AQA

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

Level 3 Technical level: Engineering
MATHEMATICS FOR ENGINEERS

Unit number: J/506/5953

Thursday 22 June 2017 Morning Time allowed: 1 hour 45 minutes

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

Instructions
- Answer all questions on the paper.
- Answer to 3 significant figures unless otherwise instructed.
- Include units in all answers, where required, as marks are given for units in some questions.

Information
- There are 80 marks available on this paper.

Advice
Do not spend too long on one question. Read each question 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	
9	
TOTAL	

Formulae sheet

Area of a circle $A = \pi r^2$ or $A = \frac{\pi D^2}{4}$	Density $\rho = \frac{m}{V}$
Sine rule $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$	Cosine rule $a^2 = b^2 + c^2 - 2bc\cos A$ $b^2 = a^2 + c^2 - 2ac\cos B$ $c^2 = a^2 + b^2 - 2ab\cos C$
Angular measure $360^0 \equiv 2\pi$ radians	Newton's second law $F = ma$
Trigonometry $\sin = \frac{opp}{hyp}$, $\cos = \frac{adj}{hyp}$ and $\tan = \frac{opp}{adj}$	Quadratic equation $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ where $ax^2 + bx + c = 0$
Mean value $\bar{x} = \frac{\sum x}{n}$	Standard deviation $\sigma = \sqrt{\left\{\frac{\sum(x - \bar{x})^2}{n}\right\}}$
Cartesian to polar conversion $r = \sqrt{x^2 + y^2}$ $\tan\theta = \frac{y}{x}$	Polar to Cartesian conversion $x = r\cos\theta$ $y = r\sin\theta$
Straight line graph $y = mx + c$	Energy Potential Energy $= mgh$ and Kinetic Energy $= \frac{mv^2}{2}$
The gravitation constant: g = 9.81 m s $^{-2}$	

Standard Derivatives

$f(x)$	$\frac{dy}{dx}$
ax^n	anx^{n-1}
$\sin ax$	$a\cos ax$
$\cos ax$	$-a\sin ax$
$\ln ax$	$\frac{1}{x}$
e^{ax}	ae^{ax}

Standard Integrals

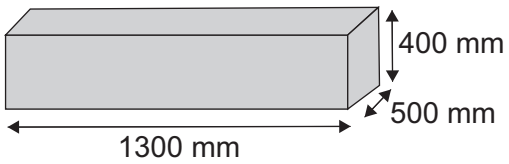
$f(x)$	$\int f(x)\,dx$
ax^n	$\frac{ax^{n+1}}{n+1} + c$ if $n \neq -1$
$\sin ax$	$-\frac{1}{a}\cos ax + c$

Section A

Answer **all** questions in this section.

0 1 An engineering company is to fabricate 20 tool storage containers. One of the containers is shown in **Figure 1 (not to scale)**.

Figure 1



0 1 . 1 Determine the volume of **one** tool storage container in both mm^3 and m^3.

Show all working.

[5 marks]

Volume in mm^3 _____

Volume in m^3 _____

0 1 . 2 Determine the surface area of the steel necessary to manufacture the 20 tool storage containers. Your answer **must** be in standard units.

[4 marks]

Surface area of a cuboid $= 2(bh + hl + lb)$ ($b =$ base, $l =$ length and $h =$ height)

Area in m^2 _____

0 1 . 3 Determine the mass of the total steel requirements to one decimal place.

[2 marks]

The mass per unit area of sheet steel $= 12.2 \text{ kg m}^{-2}$

Mass in kg _____

11

0 2 A space exploration company is testing a component for a prototype spacecraft. The component is fired vertically into the air where the initial speed, u , is given by:

$u = 25 \text{ m s}^{-1}$

The height of the component S is given by:

$$S = ut - \frac{1}{2}gt^2$$

0 2 . 1 Determine the time t taken to reach 15 m above the firing position, and determine the time t taken to get back 15 m to the firing position.

[7 marks]

Time taken on ascent _____

Time taken on descent _____

0 2 . 2 The company engineers needed to know when to ignite the rockets to slow the component down. From tests they got the following result:

$2^{t+1} = 3^{2t-5}$

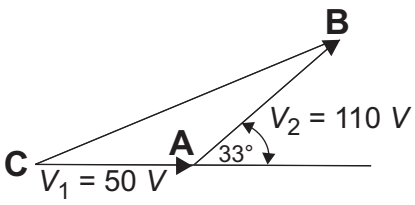
Determine the value of t.

[6 marks]

13

0 3 Two voltage phasors are shown in **Figure 2**.

Figure 2



Determine the value of their resultant phasor **CB**.

[6 marks]

6

0 4 A CNC (Computer Numerical Control) programmer needs to convert from (8, 7) Cartesian coordinates into polar coordinates before a cutting operation can begin. Perform that calculation.

[4 marks]

4

0 5 A set of 20 ingots has been cast and their masses (kg) are shown in **Table 1**.

Table 1

8.0	8.6	8.2	7.5	8.0	9.0	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

0 5 . 1 Fill out the table below and determine the median mass of the ingots.

[2 marks]

0 5 . 2 Determine the mean mass of the ingots.

[3 marks]

0 5 . 3 Determine the variance of the ingots.

Using: $\sigma^2 = \frac{\sum(m - \overline{m})^2}{n}$

[3 marks]

8

0 6 A spacecraft is moving in a straight line and has a position function

$s = -6\cos(2t) + 5t^3$ metres, where t is the time in seconds.

0 6 . 1 By using the process of differentiation, determine a function for the spacecraft's acceleration.

[6 marks]

0 6 . 2 Calculate the acceleration when $t = 5$ seconds.

[2 marks]

8

Section B

Answer **all** questions in this section.

0 7 The velocity of a satellite is given by the function:

$V = 3t^3 + 6e^{4t}$ m s^{-1} where t is the time in seconds.

By using the process of integration, determine the distance travelled by the satellite in the first 3 seconds.

Show all working.

[10 marks]

10

Turn over ▶

0 8 The decay voltage, v, across a capacitor at time t seconds is given by:

$v = 250e^{-t/3}$

0 8 . 1 Complete the cells in **Table 2**.

[4 marks]

Table 2

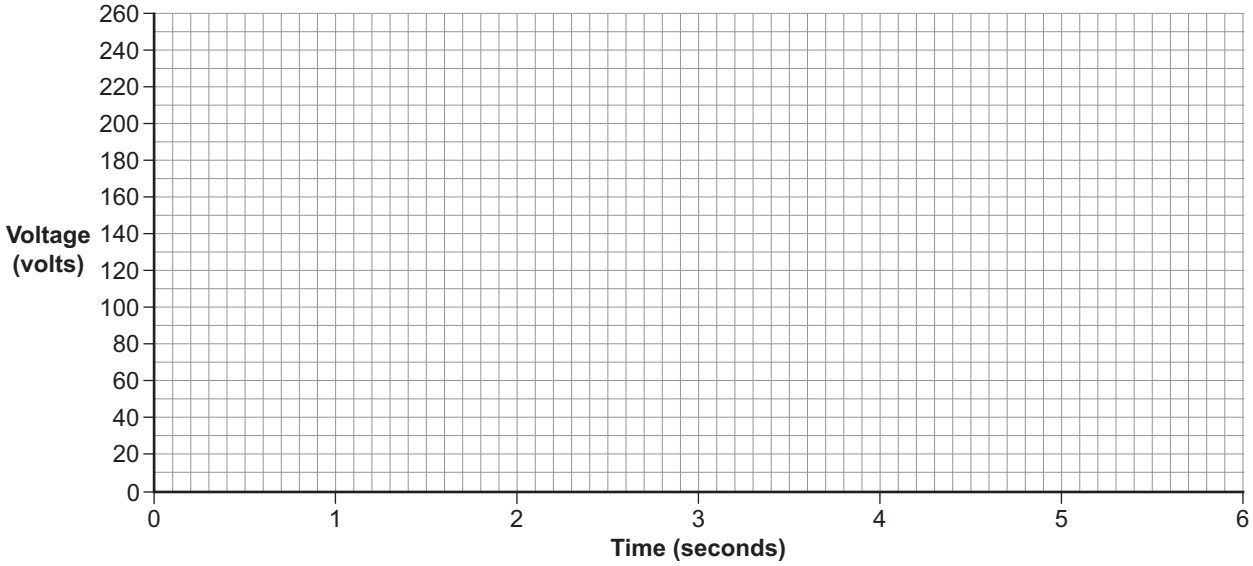
t	0	1	2	3	4	5	6
$e^{-t/3}$							
$v = 250e^{-t/3}$							

Space for working

0 8 . 2 Using your values in **Table 2**, plot the decay voltage against time on **Graph 1**.

[4 marks]

Graph 1



0 8 . 3 From **Graph 1**, determine the time when $v = 150\ V$ and when $v = 80\ V$.

[2 marks]

$v = 150\ V$ when $t =$ _____

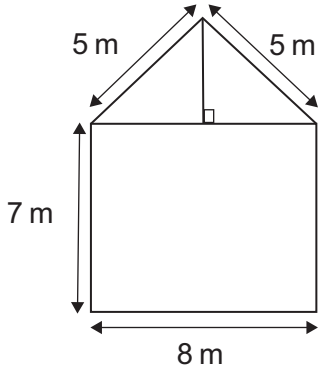
$v = 80\ V$ when $t =$ _____

10

Turn over for the next question

0 9 **Figure 3** shows the gable end of a house.

Figure 3



Area of a triangle $= \frac{1}{2}bh$

0 9 . 1 Determine the area of the gable end.

[8 marks]

0 9 . 2 The gable end requires painting. If 1.45 litres of paint cover $1\ m^2$ calculate the number of litres of paint required for complete coverage of the gable end. Answer to the nearest litre.

[2 marks]

10

END OF QUESTIONS

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