



Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

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Forename(s)

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Candidate signature

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# Level 3 Technical Level

## DESIGN ENGINEERING

## MECHATRONIC ENGINEERING

### Unit 3 Mathematics for engineers

Wednesday 13 June 2018

Morning

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	
3	
4	
5	
6	
7	
8	
<b>TOTAL</b>	



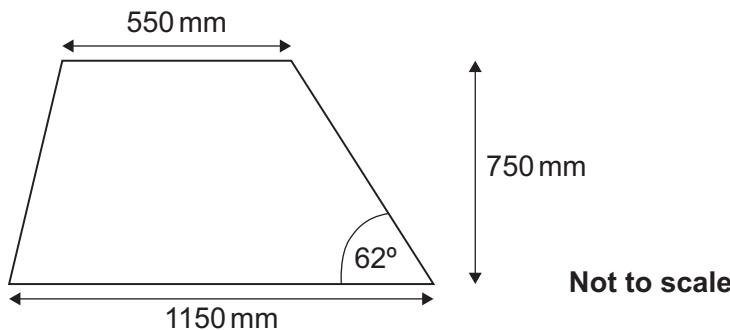
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**J/506/5953**

**Section A**Answer **all** questions in this section.**0 1**

A company is manufacturing a batch of plates from polymers. An example of one of the plates is shown in **Figure 1**.

**Figure 1**

$$\text{Area of a trapezium: } A = \left( \frac{a+b}{2} \right) h$$

**0 1 . 1**Determine the area of one plate in both  $\text{m}^2$  and  $\text{mm}^2$ **[4 marks]**Area in  $\text{m}^2$  \_\_\_\_\_Area in  $\text{mm}^2$  \_\_\_\_\_

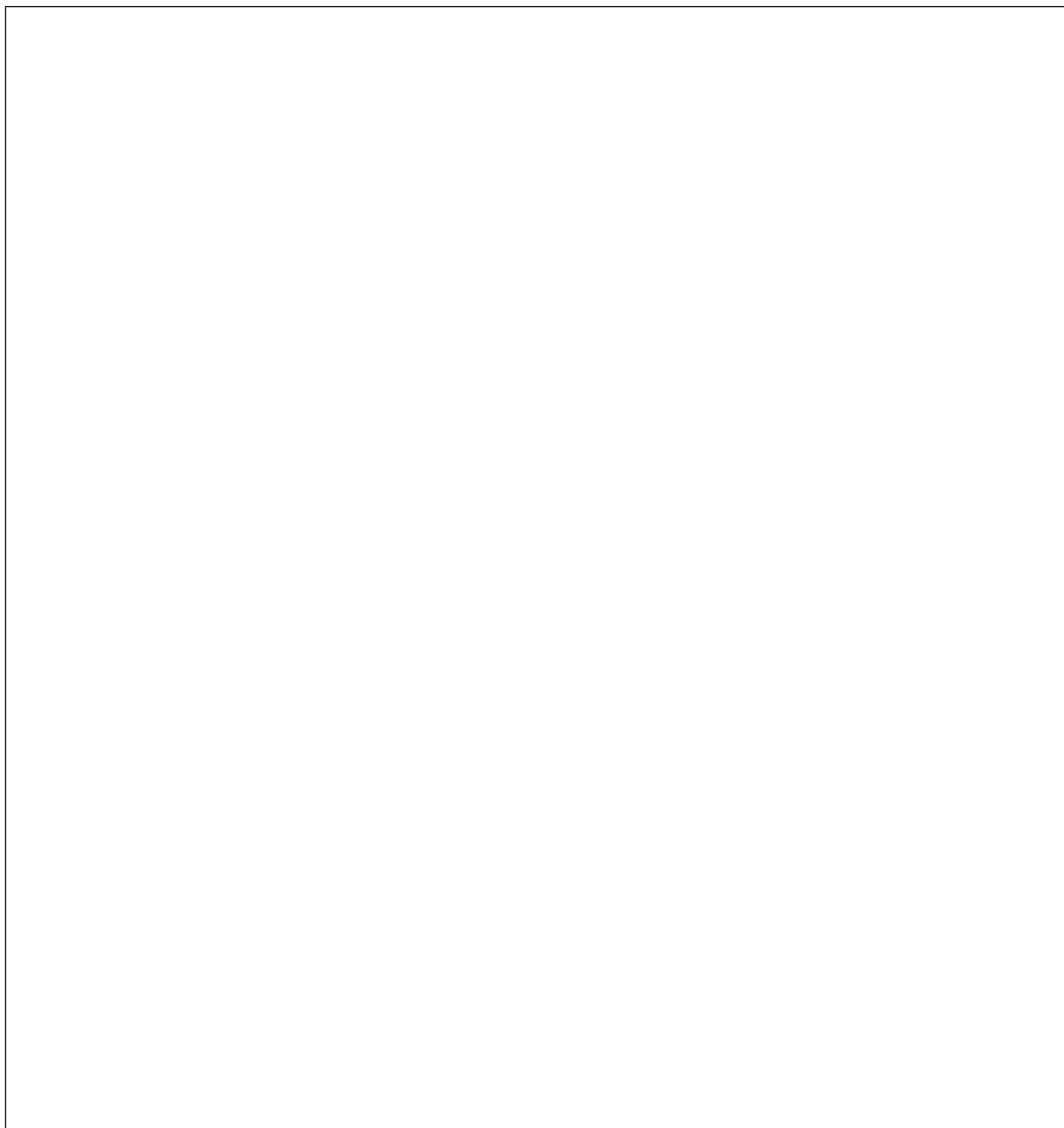
0 2

**0 1 . 2** Each plate was initially cut from a rectangular sheet of dimensions 1150 mm  $\times$  750 mm.

Calculate the percentage of waste material for each finished plate in terms of its area from the rectangle from which it was cut.

Answer to the nearest whole percentage.

**[7 marks]**



**11**

**Turn over ►**



**0 3**

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0	2
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A law connecting friction  $F$  and load  $L$  is of the form  $F = aL + b$  where  $a$  and  $b$  are values to be determined.

0	2	.	1
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Determine the values for  $a$  and  $b$ :

$$F = 100 \text{ when } L = 70 \text{ and}$$

$$F = 80 \text{ when } L = 50$$

[7 marks]

$a =$  \_\_\_\_\_ and  $b =$  \_\_\_\_\_



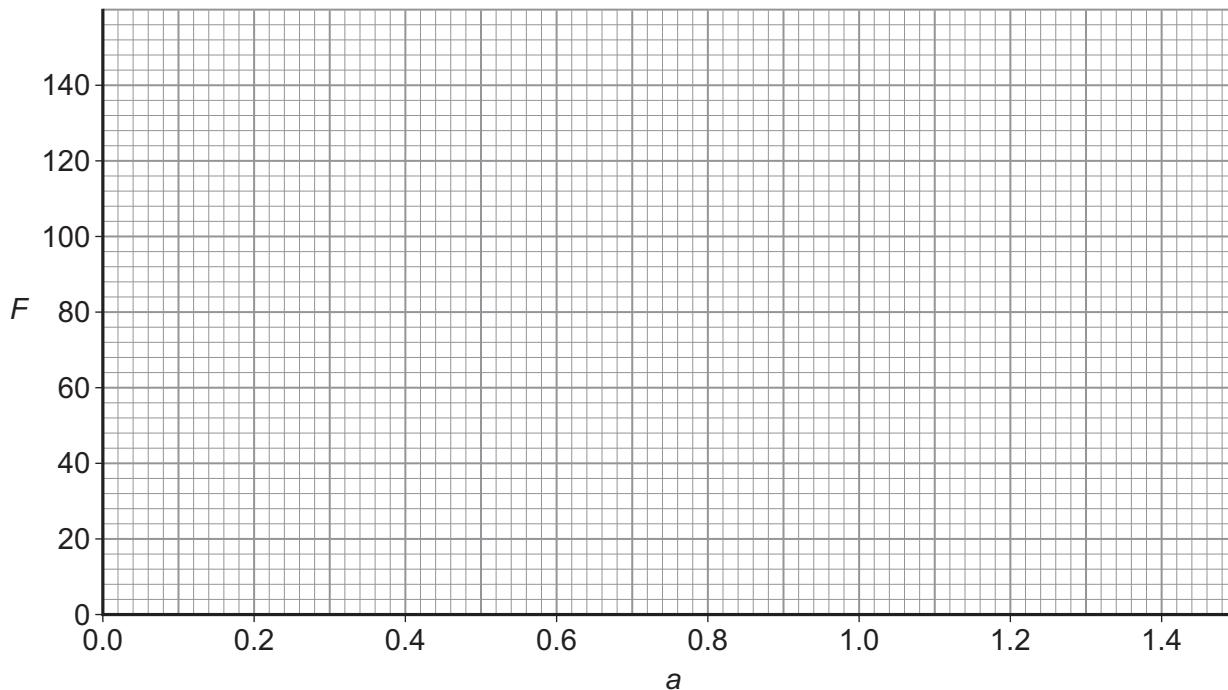
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**0 2 . 2** Confirm your values for  $a$  and  $b$  by plotting a graph on **Figure 2** where  $a$  and  $b$  are values to be determined.

**[6 marks]**

**Figure 2**



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ANSWER IN THE SPACES PROVIDED**

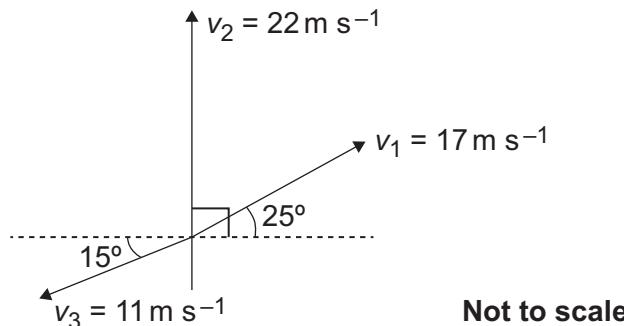


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0 3

Three old robots are being replaced by a new autonomous robot in a manufacturing company. The velocities of the older robots can be seen in **Figure 3**.

**Figure 3**

Determine the resultant velocity vector of the new autonomous robot by finding the resultant sum of the three velocity vectors of the old robots.

Draw a diagram of the resultant vector.

**[10 marks]**

10

**Turn over ►**

0 7

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**0 4**

A machine is manufacturing screws. As part of a quality control check a selection of 20 screws are taken from the machine. Their lengths (mm) have been measured and are contained in **Table 1**.

**Table 1**

12.5	12.2	12.7	12.9	11.9	12.5	12.6	12.5	11.9	12.8
11.9	12.0	12.7	12.7	12.5	12.6	12.4	11.9	12.0	12.1

**0 4**

. **1** Determine the mean length of the sample.

**[3 marks]****0 4**

. **2** Determine the median length of the sample.

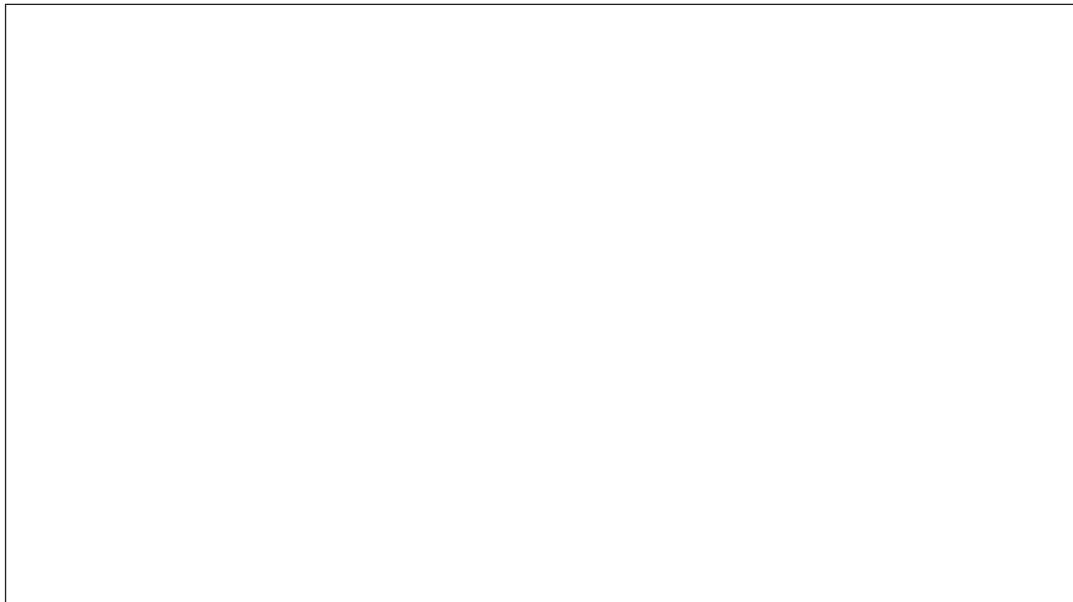
**[1 mark]**

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**0 4 . 3** Determine the standard deviation of the sample.

**[4 marks]**



**8**

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**0 9**

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Calculate the value of the definite integral.

$$\int_0^{\pi/2} -3\sin(2\theta) d\theta$$

[8 marks]

8



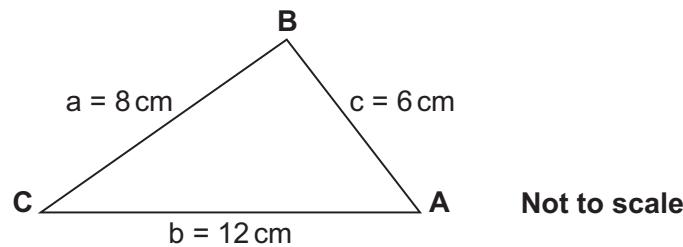
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**Section B**

Answer **all** questions in this section.

**0 6**

A flat steel plate is being cut by an engineering company. This is shown in **Figure 4**.

**Figure 4**

Calculate the **three** angles in degrees of the triangle.

Give your answer to 1 decimal place.

**[10 marks]****10****Turn over ►**

1 1

**0 7**

A steel bar is heated to a temperature of 1280.0 K ( $T_1$ ). The bar is then immersed in chilled water at a temperature of 280.0 K ( $T_0$ ). After 10 seconds ( $t$ ), the temperature of the bar drops to 329.7 K ( $T_2$ ). The temperature of the bar at time ( $t$ ) after it has been immersed in water is given by the formula:

$$T_2 = T_0 + (T_1 - T_0)e^{-kt}$$

**0 7 . 1**

Determine the value of the cooling constant  $k$ .

**[7 marks]**

1 2

**0 7 . 2**

The bar has an initial temperature of 128.0 K and it is immersed in chilled water at a temperature of 280.0 K.

Find the expected temperature of the bar after 5 seconds. Use the formula

$$T_2 = T_0 + (T_1 - T_0)e^{-kt}$$

**[3 marks]****10**

**Turn over for the next question**

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1 3

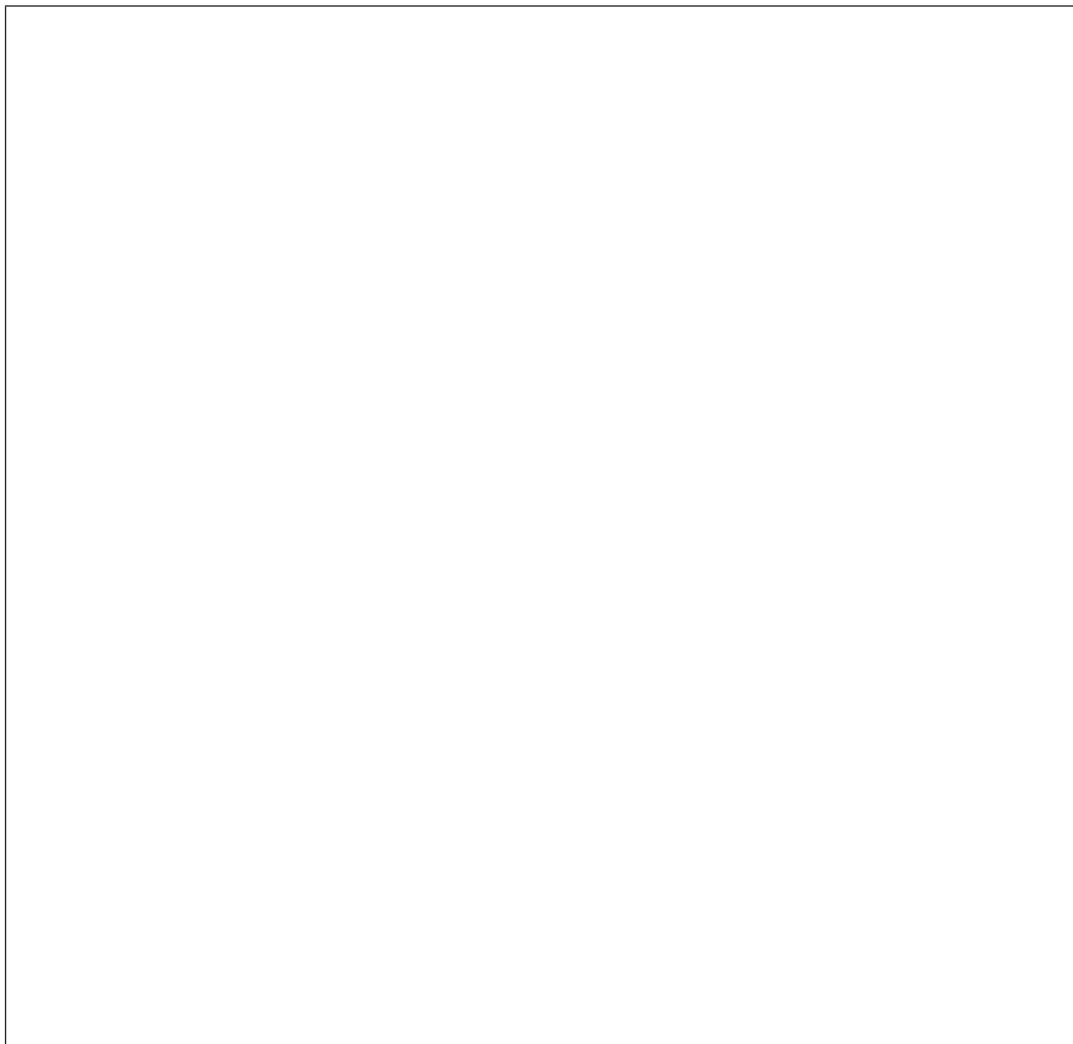
**0 8**

A 40 tonne truck has to climb 125 m up a uniform slope of 10%.

**0 8**

. **1** Calculate the change in potential energy of the truck after this climb.

**[7 marks]**



1 4

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**0 8 . 2**

If the truck was allowed to free-wheel back down the slope from rest what would be its velocity?

Assume there is no resistance to the motion.

**[3 marks]**

**10**

**END OF QUESTIONS**



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