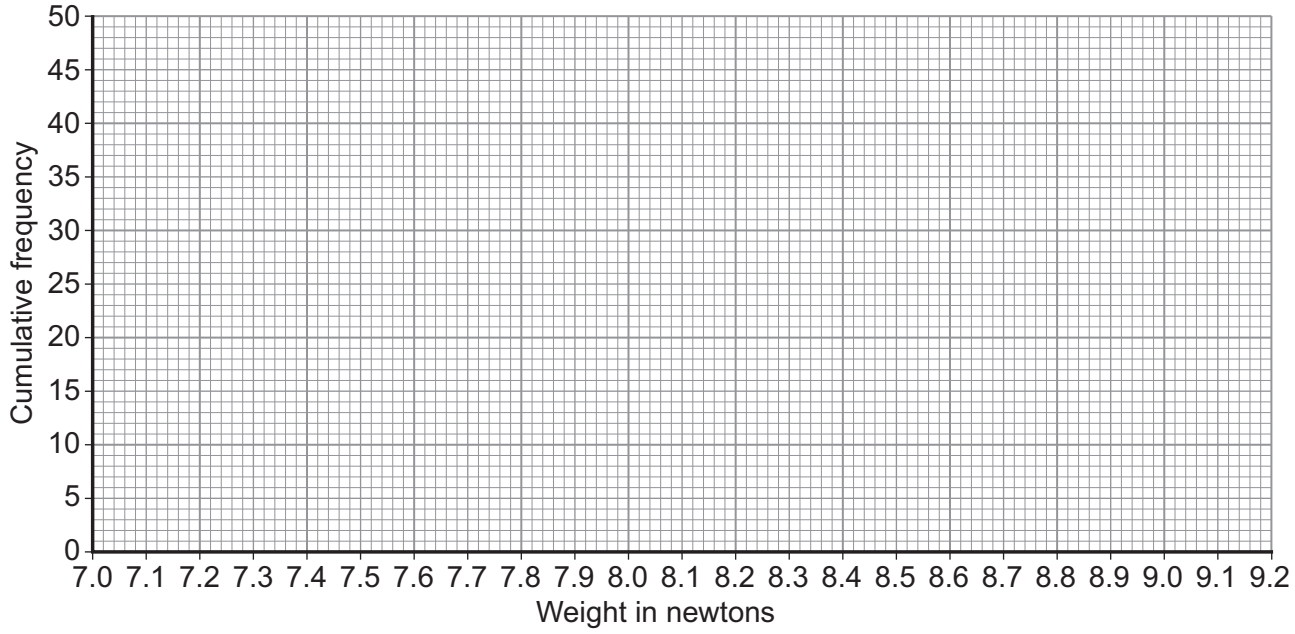
0 8 . 1 Calculate the frequency and cumulative frequencies in the space below.

[4 marks]

0 8 . 2 Using the upper class boundary, draw the cumulative frequency distribution graph of the sample on **Figure 5**.

[6 marks]

Figure 5



10

0 9 **Figure 6** shows a steam engine with two flywheels.

Figure 6

The angular displacement, θ radians, of the flywheels varies with time t seconds and follows the equation:

$\theta = 9t^2 - 2t^3$

0 9 . 1 Using the process of differentiation, determine the angular velocity of the flywheels when $t = 1\ s$

[4 marks]

0 9 . 2 Using the process of differentiation, determine the angular acceleration of the flywheels when $t = 1.2\ s$

[4 marks]

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0 9 . 3 Determine the time when the angular acceleration is zero.

[2 marks]

10

END OF QUESTIONS

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