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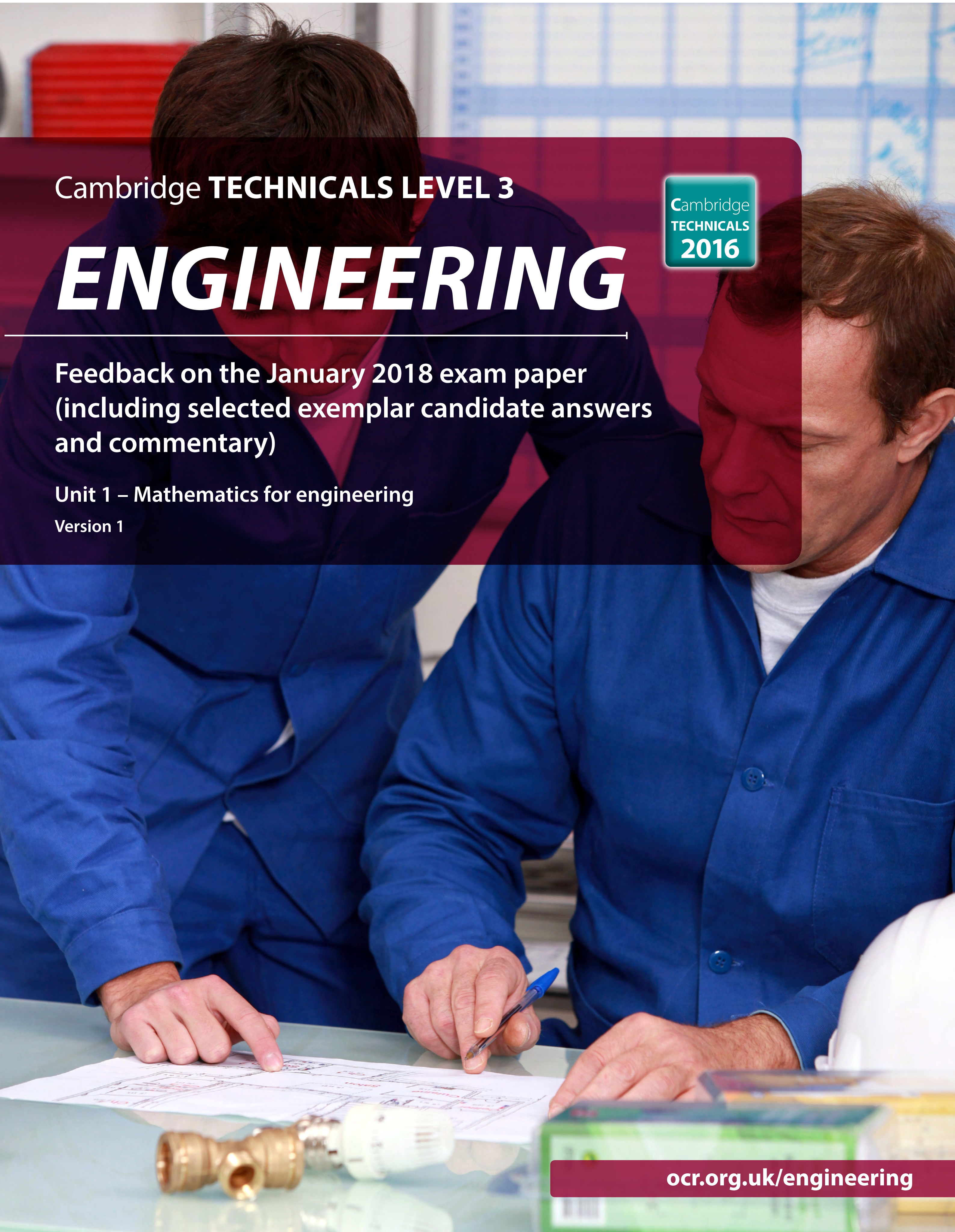


Cambridge **TECHNICALS LEVEL 3**

Cambridge TECHNICALS 2016

ENGINEERING

Feedback on the January 2018 exam paper (including selected exemplar candidate answers and commentary)

Unit 1 – Mathematics for engineering

Version 1

ocr.org.uk/engineering

CONTENTS

INTRODUCTION

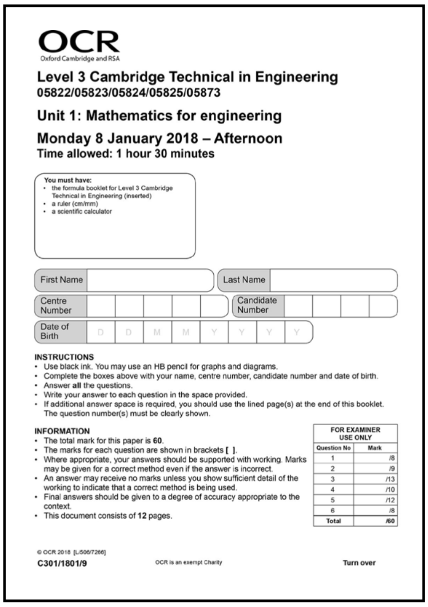
This resource brings together the questions from the January 2018 examined unit (Unit 1), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

We have also included exemplar candidate answers with commentary for Questions 2(b)(i), 2(b)(ii), 5(b)(i), 5(b)(ii), 6(a) and 6(b)(i).

The marking guidance and the examiner's comments are taken 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/Modules/PastPapers/Pages/PastPapers.aspx?menuindex=97&menuid=250



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Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 1: Mathematics for engineering

Monday 8 January 2018 – Afternoon
Time allowed: 1 hour 30 minutes

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

First Name		Last Name	
Centre Number		Candidate Number	
Date of Birth	D D M M Y Y Y Y		

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 answer 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 **12** pages.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/8
2	/9
3	/13
4	/10
5	/12
6	/8
Total	/60

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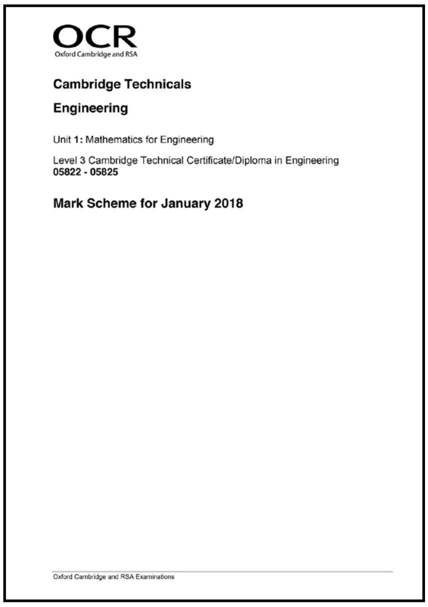
C301/1801/9 OCR is an exempt Charity **Turn over**



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Cambridge Technicals

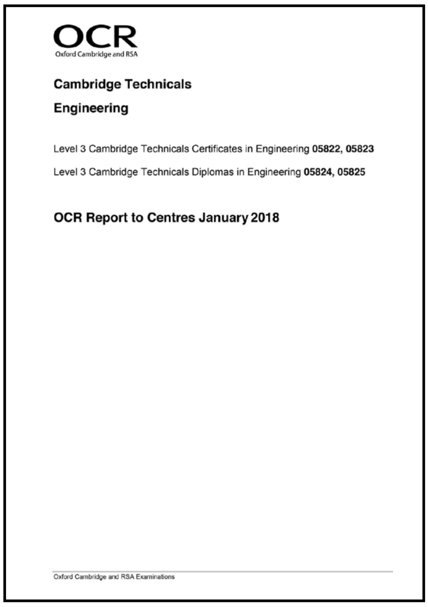
Engineering

Unit **1**: Mathematics for Engineering

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

Mark Scheme for January 2018

Oxford Cambridge and RSA Examinations



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Cambridge Technicals

Engineering

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

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

OCR Report to Centres January 2018

Oxford Cambridge and RSA Examinations

GENERAL EXAMINER COMMENTS ON THE PAPER

This is a mandatory unit across all qualifications in the Cambridge Technicals in Engineering suite.

It is hoped that the following points may help centres to prepare future cohorts of candidates for this unit.

Resources which might help address the examiner comments:

From the link below, you'll find 'The OCR guide to examinations' (along with many other skills guides)
http://www.ocr.org.uk/i-want-to/skills-guides/

Command verbs definitions
http://www.ocr.org.uk/Images/273311-command-verbs-definitions.pdf

Question 1

Answer **all** the questions.

1 **(a)** Expand the brackets and simplify the expression $4x + 3(x - 2y)$.

$= 7x$
$-6y$

[2]

(b) Factorise the following.

(i) $2xy^2 + 4x^2y$

$= 2xy(y + 2x)$

[2]

(ii) $x^2 - 3x - 10$

$(x \pm 5)(x \pm 2)$
$\Rightarrow (x - 5)(x + 2)$

[2]

(c) Solve the equation.

$2x - 3 = 1 - x$

$\Rightarrow 3x = 4$

$\Rightarrow x = \frac{4}{3}$ or 1.3 or 1.33.........

[2]

Mark scheme guidance

Question 1(a):

$7x$ No marks for question if more than 2 terms.

$-6y$

SC $4x + 3x - 6y$ **B1**

Question 1(b)(i):

One factor seen (i.e. 2 or x or y) What is left in the bracket must be two terms only consistent with factorisation.

Correct

Question 1(b)(ii):

Soi

isw

Question 1(c):

Collect terms (e.g. $3x$ or 4 seen)

Answer Don't accept 1.3 or 1.33 etc isw.

Examiner comments

While most candidates scored well on this question there were some very basic errors seen.

In (a) a significant proportion of candidates expanded $(4x + 3)(x - 2y)$ instead of $4x + 3(x - 2y)$.

In (b)(i) there was sometimes only a partial factorisation and in (ii) the signs were occasionally seen the wrong way round.

In (c) there were a large number of candidates who failed to solve the equation.

Question 2

2 **(a)** **(i)** Convert $\frac{2\pi}{3}$ radians to degrees.

120°

.... **[1]**

(ii) Convert 270° to radians, giving your answer as a multiple of π.

$\frac{3\pi}{2}$

.**[1]**

(b) The rule for placing a ladder against a wall is "bottom of ladder one unit out from the bottom of the wall, top of the ladder four units up the wall".
A ladder 6 m long is leant against a wall with its bottom 1.4 m away from the base of the wall on horizontal ground.

(i) Find how far up the wall the top of the ladder rests and explain whether the rule above is obeyed.

Apply Pythagoras correctly
$\Rightarrow h = \sqrt{6^2 - 1.4^2} = 5.83$
$1.4 \times 4 = 5.6$
The rule is not obeyed (Because 5.6 is not equal to 5.83438…)

....

.... **[3]**

(ii) Find the angle that the ladder makes with the horizontal ground.

$\theta = \cos^{-1}\frac{1.4}{6} = 76.5°$

.**[2]**

(c) Calculate the area of a semicircular rug with diameter 3 metres.

Area $= \frac{1}{2}\pi r^2 = \frac{1}{2}\pi 1.5^2 = 3.53$......

.**[2]**

Mark scheme guidance

Question 2(b)(i):

Allow 5.8 here.

5.6 must be seen but ft *their* h.

Alt: $\frac{5.83}{4} = 1.46$ or $1.45 > 1.4$ or $\frac{5.83}{4} = 4.16 > 4$

Question 2(b)(ii):

Alternative correct methods (i.e. using 3rd side) M1 but only A1 if correct.

Accept an answer in range [75, 77].

Question 2(c):

Soi formula for circle halved and diameter halved.

Allow 3.5. Accept $\frac{9\pi}{8}$

NB. 14.14 is using $r = 3$ M0.

Examiner comments

In (a) the conversion from radians to degrees and vice-versa was often muddled.

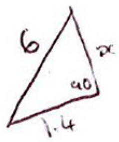
Part (b) was usually answered well, though some failed to use Pythagoras correctly.

In (c), the area of the semicircular rug was completed quite well, though there were the usual failures to use the radius rather than the diameter, and some forgot the halve the area of the circle.

Exemplar Candidate Work

Question 2(b)(i) – High level answer

(b) The rule for placing a ladder against a wall is "bottom of ladder one unit out from the bottom of the wall, top of the ladder four units up the wall".
A ladder 6 m long is leant against a wall with its bottom 1.4 m away from the base of the wall on horizontal ground.



(i) Find how far up the wall the top of the ladder rests and explain whether the rule above is obeyed.

6

6m 1.4 4 × 1.4 = 5.6

1.4 = unit 5.6

$6^2 = 1.4^2 + x$ $x = 6^2 - 1.4^2 = 34.04$

5.83

[3]

Commentary

Able candidates will know what they have to do and complete the mathematics without thinking about the question itself.

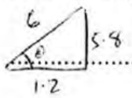
In this case the "ideal" distance of 5.6 m is found and the actual distance of this ladder up the wall of 5.83 m is found.

For full marks candidates would have to explain whether the rule was obeyed and this candidate failed to do so. Because all the rest of the work was correct, this was nevertheless a high level answer.

Question 2(b)(ii) – High level answer

(b) The rule for placing a ladder against a wall is "bottom of ladder one unit out from the bottom of the wall, top of the ladder four units up the wall".
A ladder 6 m long is leant against a wall with its bottom 1.4 m away from the base of the wall on horizontal ground.

(ii) Find the angle that the ladder makes with the horizontal ground.



~~Sin~~ $\cos\theta = \frac{b}{c}$ $\cos\theta = \frac{1.2}{6}$ $\theta = 78.5°$

$\cos^{-1}\left(\frac{1.2}{6}\right) = \theta$

[2]

Commentary

In this response the mathematics is correct in that the right ratio for the right angle is chosen and for the ratio calculated the angle is correct.

However, in this case there is a misread; the base distance given in the question was 1.4 m and not 1.2 m.

Candidates who misread a question will usually have their work marked using their values and if there is no further error then only 1 mark will be deducted from full marks.

Question 3

3 **(a)** Write as a single logarithm $\log a + 2\log b$.

> $\log ab^2$

[2]

(b) A scientist started with 100 bacteria in a container. The growth of the bacteria can be modelled by the equation $N = 100e^{t/4}$ where N is the number of bacteria after t minutes.

(i) Calculate the number of bacteria present when $t = 5$.

> $N = 100e^{1.25}$
> $= 349.03....$

[2]

(ii) After how many minutes does the number of bacteria exceed 1000?

> $1000 = 100e^{t/4} \Rightarrow e^{t/4} = 10 \Rightarrow \dfrac{t}{4} = \ln 10 = (2.30....)$
> $\Rightarrow t = 9.21....$ mins

[2]

(c) Solve the equation $x^2 + 3x - 5 = 0$. Give your answers correct to 3 decimal places.

> $x = \dfrac{-3 \pm \sqrt{9+20}}{2} = \dfrac{-3 \pm 5.385}{2} = 1.193$ or -4.193

[3]

(d) Using the factor theorem or otherwise solve the equation $x^3 - 2x^2 - x + 2 = 0$.

> By trial: any one root or factor found (1, –1, 2)
> Factor (x + 1), (x – 1) or (x – 2) seen
> Long division or inspection to get quadratic
> Solve quadratic to get all three roots, 2 – 1, 1

[4]

Mark scheme guidance

Question 3(a):

b^2 seen.

Question 3(b)(i):

Accept 349.

Question 3(b)(ii):

With or without 'minutes/mins' stated. Allow 9.2.

Alt: By T&I allow anything in range [9.2,10] www.

Question 3(c):

Correct formula.

$\sqrt{29}$ seen

Both roots correct to 3 dp. Accept answers to more than 3 dp but not less.

Alt by completing square:

$(x + 1.5)^2 =$....... **M1**

$... = \pm\sqrt{7.25}$ **B1**

Question 3(d):

Attempt at long division by a correct factor (seen by first line correct).

SC $(x + 1)(x - 1)(x + 2)$ seen **B2**

SC One root only **B2**

SC $f(2) = f(-1) = f(1) = 0$ **B2**

SC left as three factors **B3**

Examiner comments

The basic laws of logarithms in (a) were usually not known and correct answers were rare.

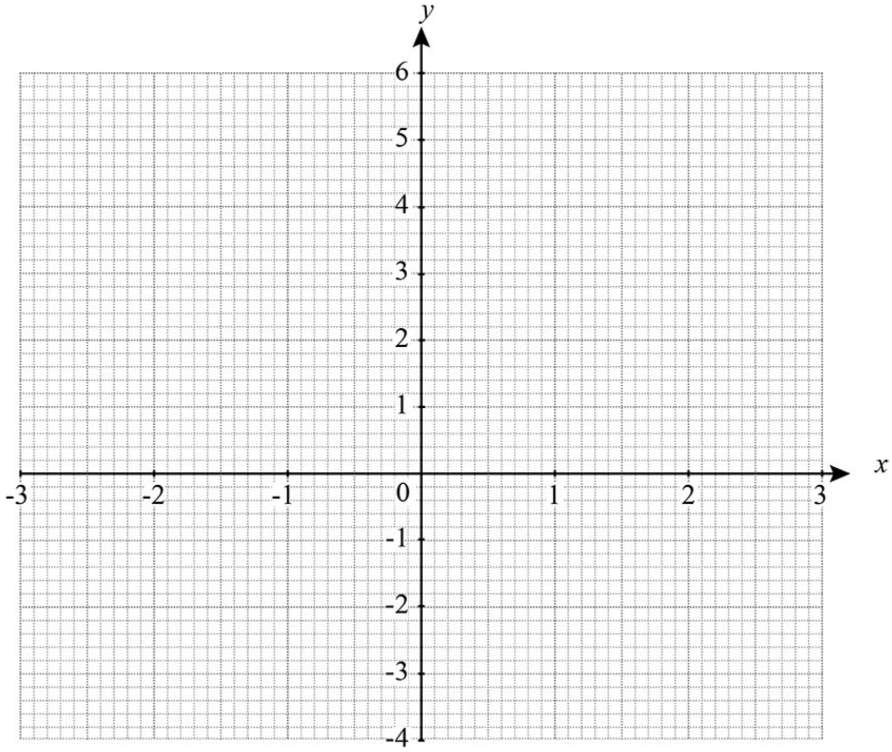
In (b)(i) the exponential calculation was usually done correctly, but the reverse, in (ii) was not usually correct. Some gained marks by finding the answer by trial and improvement.

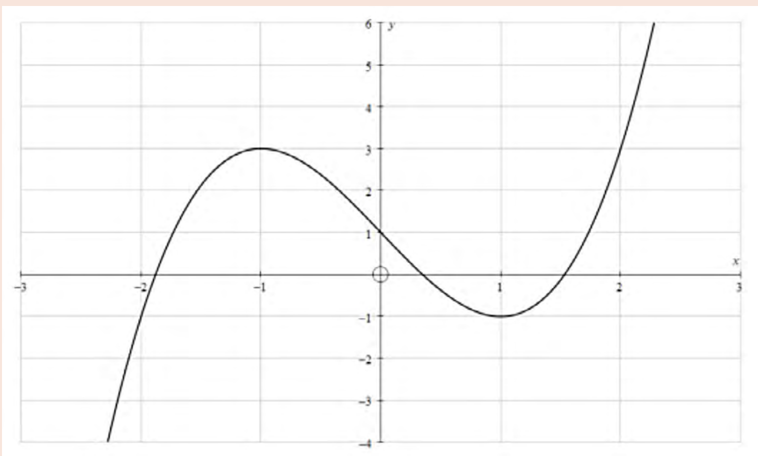
Part (c) required candidates to solve a quadratic equation and is was disappointing to see so many candidates fail to get anywhere. One or two completed the square but for many it seemed as though the formula was not known.

In (d) a fair proportion obtained all 3 roots but a large number did not seem to know where to start.

Question 4(a)

4 (a) (i) On the grid below, plot the curve $y = x^3 - 3x + 1$ for $-2 \leqslant x \leqslant 2$.





[4]

(ii) Hence write down the three roots of the equation $x^3 - 3x + 1 = 0$ correct to 1 decimal place.

Roots are as follows:
-1.9 ± 0.1
0.4 ± 0.1
1-5 ± 0.1

......

..**[2]**

Mark scheme guidance

Question 4(a)(i):

Correct coordinates (–2, –1), (–1, 3), (0, 1), (1, –1) and (2, 3) (even if curve not drawn).

B2 one error, B1 two errors.

Smooth curve through their coordinates even if wrong.

Question 4(a)(ii):

One value given where their graph crosses the axis.

All 3 correct ft their graph.

Examiner comments

In (a)(i) most candidates were able to calculate the required points and draw a smooth curve through the plots. They were then able in (ii) to write down the values of x where their curve cut the x-axis.

Question 4(b)

(b) Find the equation of the line that passes through the point (4, 2) and is perpendicular to the line $2x + 5y = 7$.

$\Rightarrow$ Gradient of required line $= \frac{5}{2}$

$\Rightarrow y - 2 = \frac{5}{2}(x - 4)$

$\Rightarrow 2y - 4 = 5x - 20$

$\Rightarrow 2y = 5x - 16$

Alternative:

Perpendicular line is of form $5x - 2y = c$

Satisfied by (4,2) $\Rightarrow c = 16$

$\Rightarrow 5x - 2y = 16$

[4]

Mark scheme guidance

Using $m_1 m_2 = -1$ soi

Using (4, 2) and *their* gradient.

Or attempt at $y = mx + c$ to find c.

ft

Oe e.g. $y = \frac{5}{2}x - 8$

Answer three terms only.

M1 A1

M1

A1

Accept alternative workings.

Examiner comments

Part (b) was not well answered. While many understood the idea of perpendicular lines, finding the gradient of the given line defeated most.

Question 5

5 (a) Find the value of $\int_0^{\pi/4} \cos 2x \, dx$.

$$\int_0^{\pi/4} \cos 2x \, dx = \left[\frac{1}{2}\sin 2x\right]_0^{\pi/4}$$

$$= \frac{1}{2}$$

[3]

(b) A cylindrical tin has radius r cm and height h cm.

Its volume, V cm³, is given by the formula $V = \pi r^2 h$.

Its surface area, S cm², is given by the formula $S = 2\pi r^2 + 2\pi rh$.

(i) Show that $S = 2\pi r^2 + \frac{2V}{r}$.

$$V = \pi r^2 h \Rightarrow h = \frac{V}{\pi r^2}$$

$$\Rightarrow S = 2\pi r^2 + 2\pi r \frac{V}{\pi r^2} = 2\pi r^2 + \frac{2V}{r}$$

[3]

A manufacturer wants to produce tins that hold 60 cm³ of liquid with a minimum surface area.

(ii) Use calculus to determine the values of r and h that will give a minimum surface area.

$$\Rightarrow S = 2\pi r^2 + \frac{120}{r} \Rightarrow \frac{dS}{dr}$$

$$= 4\pi r - \frac{120}{r^2}$$

$$= 0$$

when $4\pi r - \frac{120}{r^2} = 0 \Rightarrow r^3 = \frac{30}{\pi}$

$$\Rightarrow r = 2.12$$

$$\Rightarrow h = \frac{60}{\pi (2.12)^2} = 4.25$$

[6]

Mark scheme guidance

Question 5(a):

Sin2x

$$\frac{1}{2}$$

Allow 0.5 www.

Question 5(b)(i):

Attempting comparison.

Allow derivation the other way round but beware ag.

Question 5(b)(ii):

Differentiating (can include V as a constant).

For $\frac{dS}{dr} = 0$

Appropriate first step to solve equation.

Ft Accept 4.24

Examiner comments

The responses to this question were the weakest of the paper.

In part (a) many knew the indefinite integral but then failed to give the correct answer; it seems as though most candidates had their calculators in degree mode, being unaware that the result of the integration depended on the use of radians.

The context of part (b) is given in the specification but most failed to understand either the context or the method of solution.

In (i) there were a large number of candidates who tried to fudge the process, given that the end result was given. In such questions it is crucial that candidates work carefully through the process, writing down their steps carefully and clearly so that it is clear to the examiner that he or she knows how to achieve the end result.

A "show that" question is usually asked when the result is to be used in the next part. This means that what is given in the previous part can be used by candidates who are unable to show the result. However, in this question it was often the case that the result of (i) was not used in (ii). Some returned to the original expression for S and differentiated that, treating h as a constant.

This part question was worth up to 6 marks and consequently those who had not studied this topic in enough depth could not access the full 6 marks available.

Exemplar Candidate Work

Question 5(b)(i) – High level answer

(b) A cylindrical tin has radius r cm and height h cm.

Its volume, V cm^3, is given by the formula $V = \pi r^2 h$.

Its surface area, S cm^2, is given by the formula $S = 2\pi r^2 + 2\pi rh$.

(i) Show that $S = 2\pi r^2 + \frac{2V}{r}$.

πrh = V/r 2πrh = 2V/r
2πr2 = area of 2 circular faces
SA = Area of hollow tube + area of circles **[3]**

Commentary

The connection is made between the volume and surface area and the candidate has gone most of the way to showing the result but the final step is missing. When the question is a "show that ..." question, candidates must ensure that the marker can tell that he or she has followed correct steps through to the given answer.

Exemplar Candidate Work

Question 5(b)(ii) – High level answer

(ii) Use calculus to determine the values of *r* and *h* that will give a minimum surface area.

$60\,cm^2 = \pi r^2 h$ $\quad h = \frac{60}{\pi r^2}$ $\quad 60 = \pi r^2 h$

$S = 2\pi r^2 + 2\pi r \frac{60}{\pi r^2}$ $\quad h = \frac{60}{\pi r^2}$

$S = 2\pi r^2 + \frac{120}{r}$ $\quad h = 2$

$\frac{dS}{dr} = 4\pi r - 120 r^{-2} = 0$

$\pi r - 30 r^{-2} = 0$

$\pi r^3 - 30 = 0$

$r^3 = \frac{30}{\pi}$

$r = \sqrt[3]{30/\pi}$ $\quad 3.09$

[6]

Commentary

This candidate has worked through the question well but has failed on two counts to complete the question.

The differentiation and the process to find the stationary point have been done correctly and so this is a high level response.

However, the calculation of *r* in the last line is incorrect and so an accuracy mark has been lost. The candidate has the value for r3 correct but in fact has found the square root instead of the cube root.

This had an effect on the value of *h* by substituting for r^3 instead of r^2 – there might have been a mark available as a "follow through" had there been no further error.

Consequently this high level response was not a full mark response.

Question 6(a)

6 **(a)** A die is biased so that when it is thrown the probability of it showing a 2 is 0.15.

Find the probability that when the die is thrown twice that the side numbered 2 will be shown at least once.

P(at least one 2) = 1- P(no 2's)
= 1- $(0.85)^2$
= 0.2775

OR
P(2 then 2) = 0.15 × 0.15 = 0.0225
P (2 then not 2) = 0.15 × 0.85 = 0.1275
P(not 2 then 2) = 085 × 0.15 = 0.1275
P(at least one 2) = 0.0225 + 0.1275 + 0.1275 = 0.2775
$\left(= \frac{111}{400}\right)$

....

....**[2]**

Mark scheme guidance

M1 At least 2 out of 3 evaluated and added or full statement seen.

SC All 3 probabilities correct but not added M1

A1

Examiner comments

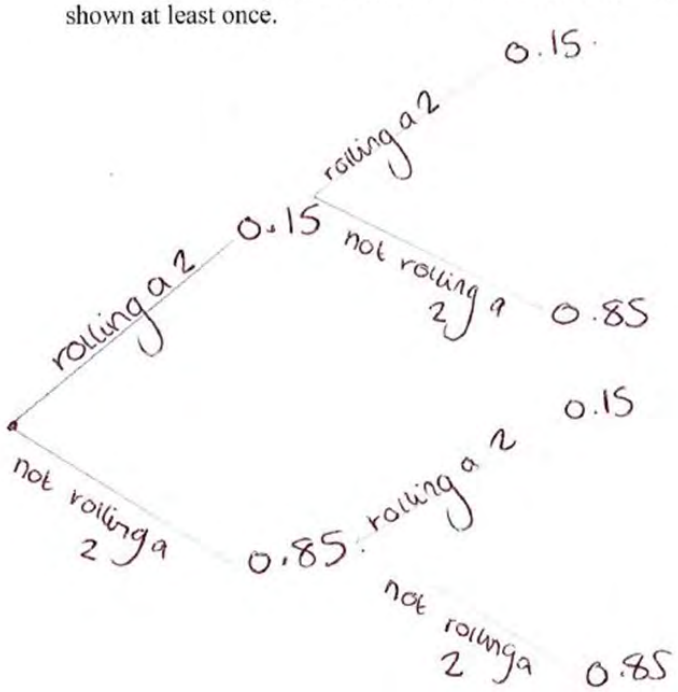
In part (a) very few candidates tackled the problem the easiest way. The statement P (at least once) = 1 – P (not once) was not known; only a handful of candidates picked up 2 marks by doing the question this way. Many did get the correct answer using a probability tree diagram and adding the end results of three of the branches but this long-winded method had many pitfalls meaning that a large number of candidates did not complete the question correctly.

Exemplar Candidate Work

Question 6(a) – High level answer

6 (a) A die is biased so that when it is thrown the probability of it showing a 2 is 0.15.

Find the probability that when the die is thrown twice that the side numbered 2 will be shown at least once.



0.85 × 0.15 = 0.1275 **[2]**

0.15 × 0.15 = 0.0225

0.15 × 0.85 = 0.1275

0.85 + 0.15 = 1

0.15 + 0.85 = 1

0.15 + 0.15 = 0.3

= 2.3.

Commentary

In probability questions where the words "at least" are given it is usually quicker and easier for the candidate to take away from 1 what is not required.

So here P(at least once) = 1 – P(none) = 1 – $(0.85)^2$ = 0.2775.

However, many candidates, even the more able ones, chose to add up all the terms of the probability that satisfy the demand – i.e. P(1) + P(2).

This requires the three terms as shown in this response. For calculating the probabilities a method mark was given even though the actual method requires the candidate to add them up. Here they are listed but not added. The working on the right involving adding probabilities was ignored.

Question 6(b)

(b) A sample of screws taken from a production line have masses, to the nearest tenth of a gram, as shown in the frequency table below.

Mass (g)	3.0	3.1	3.2	3.3	3.4	3.5
Frequency	7	13	9	4	3	2

(i) Find the mean and standard deviation of this sample.

Mean = ... Mean = 3.171... ....

Standard deviation = .. SD = 0.137... ....

[5]

(ii) State if the distribution of this sample has a negative skew, a positive skew or is approximately symmetrical.

Positive (skew). .**[1]**

Mark scheme guidance

Question 6(b)(i):

Sight of sum (120.5)

Allow 3.2

Attempt to find sum of squares.

Divide by n or $n - 1$

SC Answer stated as Variance = 0.137 **B2**

Answers seen with no working: Mean B2

SD B3

Question 6(b)(ii):

Only correct answer.

Examiner comments

In part (b) the mean and standard deviation of a set of data were required. The simplest way is to use a calculator and many candidates did so, scoring the full 5 marks. It is worth noting that when the standard deviation is done this way, the input of an incorrect value will result in an incorrect answer. Where no working to a question is shown then an incorrect answer will get zero. However, in most cases, candidates who had used their calculator obtained full marks.

For those who worked this the long way there were various errors seen caused by misunderstandings. A significant number found a mean value by adding the six different values for the mass and dividing by 3, thus obtaining 3.25. Some knew that they needed to use the frequency column to get a total of 120.5 but then divided by 6 instead of the sum of frequencies (38), obtaining an answer that was outside the range of the data given.

Likewise there were many answers for the standard deviation that were well outside the range of values given.

Exemplar Candidate Work

Question 6(b)(i) – High level answer

(b) A sample of screws taken from a production line have masses, to the nearest tenth of a gram, as shown in the frequency table below.

Mass (g)	3.0	3.1	3.2	3.3	3.4	3.5
Frequency	7	13	9	4	3	2

38

(i) Find the mean and standard deviation of this sample.

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots + x_N}{N} = \frac{3.0 + 3.0 + 3.0 + 3.0 + \ldots}{38}$$

$$= 3.1710$$

$$SD = \sqrt{\frac{1}{N}\sum_{i=1} x_i^2 - (\bar{x})^2} = \sqrt{\frac{1}{38}\sum x_i^2 - (3.17)^2}$$

$$= 0.1393$$

Mean = 3.17

Standard deviation = 0.14

[5]

Commentary

Candidates have the use of a calculator for this examination and it is wise to use it. Therefore, finding the mean and Standard deviation can be done on a calculator – not doing so can create opportunities to make simple arithmetic errors.

It is possible that a calculator was used in this response in a limited way – the sum of values is not given but from the writing it seems that they were added and then divided by 38 to give the correct value for the mean.

The formula for the standard deviation as written is also correct (either 38 or 37 in the denominator was acceptable) but there is an arithmetic error somewhere which cannot be discerned as not all the working is showing. The consequence is an answer for the SD which is not quite right and so failing to earn the final accuracy mark.

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