

MU123

EMA

2019J

Covers the whole module

Cut-off date 26 May 2020

Submission instructions

There are some important differences in the procedure for preparing and submitting this end-of-module assessment (EMA) compared to that for submitting TMAs.

Before beginning this assignment, you must read the EMA page on the MU123 website for all instructions relating to the EMA.

Your score out of 5 for good mathematical communication (GMC) will be recorded against Question 7. You do not have to submit any work for Question 7.

Question 1 – 2 marks

Think back over your experience of studying MU123. Think about what has gone well, or what has not gone so well.

- (a) Describe one change that you have made, or plan to make, to your studying. [1]
- (b) Describe how you hope that the change will make your studying more effective.

If you think that no changes are necessary, then explain why. [1]

Question 2 – 17 marks

Katie changes energy supplier to one that she believes has a lower CO₂ output. Later she discovers she was mistaken and decides to research the rates of CO₂ output of energy suppliers generally. Firstly she compares the CO₂ output of the top 20 energy suppliers in 2018 with all 17 energy suppliers in 2015. The data are recorded in Table 1. Each data value is measured in g per KWh and has been rounded to the nearest 10 g per KWh.

Table 1 Rates of CO₂ output of energy suppliers in 2018 and 2015

2018	2015
300	240
360	530
360	530
180	400
210	230
360	410
310	530
360	530
360	190
100	530
200	400
240	420
360	320
360	240
200	540
360	400
270	420
200	
420	
360	

- (a) (i) Enter the data into two new lists in Dataplotter. Copy and complete the table below. Round values, where necessary, to the nearest whole number.
- The mean, rounded to nearest whole number, is given for you as a check that you have entered the data correctly.* [2]

	2018	2015
Min		
Median		
Max		
Mean	294	404
SD		
IQ range		
Range		

- (ii) Use the two measures of location to say which year has a greater rate of CO₂ output on average. Explain your reasoning. [2]
- (iii) Use all three measures of spread to say which year has the greater variability in the rate of CO₂ output. Explain your reasoning. [2]
- (b) (i) Create boxplots for these two datasets (either drawn by hand or as a printout from Dataplotter). Include all the relevant information required for drawing boxplots as set out in Subsection 1.2 of Unit 11.
- The summary values can be displayed on the boxplots themselves or in a table to the side of the chart, as they appear in Dataplotter.* [3]
- (ii) Use the boxplot for the responses from the year 2018 to say whether the data are symmetric or skewed. If the data are skewed, then state whether they are skewed to the left or skewed to the right. What does this tell you about how the data are spread in the dataset for the year 2018? [2]
- (iii) Katie tries to summarise what the boxplot for 2018 is telling her. State whether each statement is true or false. In each case justify your answer.
- (1) About three-quarters of the providers produced less than 360 g per KWh. [2]
- (2) There were more providers producing more than 335 g per KWh than providers producing less than this. [2]

- (c) Katie also looks at the rates of output of nuclear waste for the same energy supplier for the same two years. A summary of the key statistics is recorded in Table 2. The figures are measured in g per KWh.

Table 2 Nuclear waste production in 2018 and 2015

	2018	2015
Min	0	0
Median	0.001	2.3×10^{-4}
Max	0.005	0.0038
Mean	8.42×10^{-4}	8.08×10^{-4}
SD	8.21×10^{-4}	9.57×10^{-4}
IQ range	0.0013	9.57×10^{-4}
Range	0.005	0.0038

Katie creates histograms for the nuclear waste data, shown in Figure 1, but forgets to label them. Which histogram represents the 2018 data? Explain your answer.

[2]

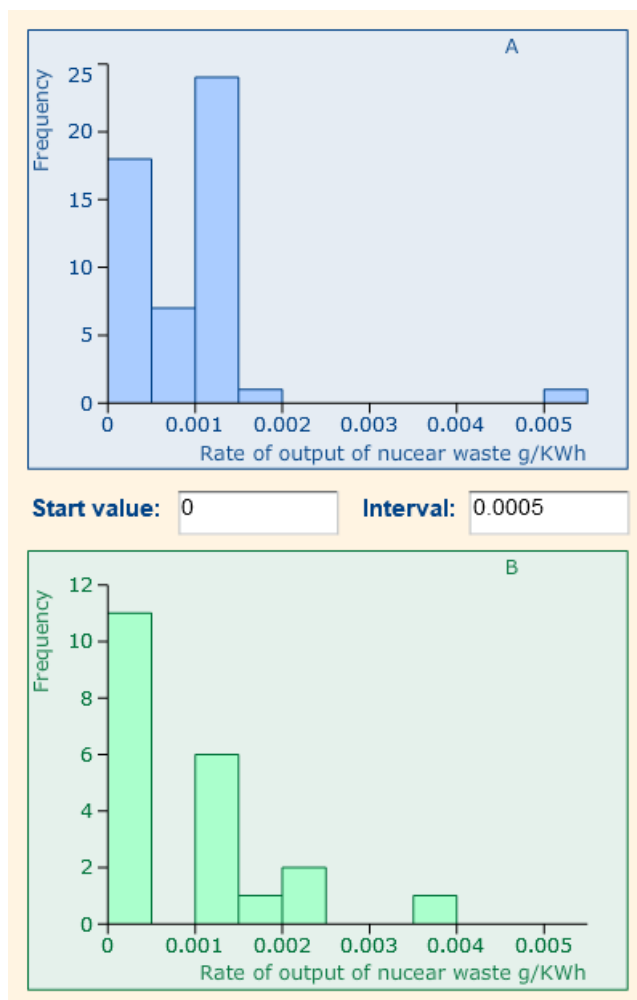


Figure 1

Question 3 – 20 marks

Throughout this question, use algebra to work out your answers. You may use a graph to check that your answers are correct, but it is not sufficient to read your results from a graph.

- (a) A straight line passes through the points $(-6, 2)$ and $(4, 16)$.
- (i) Calculate the gradient of the line. [1]
 - (ii) Find the equation of the line. [2]
 - (iii) Find the x -intercept of the line. [2]
- (b) Does the point $(5, 9)$ lie on the line that you found in part (a)(ii)? Explain your answer. [2]
- (c) Find the coordinates of the point where the lines with the following equations intersect:

$$\begin{aligned} 8x + 5y &= -7, \\ -3x + y &= -\frac{1}{4}. \end{aligned} \quad [3]$$

- (d) A skateboard ramp at a local park can be modelled by the equation

$$y = 0.2x^2 + 0.15x + 0.8 \quad (-5 \leq x \leq 5),$$

where x is the horizontal distance from the centre line of the ramp, and y is the vertical height of the ramp from the ground (both measured in metres). A sketch of the ramp is given in Figure 2.

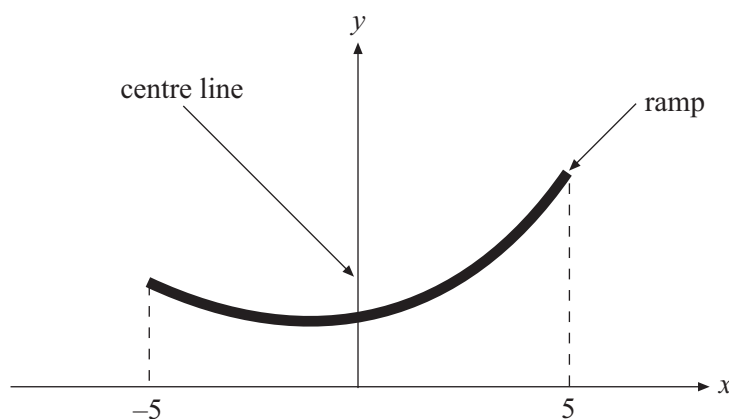


Figure 2

- (i) Find the y -intercept of the parabola
- $$y = 0.2x^2 + 0.15x + 0.8$$
- (i.e. the height of the ramp at its centre line). [1]
- (ii) (1) By substituting $x = -5$ into the equation of the parabola, find the coordinates of the point where the line $x = -5$ meets the parabola. [2]
- (2) Using your answer to part (d)(ii)(1), explain whether a ladder of height 3.5 m is long enough to reach the top of the left-hand side of the ramp. [2]
- (iii) (1) Using algebra, show that the parabola does not have x -intercepts. [4]
- (2) Explain what this means in the context of the situation being modelled. [1]

Question 4 – 17 marks

You should use algebra in all parts of this question, showing your working clearly.

- (a) Solve the following equations, giving your answers as integers or fractions in their simplest form.

(i) $9x - 5 = -3x + 1$ [2]

(ii) $5 - \frac{1}{4}(8 + 12x) = \frac{2}{3}x + 6$ [3]

(iii) $\frac{2x}{x+3} - \frac{2}{x-2} = 2$ [4]

- (b) Solve the equation $3x^2 - 27x + 54 = 0$ by factorisation. [3]

- (c) A student was asked to rearrange the formula

$$-a + \frac{6}{7}b = 3b - 2c \left(\frac{3b}{2} - 3 \right)$$

to make b the subject, where $15 - 21c \neq 0$. The student's **incorrect** attempt is shown below.

$$-a + \frac{6}{7}b = 3b - 2c \left(\frac{3b}{2} - 3 \right)$$

$$-7a + 6b = 3b - 2c \left(\frac{3b}{2} - 3 \right)$$

$$-14a + 12b = 6b - 4c(3b - 6)$$

$$-14a + 12b = 6b - 12bc + 24c$$

$$-14a - 24c = -6b - 12bc$$

$$-14a - 24c = b(-6 - 12c)$$

$$b = \frac{-14a - 24c}{-6 - 12c} = \frac{14a + 24c}{6 + 12c} = \frac{7a + 12c}{3 + 6c}$$

- (i) Write out a correct rearrangement of the formula. [3]

- (ii) Identify and explain, as if directly to the student, two of the three mistakes made by the student. [2]

Question 5 – 20 marks

Throughout this question, take care to explain your reasoning carefully. You should round your answers, where necessary, to two significant figures.

A centre is being renovated to be more accessible to wheelchair users.

A standard manual wheelchair has wheel diameter 0.6 m. The maximum regulation angle that a manual wheelchair ramp can be is 4.8° . The proposal is to make a ramp to a doorway that is 0.2 m high and which meets the ground 2.8 m from the doorway and which is 1 m wide. A side view of the ramp is shown in Figure 3 with the start of the ramp on the ground labelled A , the doorway end labelled C and the point beneath the doorway labelled B . Angle ABC is a right angle.

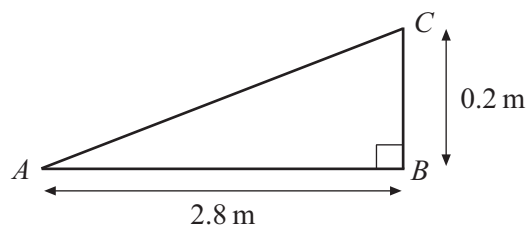


Figure 3

- (a) Find the length AC , i.e. the length of the ramp. [2]
- (b) Find the circumference of the wheel of a standard manual wheelchair. [2]
- (c) How many revolutions will the wheels turn through in covering the length of the ramp? [1]
- (d) Find the angle of elevation ($\angle BAC$) of the proposed ramp and explain whether the ramp is suitable. [3]
- (e) A scale model of the centre, including the proposed ramp, is made. The ramp on the model has width 10 cm.
 - (i) Find the length corresponding to AB on the model. [1]
 - (ii) Is the angle corresponding to BAC on the model greater than, less than or the same as angle BAC ? Explain your answer. [1]
- (f) A wheelchair skate park is to be built at the centre which includes a triangular platform DEF . With all lengths measured in metres, $DE = 3.7$, $DF = 6.2$ and $\angle EDF = 125^\circ$.
 - (i) Find the length EF . [4]
 - (ii) Find the angle DEF . [3]
 - (iii) Find the area of triangle DEF . [3]

Question 6 – 19 marks

In this question, where necessary, you should round answers appropriately.

- (a) A journalist writing an article on electric vehicles observes that the number of electric vehicles registered in Norway between 2014 and 2018 can be modelled by the equation

$$y = 15\,787t + 22\,815 \quad (0 \leq t \leq 4),$$

where y is the total number of electric vehicles registered to date, and t is the number of years since 2014 (that is at the start of 2014, $t = 0$).

- (i) Find the number of electric vehicles registered at the start of 2017 according to this model. [2]
- (ii) Explain in the context of the question the inequality $(0 \leq t \leq 4)$ that follows the equation. [1]
- (iii) Using algebra, calculate the year in which 50 000 electric vehicles were registered. [3]
- (iv) Write down the gradient of the straight line represented by the equation

$$y = 15\,787t + 22\,815.$$

What does this measure in the practical situation being modelled? [2]

- (v) Either using Graphplotter or by hand, sketch the graph of

$$y = 15\,787t + 22\,815,$$

covering the time interval $(0 \leq t \leq 4)$. [1]

- (vi) Explain why the model cannot be extended to model accurately the number of electric vehicles registered in 2010. [2]

- (b) The journalist further observes that the number of electric vehicles registered between 2009 and 2014 can be modelled by the equation

$$y = 404 \times (2.26)^t \quad (0 \leq t \leq 5),$$

where y is the total number of electric vehicles registered in Norway, and t is the number of years since 2009 (that is at the start of 2009, $t = 0$).

- (i) Calculate the number of electric vehicles registered at the start of 2011. [2]
- (ii) Write down the scale factor, and use this to find the percentage increase in the number of electric vehicles registered each year. [2]
- (iii) Use the method shown in Subsection 5.2 of Unit 13 to find the year in which the number of electric vehicles registered exceeds 11 000. [4]

Question 7 – 5 marks

A score out of 5 marks for good mathematical communication over the entire EMA will be recorded under Question 7.