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Oxford Cambridge and RSA

LEVEL 3 CERTIFICATE

Examiners' report

CORE MATHS B (MEI)

H869

For first teaching in 2016

H869/01 Summer 2024 series

Version 1

ocr.org.uk/maths

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. A selection of candidate answers is also provided. 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.

Paper 1 series overview

Most candidates were able to attempt all the questions, giving them the opportunity to show what they could achieve. The commentaries and exemplars provided are from candidates across both H868/01 and H869/01.

The most successful candidates found these items of content the most challenging:

- recognising the shape of a Normal frequency distribution curve (Question 2 (d) (ii))
- recognising a misleading element in a line graph (Question 5 (d))
- drawing to scale an elevation of a 3-D object (Question 6 (a)).

Competency was particularly evident when:

- carrying out financially-related calculations (Question 5)
- carrying out multi-calculation problem-solving activities (Questions 1 (b), 3 (a) and 4 (c) (ii))
- interpreting a simple spreadsheet formula (Question 5 (c))
- calculating or estimating probabilities (Question 6 (c)).

The least successful candidates found these content areas the most challenging:

- using standard form and rounding to a specified degree of accuracy (Questions 1 (a) (i))
- carrying out multi-calculation problem-solving activities (Questions 1 (b), 3 (a) and 4 (c) (ii)).

Overall, there were several questions where some marks could have been lost by truncating or premature rounding. Candidates are instructed to ‘Give your final answers to a degree of accuracy that is appropriate to the context’. Notably, there is an expectation that money (£s) be given correct to two decimal places.

Other instances that may result in mark loss, essentially because of less successful technique as opposed to lack of knowledge and understanding, include:

- incomplete or ambiguous crossing out of work
- incorrect use or omission of units
- digits poorly formed leading to ambiguous working and responses
- misunderstanding what the question is asking for; an example of this is Question 1 (b): ‘Is spamming a financially effective way for *Useful Bookz* to advertise the book?’. To gain the final mark there must be a clear decision shown in answer to the question.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• approached extended problem-solving questions logically and clearly presented their responses in Questions 1 (b), 3 (a) and 4 (c) (ii) • showed appropriate units in final responses in Questions 4 (c) (i), 5 (a) (ii) and 6 (d) (ii) • interpreted a wide range of charts, tables and graphs in Questions 1 (a) (ii), 2 (a), 2 (c), 2 (d), 3 (b), 4 (a), 5 (a), 5 (d) and 6 (d).	• were unable to recall and use formulae relevant to the calculation of the area of a circle in Question 3 (a) • were unable to construct a complete scale drawing of a 3-D object in Question 6 (a) • were unable to estimate the mean of a grouped frequency distribution in Question 3 (d) • did not apply logical processes to reach conclusions in extended problem-solving in Questions 1 (b), 3 (a) and 4 (c) (ii).

Question 1 (a) (i)

1 This question refers to article A in the pre-release material, 'Spam emails'. You can find the article on the Insert accompanying this paper.

(a) In 2018 a total of 102.6 trillion emails were sent and received globally.
Of these, 53.9 trillion were spam emails.

(i) Use the definition of a trillion provided in article A to write 102.6 trillion in standard form.
Give your answer to **2** significant figures. **[2]**

Very few candidates achieved maximum marks for this question. This was due to unsuccessfully rounding to the required level of accuracy with many providing responses to 3 significant figures.

Exemplar 1

1(a)(i)	1.03×10^{14}

In Exemplar 1, the candidate has achieved 1 mark for providing a response in standard form but has not achieved the second mark as the answer has been rounded to 3 significant figures rather than 2.

Question 1 (a) (ii)

(ii) Some people find such large numbers hard to interpret.
It can be helpful to use index numbers.

Fig. 1.1 gives the spam emails in recent years as actual numbers and as index numbers with 2018 as the base year.
The index numbers are given to **1** decimal place.

Complete the table by filling in the empty cell. **[1]**

Candidates generally achieved the mark on this question.

Question 1 (b)

(b) *Useful Bookz* are online book sellers. They are planning to use a spamming company for an advertising campaign to sell their latest vegan recipe book.

The spamming company provides this information:

- Spam filters are able to **reject** spam emails 99.9% of the time.
- About 40% of recipients open any spam emails that have arrived in their inboxes.
- Of those who open the spam emails, about 2% will click on the link to go to the homepage. They **might** make a purchase there.

The spamming company use a specialised list and charge £0.0005 per spam email.

Useful Bookz plan to pay for 100 000 spam emails and they make a profit of £8 for each copy of their vegan recipe book they sell.

Is spamming a financially effective way for *Useful Bookz* to advertise the book?
Justify your decision using calculations.
State any assumptions you make. **[6]**

Candidates generally achieved well on this question. Where marks were lost, these were due to inaccuracies when converting from percentages to decimals.

Question 2 (a)

2 This question refers to article B in the pre-release material, 'Volcanoes'.
You can find the article on the Insert accompanying this paper.

Table 2.1 shows the volume of material ejected by volcanoes and their corresponding VEIs.

Table 2.1

Volume of material ejected E **km**^{3}	**VEI (Volcanic Explosivity Index)**
$E < 10^{-5}$	0
$10^{-5} \leqslant E < 10^{-3}$	1
$10^{-3} \leqslant E < 10^{-2}$	2
$10^{-2} \leqslant E < 10^{-1}$	3
$10^{-1} \leqslant E < 1$	4
$1 \leqslant E < 10^{1}$	5
$10^{1} \leqslant E < 10^{2}$	6
$10^{2} \leqslant E < 10^{3}$	7
$10^{3} \leqslant E$	8

(a) In the year 79, Vesuvius erupted, ejecting $3.3\,\text{km}^3$ of material.

What was the VEI (Volcanic Explosivity Index) of this volcanic eruption? **[1]**

Candidates generally achieved the mark on this question.

Question 2 (b)

(b) An alternative method of calculating the VEI of a volcano makes use of the height, H kilometres, of its plume.

The VEI, V, is given by $V = \dfrac{H+25}{9}$.

This is then rounded to the nearest whole number.

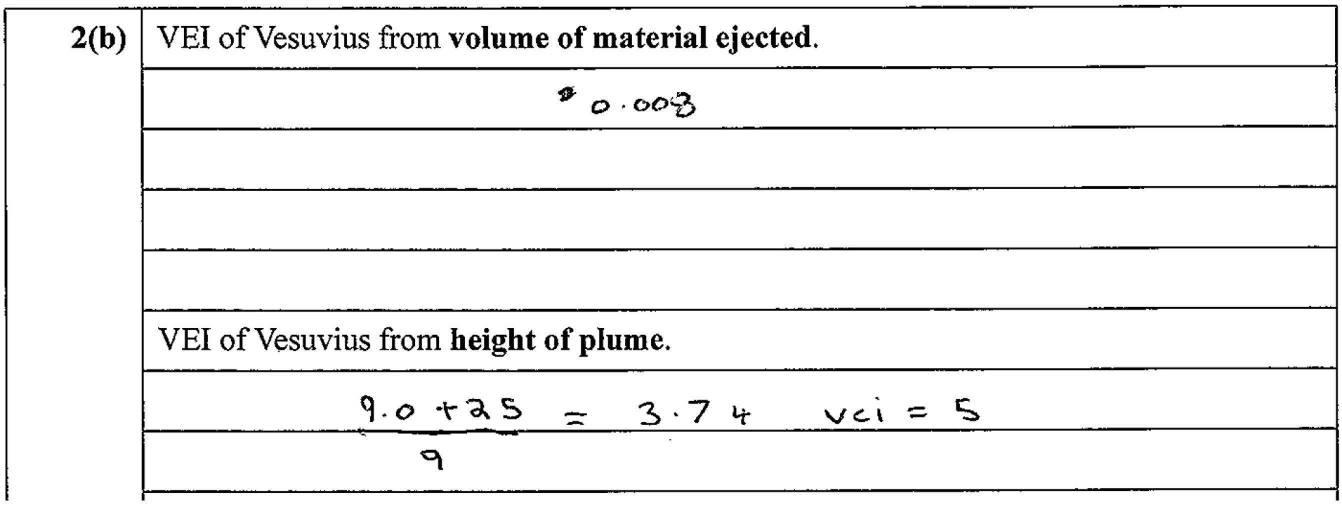
Vesuvius had another eruption in the year 512.
Written accounts at the time suggest that:

- The volume of material ejected was $0.008\,\text{km}^3$.
- The plume rose to a height of 9.0 km.

Use both methods to calculate values for the VEI of this eruption. **[3]**

A significant number of candidates attempted to use the same method of calculation (the formula) twice. Several candidates did not round the result of the formula or rounded it incorrectly.

Exemplar 2



2(b)	VEI of Vesuvius from **volume of material ejected.**
	0.008
	VEI of Vesuvius from **height of plume.**
	$\frac{9.0+25}{9} = 3.74$ vei = 5

In Exemplar 2, the candidate has gained 1 mark for the correct application of the formula but was unable to gain the final mark due to rounding 3.7 to 5.

Question 2 (c)

(c) **Table 2.2** shows the VEIs, determined using both methods, of a representative sample of volcano eruptions.

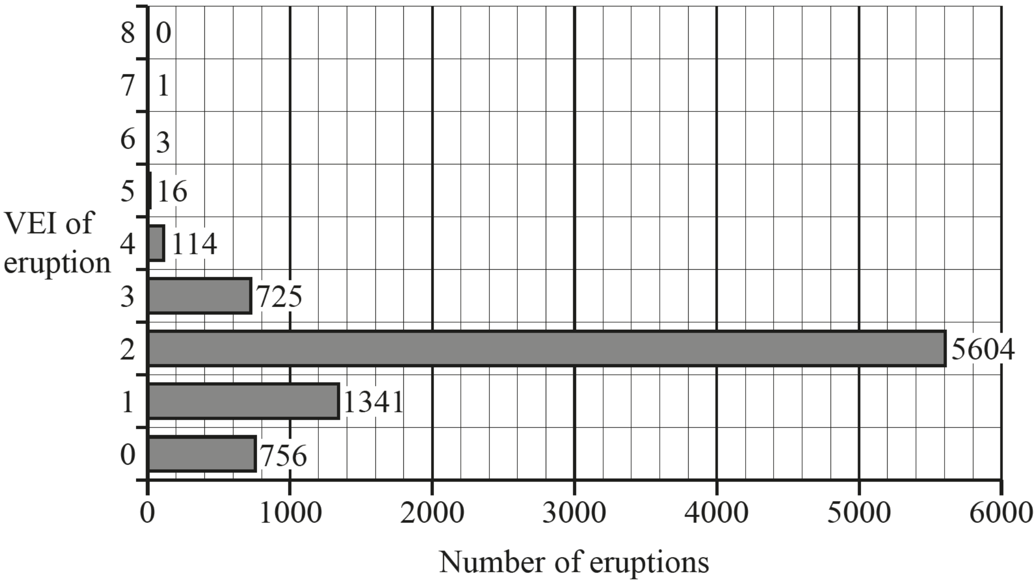
Make **two** comments comparing the values given by the two methods. **[2]**

Comments provided tended to be general rather than specific statements.

Question 2 (d) (i)

(d) The bar chart in **Fig. 2.3** shows the VEIs of known volcanoes over the last 500 years.

Fig. 2.3



(i) Eruptions of VEI 4 or more are considered devastating.
A TV programme states that,
"*A volcano eruption of Volcanic Explosivity Index 4 or more can be expected roughly once every ten years*".

Investigate whether this is supported by the data in the bar chart. **[3]**

While this question generally gained full marks, lost marks were often due to candidates not appreciating that the statement referenced an Index of 4 or more, resulting in calculations based on 114 rather than 134.

Question 2 (d) (ii)

(ii) Give **one** reason, based on the bar chart, for assuming that the distribution of VEIs is **not** Normal? **[1]**

A wide variety of responses were provided.

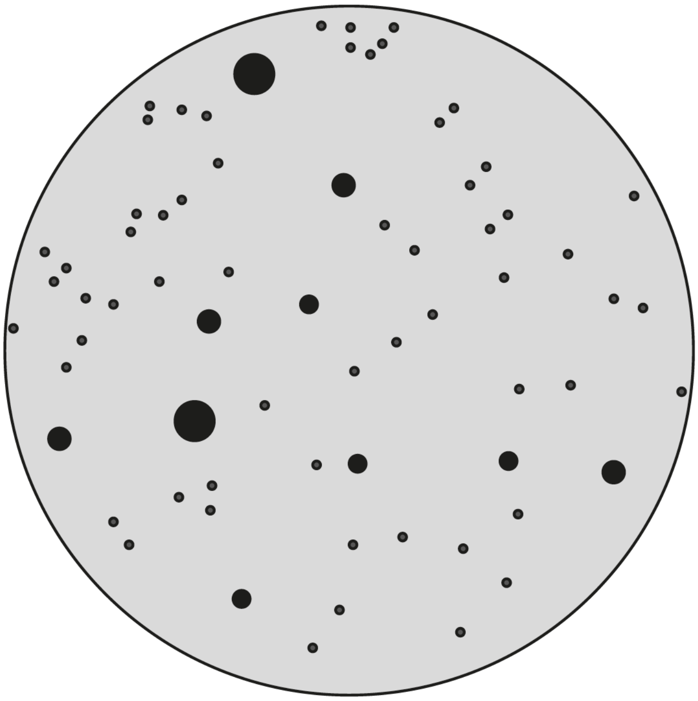
Question 3 (a)

3 This question refers to article C in the pre-release material, 'Water-drops'. You can find the article on the Insert accompanying this paper.

(a) Some students use the stain method to investigate the number and sizes of raindrops. They expose a piece of circular filter paper, covered with a colourless water-soluble dye, to a shower of rain for **10 seconds**.

Fig. 3.1 shows the resulting stains on the filter paper.
The diameter of the filter paper is 9 cm.

Fig. 3.1



Calculate an estimate of the number of raindrops **per minute** that fall on each **square metre** of ground the shower falls on.
Give your answer to an appropriate degree of accuracy.
Show your calculations. **[5]**

While most candidates who attempted this question arrived at an appropriate total number of raindrops on the filter paper, many did not correctly calculate the area of the paper as a basis to convert to a square metre.

Assessment for learning

Candidates should have a clear understanding of the difference between the radius and the diameter of a circle and of their application in formulae relating to circles.

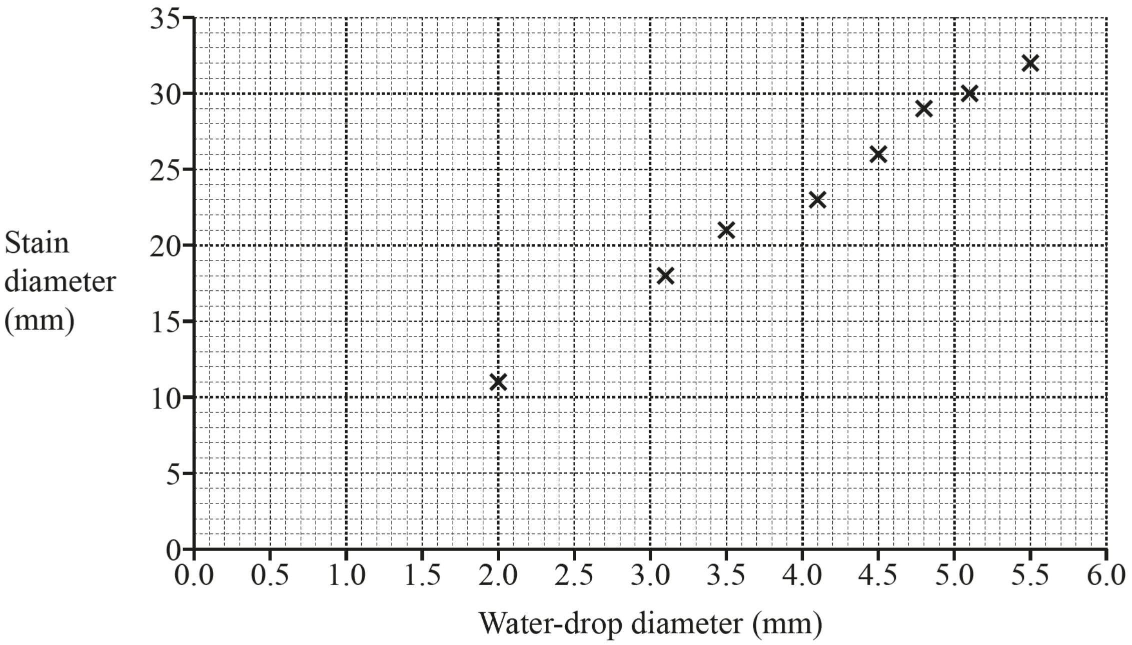
Candidates should be familiar with all the formulae known from GCSE.

Question 3 (b) (i)

(b) **Fig. 3.2** shows the scatter diagram for water-drop diameters and the resulting stain diameters when they fall onto Whatman No.1 filter paper.

(i) Draw a line of best fit on the scatter diagram. **[1]**

3(b)(i) **Fig. 3.2**



Candidates generally achieved well on this question. Where the mark was lost, it tended to be that the candidate had not appreciated the need for a straight line.

Question 3 (b) (ii)

The straight line model represented by your line of best fit can be used to estimate the stain diameter for a given water-drop diameter, and vice versa.

(ii) Use your line of best fit to estimate the diameter of a water-drop which leaves a stain of diameter 15 mm. **[1]**

Candidates generally achieved well on this question.

Question 3 (b) (iii)

(iii) A formula is proposed that gives stain diameter, s mm on Whatman No. 1 filter paper, as a function of water-drop diameter, d mm. The formula is $s = 6d - 1$.

Does the formula fit your answer to part **(b)(ii)**? **[2]**

Many candidates achieved well on this question although some did not understand the link to their response to the previous question.

Question 3 (c)

(c) The formula $d = \sqrt[3]{\frac{6M}{\pi}}$ gives the diameter d mm of a spherical water-drop mass M mg.

Without using a calculator, estimate the value of d in $d = \sqrt[3]{\frac{6 \times 3.8}{\pi}}$.

Show all the approximations that you make. **[2]**

Candidates were less successful on this question due to misreading the question and not appreciating that estimations were required and that a calculator should not be used.

Question 3 (d)

(d) **Table 3.3** shows the distribution of raindrop diameters in a heavy shower.

Table 3.3

Diameter d mm	**Frequency**	**Mid-interval**	**Frequency × Mid-interval**
$0.5 \leqslant d < 1.0$	61	0.75	45.75
$1.0 \leqslant d < 1.5$	109	1.25	136.25
$1.5 \leqslant d < 2.0$	116	1.75	203.00
$2.0 \leqslant d < 2.5$	30	2.25	67.50
$2.5 \leqslant d < 3.0$	3	2.75	8.25

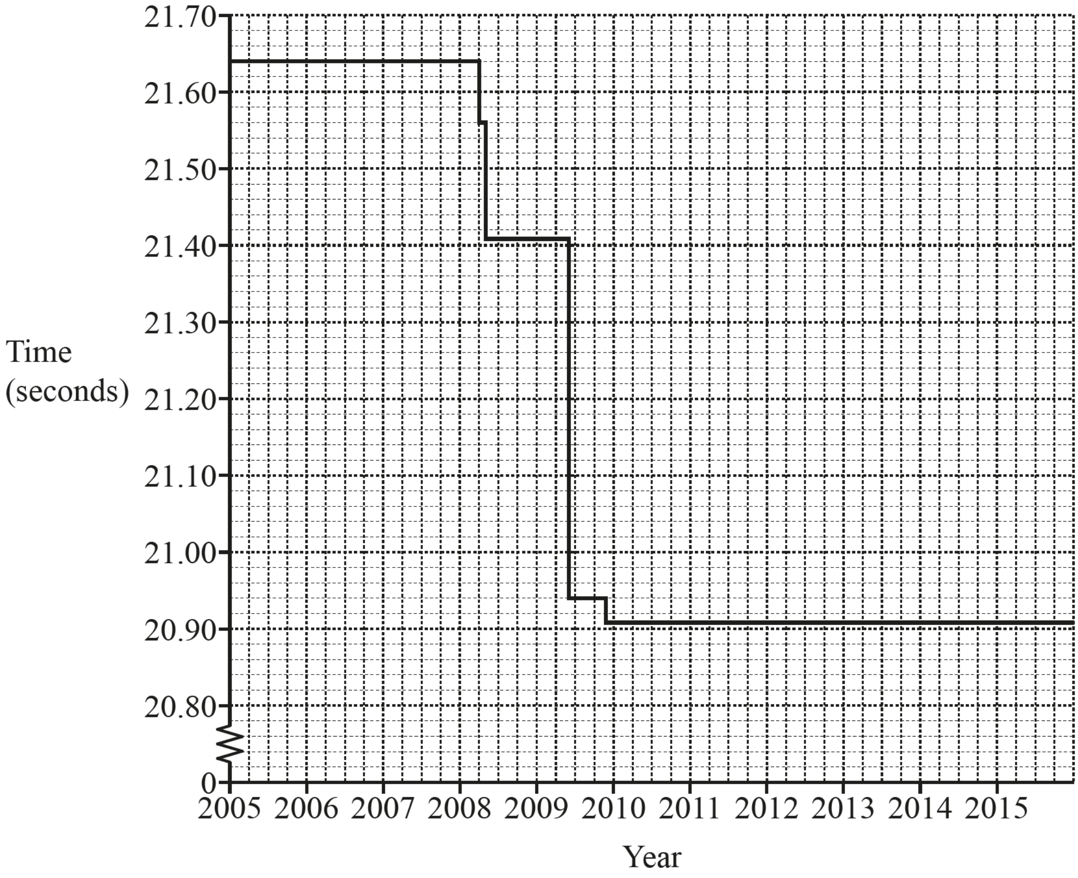
Calculate an estimate of the mean raindrop diameter.
Give your answer correct to the nearest 0.1 mm. **[3]**

While many candidates successfully achieved maximum marks for this question, a number demonstrated a lack of understanding of methods of calculating the mean from a grouped frequency distribution or interpreted the word 'estimate' to mean that all figures were rounded in calculations.

Question 4 (a) (i)

4 The international 50 m swimming race is one length of a 50 m long pool.

(a) The step graph shows the World record times for the 50 m men's race from 2005 to 2015.



(i) What was the World record time in 2005? **[1]**

This question was correctly answered by most candidates.

Question 4 (a) (ii)

(ii) In which year did the World record time fall below 21.45 seconds? **[1]**

This question was correctly answered by most candidates.

Question 4 (a) (iii)

(iii) Explain why the lines on the graph are either horizontal or vertical. **[2]**

Responses to this question didn't address specifically the meaning of the horizontal and vertical lines or demonstrated a lack of understanding of the terms.

Question 4 (a) (iv)

(iv) Make **one** detailed observation about how the World record times changed from 2005 to 2015. **[1]**

This question was answered well by most candidates with clear statements giving the specific time by which the world record had improved or the number of records which had been created.

Question 4 (b)

(b) Below is a screenshot from a spreadsheet. Columns B and C are in number format, set to **2** decimal places.

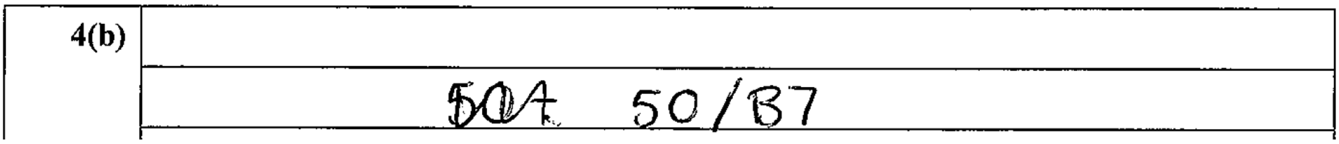
Column B shows the ten best women's times in the 50 m swimming race at the 2020 Olympics.
These times are used to calculate the average speed of each swimmer, shown in column C.

	A	B	C
1	**Rank order**	**Time (s)**	**Speed ($m\,s^{-1}$)**
2	1	24.02	2.08
3	2	24.12	2.07
4	3	24.15	2.07
5	4	24.26	2.06
6	5	24.31	2.06
7	6	24.36	2.05
8	7	24.37	2.05
9	8	24.41	2.05
10	9	24.52	2.04
11	10	24.55	2.04

Write down the formula which should be in cell C7. **[2]**

This question was generally well answered. Marks were lost when candidates did not start the formula with '=' as in the exemplar below.

Exemplar 3



Exemplar 3 shows a response where the candidate did not start the formula with '='.

OCR support

Practical spreadsheet activities to develop understanding of simple formulae can be downloaded from Teach Cambridge:
[Notes on the pre-release data set]

Question 4 (c) (i)

(c) Time measurements and distances in international races must be accurate within certain limits.

- Times must be accurate to ± 0.005 seconds.
- The length L, in metres, of a 50 m length pool must be such that $50 \leqslant L \leqslant 50.010$.

(i) Would a pool judged to be 5 mm longer than 50 m be acceptable?
Show how you decided. **[2]**

Responses to this question generally achieved maximum marks. Where marks were lost, this was due to incorrect conversion between units.

Question 4 (c) (ii)

(ii) Two women in an international 50 m race are given the same time but video evidence shows that one of them finished 0.8 cm ahead of the other.

Explain how this happened.
State clearly any estimations you make in your calculations. **[5]**

This question was challenging for candidates. Some referenced the possibility of the pool being different lengths and some referenced the physical characteristics of the two swimmers (e.g. length of nails or length of arms). Many candidates were unsuccessful in understanding the requirements to estimate the time it would take to swim 0.8 cm and then apply this to the allowable level of accuracy in timings.

Question 5 (a) (i)

5 In this question, compound interest is charged, and the rate quoted is applied daily.

Amit and Kai are discussing short term loans.
Although daily interest rates look small, the total amount owed increases rapidly.

(a) To illustrate this, Kai builds a spreadsheet showing the total amount owed on £100 borrowed for various times in days and daily rates of compound interest. This is shown in **Fig. 5.1**.

For example, borrowing £100 for 21 days at a daily compound interest rate of 6% results in a total amount owed of £339.96.

Fig. 5.1

	Daily compound interest rate (%)						
Days	**0.1**	**0.4**	**0.8**	**1.2**	**3.0**	**5.0**	**6.0**
1	100.10	100.40	100.80	101.20	103.00	105.00	106.00
2	100.20	100.80	101.61	102.41	106.09	110.25	112.36
3	100.30	101.20	102.42	103.64	109.27	115.76	119.10
4	100.40	101.61	103.24	104.89	112.55	121.55	126.25
5	100.50	102.02	104.06	106.15	115.93	127.63	133.82
6	100.60	102.42	104.90	107.42	119.41	134.01	141.85
7	100.70	102.83	105.74	108.71	122.99	140.71	150.36
8	100.80	103.25	106.58	110.01	126.68	147.75	159.38
9	100.90	103.66	107.43	111.33	130.48	155.13	168.95
10	101.00	104.07	108.29	112.67	134.39	162.89	179.08
11	101.11	104.49	109.16	114.02	138.42	171.03	189.83
12	101.21	104.91	110.03	115.39	142.58	179.59	201.22
13	101.31	105.33	110.91	116.77	146.85	188.56	213.29
14	101.41	105.75	111.80	118.18	151.26	197.99	226.09
15	101.51	106.17	112.70	119.59	155.80	207.89	239.66
16	101.61	106.60	113.60	121.03	160.47	218.29	254.04
17	101.71	107.02	114.51	122.48	165.28	229.20	269.28
18	101.82	107.45	115.42	123.95	170.24	240.66	285.43
19	101.92	107.88	116.35	125.44	175.35	252.70	302.56
20	102.02	108.31	117.28	126.94	180.61	265.33	320.71
21	102.12	108.74	118.21	128.47	186.03	278.60	339.96

(i) A loan of £100 is borrowed at a daily rate of 3%.

After how many days will the total amount owed on it exceed £150? **[1]**

Most candidates achieved the mark for this question.

Question 5 (a) (ii)

(ii) The total amount owed is proportional to the amount borrowed.

Find the total amount owed on **£300** borrowed for 14 days at a daily interest rate of 0.8%. **[2]**

This question was generally well answered. Where marks were lost, it was either due to a misunderstanding of appreciating that the total amount owing was required, or unsuccessfully showing the total amount in correct currency format.

Question 5 (b) (i)

(b) Kai finds an approximate rule to show how quickly the total amount owed increases. It gives the number of days needed for the total amount owed to be double the original loan.

Divide 72 by the daily interest rate, % per day.
This figure, if not a whole number, is rounded up to the next whole number.

(i) Use the rule to calculate how many days the total amount owed would take to first become at least double the total amount initially borrowed at a daily interest rate of 6%. **[1]**

While this question was generally well answered, some candidates experienced challenges in translating the worded formula into numbers.

Question 5 (b) (ii)

(ii) How does your answer to part **(b)(i)** compare to the one given by Kai's spreadsheet (**Fig. 5.1**)? **[1]**

This question was generally well answered by most candidates.

Question 5 (c)

(c) Amit is not sure of Kai's figures and asks to see the spreadsheet coding. Part of this is shown in **Fig. 5.2**.

Fig. 5.2

	A	B	C
1			
2	**Days**	**0.1**	**0.4**
3	**1**	=100*(1+(B$2/100))^$A3	=100*(1+(C$2/100))^$A3
4	**=A3+1**	=100*(1+(B$2/100))^$A4	=100*(1+(C$2/100))^$A4
5	**=A4+1**	=100*(1+(B$2/100))^$A5	=100*(1+(C$2/100))^$A5

Write down the algebraic formula for the total amount owed, £T

- when borrowing £100
- for n days
- at a daily interest rate of r%.

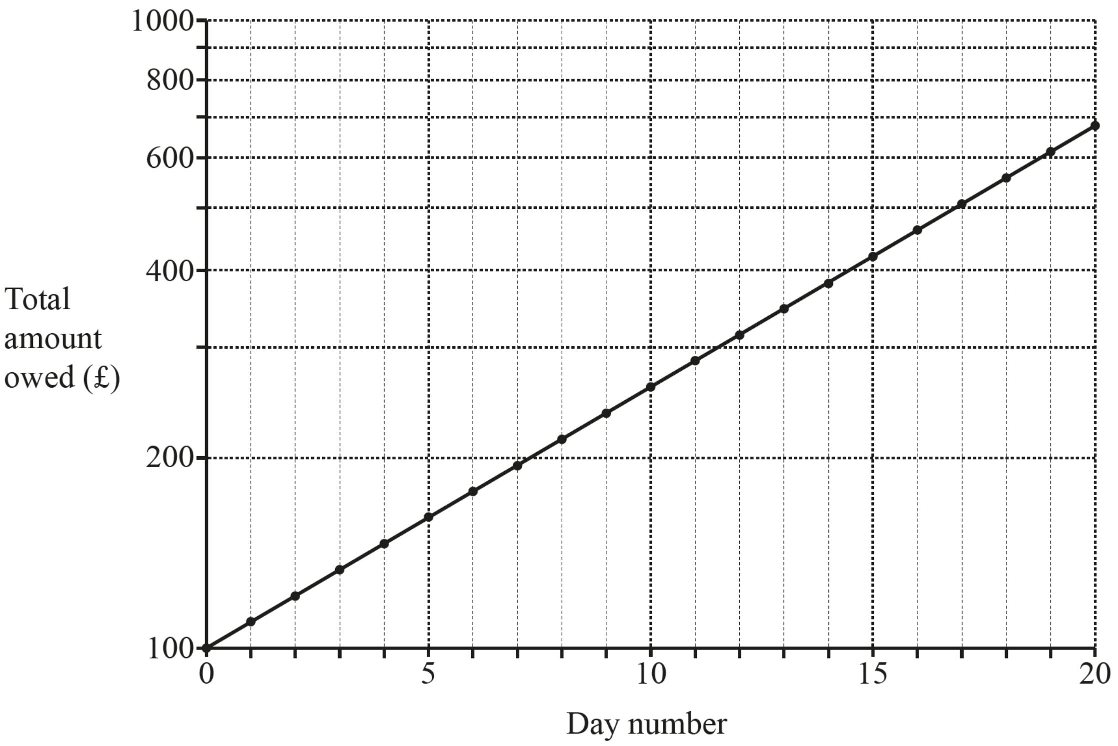
You may find the spreadsheet formulae in **Fig. 5.2** useful. **[2]**

Many candidates found the reference to the spreadsheet formula confusing with responses including spreadsheet notation. Many did not include the subject of the formula (T) or make sure that brackets were matching.

Question 5 (d)

(d) **Fig. 5.3** shows the graph Kai correctly obtained when plotting total amount owed against day number for a 10% per day interest rate.
The same general shape was found for all the daily percentage interest rates.

Fig. 5.3



Amit concludes that:
"The straight line shows that the increase in the total amount owed is the same each week."

Explain the error Amit has made. **[1]**

While a significant number of responses correctly identified the use of a logarithmic scale on the *y*-axis, many provided responses relating to the *x*-axis being in days rather than weeks.

Question 5 (e)

(e) Amit agrees with all Kai's calculations.
Daily compound interest charges are set at a **maximum** of 0.8% by law.
Fig. 5.4 shows the total amount owed for various daily compound interest rates for £100 borrowed, calculated by Kai.

Fig. 5.4

	Daily compound interest rate (%)					
Days	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**	**1.2**
1	100.20	100.40	100.60	100.80	101.00	101.20
2	100.40	100.80	101.20	101.61	102.01	102.41
3	100.60	101.20	101.81	102.42	103.03	103.64
4	100.80	101.61	102.42	103.24	104.06	104.89
5	101.00	102.02	103.04	104.06	105.10	106.15
6	101.21	102.42	103.65	104.90	106.15	107.42
7	101.41	102.83	104.28	105.74	107.21	108.71
8	101.61	103.25	104.90	106.58	108.29	110.01
9	101.81	103.66	105.53	107.43	109.37	111.33
10	102.02	104.07	106.16	108.29	110.46	112.67

Brisk Bread offers Amit a loan of £250 **for a week** with a total of £15 interest charged.

Use the table to decide if this is a legal loan.
Show your working. **[3]**

A variety of methods were employed in the responses provided. Marks were lost by some candidates for either providing no decision or an incorrect decision despite correct calculations being shown.

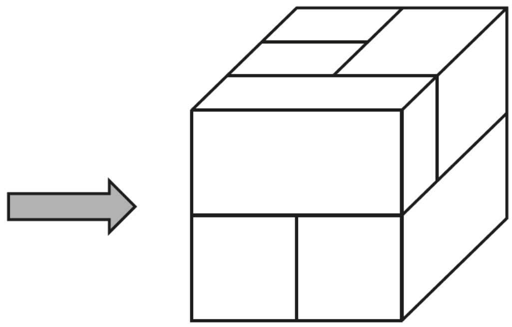
Question 6 (a)

6 This question refers to article D in the pre-release material, 'CubeSats'. You can find the article on the Insert accompanying this paper.

(a) **Fig. 6.1** shows a drawing of a CubeSat package consisting of two 1U, two 2U and two 3U CubeSats, six CubeSats in total.
Like those shown in **Fig. D.2** on the Insert, all six CubeSats are cuboids.

Draw to scale the side view of the CubeSat package in the direction of the arrow. **[2]**

Fig. 6.1



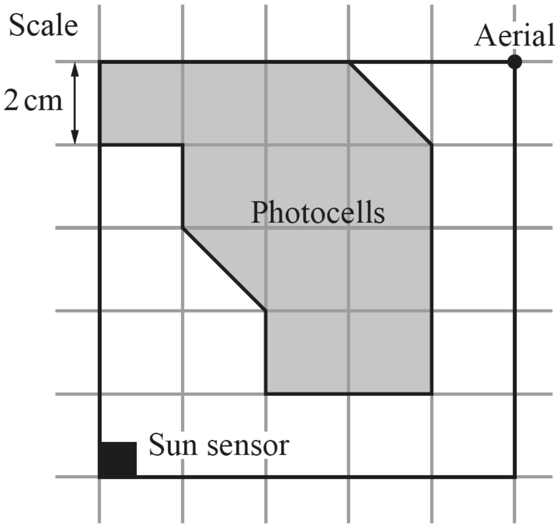
Many of the responses attracted full marks for this question. Only a few candidates were unable to visualise the correct internal structure of the package.

Question 6 (b)

(b) A university is making a 1U CubeSat to investigate how bacteria behave in space. **Fig. 6.2** shows a scale drawing, on a square grid, of one of the three identical faces which have photocells on them. The photocells are shown in grey.

When in orbit the CubeSat will be positioned so as to catch as much sunlight as possible.

Fig. 6.2



- To run the experiments and transmit data back to Earth the CubeSat will need 2.5 watts of electrical power in total.
- When the CubeSat is in position, each square centimetre of photocell will generate 0.019 watts of electrical power.

Does the planned CubeSat have sufficient electrical power in total?
Show your working. **[3]**

Although the majority of candidates attempted this question, many were not given the maximum available marks due to errors in calculating the total area of the photocells.

Question 6 (c) (i)

(c) (i) The number of CubeSats launched between 2003 and 2014 was 178.
Of these, only 108 completed their mission.

Use this information to estimate the probability that a randomly chosen CubeSat launched between 2003 and 2014 successfully completed its mission. **[1]**

Although this question was generally answered well, marks were lost where candidates calculated the failure rate rather than the required success rate.

Question 6 (c) (ii)

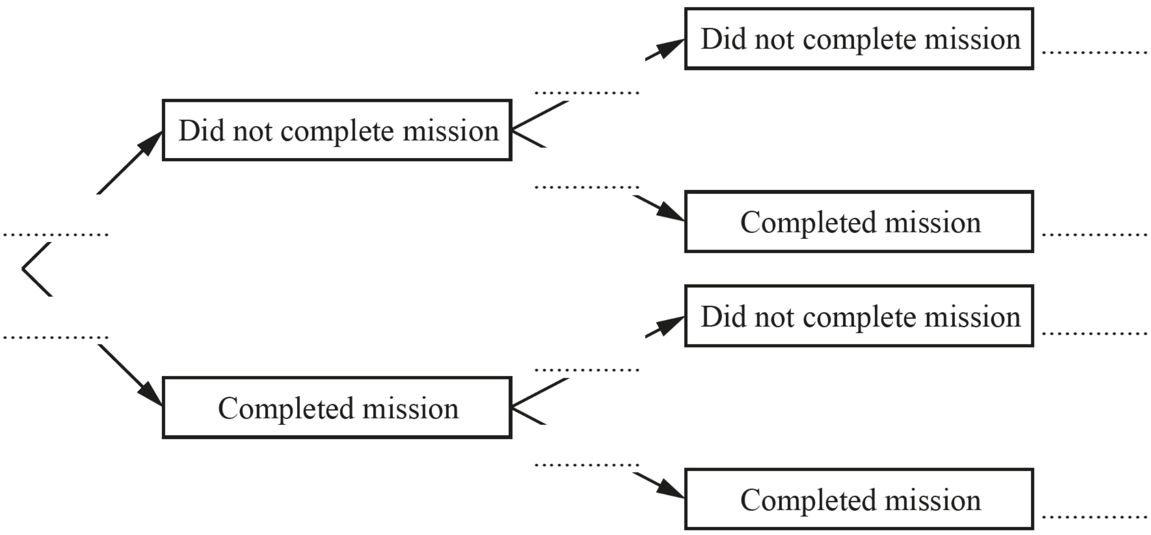
(ii) Since 2015 the reliability of CubeSats has increased.
The probability of one completing a mission once in orbit is now 0.80.

It is common to have several CubeSats working together.
Two CubeSats are working together. The mission needs both to work.

Complete the tree diagram in **Fig. 6.3**. **[2]**

6(c)(ii)

Fig. 6.3



While many correct responses were seen, several candidates did not fully complete all three columns of the tree diagram or gave an incorrect response throughout the final column.

Question 6 (c) (iii)

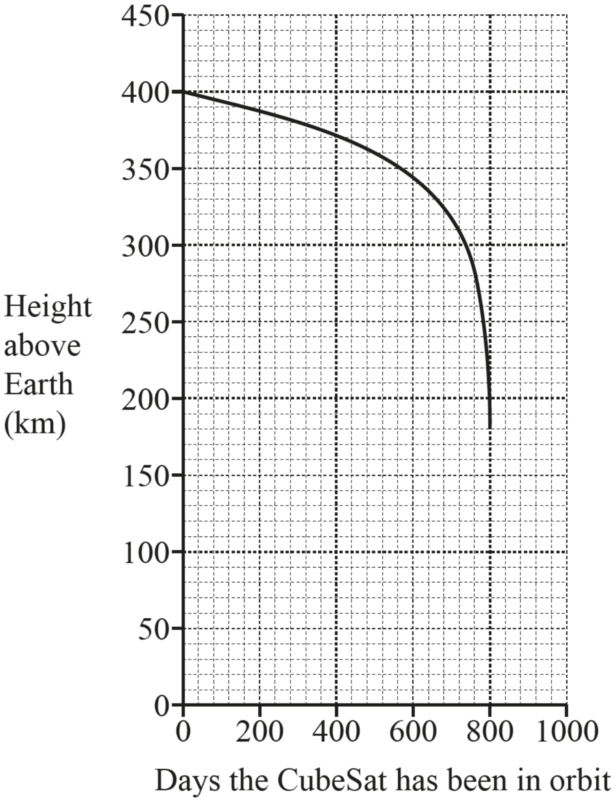
(iii) Work out the probability of **both** CubeSats completing the mission. **[1]**

Many correct responses were seen with some candidates opting to calculate the outcome based on the information provided in the question rather than from the completion of the probability tree.

Question 6 (d) (i)

(d) Unless they have some form of propulsion, all CubeSats will eventually fall to Earth and burn up in the Earth's atmosphere.

The graph shows how the height above the Earth of a particular 1U CubeSat changes with time.



(i) What was the CubeSat's height 400 days after being put into orbit? **[1]**

Many candidates who attempted this question achieved the available mark.

Question 6 (d) (ii)

(ii) Estimate the rate that the CubeSat is falling to Earth when it has been in orbit for 720 days.
Give the units of your answer. **[3]**

While some candidates correctly found the gradient by use of a tangent, many did not recognise that this process should be used.

Question 6 (d) (iii)

(iii) Calculations are carried out to estimate the expected lifetimes of 3U CubeSats of various masses and initial orbital heights.

The table below shows the lifetimes (in days) of 3U CubeSats of various masses and initial orbit heights to **2** significant figures.

	Height launched into orbit (km)			
Mass of 3U CubeSat (kg)	**200**	**250**	**400**	**500**
5	1.9	16	1000	11 000
4	1.6	13	820	8 700
3	1.2	10	610	6 500
2	0.8	6.6	410	4 400
1	0.4	3.4	210	2 200

A student stated that the lifetime for a particular mass of CubeSat is directly proportional to its initial orbit height.

Use the data in the table to investigate whether this is **true** or **false**.
Support your answer with a reason. **[1]**

A significant number of candidates incorrectly identified the data as supporting the statement. Of those who correctly identified that the statement was false, many either did not provide any supporting evidence or provided generalised responses rather than specific examples.

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