

Monday 10 January 2022 – Afternoon

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873 Unit 1: Mathematics for engineering

Time allowed: 1 hour 30 minutes
C301/2201



You must have:

- the Formula Booklet for Level 3 Cambridge Technical in Engineering (inside this document)
- a ruler (cm/mm)
- a scientific calculator



Please write clearly in black ink.

Centre number

Candidate number

First name(s) _____

Last name _____

Date of birth

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give your final answers to a degree of accuracy that is appropriate to the context.

INFORMATION

- The total mark for this paper is **60**.
- The marks for each question are shown in brackets [].
- This document has **12** pages.

ADVICE

- Read each question carefully before you start your answer.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/11
2	/8
3	/9
4	/8
5	/6
6	/9
7	/9
Total	/60

Answer **all** the questions.

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

.....
.....
..... [2]

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

.....
..... [2]

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

.....
.....
..... [2]

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

.....
.....
..... [2]

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

.....
.....
..... [3]

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

Give your answers correct to 3 significant figures.

.....

.....

.....

..... [3]

- (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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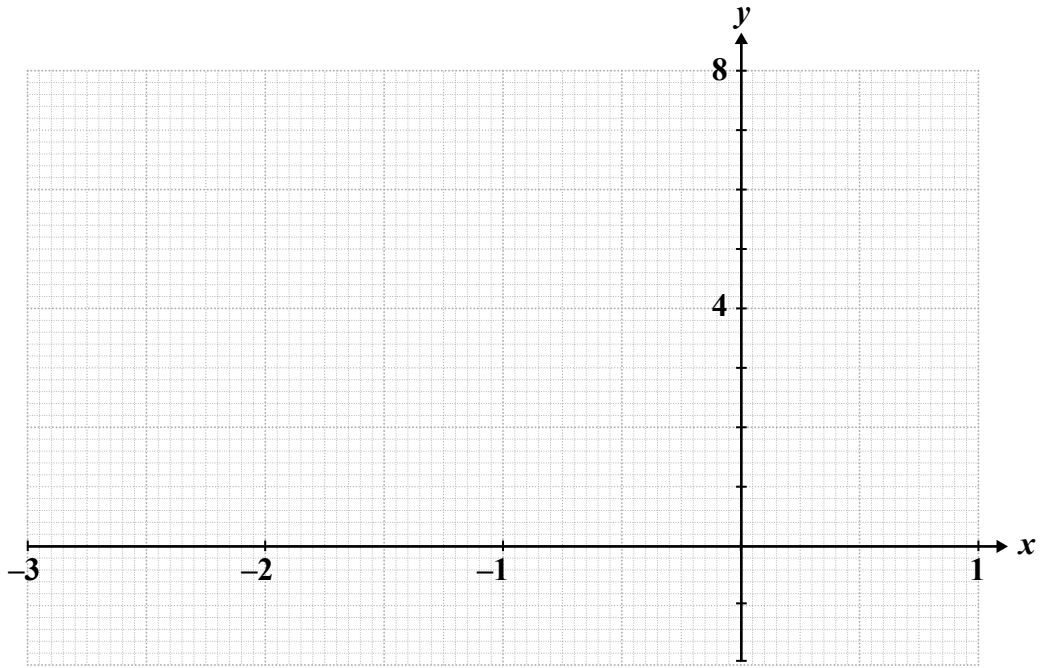
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.....

..... [5]

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

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



[3]

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

.....
 [2]

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

The side BC is 8 m in length.

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

.....

 [4]

- 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 $1000 \mu\text{F}$ initially has a potential difference of 12 Volts across it. It is discharged through a 500Ω resistor.

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

.....

 [2]

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

.....

 [3]

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

.....
 [1]

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

.....

 [2]

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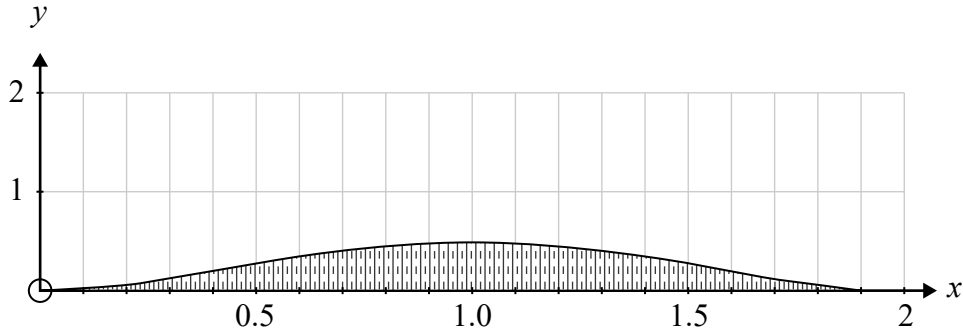
Question 5 begins on page 7

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

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

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 $\frac{8}{15}$ m².

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..... [4]

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

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

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..... [2]

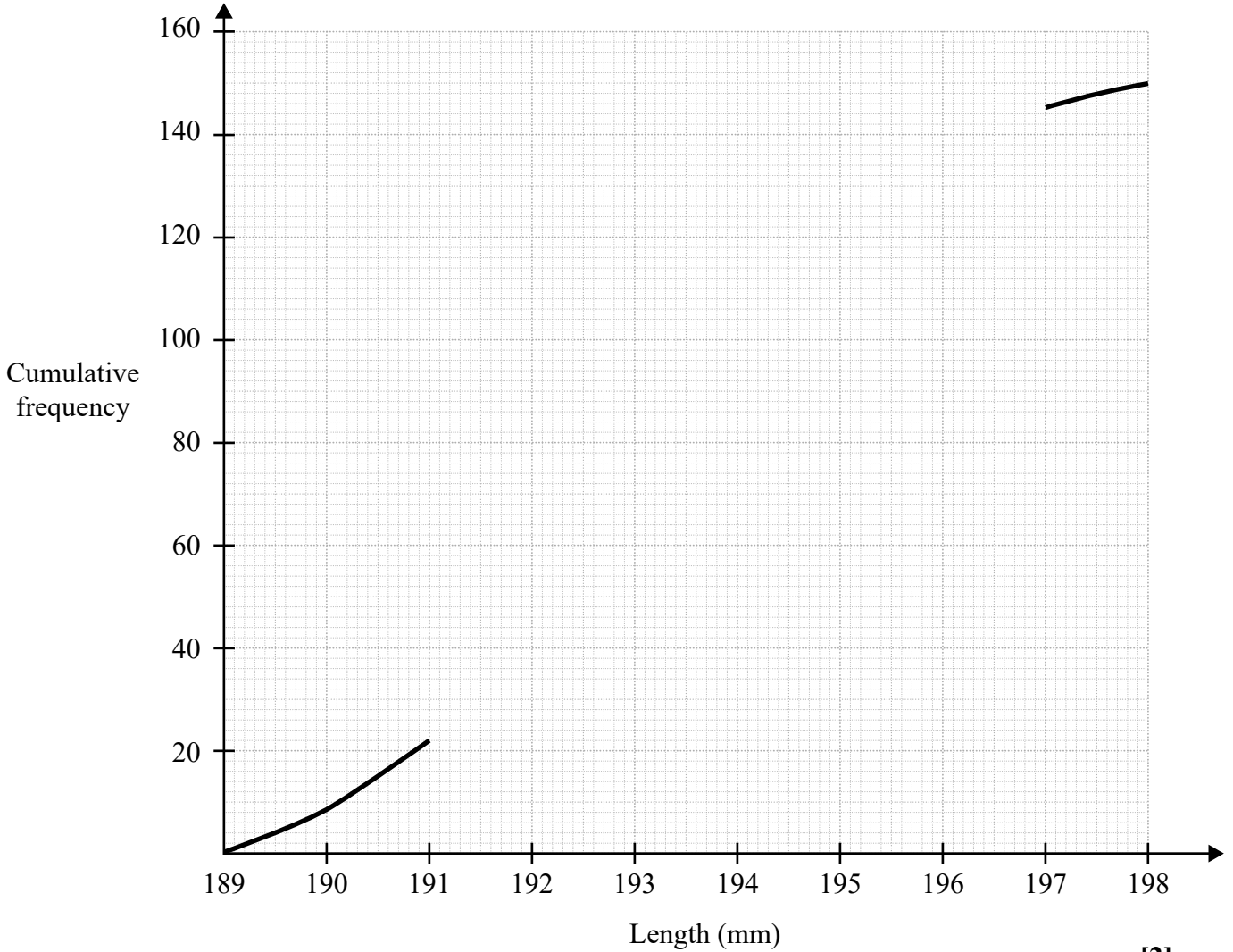
6 The data in the table shows the lengths, l mm of 150 brass rods.

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

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

[2]

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



[2]

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

.....
 [2]

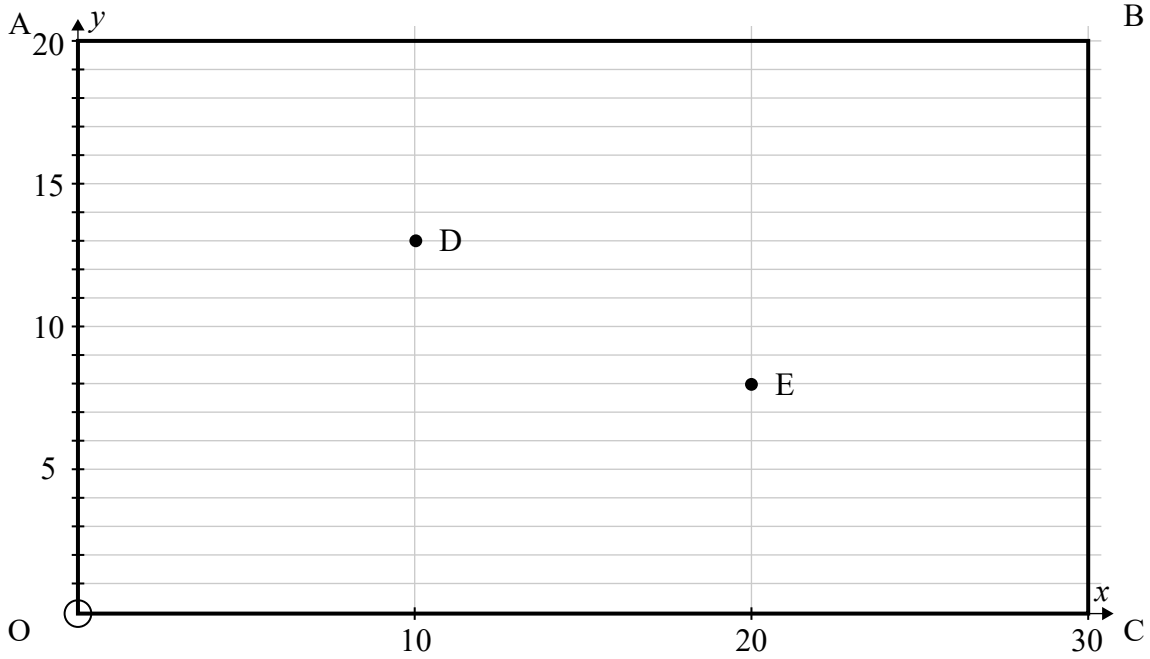
(iv) You are given that the arithmetic mean is 193.2 mm and the standard deviation is 1.8 mm. The brass rods are only acceptable if they have a length within 2 standard deviations of the mean.

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

.....

 [3]

- 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 $(x - a)^2 + (y - b)^2 = r^2$.
-
-
- [2]
- (ii) Calculate the volume of the metal plate remaining when the circles have been cut out.
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-
-
-
- [4]
- (iii) By finding the distance DE, determine the smallest distance between the circles.
-
-
- [3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 1(c) or 6(i).

A vertical line on the left side of the page is followed by 25 horizontal dotted lines, providing a ruled area for writing answers.



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