OCR
Oxford Cambridge and RSA

# Wednesday 10 January 2024 – Afternoon

## Level 3 Cambridge Technical in Engineering

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

**Time allowed: 1 hour 30 minutes**
**C301/2401**

C301 – 2401

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

0 5 8 2 2 – 0 1

Please write clearly in black ink. **Do not write in the barcodes.**

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 **[ ]**.
- This document has **16** pages.

**ADVICE**
- Read each question carefully before you start your answer.

**1**

**(a)** Multiply out the brackets and simplify $2(2x + 7) - 3(x + 2)$.

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

**(b)** Factorise $4x + 10y$.

..... **[1]**

**(c)** Solve the equation $2x - 1 = 5$.

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

**(d)** Solve the equation $x^2 + x - 6 = 0$.

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**(e)** Divide $x^3 + 2x^2 - 4x + 3$ by $x - 2$.

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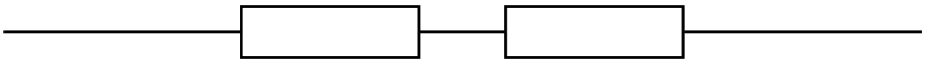
..... **[3]**

**2**

**(a)** When resistors are connected in series the total resistance is the sum of the separate resistances.



An engineer has two types of resistors which have resistances, A and B.
If they connect 5 of type A and 3 of type B in series the total resistance is 670 Ω.
If they connect 4 of type A and 5 of type B in series the total resistance is 640 Ω.

Form two equations in A and B and solve simultaneously to find the value of each resistance.

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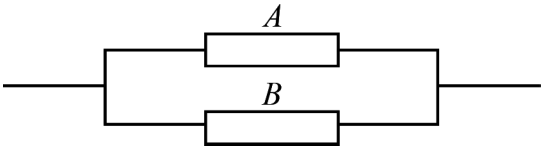
..... **[5]**

**(b)** When two resistances are connected in parallel the total resistance, $R$, is given by the following formula.

$$\frac{1}{R} = \frac{1}{A} + \frac{1}{B}$$




Rewrite the formula so that $R$ is the subject.

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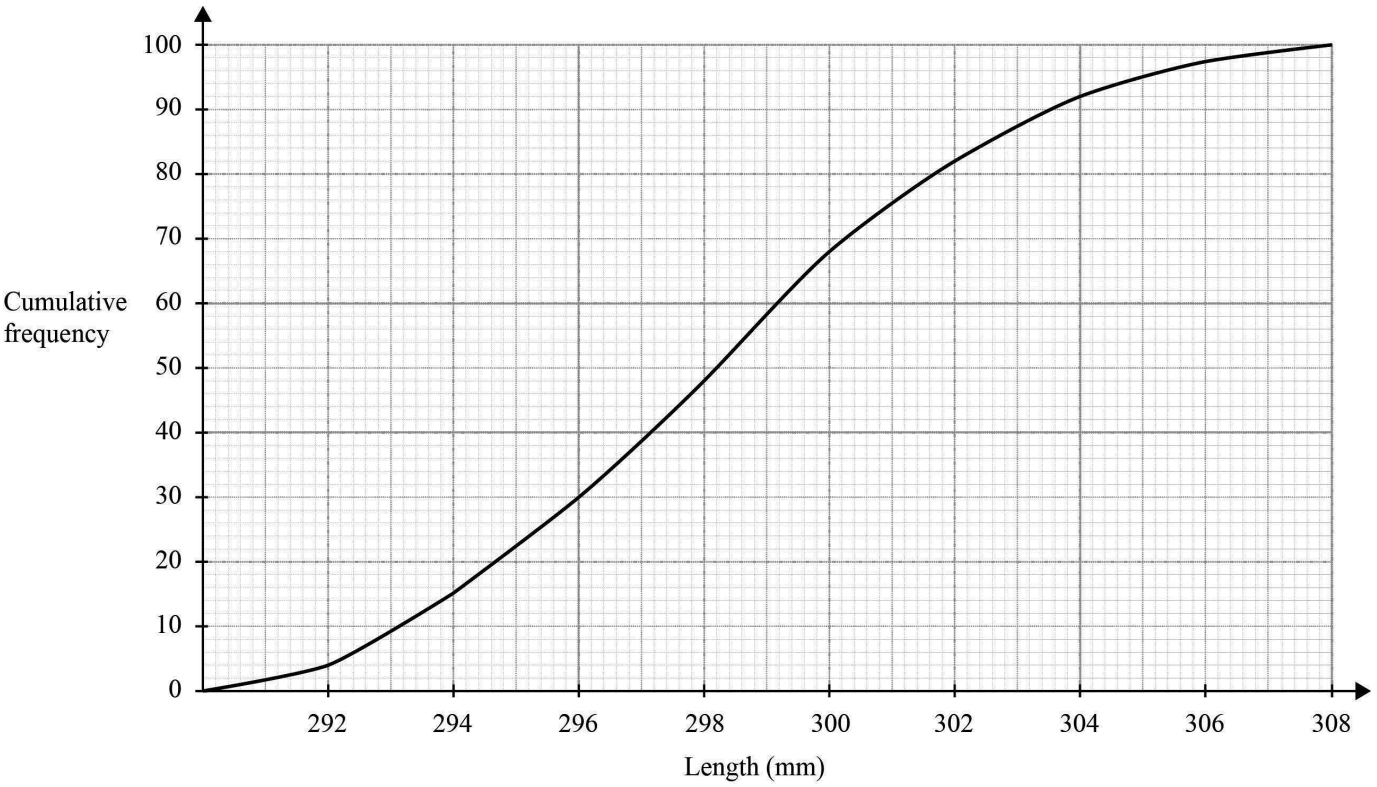
**3**

**(a)** Steel bars are made to a nominal length of 300 mm. They cannot be used if they have a length over 305 mm.

An engineer chooses a sample of 100 bars each day and measures their length.

The cumulative frequency diagram below has been constructed from the data for one particular day.




How many bars in the sample cannot be used?

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

**(b)** On another occasion, the engineer chooses 10 bars at random. Their lengths are

292 296 297 300 301 302 303 304 307 308.

You are given that the mean length of this sample is 301.

Calculate the standard deviation of this sample.

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

**(c)** A machine has two components, A and B. It is found that the probability of component A failing within 24 hours is $\frac{1}{4}$ and the probability of component B failing within 24 hours is $\frac{1}{5}$.

The machine can only work if both components are functioning.

The probability that components fail is independent of the other.

One Monday morning the two components are replaced.

Find the probability that

**(i)** the machine is still working at the end of 24 hours,

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

**(ii)** the machine breaks down before the end of 24 hours.

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..... **[1]**

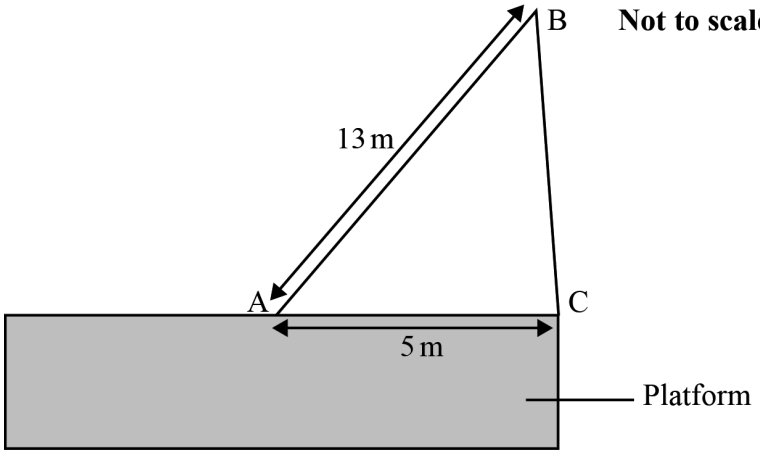
**4**

**(a)** A crane arm, AB, and a support arm, CB, are mounted so that AC is horizontal and at the edge of a platform as shown in **Fig. 1**.

The crane arm, AB, can be rotated in a vertical plane. BC has variable length.

AB = 13 metres and AC = 5 metres.

**Fig. 1**




**(i)** Find the angle BAC when B is vertically above C.

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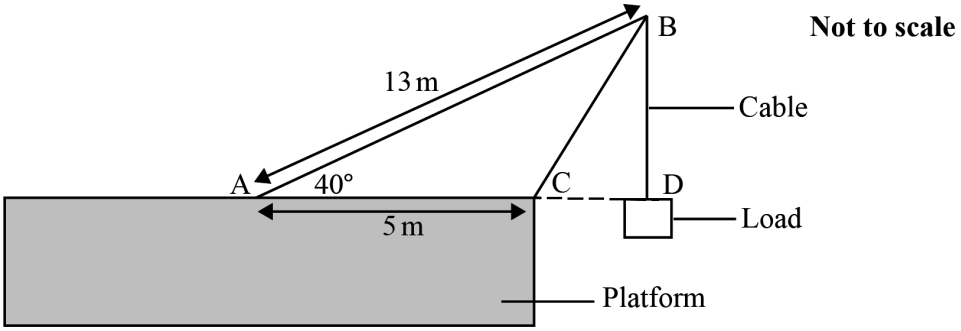
AB is now rotated so that angle BAC = 40° as shown in **Fig. 2**.

The top of the crane arm, B, now extends over the edge of the platform. A load hung from the end of the cable BD can now be lowered below the surface of the platform.

**Fig. 2**



**(ii)** Calculate the length of the cable BD when D is level with the top surface of the platform (so that ACD is a straight line).

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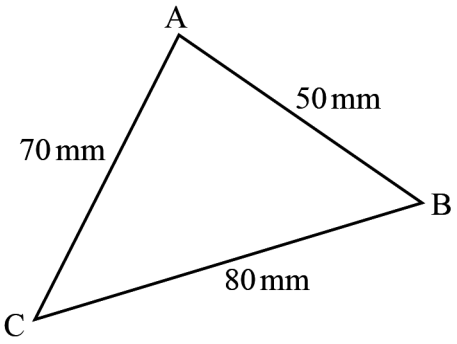
**(b)** A triangular piece of metal ABC has sides AC = 70 mm, CB = 80 mm and BA = 50 mm.




**Not to scale**

Find the angle ABC.

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..... **[4]**

**5**

**(a)** Solve the equation $2^x = 3$. Give your answer correct to 3 decimal places.

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..... **[4]**

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

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**(c)** Find the equation of the line that passes through the points (3, 4) and (7, 6).

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

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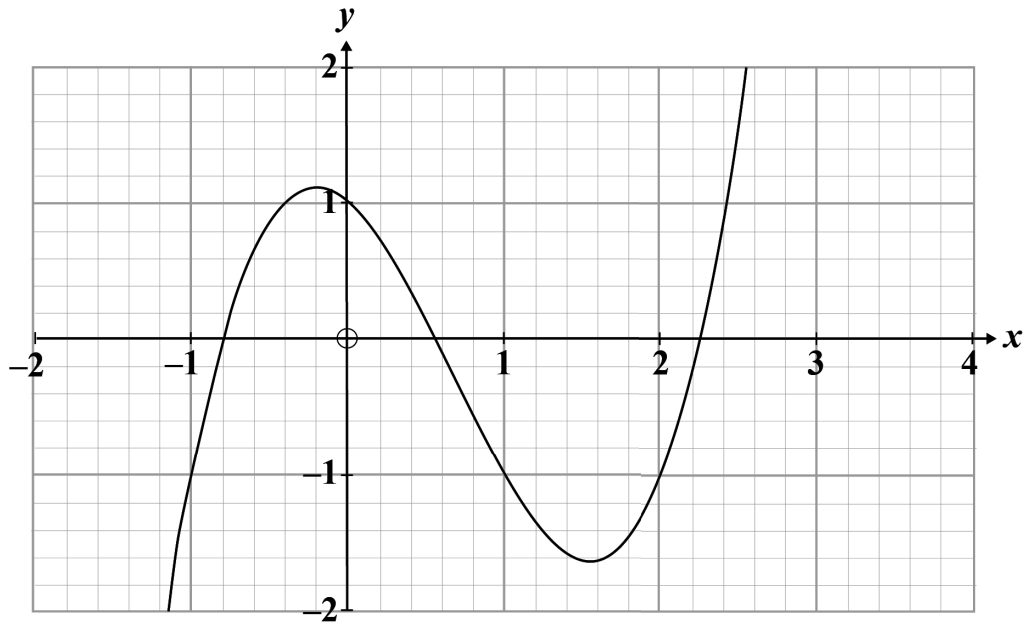
**(e)** The curve $y = x^3 - 2x^2 - x + c$ for $-2 \leqslant x \leqslant 3$ is shown on the graph below.




**(i)** Given that $c$ is an integer, write down the value of $c$.

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**(ii)** Write down the three values of $x$ for which $x^3 - 2x^2 - x + 1 = 0$ correct to 1 decimal place.

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**6** An engineer is modelling a flood bank between a road and a river.

**Fig. 3a** shows the cross section of the riverbank between the road and the river.

**Fig. 3b** shows the cross section with the proposed flood bank.

The level of the river is shown at its lowest level.

**Fig. 3a**

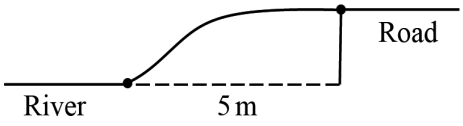
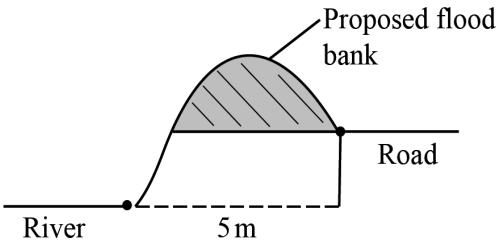



**Fig. 3b**



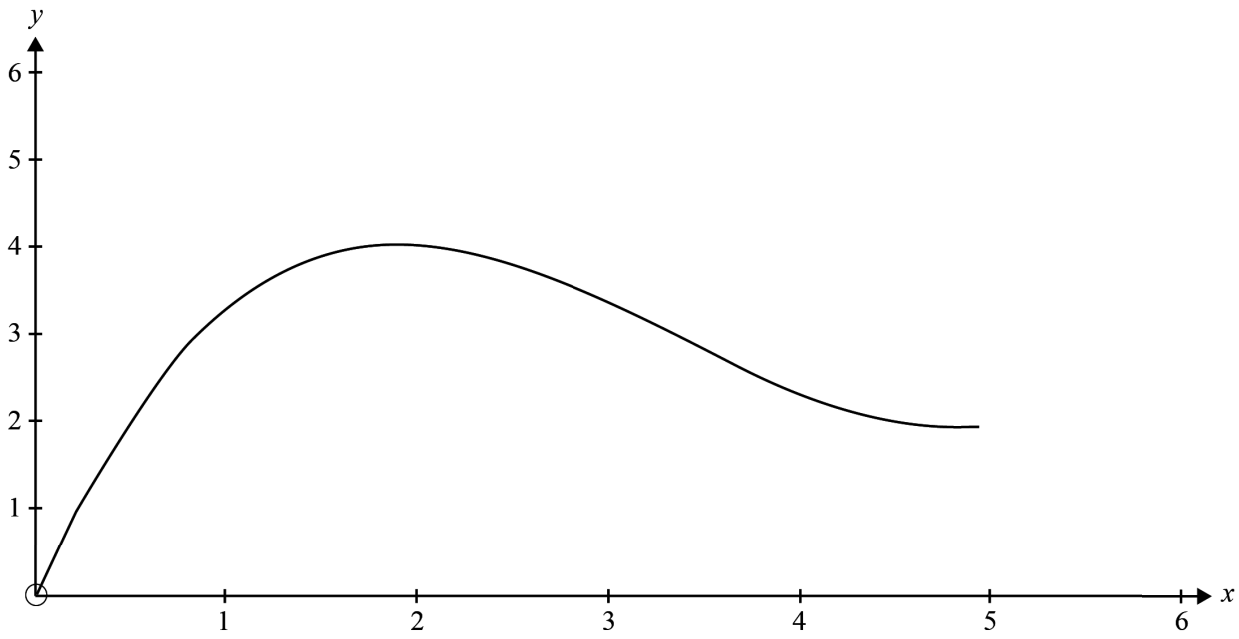

On a coordinate system the equation of the surface of the proposed flood bank is

$$y = \frac{1}{13}(2x^3 - 21x^2 + 60x)$$

for $0 \leqslant x \leqslant 5$, as shown in **Fig. 4**.

The edge of the river when at its lowest level is at (0, 0) and the edge of the road is where $x = 5$.

**Fig. 4**



**(a)** Show that $\frac{dy}{dx} = 0$ when $x = 2$ and $x = 5$.

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**(b)** The river level rises at certain times of the year and at present frequently floods the road.

**(i)** Calculate the height of the road above the river when the river is at its lowest level.

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**(ii)** After the flood bank is built, calculate the height the river must rise before it will flood the road. Show your working.

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

**END OF QUESTION PAPER**

## EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.