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Cambridge **TECHNICALS LEVEL 3**

ENGINEERING

Combined feedback on the June 2016 Exam Paper

Unit 1 - Mathematics for engineering

Version 1

ocr.org.uk/engineering

CONTENTS

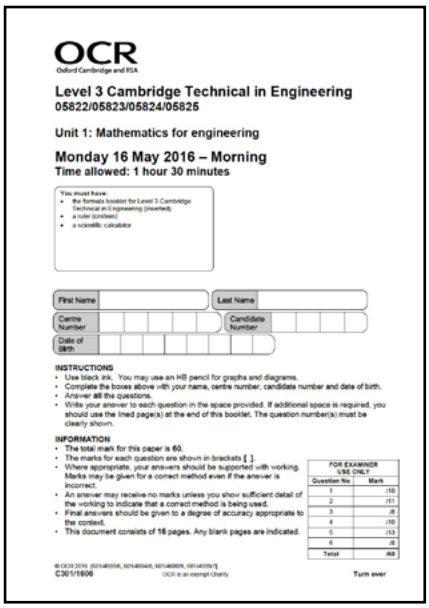
INTRODUCTION

This resource brings together the questions from the June 2016 examined unit (Unit 1), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

The marking guidance and the examiner's comments are taken straight from the Report to Centre for this question paper.

The Question Paper, Mark Scheme and the Report to Centre are available from:

https://interchange.ocr.org.uk/



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Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825

Unit 1: Mathematics for engineering

Monday 16 May 2016 – Morning
Time allowed: 1 hour 30 minutes

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (protractor)
- a scientific calculator

First Name | Last Name
Centre Number | Candidate Number
Date of Birth

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **16 pages**. Any blank pages are indicated.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/10
2	/11
3	/8
4	/10
5	/13
6	/8
Total	/60

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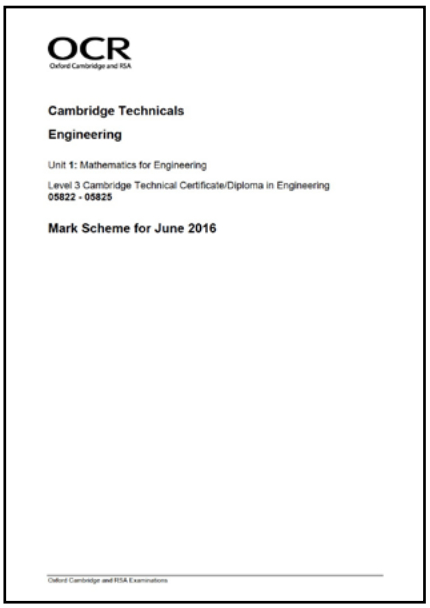
Turn over



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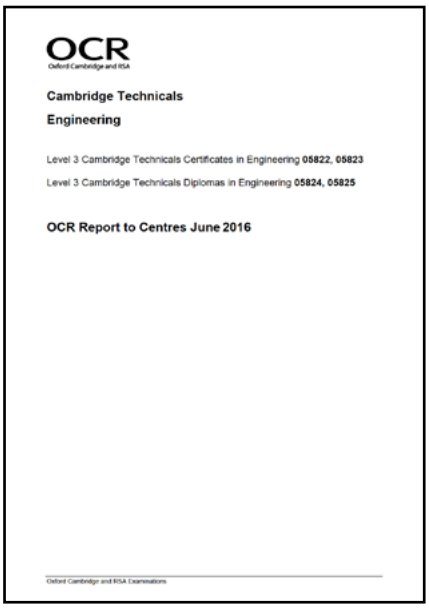
Cambridge Technicals
Engineering

Unit 1: Mathematics for Engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for June 2016

Oxford Cambridge and RSA Examinations



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Level 3 Cambridge Technicals Certificates in Engineering **05822, 05823**

Level 3 Cambridge Technicals Diplomas in Engineering **05824, 05825**

OCR Report to Centres June 2016

Oxford Cambridge and RSA Examinations

GENERAL EXAMINER COMMENTS ON THE PAPER

This unit has six learning outcomes that are not equally weighted. Centres should not therefore expect that every question paper will always have six questions or that each question will contain an equal number of marks or that each question will assess just one learning outcome.

The six learning outcomes did not attract equal successful responses. It is hoped that the following points may help centres to prepare future cohorts of candidates for this unit.

Question 1

Question 1

1 (a) Remove the brackets and simplify $2(x+3)+(2x-5)$.

$2x+6+2x-5$

$=4x+1$ [2]

(b) Factorise $4x^2+2xy$.

$=2x(2x+y)$ [2]

(c) Express as a single fraction $\frac{x-2}{3}+\frac{2x+1}{4}$.

$=\frac{4(x-2)+3(2x+1)}{12}$

$=\frac{10x-5}{12}$ [3]

(d) Transpose $s=ut+\frac{1}{2}at^2$ to make a the subject.

$\frac{1}{2}at^2=s-ut$

$\Rightarrow a=\frac{2(s-ut)}{t^2}$

Accept $a=\frac{2s-2ut}{t^2}$ [3]

Mark scheme guidance

1 (a) Sight of $2x + 3$ soi

1 (b) One of x and 2 removed correctly

SC sight of $2x + y$ B1

1 (c) Sight of 12

Top line unsimplified soi

1 (d) For $s - ut$

Multiply by 2 and divide by t^2

$a=\frac{s-ut}{\frac{1}{2}t^2}$ M1 M1 A0

Examiner comments

1 Algebra

Most of the basic topics assessed in this question were understood by candidates who usually performed well. A few candidates had not got a good enough grasp of Algebra and made some quite elementary errors.

The part that was least well answered was part (d), changing the subject of a formula. When there are three terms, multiplying one term by, for instance, 2, requires every term to be treated similarly, for otherwise the equality ceases to hold. Typical errors were for instance, changing

$s = ut + \frac{1}{2}at^2$ to $2s = ut + at^2$

Question 2

2 (a) Solve the equation $2(x-1)+3(4-x)=5$.

$\Rightarrow 2x-2+12-3x=5$

$\Rightarrow -x+10=5$

$\Rightarrow x=5$ [2]

(b) You are given that $f(x)=x^3-7x+6$.

(i) Show that f(2) = 0.

$f(2) = 8 - 14 + 6 = 0$

[1]

(ii) Using f(2) = 0, solve the equation f(x) = 0 given that there are three integer roots.

Sight of $(x-2)(x^2+2x-3)$

$\Rightarrow (x-1)(x-2)(x+3)=0$

$\Rightarrow x=1,2,-3$

[3]

(c) Fig. 1 shows a wooden shape ABCD, constructed in the form of a kite.
The coordinates are A (0, 16), C (12, 0) and D (2, 5).

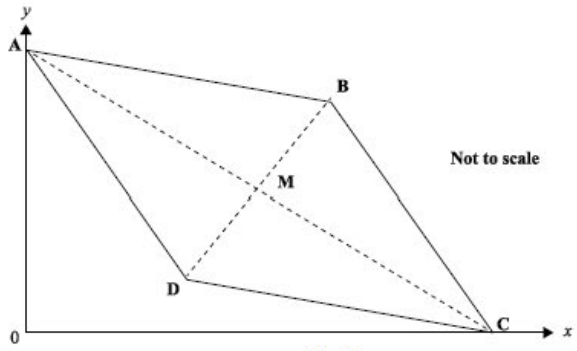


Fig. 1

(i) Calculate the coordinates of the mid-point, M, of AC.

(6, 8) [1]

(ii) Show by calculation that the line DM is perpendicular to AC.

$$\text{Grad AC} = \frac{16-0}{0-12} = -\frac{4}{3}$$

$$\text{Grad DM} = \frac{8-5}{6-2} = \frac{3}{4}$$

$m_1 \times m_2 = -1$ so perpendicular [2]

(iii) Calculate the coordinates of point B.

$$\overline{DM} - \overline{MB} \rightarrow B = (6,8) + \begin{pmatrix} 6-2 \\ 8-5 \end{pmatrix} - (10,11)$$

[2]

Mark scheme guidance

2 (a) Expansion of brackets and collection of terms soi

2 (b) (i) Clear sight of substitution

2 (b) (ii) Either by long division and then factorisation of quadratic
Or continued trials - at least one seen including 1 or –3

S.C. B1 for $x = 2$

2 (c) (ii) Both gradients

Or a numeric statement

2 (c) (iii) Finding vector. Any acceptable method. ft from (c)(i)

Examiner comments

2(a) Algebra solution of equations

This part was similar to question 1. Many candidates were proficient in solving this equation; others made a variety of errors, mainly involving signs.

2(b) The use of the factor theorem

This was the least well done topic within the Algebra section. While f(2) was calculated satisfactorily few candidates were able to use this to factorise f(x) into the factor (x – 2) and a quadratic factor. Those that did were able to finish the question though a number left the answer as f(x) in factorised form.

2(c) Coordinate geometry

The midpoint of AC was found quire easily. The demonstration that the two diagonals were perpendicular was mostly done well, though some candidates did it the "wrong way round" - in other words using the negative reciprocal of one to be the other without proving it.

The coordinates of B required candidates to appreciate that for this diagram the midpoint of AC was also the midpoint of BD.

Question 3

3 A cup of water is brought to the boil. When the temperature is 100 °C the heat is removed and the cup is allowed to cool.

The formula for the temperature of the water, T °C, at time t minutes after the heat is removed is:

$$T = T_R + (T_0 - T_R)e^{-kt}$$

where T_R is the room temperature, T_0 is the initial temperature and k is the cooling constant.

You are given that $T_0 = 100$ and $T_R = 20$.

(i) Using the values given above for T_0 and T_R, write the formula for T in its simplest form.

$$T = 20 + (100 - 20)e^{-kt}$$
$$\Rightarrow T = 20 + 80e^{-kt}$$

[1]

(ii) Calculate k, given that $T = 70$ when $t = 6$.

$$70 = 20 + 80e^{-6k} \Rightarrow e^{6k} = \frac{8}{5} \quad \text{oe}$$
$$\Rightarrow k = \frac{1}{6}\ln\frac{8}{5} = 0.078(33...)$$

[3]

(iii) Calculate the time taken, to the nearest minute, for the temperature of the water to drop to 50 °C.

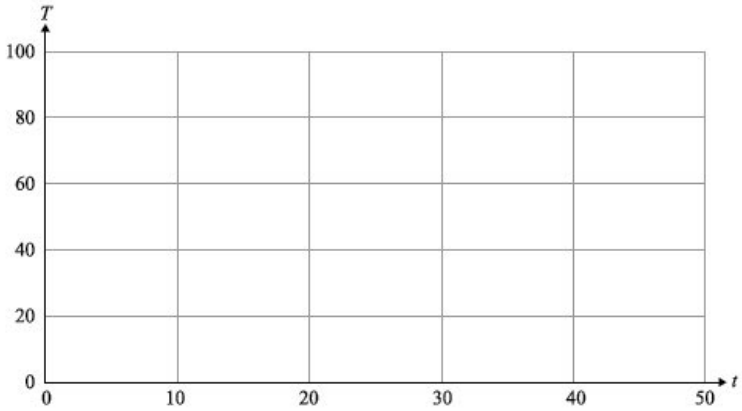
$$50 = 20 + 80e^{-tk}$$

$$\Rightarrow e^{tk} = \frac{8}{3}$$

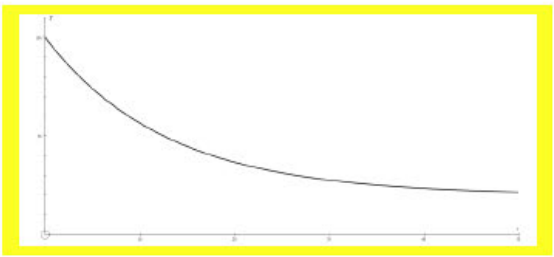
$$\Rightarrow t = \frac{1}{k}\ln\frac{8}{3} = 12.57 = 13 \text{ minutes}$$

[2]

(iv) On the grid, sketch the graph of T against t.



[2]



Mark scheme guidance

3 (i) Isw

3 (ii) Solve for k

Accept answers between 0.078 and 0.079

3 (iii) Must be rounded

3 (iv) Exponential curve starting at (0, 100)

Clearly approaching an asymptote of $T = 20$

Examiner comments

3 Exponential functions

This was the least well answered topic. Many candidates seemed to find difficulty in understanding the question. Exponential decay means that the temperature-time graph decreases steadily, "flattening out" as it goes, approaching but never reaching its limit. The limit in this case was room temperature, 20^{0}C so in part (iv) the graph started at 100^{0}C and approached 20^{0}C. This was not often seen.

The first 3 parts contained a number of algebraic errors, including from those who had gained good marks in Questions 1 and 2. In part (i) for instance the formula $T = 20 + (100–20)\ e^{-kt}$ often became $T = 20 + 100 – 20e^{-kt} = 120 – 20e^{-kt}$ rather than $T = 20 + 80e^{-kt}$ and this affected the answers of the remaining parts. Contrasting the responses here with those in Question 1 indicates that candidates may be able to manipulate letters according set rules but that applying this knowledge to real life situations causes difficulties.

Question 4

4 (a) A triangular plate, ABC, has dimensions AB = 120 mm, AC = 110 mm and BC = 100 mm.

Calculate angle C.

$$\cos C = \frac{110^2 + 100^2 - 120^2}{2 \times 110 \times 100}$$
$$= 0.35$$
$$\Rightarrow C = 69.5^0$$

..... [3]

(b) An alternating e.m.f. is represented by $v = 40 \sin x$.

(i) Calculate v when $x = 30°$.

$v = 40 \sin 30 = 20$

..... [1]

(ii) Calculate the two values of x in the range $0° < x < 360°$ when $v = 10$.

$\sin x = 0.25$

$\Rightarrow x = 14.5$ and 165.5

..... [3]

(c) A machine used by surveyors is a wheel of diameter 300 mm which is used to measure the length of a line.

The wheel is placed on the ground and rolled along the line. It rotates exactly 25 times.

Calculate the length of the line.

circumference $= 300\pi$ $(= 942.45)$

Length along ground $= 25 \times 300\pi$

$= 23562$ mm

..... [3]

Mark scheme guidance

4 (a) Correct application of cosine formula for any angle
Accept $120^2 = 100^2 + 110^2 - 2\text{x}100\text{x}110\cos C$ oe for other angles

4 (b) (ii) Solve
One value
Other value

4 (c) Circumference soi
25 × anything
Accept answer in other units if correct

Examiner comments

4 Trigonometry

The form of the cosine rule, $\cos C = \dfrac{a^2 + b^2 - c^2}{2bc}$ was not well known; candidates usually used the form $c^2 = a^2 + b^2 - 2bc\cos C$ as it appears in the Formulae book which is much more prone to arithmetic errors. For instance, $14400 = 22100 - 22000\cos C$ often became $14400 = 100\cos C$ with inevitable failure.

Part(c) was also almost universally correct.

Question 5

5 (a) A small open box is to be made out of a rectangular piece of metal 50 mm by 80 mm of negligible thickness, as shown in Fig. 2. From each corner a square of length x mm is cut and the sides turned up to form the open box.

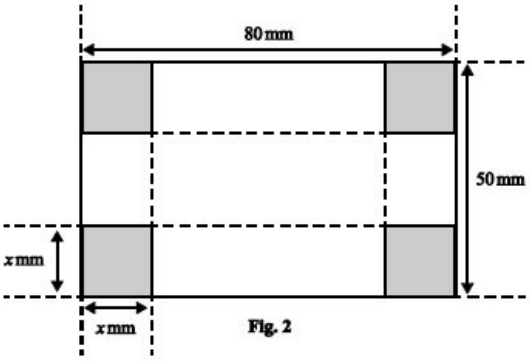


Fig. 2

(i) Show that the formula for the volume, V mm^3, of the box, is given by

$$V = 4x^3 - 260x^2 + 4000x.$$

$$V = (80-2x)(50-2x)x$$
$$= 4x^3 - 260x^2 + 4000x$$

[2]

(ii) Using calculus, calculate the value of x that gives the maximum volume.

$$\frac{dV}{dx} = 4000 - 520x + 12x^2$$
$$= 0 \text{ when } 3x^2 - 130x + 1000 = 0$$
$$\Rightarrow x = 10$$
$$\text{or } x = 33.3.....$$
$$\Rightarrow x = 10$$

[6]

(iii) For this value of x, calculate the volume of the box.

18000 (mm^3)

[1]

(b) The side panel of a children's slide is as shown on a coordinate system in Fig. 3.

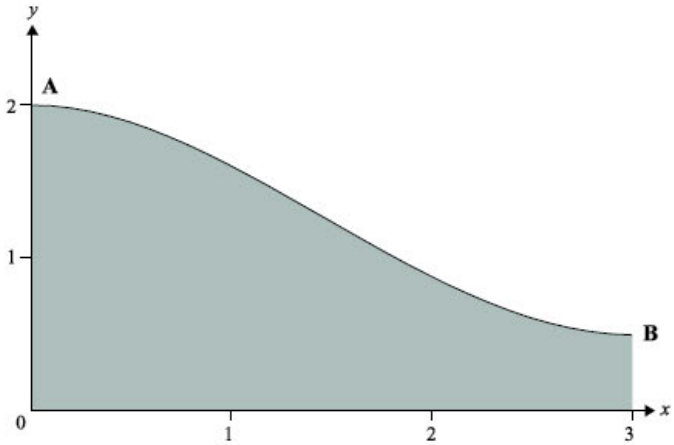


Fig. 3

The coordinates of A are (0, 2) and B are (3, $\frac{1}{2}$). The equation of the top edge, AB, is

$$y = \frac{1}{9}x^3 - \frac{1}{2}x^2 + 2.$$

Units are metres.

Using calculus, calculate the area of the side panel.

$$A = \int_0^3 \left(\frac{1}{9}x^3 - \frac{1}{2}x^2 + 2\right) dx$$

$$= \left[\frac{1}{36}x^4 - \frac{1}{6}x^3 + 2x\right]_0^3 = \left(\frac{81}{36} - \frac{27}{6} + 6\right)$$

$$= 3.75 \text{ (m}^2\text{)}$$

[4]

Mark scheme guidance

5 (a) (i) Multiply 3 correct lengths
Shows answer given with at least one intermediate step

5 (a) (ii) Diffn **(at least one of $-520x$ and $12x^2$ seen) ecf**
Correct quadratic
Set = 0 and solve *their quadratic* by factorisation or by correct formula
Must be stated as final answer

5 (a) (iii) **Cao isw**

5 (b) Integrate: ignore limits (At least one power increased by 1)
Correct function
Substitute correct limits into *their* function.

Examiner comments

5 (a) Calculus – Maximum value

Some found the context of this question hard to grasp and made algebraic errors. The formula for the volume was given in part (i) so that candidates who were unable to obtain the formula could use what was given in the later parts. There were a couple of common errors to note:

- Some candidates wrote the formula given at the end of their solution possibly thinking that writing the required formula at the end of some inaccurate algebra would gain marks.
- Some candidates, who were unable to obtain the correct formula, used their own result in the rest of the question rather than that given in part (i).

Question 5(b) Calculus - Area under a curve.

There were clearly a number of candidates who had not covered this topic, but those that had were usually successful. Because of the symmetry of the curve it was possible to obtain the correct answer using the midpoint rule, but since the question demanded the use of calculus this was not given credit.

Question 6

6 (a) A machine is set to produce metal bars of length 60 mm. It is known that over a long period the lengths are normally distributed with mean 60 mm and standard deviation 0.39 mm.

One day a check is carried out on the lengths of the bars and the following lengths, correct to the nearest 0.2 mm, are recorded.

Length, x	Frequency, f	$x \times f$
59.0	0	
59.2	3	
59.4	5	
59.6	10	
59.8	14	
60.0	16	
60.2	15	
60.4	9	
60.6	5	
60.8	2	
61.0	1	
SUM	$\sum f = 80$	$\sum fx =$

0
177.6
297.0
596.0
837.2
960.0
903.0
543.6
303.0
121.6
61.0
Sum 4800

$$\text{Mean} = \frac{\sum xf}{\sum f} = \frac{4800}{80} = 60$$

(i) Fill in the cells in the table above and show that the mean of these data is 60 mm.

..... [3]

(ii) You are given that the standard deviation of this set of data is 0.39, correct to 2 decimal places.
For a normal distribution it is known that 99% of data lie within 2.58 standard deviations of the mean.

Identify the element in this set of data that might not lie within 2.58 standard deviations of the mean, given that the data above are recorded to the nearest 0.2 mm.

Mean + 2.58SD = 61.006
61

..... [2]

(b) A machine has two components, A and B. In order to operate at least one of the components needs to be working. The machine is serviced overnight so that it is set to operate at the beginning of the day with both components working. During the course of the day the probability of A failing is $\frac{1}{4}$ and the probability of B failing is $\frac{1}{5}$.

Find the probability that the machine is still operating at the end of the day.

P(machine running) = P(One or both components are working)
= 1 – P(both fail)
$= 1 - \frac{1}{4} \times \frac{1}{5} = 1 - \frac{1}{20}$
$= \frac{19}{20}$

..... [3]

Mark Scheme Guidance

6 (a) (i) All entries correct, B1 one error

Demonstration of mean = 60 if sum = 4800

6 (a) (ii) **soi**

Ignore anything to do with Mean – 2.58SD

If these two marks not earned then S.C B1 for looking at

Mean – 2.58SD

Give B2 for answer of 61 seen

6 (b) For 1 – one term

$$\text{Accept} = \frac{3}{4} \text{x} \frac{1}{5} + \frac{1}{4} \text{x} \frac{4}{5} + \frac{3}{4} \text{x} \frac{4}{5} = \frac{19}{20} \quad \text{M1 adding 3 terms}$$

A1 2 out of 3 correct

$$\text{SC} \frac{1}{4} \text{x} \frac{1}{5} = \frac{1}{20} \quad \text{B1}$$

Examiner comments

Question 6(a) Handling data

Most candidates filled in the table correctly, but many divided by 11 (the number of cells) rather than 80 (the number of items of data). The question said that the mean was 60, but some candidates interpreted this as being "approximately 60" and so were satisfied with their answer rather than look for an error.

In part (ii) the crucial piece of information from the stem was that the data was recorded correct to the nearest 0.2 mm. The largest value, therefore could have been as large as 61.1 and outside the range. A measurement of 59.0 could have been as small as 58.9 and this also was outside the range, but as there was no such value in the table any work at the lower end of the scale received no credit.

Question 6(b) Probability

The only way that the machine will fail during the day is if both components fail. It was therefore necessary to calculate this probability; many candidates added the two probabilities rather than subtract and a few demonstrated their lack of understanding of the topic by giving an answer greater than 1.

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