CAMBRIDGE TECHNICALS

Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 1 January 2022 series

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

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Unit 1 series overview

Many candidates performed well in this paper with a number obtaining full marks. It was clear however that a number of candidates had not covered all the topics of the specification. To progress well in engineering, all topics of this unit need to be covered. It is clear that many candidates have a good understanding of all topics but equally clear that a number have a poor or no understanding of some topics, which have not been underpinned by confidence in basic mathematics.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• Had an understanding of all the topics in the specification. • Had written their responses carefully.	• Missed out on some topics of the specification. • Did not lay out their work clearly so that the development of the response to its conclusion was not clear.

Question 1 (a)

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

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.... **[2]**

The most common error here was to expand the second bracket, failing to change the sign. Candidates also did not multiply throughout the second bracket by 2.

Question 1 (b)

(b) Factorise $4x + 6xy$.

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.... **[2]**

A number of candidates extracted one factor but not both.

Question 1 (c)

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

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.... **[2]**

This part was usually well done; only a very small number of candidates did not use the lowest common multiple of the denominators.

Question 1 (d)

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

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.... **[2]**

Candidates should understand that the demand "solve the equation" means that an exact answer is required. So, $x = -1.3$ was not accepted unless $x = -\frac{4}{3}$ could be seen earlier in the working. There are standard steps to solve equations and those that followed them usually obtained the correct outcome.

Question 1 (e)

(e) Rearrange $s = vt - \frac{1}{2}at^2$ to make v the subject.

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.... **[3]**

A significant majority of candidates did not score any marks in this transposing question. Isolating the *v* term was the first step and then dividing by *t*. A variety of ways of writing the expression for *v* were accepted.

Question 2 (a)

2 **(a)** Use the quadratic formula to solve the equation $x^2 + 3x - 7 = 0$.

Give your answers correct to 3 significant figures.

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.... **[3]**

This question requires the use of the quadratic formula which is given in the formula booklet (3.1 on page 9). Most candidates who did not score marks in this part did not remember the formula well and did not copy it from the formula booklet. The most significant error was to fail to take the denominator under the whole of the numerator.

Additionally, the question asked for roots "correct to 3 significant figures". Failure to do so lost the last mark.

Key point call out

Instructions state that "answers should be given to a degree of accuracy appropriate to the context". Even if there is no context to the question it would be unusual for an answer which is not exact to be required that is more than 2 decimal places or 3 significant figures.

Question 2 (b)

(b) An engineer is buying electrical components that are made in two types, type A and type B.

3 of type A and 4 of type B will cost £39.
4 of type A and 3 of type B will cost £38.

Let the cost of a type A be £a and the cost of a type B be £b.

Form two equations in a and b and solve simultaneously to find the cost of each type.

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.... **[5]**

This was a straightforward question on simultaneous equations.

Many responses showed poor algebra. The question asked for the cost of two types of components. The correct response was "Type A cost £5 and type B cost £6", but this was rarely seen. Most wrote a = 5, b = 6 but many also wrote a = £5, b = £6, displaying a lack of understanding of algebra.

It is worth pointing out that the question asked candidates to form two equations. A few candidates found the answer correctly with no working, either because they worked on another paper which was not handed in or using their calculators. Failure to write two equations in these instances cost 2 marks.

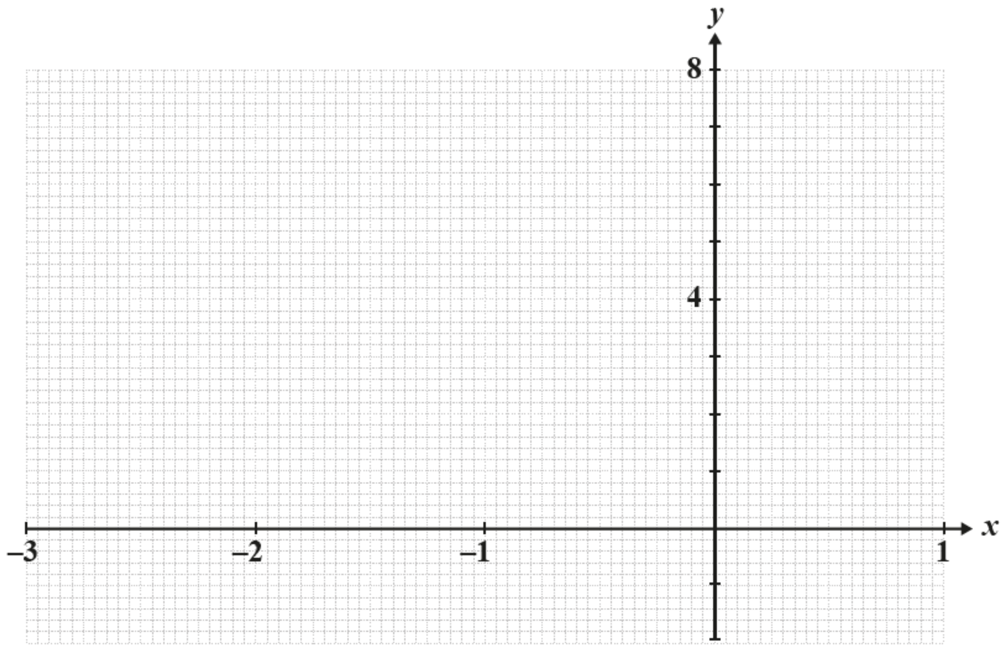
Key point call out

Candidates should think carefully about the use of variables in equations to satisfy given conditions. In this case a and b have no units, so it is not correct to say that a = £5. From the equations, a = 5 and so the cost of type A is £5.

Question 3 (a) (i)

3 **(a)** A curve has equation $y = x^3 + 3x^2 - 1$.

(i) Plot the curve in the region $-3 \leqslant x \leqslant 1$.



[3]

A few candidates did not understand what a cubic curve looked like and so were unable to correct their arithmetic for the plotting of points. Others drew straight lines between the correct points.

Question 3 (a) (ii)

(ii) Hence write down the roots of the equation $x^3 + 3x^2 - 1 = 0$ correct to 1 decimal place.

....

.... **[2]**

Some candidates did not understand the word "roots" and wrote some coordinates instead. Three roots were required.

Question 3 (b)

(b) A piece of land ABC is triangular in shape with angle A = 80° and angle B = 55°.

The side BC is 8 m in length.

Use the sine rule to find the length of the side AB.

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.... **[4]**

This was a two stage question in that the third angle was required to solve the question using the sine rule. It would have been helpful for candidates to have drawn a triangle, correctly labelled. Most drew a triangle but then did not label it correctly. Once the third angle was calculated the result usually followed.

Question 4 (i)

4 When a capacitor is discharged through a resistor the voltage, V, at time t, is given by the formula $V = V_0 e^{\frac{-t}{RC}}$.

V_0 is the initial voltage, C is the capacitance and R is the resistance.

A capacitor of 1000 μF initially has a potential difference of 12 Volts across it. It is discharged through a 500 Ω resistor.

(i) Find an expression for the voltage at time t.

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.... **[2]**

This question was not answered well and many candidates seemed unfamiliar with the topic. Additionally a number of candidates misread the question and tried to express t as a function of V rather than using the formula given and substituting the values for the variables that were given.

Question 4 (ii)

(ii) Find the time taken before the voltage across the capacitor is 0.12 Volts.

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....

.... **[3]**

Without an appropriate expression from part (i) of the form V_0e^{-kt} it was not possible to complete this part of the question, although the substitution $V = 0.12$ earned the first mark.

Question 4 (iii)

(iii) Find the voltage across the capacitor in the long term.

....

.... **[1]**

There is a lack of understanding of "decay" so "approaches 0" or just 0 was not often seen.

Question 4 (iv)

(iv) Find an expression for the rate of change of the voltage with respect to time, $\dfrac{dV}{dt}$.

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.... **[2]**

This last part involved calculus of the exponential function. Given that these two topics were not well understood, few candidates were able to give the correct response.

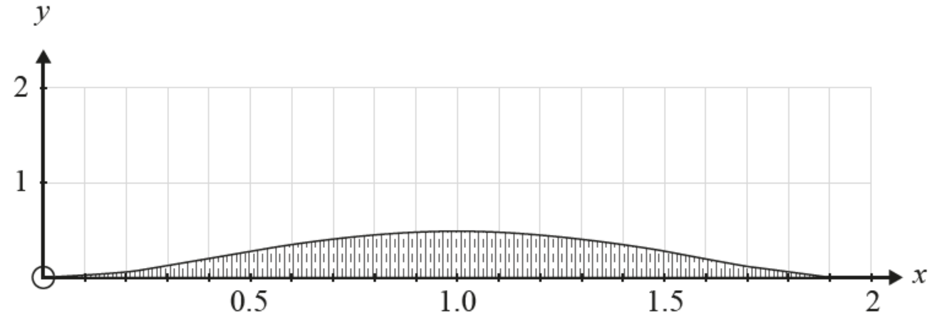
Question 5 (i)

5 Speed bumps are being installed on a road to slow traffic.

A civil engineer suggests that the cross section of each bump is given by the equation

$y = \frac{1}{2}x^4 - 2x^3 + 2x^2$ for $0 \leqslant x \leqslant 2$.

The cross-sectional area of each bump is represented by the shaded area under the curve as shown in the diagram. Units are metres.



(i) Show that the cross-sectional area of the bump is $\frac{8}{15}$ m^2.

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.... **[4]**

Calculus is also a topic that many candidates find difficult. Some candidates differentiated without any understanding of what the question was asking. Candidates should be aware that when the question is a "show that" question, full working to derive the given answer should be shown. In some cases the "leap" from initial working to the final (given) answer was too large. In this case the sight of limits being substituted was necessary for the award of full marks.

Key point call out

The demand "show that" means that all steps must be shown to demonstrate convincingly that the candidate has progressed from the starting point to the given answer. Just writing the given answer at the end of the working does not satisfy this criterion.

Question 5 (ii)

(ii) The width of the road is 5 m.

Find the volume of material required to make **one** bump.

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.... **[2]**

The first part was a "show that" question which usually means that the answer can be used in a subsequent part even if not derived. Candidates often earned full marks for this part using the given answer of part (i) even though they did not score in that part.

Candidates should be encouraged to think about units in all their problem solving. There are many answers in this question paper which have units. A requirement to give the units, even if not explicitly asked to do so, will occur at least once in the paper and the units (m^3) were required here for the second mark.

Key point call out

Candidates should be encouraged to think about the units of values in problem solving. Sometimes the question will say "Show the units of your answer". That will often be when the answer could be given in different units. For instance a length could be 60 cm or 600 mm or 0.6 m. So the answer 60 would not be good enough. In other cases, the need to write down the units will be expected but not demanded. In this case, a volume is required, so the answer should be $\frac{8}{3}\,\mathrm{m}^3$. To say that the volume is $\frac{8}{3}$ is not good enough. Some candidates did not understand the situation and, because (i) is an area the answer here was given as $\frac{8}{3}\,\mathrm{m}^2$.

Question 6 (i)

6 The data in the table shows the lengths, l mm of 150 brass rods.

Length (mm)	Frequency	Cumulative frequency
$l < 189$	0	0
$189 \leqslant l < 190$	10	10
$190 \leqslant l < 191$	12	
$191 \leqslant l < 192$	17	
$192 \leqslant l < 193$	24	
$193 \leqslant l < 194$	26	
$194 \leqslant l < 195$	25	
$195 \leqslant l < 196$	20	
$196 \leqslant l < 197$	11	
$197 \leqslant l < 198$	5	150

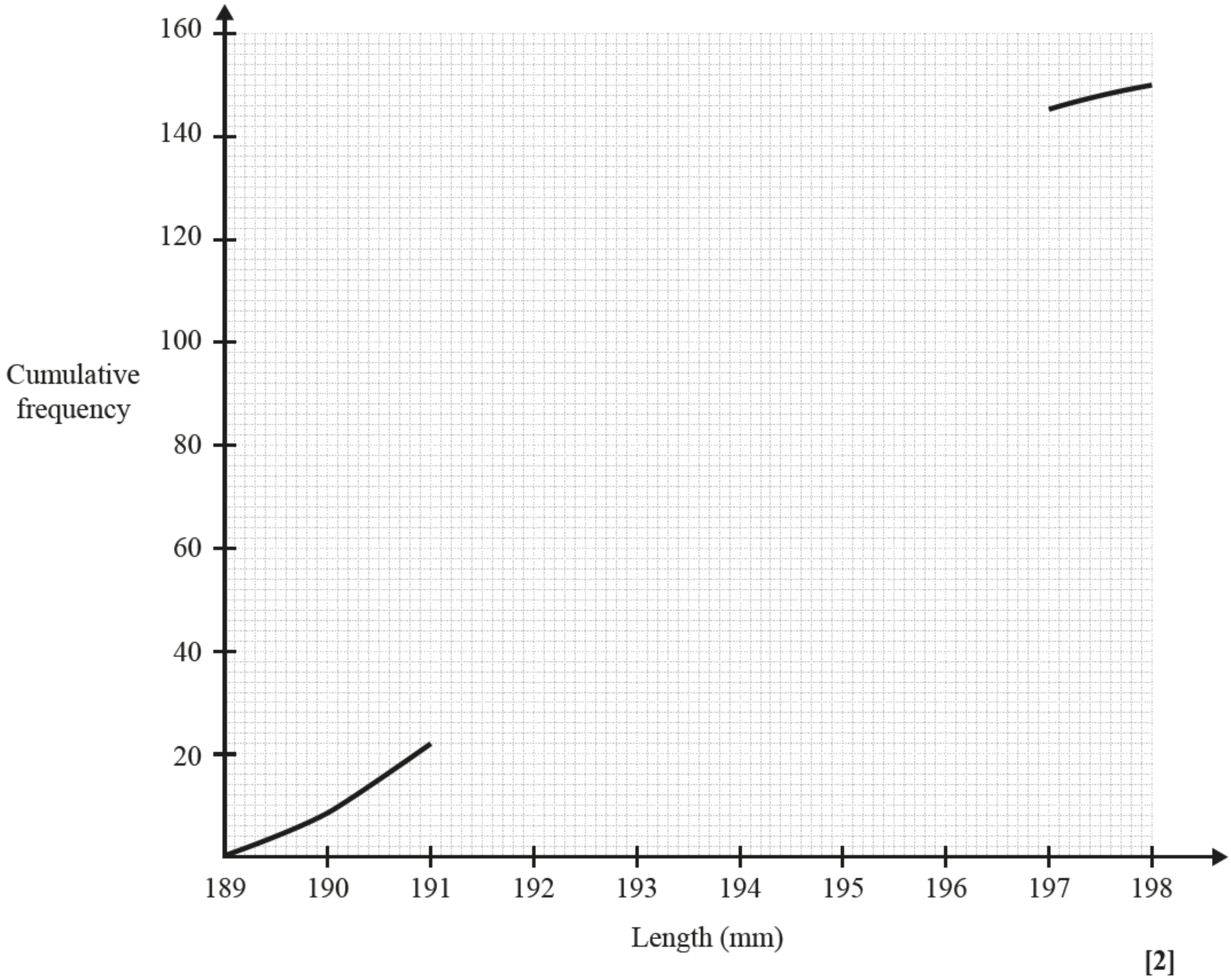
(i) Complete the cumulative frequency column in the table above.

[2]

The vast majority of candidates understood what was required in this question and completed the cumulative frequency table correctly.

Question 6 (ii)

(ii) Complete the cumulative frequency curve on the grid below.



[2]

The resulting curve was also well done. A small number of candidates drew straight lines between the plotted points even though the question asked for a curve. A few also plotted at midpoints of the ranges instead of at the end.

Question 6 (iii)

(iii) Find the median length of the brass rods from your curve.

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.... **[2]**

Many found a value for the answer from the cumulative frequency of 80 instead of the halfway mark for the data which was 75. Candidates should be encouraged to draw straight lines from a given value on one axis to the curve and thence to the other axis. It was not always clear in this question where the answer came from.

Question 6 (iv)

(iv) You are given that the arithmetic mean is 193.2 mm and the standard deviation is 1.8 mm. The brass rods are only acceptable if they have a length within 2 standard deviations of the mean.

Find the number of brass rods that are rejected because they are either too long or too short.

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.... **[3]**

The standard deviation in this part was given. Nonetheless a number of candidates attempted to calculate the standard deviation for the data, presumably taking a considerable amount of time either by a long calculation or by inputting the data into their calculator.

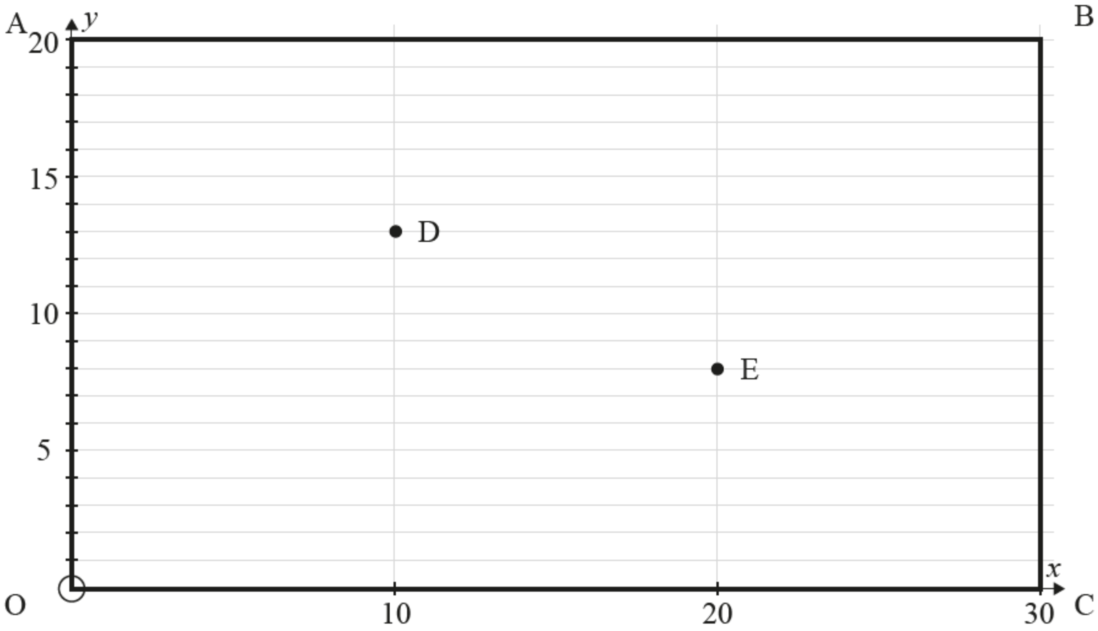
The focus of this question was not, however, to assess the ability to compute a standard deviation but to find a range of acceptable values from the curve. Again, there were some responses with no working and no indication of what was being found from the graph. Many candidates also misread the question and took the range of values within one standard deviation rather than the two required by the question.

Question 7 (i)

7 A metal plate, OABC, is rectangular with sides of length 30 cm by 20 cm. The plate is 2 cm thick. Two circles with radius 5 cm need to be cut out from the plate.

On a coordinate system the plate has coordinates O(0, 0), A(0, 20), B(30, 20) and C(30, 0) as shown in the diagram.

The two circles are to have centres D and E at (10, 13) and (20, 8).



(i) Write down the equations of the two circles in the form $(x - a)^2 + (y - b)^2 = r^2$.

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.... **[2]**

Coordinate geometry of circles is often misunderstood; the requirement here was to substitute the coordinates of the centre and the radius of each circle. Many candidates substituted values for *x* and *y* instead of *a* and *b*.

Question 7 (ii)

(ii) Calculate the volume of the metal plate remaining when the circles have been cut out.

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.... **[4]**

Part (ii) was a good source of marks, even for the weaker responses. The volume of the two cylinders taken out of the cuboid simply required the subtraction of one volume from another. Many candidates worked in areas to give an answer for the area of the rectangle left, followed by (sometimes, but not always) the depth of 2 cm. Others worked in volumes throughout but unfortunately then didn't go on to multiply the area of a circle by 2 to give the volume and then another 2 because there were two circles.

Question 7 (iii)

(iii) By finding the distance DE, determine the smallest distance between the circles.

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.... **[3]**

This part was an application of Pythagoras theorem and many candidates obtained the correct answer for the distance between the centres of the circles. This was not the question, however, and many did not realise that to find the shortest distance between the edges of the circle required them to subtract 10 from their answer.

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