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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

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 plus your additional time allowance

You must have:
the Formula Booklet for Level 3 Cambridge Technical in Engineering (with this document)
the Loose Sheet for Question 7(i), (ii) and (iii)
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 | D | D | M | M | Y | Y | Y | Y |

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 [ ].

ADVICE

Read each question carefully before you start your answer.

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.

[5]

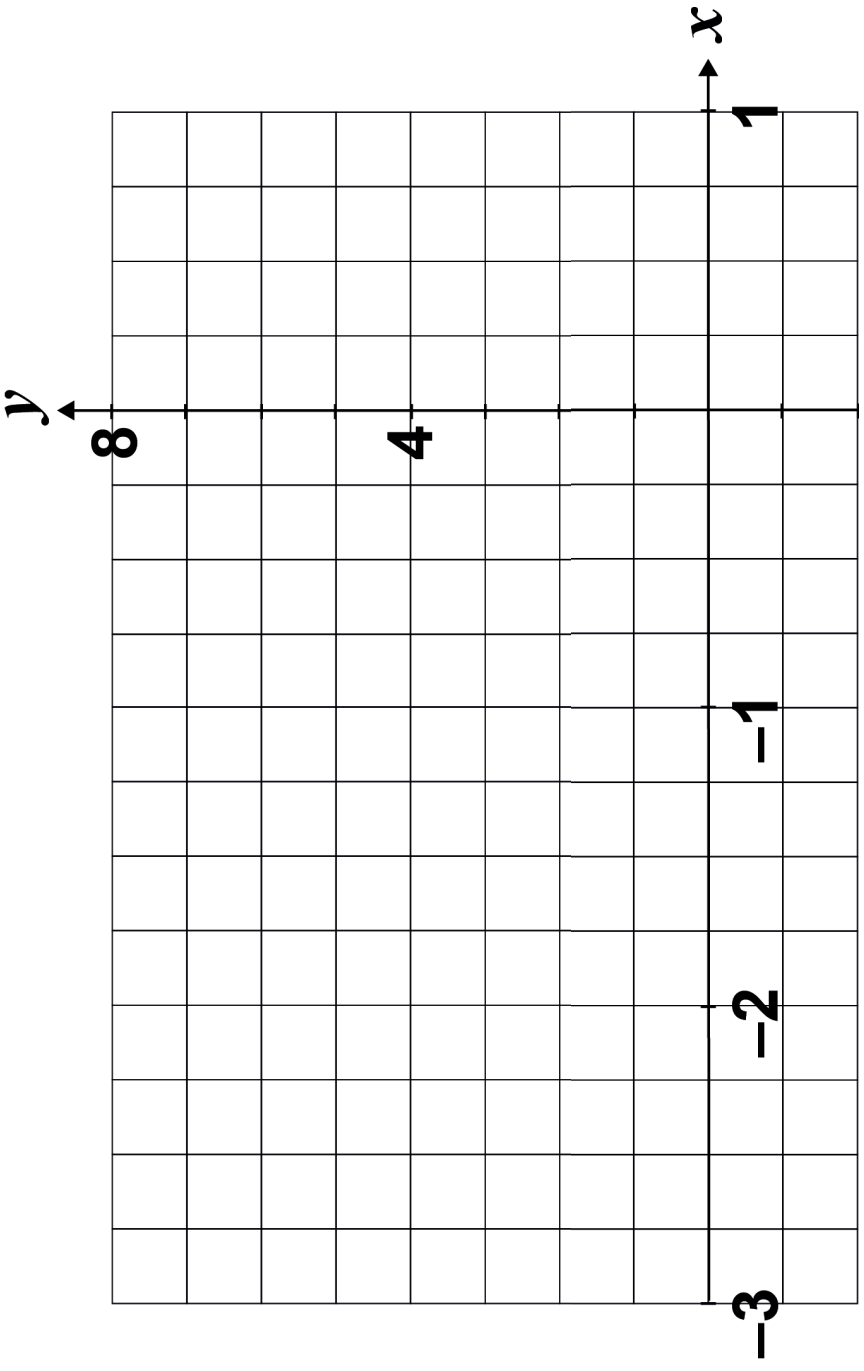
3 (a) A curve has equation
$y = x^3 + 3x^2 - 1$.

(i) On the diagram opposite, plot the curve in the region $-3 \leqslant x \leqslant 1$. [3]

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

_____

_____ [2]


x
y
8
4
1
−1
−2
−3

(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.

[4]

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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.

_____

_____

_____

_____ [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, $\frac{\mathrm{d}V}{\mathrm{d}t}$.

[2]

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

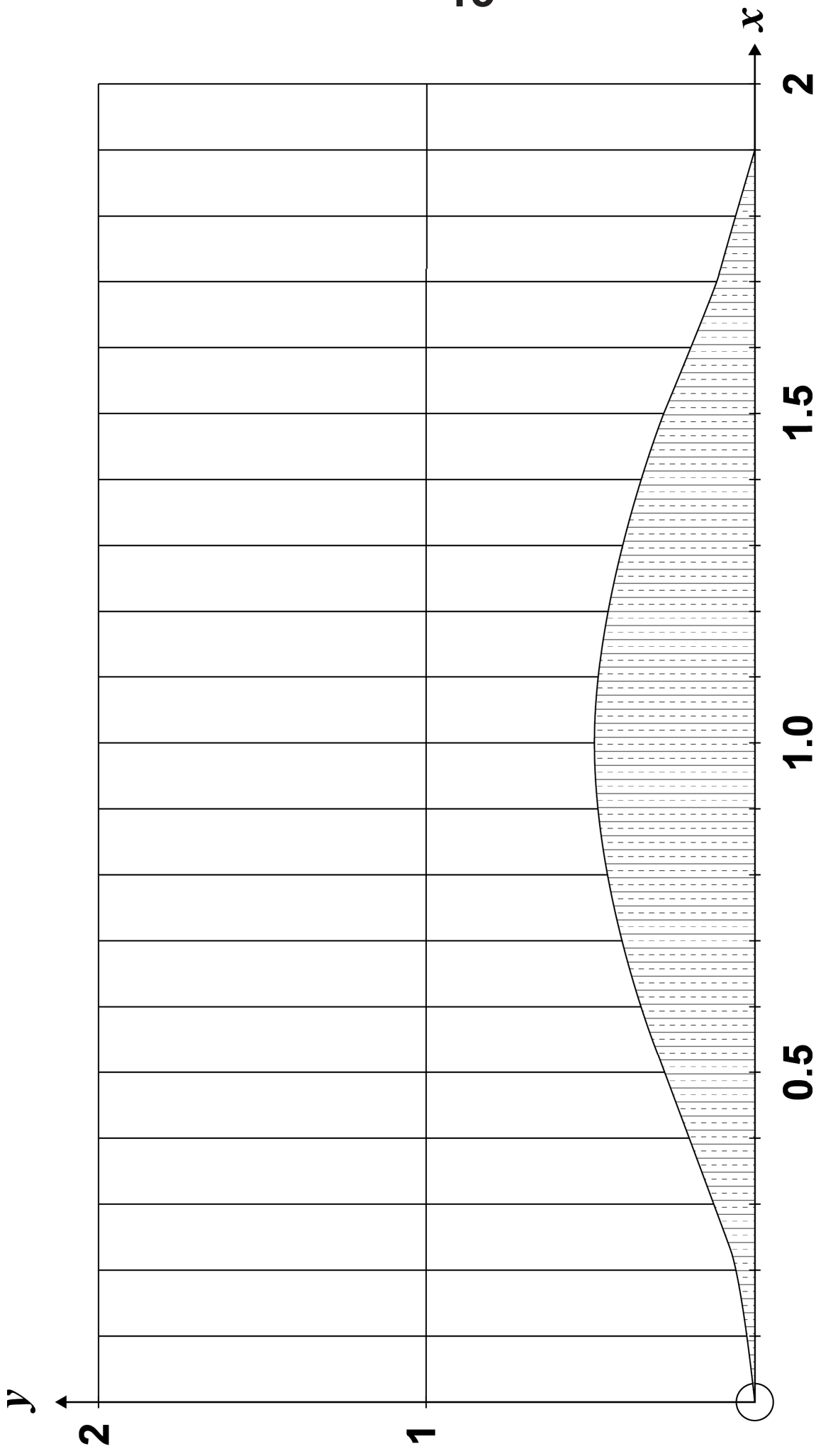
A civil engineer suggests that the cross section of each bump is given by the equation

$y = \frac{1}{2}x^4 - 2x^3 + 2x^2$ 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 opposite. Units are metres.

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

[4]


x
2
1.5
1.0
0.5
y
2
1

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

Find the volume of material required to make ONE bump.

_____

_____

_____ [2]

17

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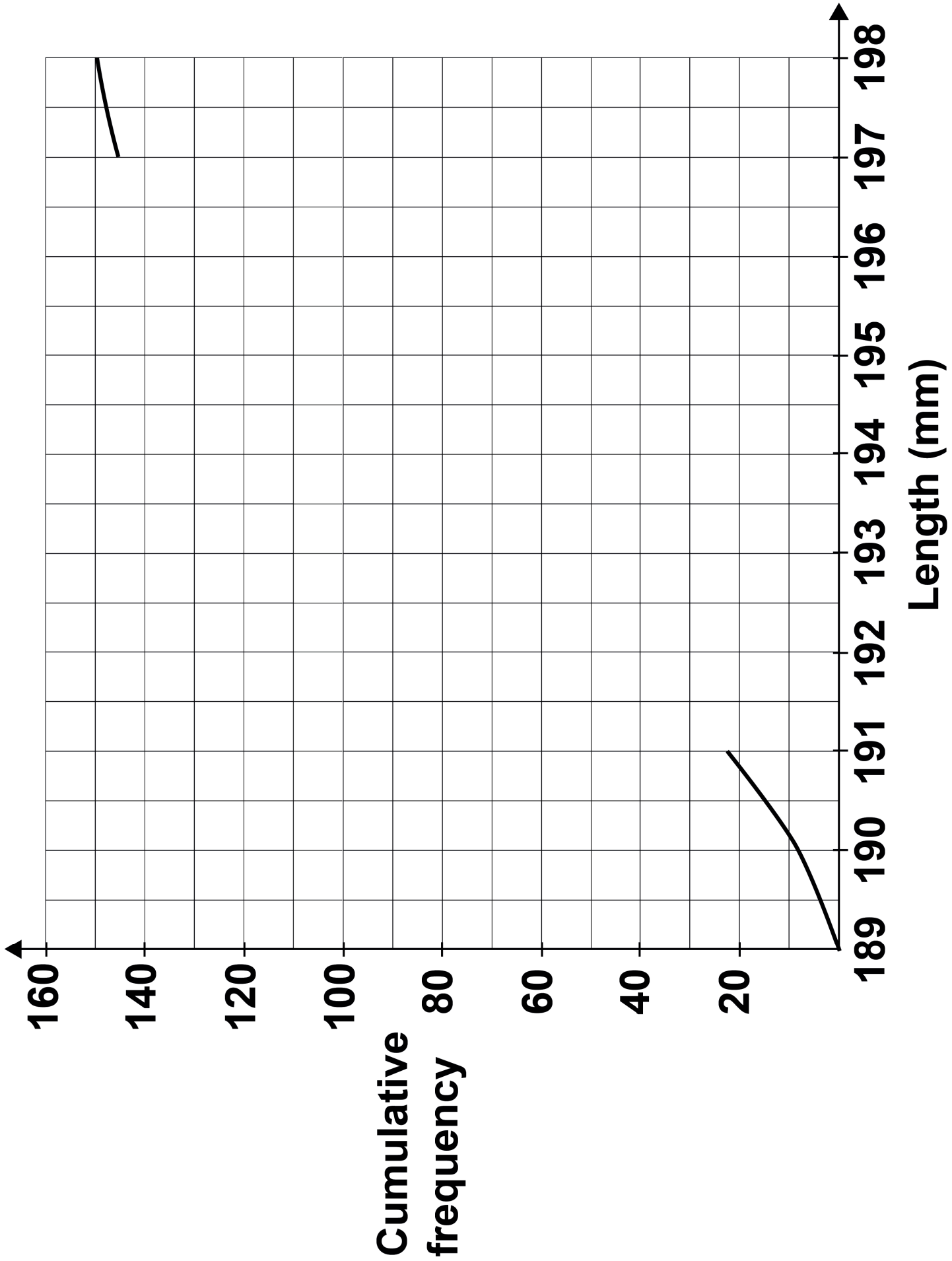
6 The data in the table shows the lengths, l mm of 150 brass rods.

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]

(ii) Complete the cumulative frequency curve on the grid opposite. [2]


Cumulative frequency
160
140
120
100
80
60
40
20
189
190
191
192
193
194
195
196
197
198
Length (mm)

(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]

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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 on the Loose Sheet.

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.

_____

_____

_____

_____

_____ [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).

Oxford Cambridge and RSA

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