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OCR
Oxford Cambridge and RSA

GCSE (9–1)

Exemplar Candidate Work

MATHEMATICS

J560
For first teaching in 2015

J560/06 Summer 2019 examination series

Version 1

Contents

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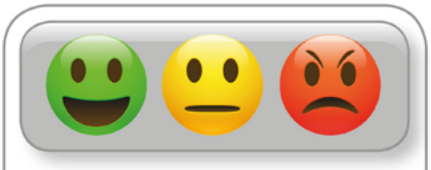

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Introduction

These exemplar answers have been chosen from the summer 2019 examination series.

OCR is open to a wide variety of approaches and all answers are considered on their merits. These exemplars, therefore, should not be seen as the only way to answer questions but they do illustrate how the mark scheme has been applied.

Please always refer to the specification https://www.ocr.org.uk/Images/168982-specification-gcse-mathematics-j560.pdf for full details of the assessment for this qualification. These exemplar answers should also be read in conjunction with the sample assessment materials and the June 2019 Examiners' report or Report to Centres available from Interchange https://interchange.ocr.org.uk/.

The question paper, mark scheme and any resource booklet(s) will be available on the OCR website from summer 2020. Until then, they are available on OCR Interchange (school exams officers will have a login for this and are able to set up teachers with specific logins – see the following link for further information http://www.ocr.org.uk/administration/support-and-tools/interchange/managing-user-accounts/).

It is important to note that approaches to question setting and marking will remain consistent. At the same time OCR reviews all its qualifications annually and may make small adjustments to improve the performance of its assessments. We will let you know of any substantive changes.

Question 1 (a)

1 A grain of salt weighs 6.48×10^{-5} kg on average.
A packet contains 0.35 kg of salt.

(a) Use this information to calculate the number of grains of salt in the packet.

(a) ..... [2]

Exemplar 1 2 marks

$0.35 \div (6.48 \times 10^5)$

=

(a) 5401 [2]

Examiner commentary

The weight of the packet is divided by the average weight of a grain to obtain the correct answer and is given full marks.

The candidate has almost certainly used the standard form facility on their calculator. This was more typical of high ability candidates.

Exemplar 2 1 mark

$6.48 \times 10^{-5} = 0.0000648$ kg

$\frac{0.35 \text{ kg}}{0.0000648 \text{ kg}} = 5401.234567901$

(a) 5401.2 [2]

Examiner commentary

M1 is given for either the correct conversion from standard form into ordinary form, for the correct operation of figures 35 ÷ figures 648 or for an answer with figures 540[1…]. The exemplar shows all three ways of scoring the M1.

For 2 marks, the answer needed to be 5400, 5401 or 5402. A decimal answer is not appropriate in this context.

Question 1 (b)

(b) Explain why your answer to part **(a)** is unlikely to be the actual number of grains of salt in the packet.

.....

.....

..... [1]

Exemplar 1 1 mark

because it is likely there is a variation in the weight of the salt grains

..... [1]

Examiner commentary

The vast majority of candidates gave an acceptable explanation, usually referencing that the weight of the grains of salt will vary or that the calculation was based on an average. Following a decimal answer in part (a), comments that this was not possible were accepted.

Exemplar 2 0 marks

As each grain of salt has not much a low weight, it will be difficult to tell is there is a change of number of grains

..... [1]

Examiner commentary

Comments suggesting that the grains were too small to count were not accepted.

Question 2

2 Tom researches the weights of plant seeds.

- One poppy seed weighs 3×10^{-4} grams.
- 250 pumpkin seeds weigh 21 grams.
- One sesame seed weighs 3.64×10^{-6} kilograms.

Write the three types of seed in order according to the weight of one seed.
Write the lightest type of seed first.
You must show how you decide.

..... , ... , ...[4]
lightest

Exemplar 1

4 marks

one poppy seed = 3×10^{-4} grams
pumpkin seed = $\frac{21}{250}$ g = 0·084 grams = 8.4×10^{-2}
one sesame seed = 3.64×10^{-3} g

poppy , sesame , pumpkin [4]
lightest

Examiner commentary

The weight of each type of seed is found in grams and in standard form. The three values are correct and in a comparable form, and are ordered correctly. The exemplar, therefore, is given full marks.

Candidates who only obtained the weight of a pumpkin seed in grams in standard form scored B2, as this is in comparable form to the given weight of a poppy seed.

High ability candidates were the most likely to work in standard form.

Exemplar 2

4 marks

Poppy = 0.0003 grams

~~Sesame~~ 21 ÷ 250 = 0.084 grams

Sesame = 0.00000364 kg ×1000

= 0.00364g

Poppy , Sesame , Pumpkin [4]

lightest

Examiner commentary

The weight for each type of seed is found in grams as a decimal. The three values are correct and in a comparable form, and are ordered correctly. The exemplar, therefore, is given full marks.

Candidates who only obtained the weight of a pumpkin seed in grams in ordinary form scored B1, as this is not in comparable form to the given weights of a poppy or sesame seed.

Exemplar 3

2 marks

0.0003g : one poppy

0.084g : one pumpkin

3.64×10^{-9}g : one sesame seed

$\frac{21}{250} = 0.084$

0.00000364kg : 1 sesame seed.

÷1000 = 0.000000000364g.

~~Sesame~~ , ~~Poppy~~ , ~~Pumpkin~~ [4]

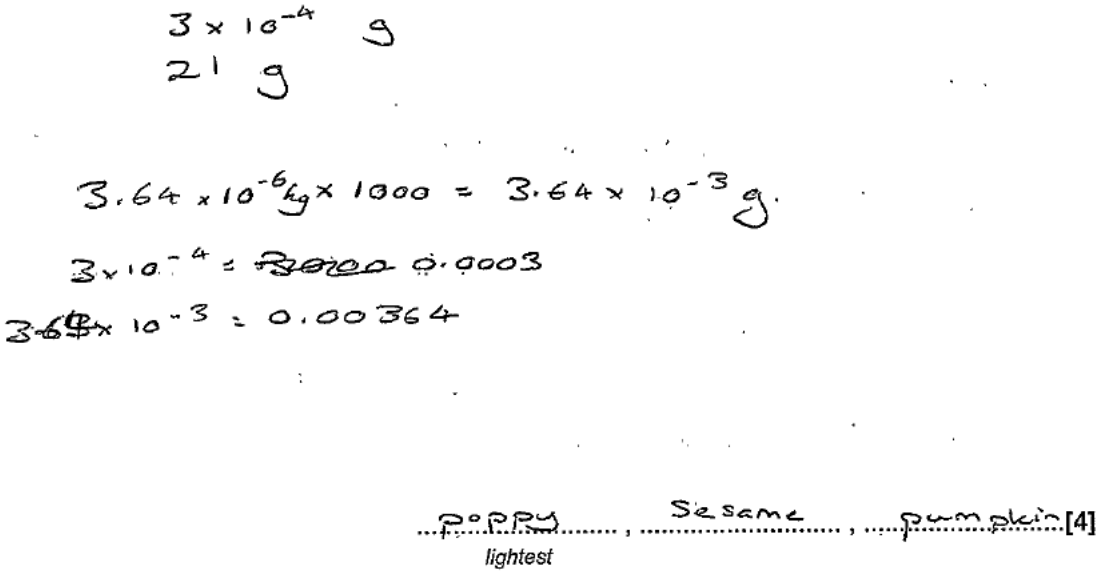
lightest

Examiner commentary

The weights of a poppy seed and a pumpkin seed are found in grams as decimals. The conversion of a sesame seed from kg to g is incorrect and was a very common error. The exemplar is given B2 for having poppy and pumpkin correct and in comparable form.

Exemplar 4

1 mark



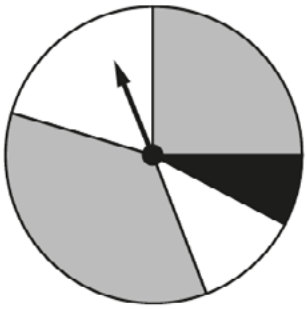
Examiner commentary

Although the answer line is correct, the candidate has not presented the weight of a pumpkin seed in a comparable form. Instead, the script scores B1 only, for either poppy and sesame in grams in standard form or poppy and sesame in grams as ordinary numbers.

Pumpkin needed to be one of the two seeds in comparable form for an award of B2.

Question 3 (a)

3 **(a)** This spinner has two grey sections, two white sections and one black section.



Vlad says

The probability of the spinner landing on black is $\frac{1}{5}$.

Explain why Vlad is not correct.

..... [1]

Exemplar 1 — 1 mark

because black does not occupy 1/5 of the area of the spinner ~~which mostly shows~~

..... [1]

Examiner commentary

Most candidates did not appreciate the detail needed in the explanation. Valid explanations, such as in this exemplar, usually referred to the sector's angle or area.

Exemplar 2 — 0 marks

The black section is a different ~~si~~ size to other sections.

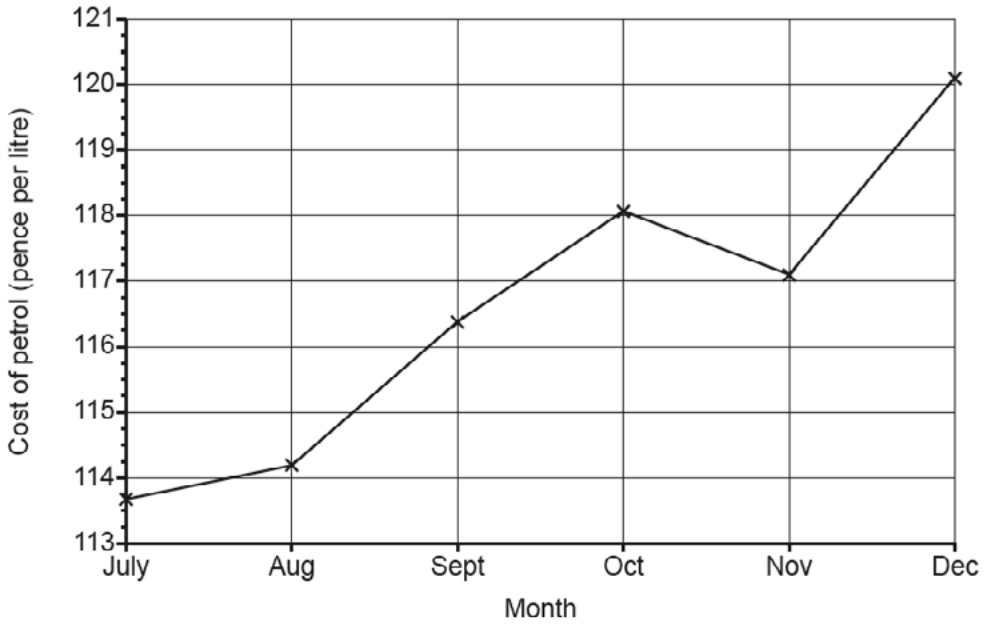
..... [1]

Examiner commentary

Responses only reflecting that the sectors were of different size or that the black sector was the smallest were insufficient.

Question 3 (b)

(b) The graph shows the cost of a litre of petrol for the last six months of 2017.



Explain why this graph is misleading.

.....

.....

..... [1]

Exemplar 1

1 mark

cost of petrol does not start at 0 meaning changes look more dramatic

..... [1]

Examiner commentary

The candidate identifies a reason why the graph appears to show a "dramatic" increase and so scores the mark. Only stating that the graph shows a "dramatic" increase would be insufficient.

Question 4

4 Sophie is organising a raffle.

- Each raffle ticket costs 50p.
- She sells 400 tickets.
- The probability that a ticket, chosen at random, wins a prize is 0.1.
- Each winning ticket receives a prize worth £3.

Sophie says

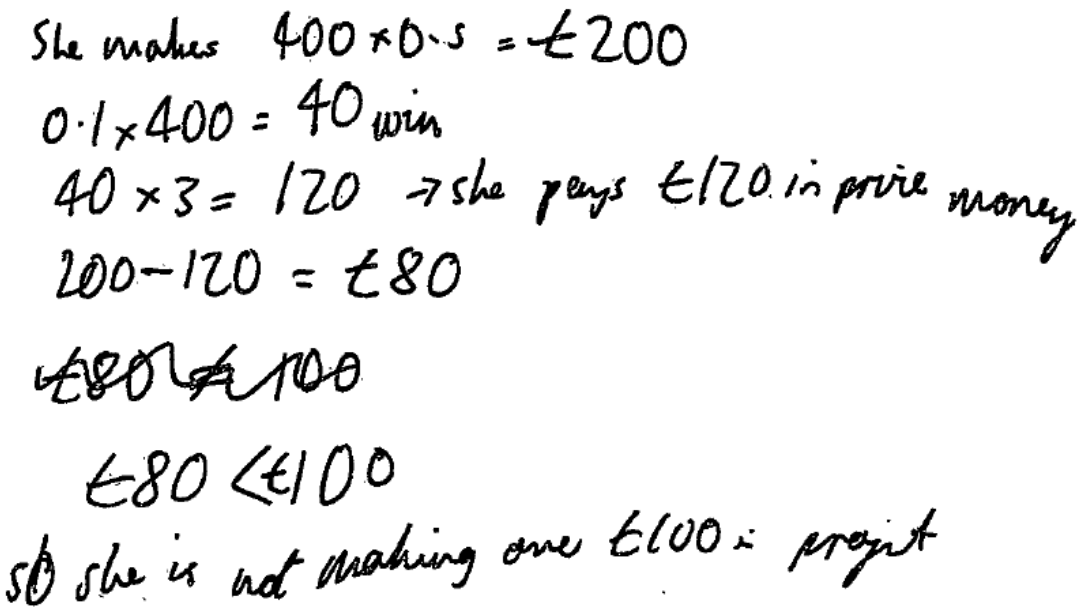
I expect the raffle to make over £100 profit.

Show that Sophie is wrong.

.....

..... [4]

Exemplar 1 4 marks



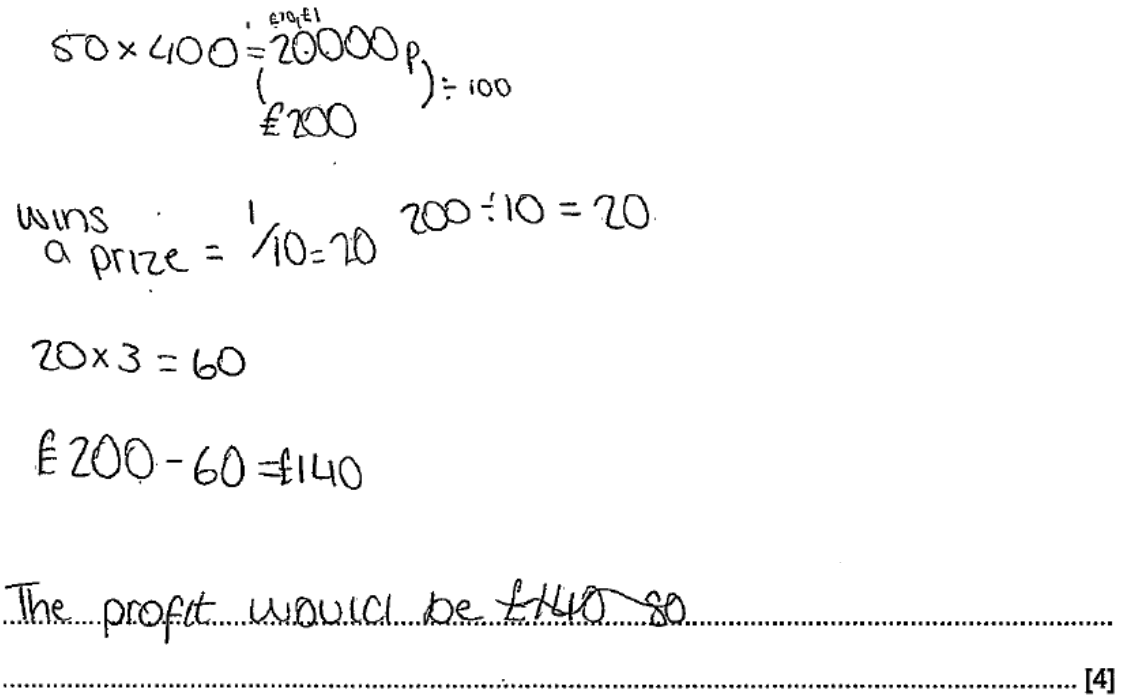
Examiner commentary

The vast majority of candidates scored full marks but the work was not always clearly presented. This exemplar shows excellent presentation. There is multi-strand processing involved and the candidate's addition of a few words are helpful to both themselves and to the examiner.

Finding the income of £200 scores B1. Obtaining 40 winning tickets scores M1, which becomes M2 on finding £120 in prize money. The profit of £80 is then accompanied by an appropriate conclusion and so full marks are given.

Exemplar 2

1 mark

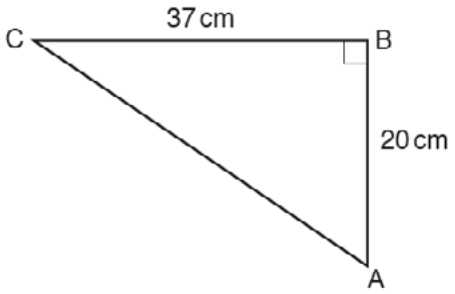


Examiner commentary

Finding the income of £200 scores B1. However, that answer of 200 is then used as the number of tickets sold instead of the 400 stated in the question.

Question 5

5 ABC is a right-angled triangle.
AB = 20 cm and BC = 37 cm.



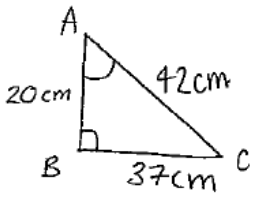
Not to scale

Calculate angle BAC.

..... ° **[3]**

Exemplar 1

2 marks



$20^2 + 37^2 = AC^2 = 42.1$

$\frac{\sin 90}{42} = \frac{\sin BAC}{37}$

62° ..... ° **[3]**

$\sin^{-1}\left(37 \times \left(\frac{\sin 90}{42}\right)\right) = 61.75 = 62°$

Examiner commentary

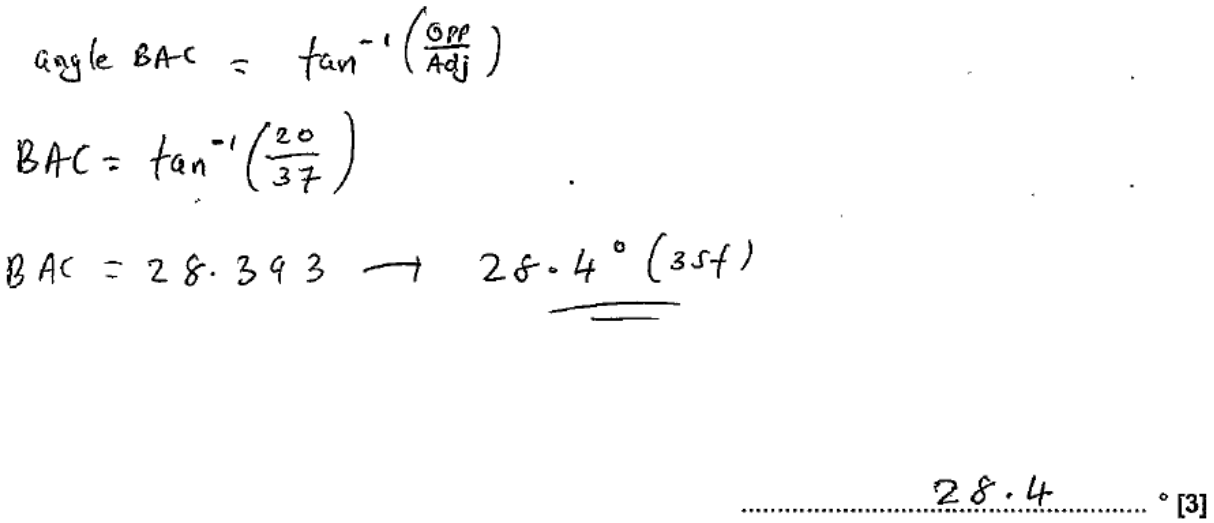
It was quite common for candidates to not use the most efficient method of tan inverse. Instead, Pythagoras was used to find the hypotenuse and then sin inverse. Premature rounding of the hypotenuse sometimes caused an accuracy error in the final answer. The exemplar, therefore, scores M2 only.

An answer of 62° was given full marks if it followed correct working, such as $\tan^{-1}\left(\frac{37}{20}\right)$ or interim answers by the above method that rounded to 61.6°.

All the marks are for trig. work. Finding length AC as 42.0 to 42.1 by Pythagoras does not merit any marks as it is unnecessary in answering the question. This candidate's use of the sine rule, although not wrong, is also unnecessary as it is a right-angled triangle.

Exemplar 2

1 mark



Examiner commentary

The tan ratio is inverted and so the wrong angle has been found. SC1 is given.

Question 6

6 A bag contains some counters.

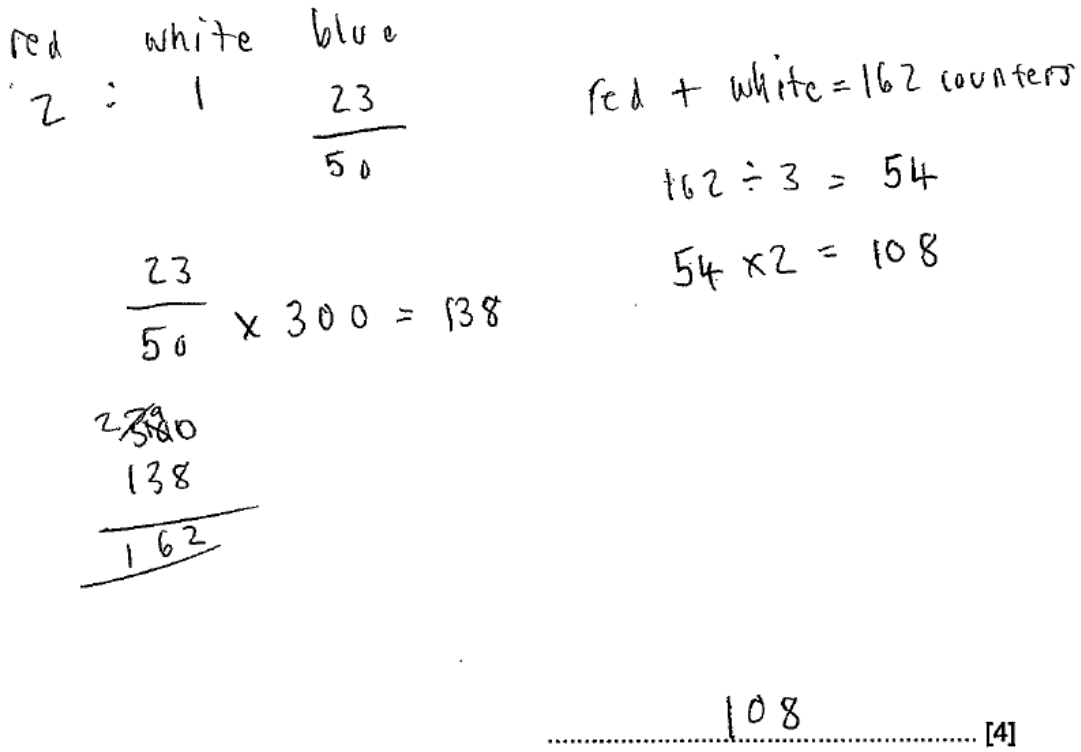
- There are 300 counters in the bag.
- There are only red, white and blue counters in the bag.
- The probability of picking a blue counter is $\frac{23}{50}$.
- The ratio of red counters to white counters is 2 : 1.

Calculate the number of red counters in the bag.

..... [4]

Exemplar 1

4 marks



108 [4]

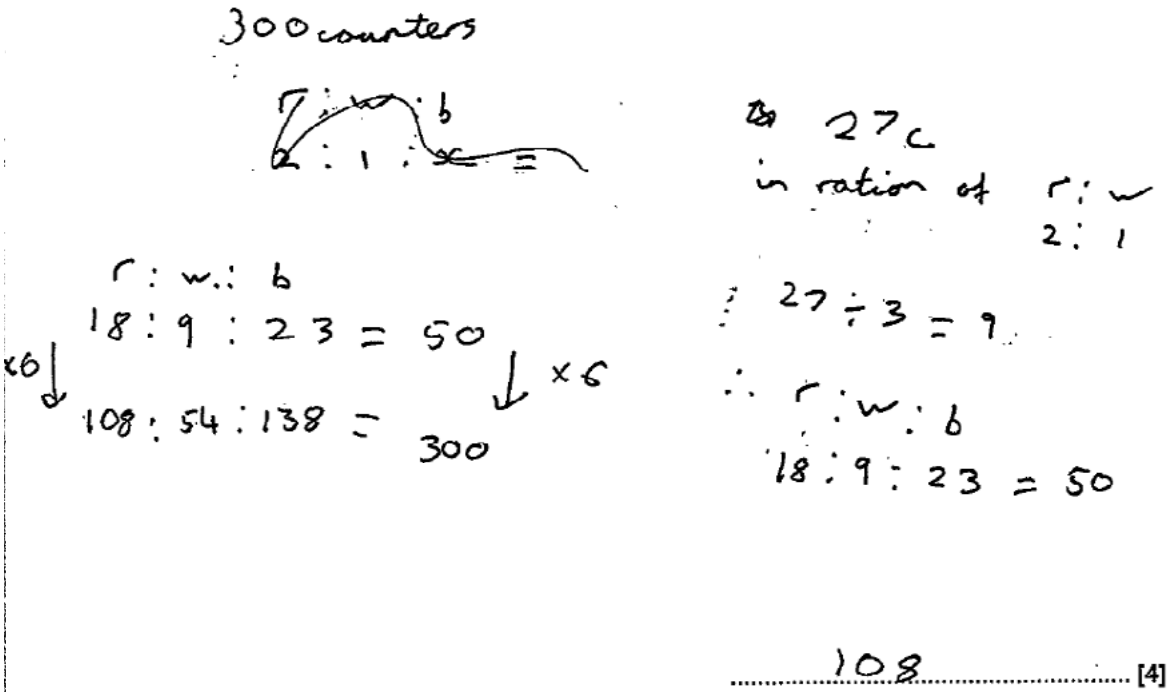
Examiner commentary

The vast majority of candidates scored full marks. This exemplar shows the most frequently used method and scores full marks for the correct answer with no wrong working.

The candidate has taken a chance by performing 300 – 138 by hand rather than using a calculator. Other candidates made errors in performing the fraction calculations by hand. It is recommended that a calculator is used on this calculator paper.

Exemplar 2

4 marks

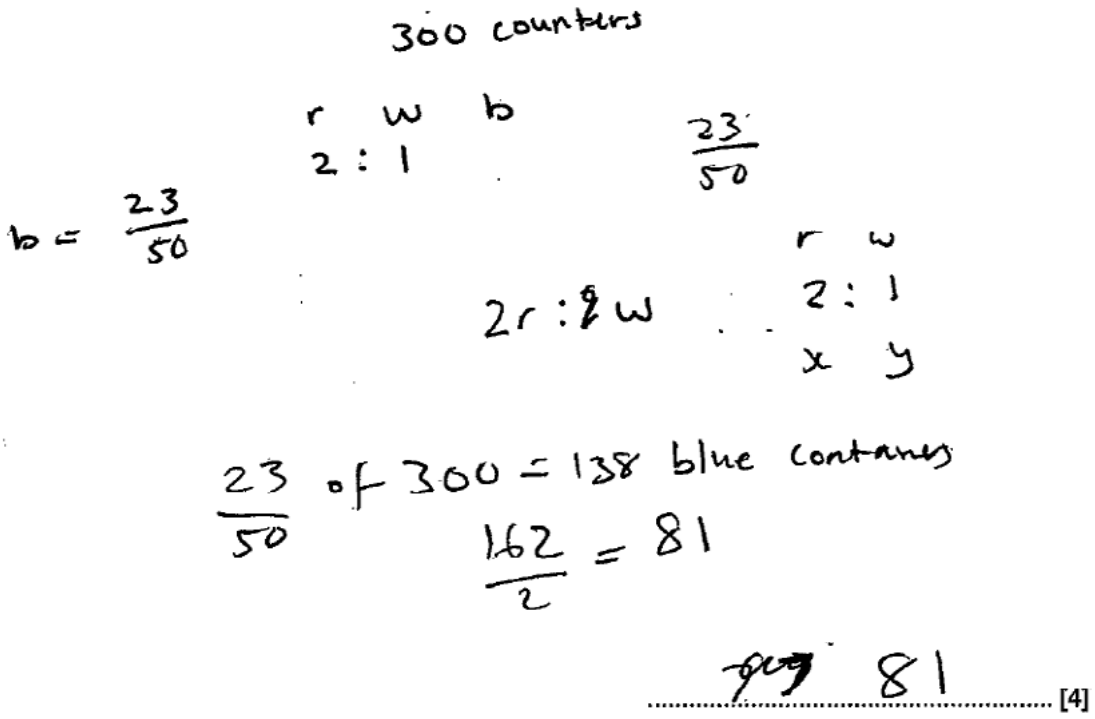


Examiner commentary

This solution was seen less often but also scores full marks. The candidate deduces that "white or red" is 27[/50] scoring M1, and then divides this in the ratio 2 : 1. Reaching $r : w : b$ as 18 : 9 : 23 scores M2 overall (and supersedes the M1 already earned), and there is another M1 for multiplying through by 6. Extracting the correct final answer gives the final mark.

Exemplar 3

2 marks

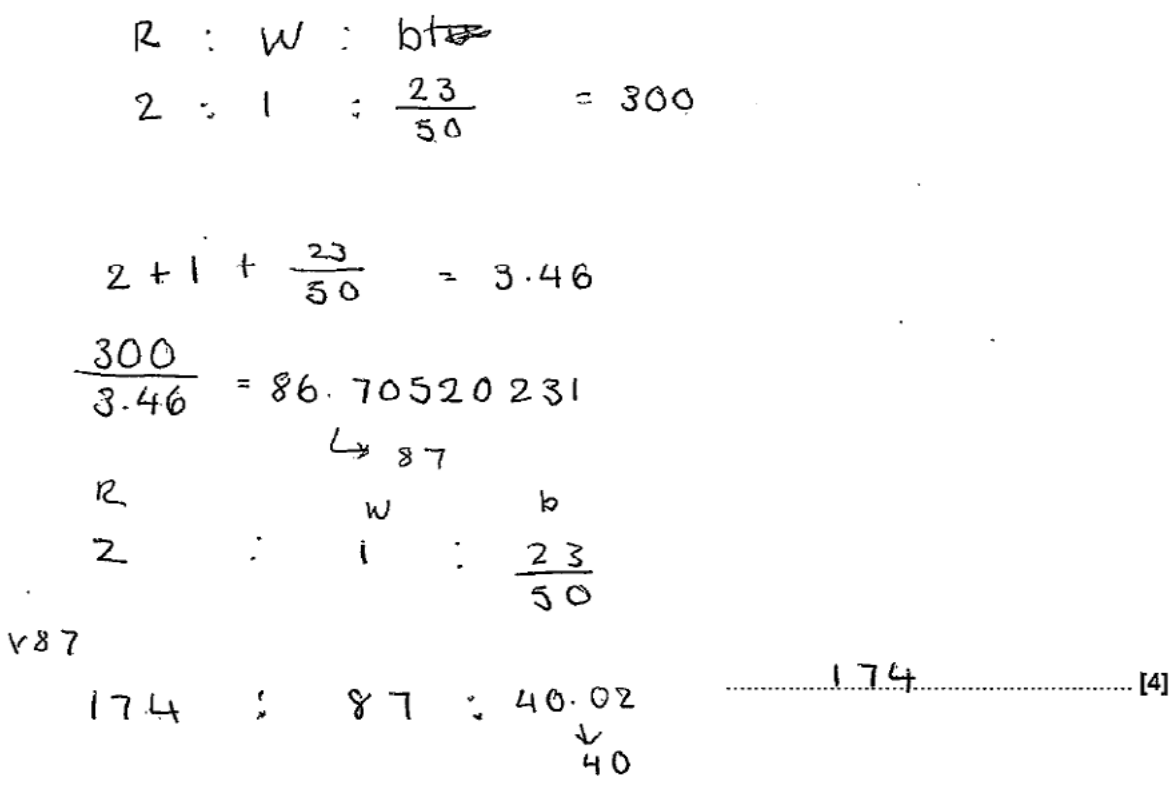


Examiner commentary

The candidate finds 138, scoring M1. Ideally, they should use "×" rather than "of" in case they make an error in the calculation. They then find 162, scoring another M1. Ideally, they should write "300 – 138" in case they make an error in the subtraction. They then have an invalid method for the ratio step and so no further marks are given. 2 marks overall.

Exemplar 4

0 marks

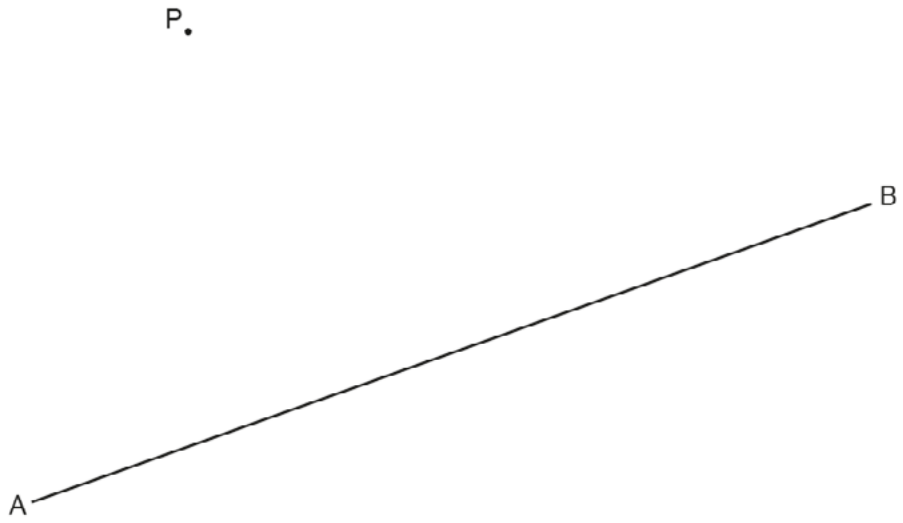


Examiner commentary

Some lower ability candidates tried to work in ratios from the outset. This exemplar is fairly typical. They misinterpret the given information as an incorrect triple ratio. There are no marks for this nor the subsequent division of 300 into that ratio.

Question 7

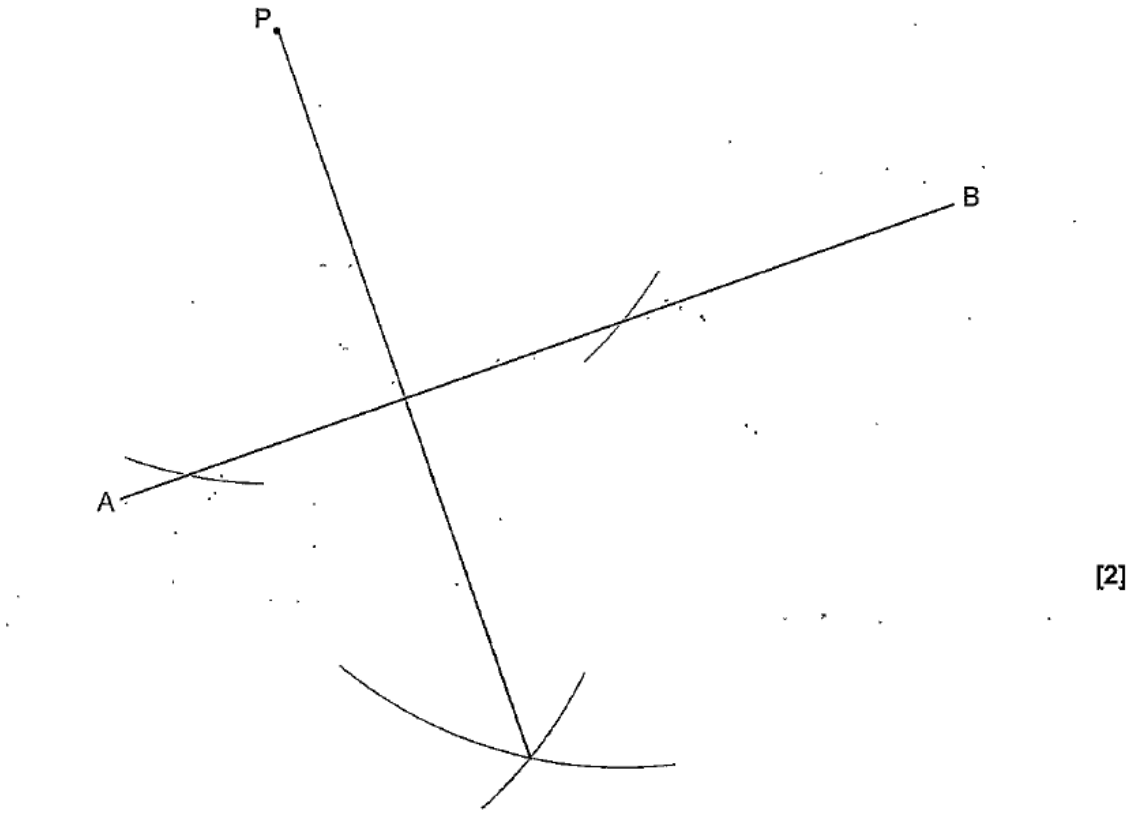
7 Construct the perpendicular from the point P to the line AB.
Show all of your construction lines.



[2]

Exemplar 1

2 marks



[2]

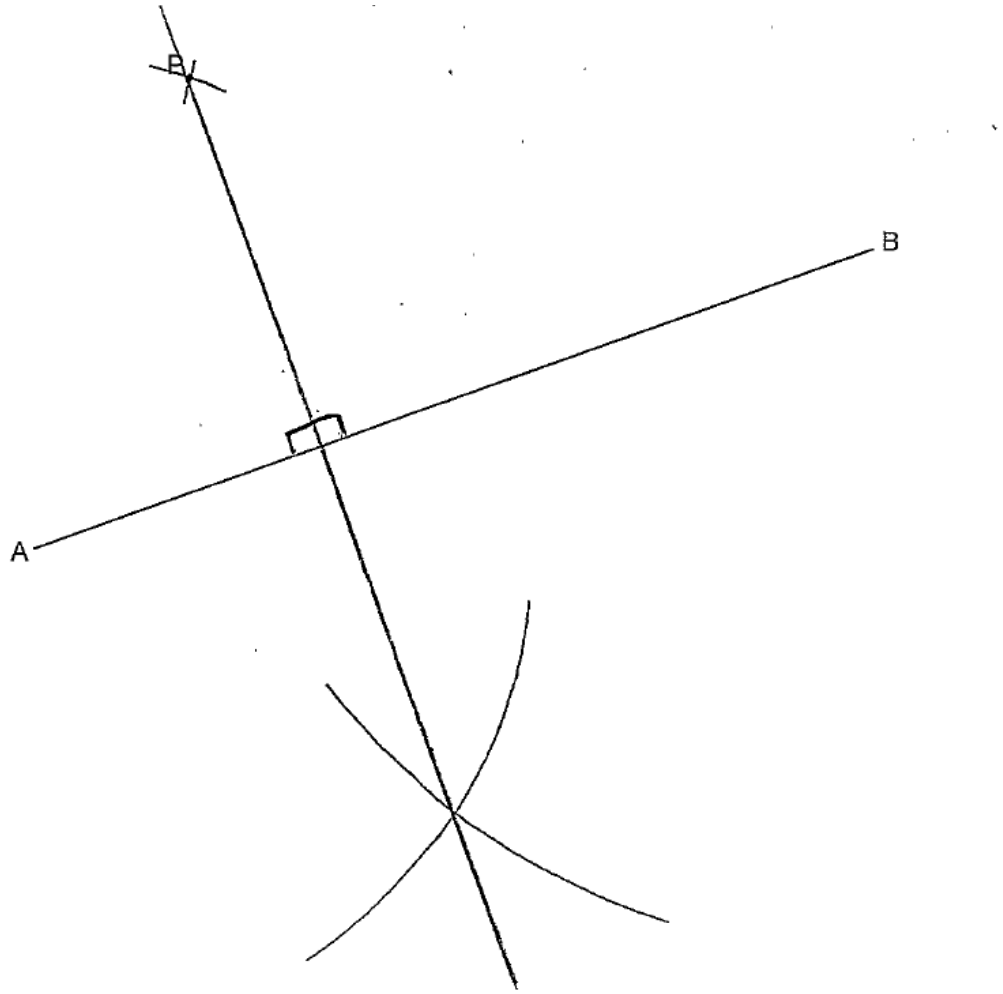
Examiner commentary

About half of the candidates were able to construct the perpendicular from P, although only about half of these used the standard textbook method shown.

The fact that the perpendicular crosses line AB was condoned.

Exemplar 2

2 marks



[2]

Examiner commentary

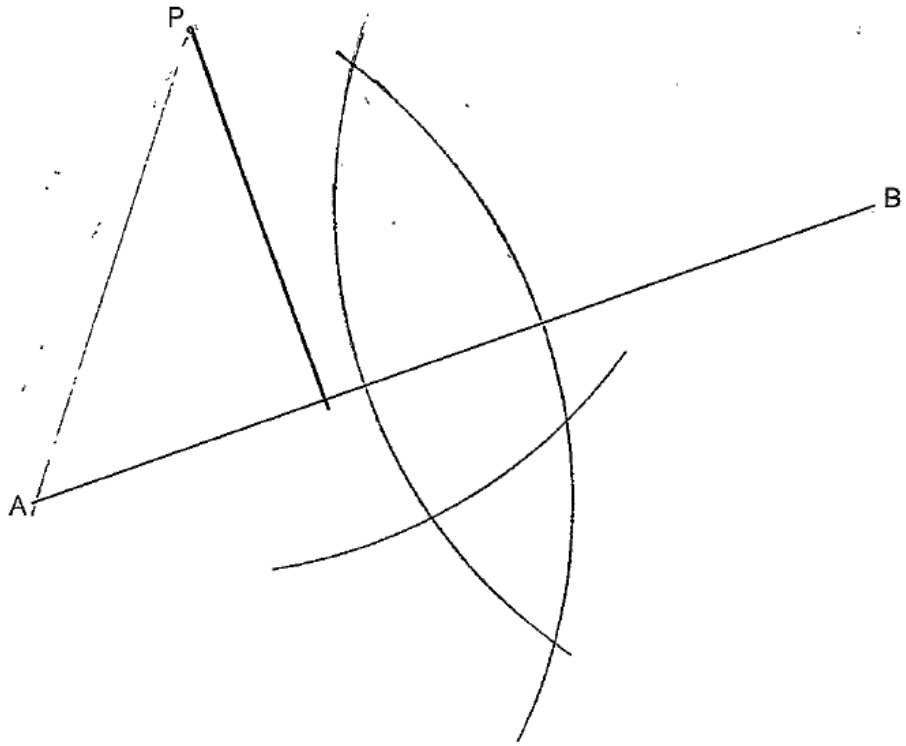
This alternative construction was very common and was given full marks. The fact that the perpendicular crosses line AB was condoned.

An arc from A goes through P and is also drawn below line AB. This is repeated using point B. The construction is then completed by the line drawn from P.

If A, P, B and the intersection of the two arcs are joined, a kite is produced. The construction uses the property that the diagonals of a kite are perpendicular. Some candidates used points other than A and B, and this construction was also given full marks.

Exemplar 3

1 mark



[2]

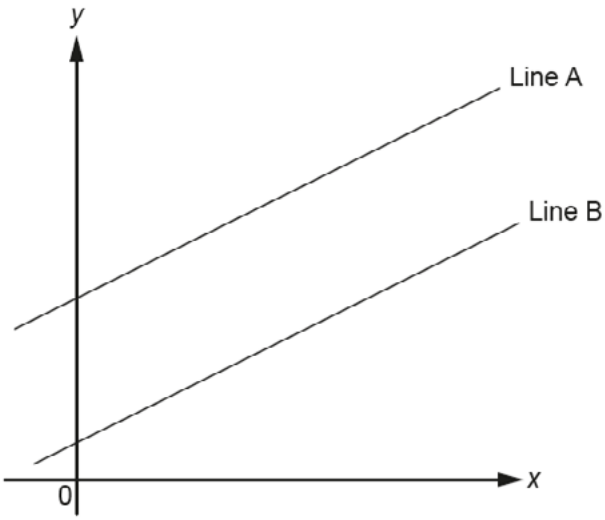
Examiner commentary

B1 is given for a correct ruled perpendicular from P, unsupported by correct arcs.

Some candidates appeared to construct the perpendicular bisector of AB, which is started here, and then a parallel line through P. Unless there was evidence to the contrary, it was assumed that the perpendicular through P was not fully constructed and only B1 given.

Question 8

8 The graph shows two parallel lines, Line A and Line B.



Not to scale

Line A has equation $y = 6x + 7$.
Line B passes through the point (4, 26).

Find the equation of Line B.

..... [4]

Exemplar 1

4 marks

$y = mx + c$ — same gradient = parallel

$y = 6x + c$

x y

$(4, 26)$

$y = 6 \times 4 + c$

$y = 24 + c$

$y = 24 + 2$

$y = 6x + 2$

$y = 6x + 2$ [4]

Examiner commentary

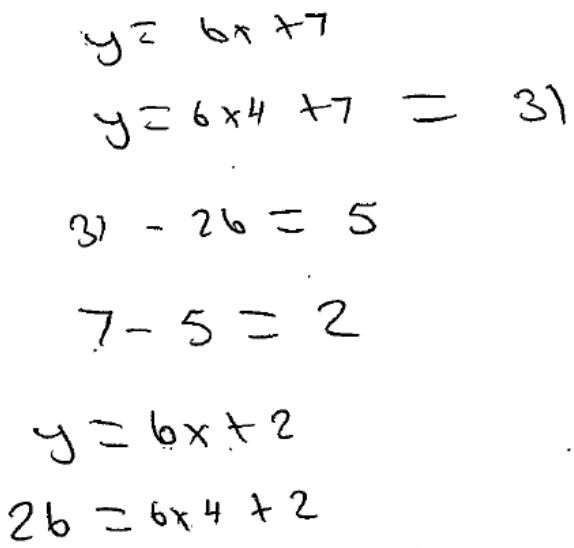
It was not unusual to see middle to high ability candidates obtain the correct answer with little or no working.

Where working was seen, most substituted (4, 26) into $y = 6x + c$ and rearranged to find c. This was the most common method and the candidate scores full marks.

There was M1 for 6×4 or 24; M1 for 26 – *their* 24 implied by 2; M1 for 6x + *their* 2.

Exemplar 2

4 marks



y = 6x + 2 [4]

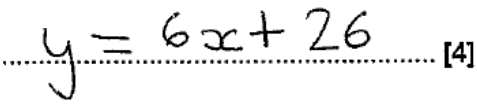
Examiner commentary

This alternative method was less common and also scores full marks.

There was M1 for finding the *y* value (31) of the given line when $x = 4$; M1 for identifying that the line they are trying to find is *their* 31 – 26 or 5 units below the given line; and M1 for deducing the *y*-intercept will be 7 – *their* 5 or 2.

Exemplar 3

1 mark



[4]

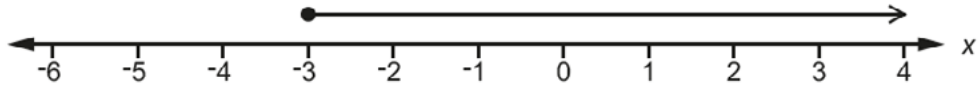
Examiner commentary

The candidate showed no working. B1 is given for the gradient part of the equation, $y = 6x$.

From the diagram, it should be clear that the intercept will be between 0 and 7. B2 was given where this was recognised, such as an answer of $y = 6x + 4$.

Question 9

9 Martha's solution to the inequality $8x + 5 \leqslant 3x - 10$ is shown on the number line.



Is her solution correct?
Explain your reasoning.

.....

..... [4]

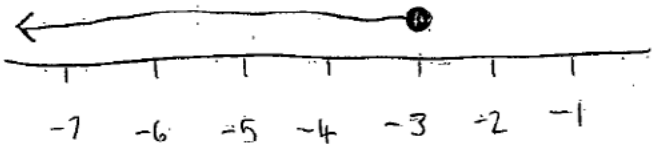
Exemplar 1

4 marks

$5x + 5 \leq -10$

$5x \leq -15$

$x \leq -3$



Her solution is incorrect as her solution is $x \geq -3$ when it should be $x \leq -3$. [4]

Examiner commentary

The exemplar scores full marks.

Most candidates attempted to solve the inequality algebraically, scoring M1 for collecting the x terms on one side and another M1 for collecting the constant terms on the other side. Incorrect inequality or equals sign were condoned up to the award of M2. For M3, candidates needed to reach $x \leq {}^{-}3$.

The final mark was dependent on M3 having been achieved. It required "No/incorrect" with a justification such as drawing the correct inequality on the number line (shown here), stating the number line shows $x \geq {}^{-}3$ (also shown here), or that the arrow was pointing in the wrong direction. About a quarter of the candidates who reached $x \leq {}^{-}3$ concluded "yes" and so only scored M3.

Exemplar 2

1 mark

$8x + 5 \leq 3x - 10$

$5x + 5 \leq -10$

$5x - 5$

..... [4]

Examiner commentary

The candidate collects the *x* terms together correctly and so scores M1. They need to collect the constants on the other side to score M2 overall.

Exemplar 3

1 mark

$x = -3$, $x \leq -19 \leq x = -19$

$x =$ more 4 $x = 37 \leq x = 2$.

$x = -2$ $x = -11 \leq x - 16$

$x = -1$ $x = -3 \leq x = -13$

$x = 0$ $x = 5 \leq x = -10$

$x = 1$ $x = 13 \leq x = -7$

$x = -4$ $x = -27 \leq x = -22$

Yes because

$3x - 10$ is always smaller unless you go past [4]

-3 where $8x + 5$ is smaller

Examiner commentary

An algebraic method was anticipated and used by most candidates. However, there were also attempts using trials.

In this exemplar, both sides of the inequality are evaluated correctly using values of *x* where $x < {}^{-}3$, $x = {}^{-}3$ and $x > {}^{-}3$. The ambiguous use of the inequality signs in their comparisons is condoned. With a correct conclusion, this would have been given full marks. Instead, it is given SC1.

Question 10

10 In 2017, the value of a house increased by 4%.
In 2018, the value of the house then decreased by 3%.

Teresa says

Over the two years the value of the house increased by exactly 1% because 4 – 3 = 1.

Show that Teresa is wrong.

.....

..... **[6]**

Exemplar 1 5 marks

$x \times 1{\cdot}04 \times 0{\cdot}97 = 1{\cdot}0088x$

1·0088 does not show a 1% increase, so she is wrong

this is because after initial increase of 4%, house value is more

so 3% decrease will have a greater effect than it would have

in 2017

Examiner commentary

This exemplar shows an efficient method used by about half of the candidates, with *x* representing the value of the house. It scores B5.

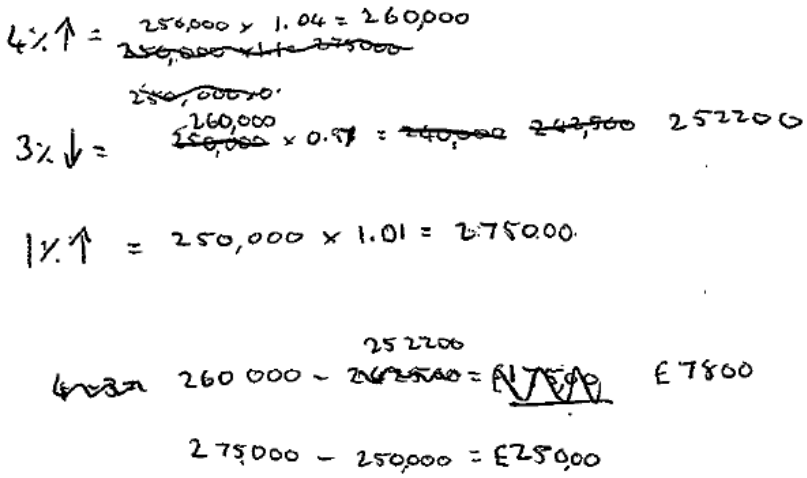
They do not score full marks because they do not interpret 1.0088 as being a 0.88% increase; instead, it reads as though the increase could be 1.0088%.

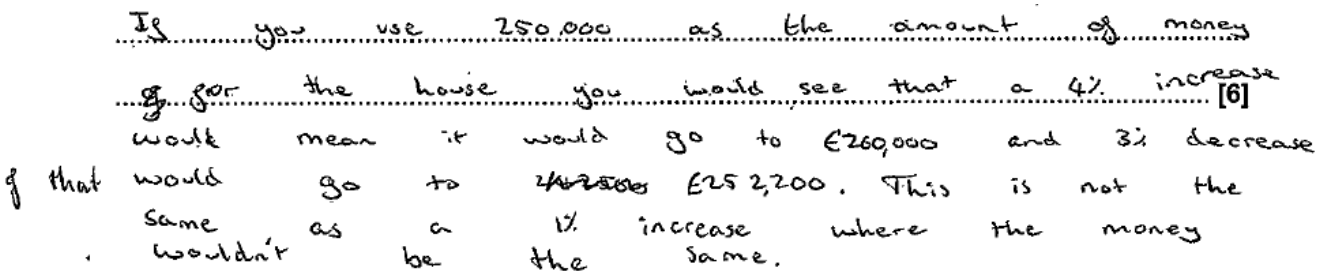
Reaching 1.0088 scores B5, whereas stopping at 1.0088x would have scored B4.

The question could also be answered without using *x* at all, and this would take them straight to 1.0088. However, most of the other half of the candidates replaced *x* with a value.

Exemplar 2

4 marks





Examiner commentary

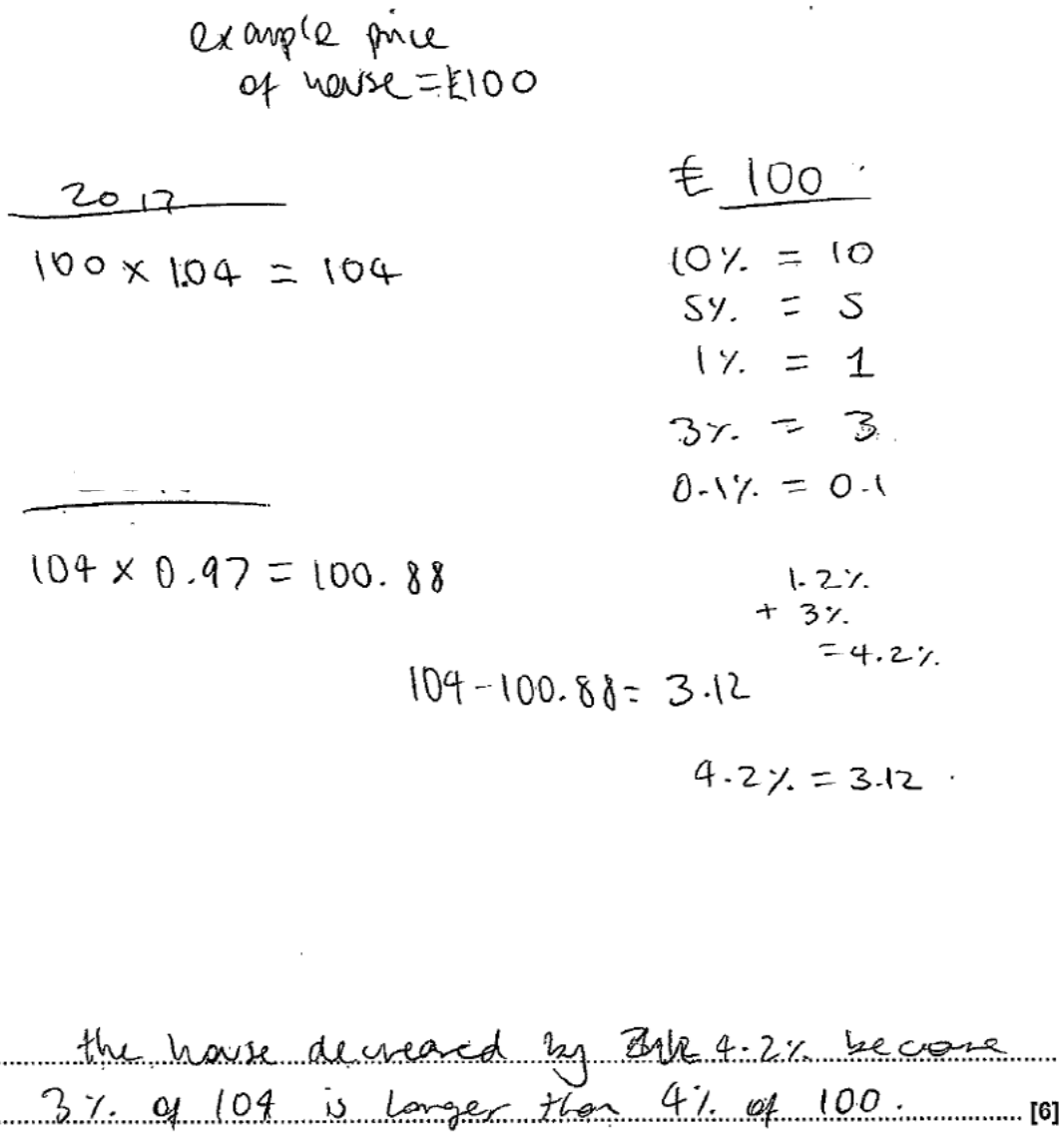
This exemplar scores 4 marks.

The crossed out work clarifies that they have assumed a house value of £250 000, although that can be deduced from the working. They first increase this using a multiplier of 1.04, scoring M2 and then decrease the answer using a multiplier of 0.97, scoring another M1. They then attempt to find Teresa's answer but make an error. However, this is a method mark and so M1 is given.

To achieve 5 marks (B5), they needed to have both their final house value and Teresa's house value correct. They do have the correct conclusion that the answers are "not the same", but this final mark is dependent on B5 and so is not given.

Exemplar 3

3 marks



Examiner commentary

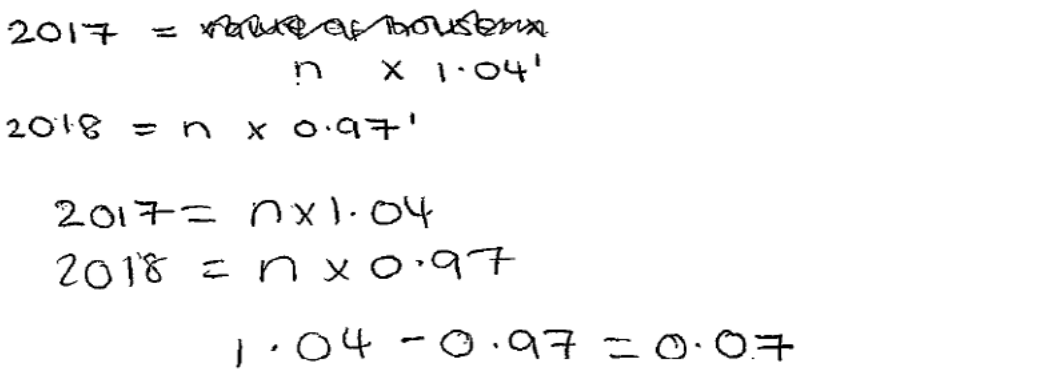
This was a fairly standard response scoring 3 marks. The candidate assumes a house value of £100. They first increase this using a multiplier of 1.04, scoring M2 and then decrease the answer using a multiplier of 0.97, scoring another M1. It was also acceptable to do these calculations in stages, such as finding 4% and adding on to the starting value. No further progress is made.

Full marks would have been achieved if the candidate had either interpreted their answer of 100.88 as a 0.88% increase or had found and compared with Teresa's 1% increase.

As evidenced by this and the previous exemplar, a wide range of house values was used by the candidates in their calculations.

Exemplar 4

2 marks



the value of the house will have increased by 7% so theresa is wrong [6]

Examiner commentary

This scores M2 for $n \times 1.04$.

To achieve M3 they needed $n \times 1.04 \times 0.97$, while just 1.04 or 0.97 scored M1.

Question 11 (a) (i)

11 You are given that

$270 = 3^3 \times 2 \times 5$ and $177\,147 = 3^{11}$

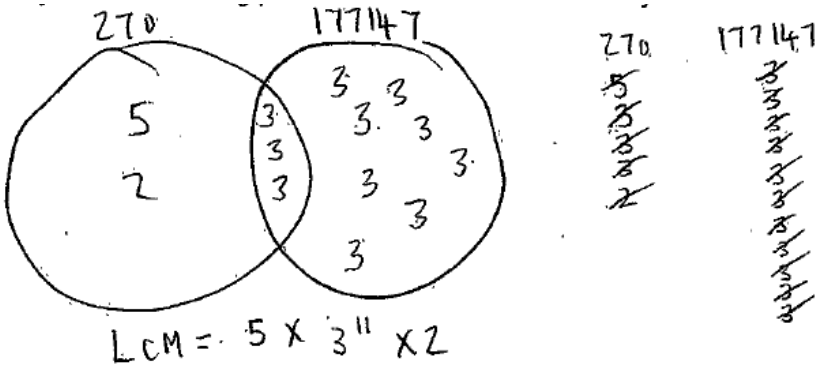
(a) (i) Find the lowest common multiple (LCM) of 270 and 177 147.
Give your answer using power notation and as an ordinary number.

(a)(i) using power notation .....

as an ordinary number ..... **[2]**

Exemplar 1

2 marks



(a)(i) using power notation $2 \times 3^{11} \times 5$

as an ordinary number 1771470 **[2]**

Examiner commentary

Both answers are correct and so 2 marks are scored.

Method marks were not available and many just wrote down the answers. Where seen, the usual working was a Venn diagram or similar. The common error using this method was to give the highest common factor answers 3^3 and 27.

Question 11 (a) (ii)

(ii) Write 177 147 000 000 as a product of its prime factors.

(ii) ..... [3]

Exemplar 1

3 marks

$= 3^{11} \times 10^6$

$= 3^{11} \times 5^6 \times 2^6$

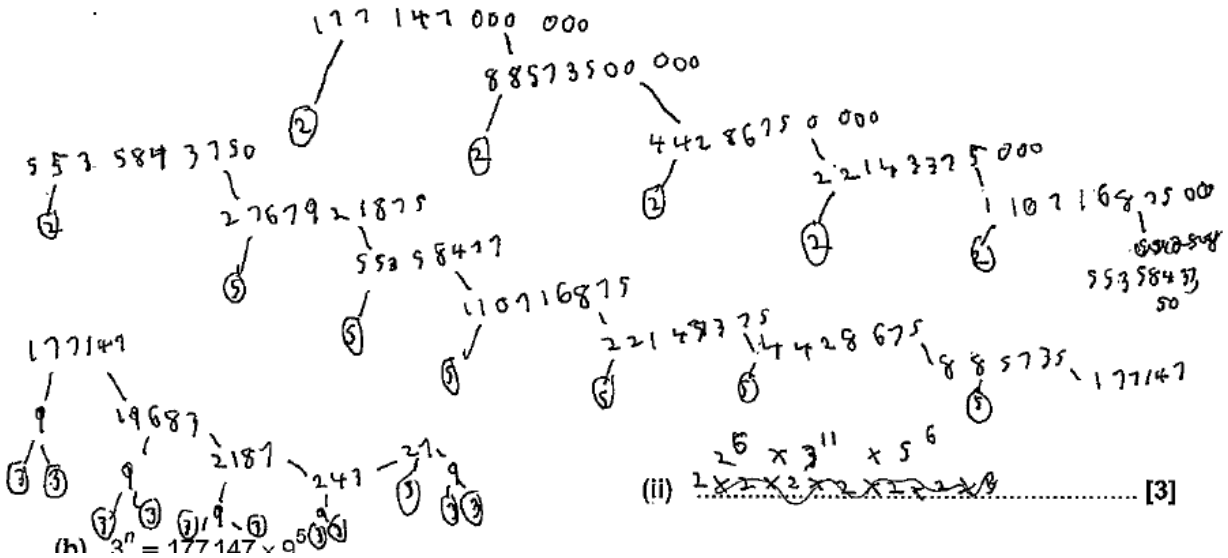
(ii) $3^{11} \times 5^6 \times 2^6$ ..... [3]

Examiner commentary

High ability candidates recognised that this was just an extension of part (a)(i) and so were able to answer the question quickly and efficiently.

Exemplar 2

3 marks



Examiner commentary

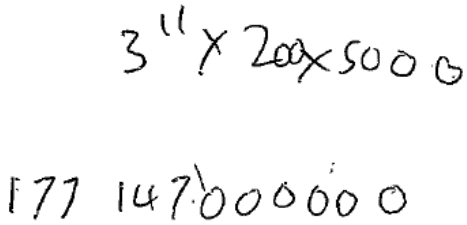
This exemplar is by a very high ability candidate. They did very well to complete all the processing without error as almost all candidates attempting this method made mistakes or gave up. It is interesting to note how methodical they have been in first removing 2^6 and then 5^6. Now left with 177 147, it is a shame they did not realise they already had this as 3^{11}. However, they got there in the end and so full marks are given.

Examiner commentary continued

3^{11} on the answer line would have scored B1, and evidence of 2 and 5 as factors, such as appearing in a prime factor tree or as part of the product on the answer line, would have scored a separate M1.

A prime factor tree was not the expected or intended method. Candidates should take note of a question's mark allocation, the amount of working space given, and whether it is taking a disproportionate amount of time to answer using the same process repetitively. A further pointer is that this is labelled part (a)(ii) and so is connected to (a)(i), rather than being labelled part (b).

Exemplar 3 1 mark



(ii) $3^{11} \times 200 \times 5000$ [3]

Examiner commentary

The candidate replaces 177 147 with 3^{11} in their answer and so score B1. Although they write 1 000 000 as 200×5000, they do not reach 2 and 5 as factors and so score M0.

Question 11 (b)

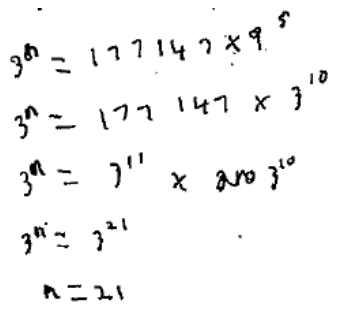
(b) $3^n = 177\,147 \times 9^5$.

Find the value of n.

(b) $n =$ ..... **[3]**

Exemplar 1

3 marks



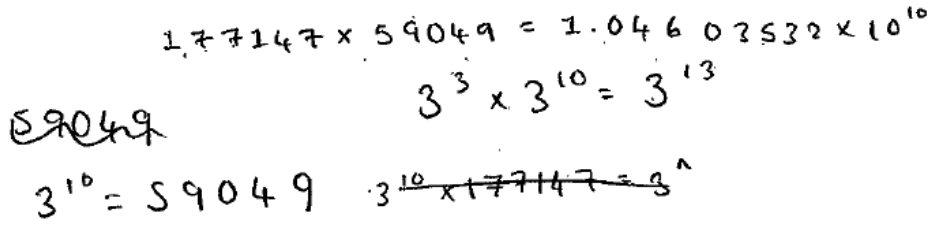
(b) $n =$ 21 **[3]**

Examiner commentary

This exemplar shows well presented working through to the correct answer and scores full marks.

Exemplar 2

1 mark



(b) $n =$ 13 **[3]**

Examiner commentary

The candidate scores M1 for changing 9^5 into 3^{10}.

Although they have applied the law of indices correctly, an M1 was only available for $3^{11} \times 3^{\textit{their}\ 10}$.

Question 12 (a)

12 Antonio rolls two fair six-sided dice and calculates the **difference** between the scores.
For example, if the two scores are 2 and 5 or 5 and 2 then the difference is 3.

(a) Complete the sample space diagram to show the possible outcomes from Antonio's dice.

Dice 2

Dice 1 / difference	1	2	3	4	5	6
1	0					
2					3	
3		1				
4						
5		3				
6						

[2]

Exemplar 1

2 marks

Dice 2

Dice 1 / difference	1	2	3	4	5	6
1	0	1	2	3	4	5
2	1	0	1	2	3	4
3	2	1	0	1	2	3
4	3	2	1	0	1	2
5	4	3	2	1	0	1
6	5	4	3	2	1	0

[2]

Examiner commentary

Correct, so 2 marks given.

It was very rare for a candidate to not score 2 marks. A few had some negative differences. The probability needed for part (b) was followed through from their table.

Question 12 (b)

(b) Antonio rolls the two dice three times.

Calculate the probability that he gets a difference of 1 on all three rolls.
Give your answer as a fraction in its lowest terms.

(b) ..... **[4]**

Exemplar 1 — 3 marks

$\frac{10}{36} \times \frac{10}{36} \times \frac{10}{36} = \frac{1000}{46656} = \frac{500}{23328} = \frac{250}{11664} = \frac{175}{5832}$

(b) $\frac{175}{5832}$ **[4]**

Examiner commentary

This scores B3 for reaching $\frac{1000}{46656}$. It was very rare to not reach the correct answer of $\frac{125}{5832}$ from here, and the candidate should have used their calculator to do the simplification.

If they had not evaluated the expression, they would score B1 for $\frac{10}{36}$ and M1 for cubing it.

Exemplar 2 — 1 mark

36 different outcomes

$36 \times 3 = 108$

10 ways to get 1

$10 \times 3 = 30$

$\frac{30}{108} \div 6$

$\frac{5}{18}$

(b) $\frac{5}{18}$ **[4]**

Examiner commentary

This response is not well presented. "36 different outcomes" and "10 ways to get 1" suggests the candidate has identified the correct totals from the table but $\frac{10}{36}$ is not seen as a probability and so, on their own, the words would score 0 marks. However, they appear to have multiplied both the numerator and denominator by 3 in reaching $\frac{30}{108}$, so a B1 with bod ("benefit of the doubt") is given. They do not seem to realise that, after "multiplying by 3", their final answer is the same probability as they started with.

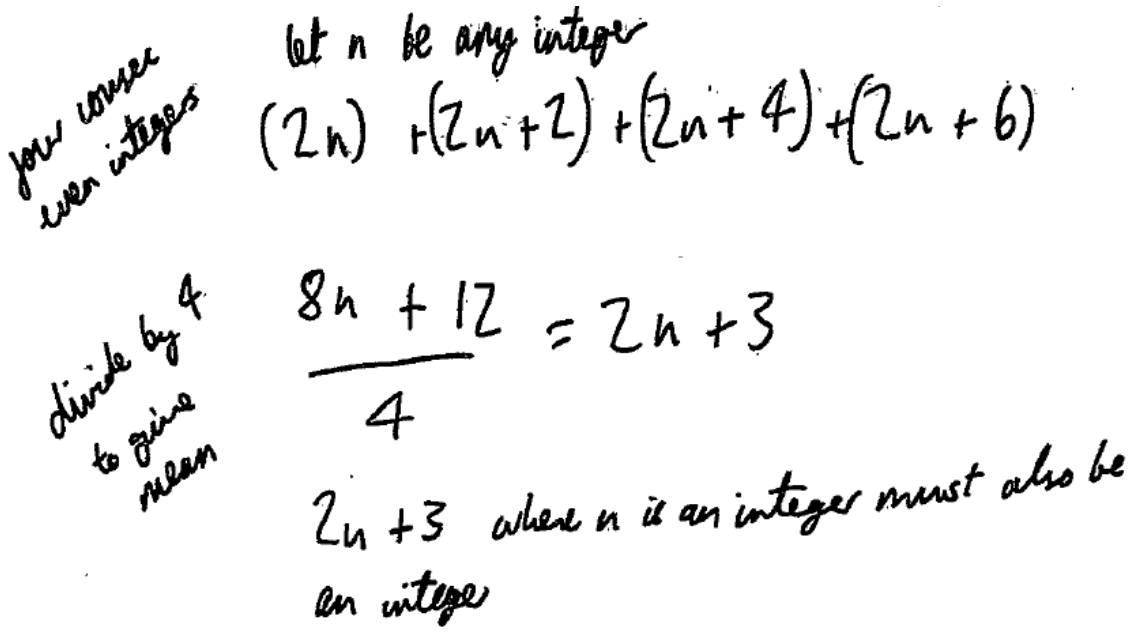
Although the attempted process was wrong on this occasion, the candidate should have presented their working as $\frac{10}{36} \times 3$ and used a calculator to get it right.

Question 13

13 Prove that the mean of any four **consecutive** even integers is an integer. [4]

Exemplar 1

4 marks

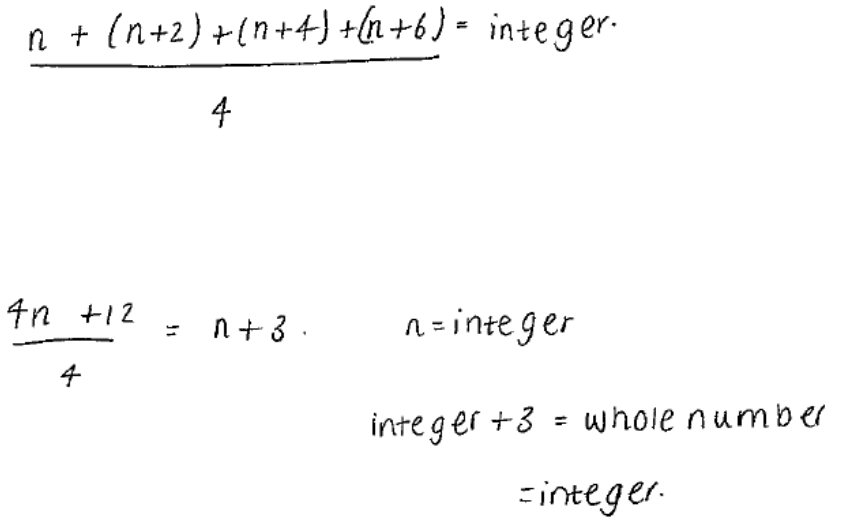


Examiner commentary

This is an excellent example of how to present an algebraic proof. The candidate defines n as an integer. Here, because they are using the form 2*n*, the mark scheme did not require that step but it is best practice to include it. All of the algebraic processing is correct and the words add even more clarity.

Exemplar 2

3 marks



Examiner commentary

n, *n* +2, *n* + 4, *n* + 6 could be consecutive even numbers or consecutive odd numbers. *n*, therefore, needed to be defined as an even integer and the first M mark is not given. The candidate then adds the four terms (M1), divides by 4 (M1) and makes a correct concluding statement (A1). The final A1 mark is dependent on M0M1M1 or M1M1M1 and so is given. The script scores 3 marks.

Exemplar 3

1 mark

2, 4, 6, 8

2 + 4 + 6 + 8 = 20

20 ÷ 4 = 5

250, 252, 254, 256

250 + 252 + 254 + 256 = 1012

1012 ÷ 4 = 253

1000 + 1002 + 1004 + 1006 = 1312

1312 ÷ 4 = 328.

Examiner commentary

SC1 is given for a numerical example with any four consecutive even integers and the mean correctly calculated. The final case is incorrect but just one correct example was required and so this is not marked as a choice of answer.

Question 14

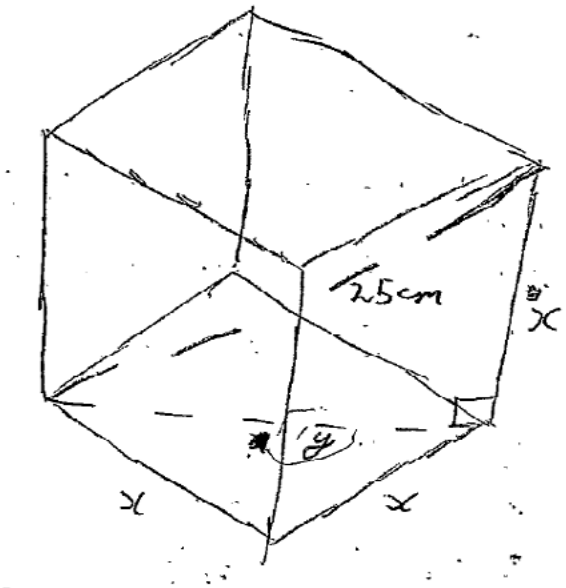
14 The length of the longest diagonal of a cube is 25 cm.

Calculate the total surface area of the cube.

..... cm^2 **[5]**

Exemplar 1

5 marks



$x^2 + x^2 = y^2$ $2x^2 = y^2$

$x^2 + y^2 = 25^2$

$x^2 + 2x^2 = 25^2$

$3x^2 = 25^2$

$x^2 = \frac{625}{3}$

$6x^2 = 1250$

1250 cm^2 **[5]**

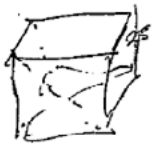
Examiner commentary

The candidate starts with a helpful and correct diagram. Although it could have been quoted, they show the build up to $3x^2$ (M1) and equate this to 25^2 (M1). They have then finished the question very efficiently and score full marks.

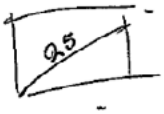
Most candidates who obtained $3x^2 = 25^2$ proceeded to find x before substituting into $6x^2$. If maintaining full accuracy, they should reach exactly 1250 and score full marks. However, if they used a rounded version of x, indicated by other answers from 1244 to 1250.05, then only B4 was given. For interim answers, candidates are advised to use surd form or the "Ans" button on their calculator.

Exemplar 2

3 marks



25



$25^2 = \frac{625}{2} = 312.5 = 17.67$

~~17.67 x 6~~

$17.67 \times 17.67 = 312.5$

$312.5 \times 6 = 1875$

1875 cm² **[5]**

Examiner commentary

This was probably the most common, wrong, starting point. It scores 3 out of 5.

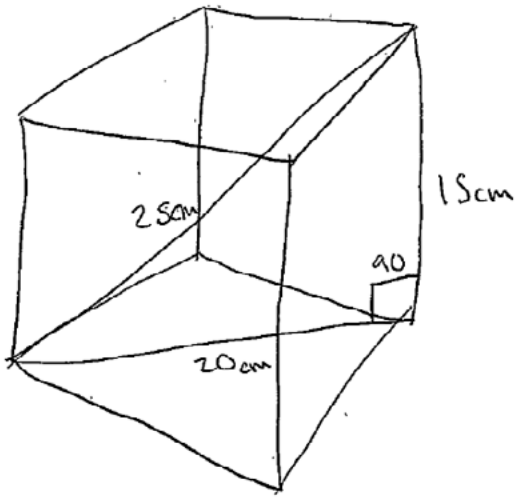
The low standard of presentation and notation in the first line was fairly typical.

The square diagram shows they are using 25 as the diagonal of a face of the cube. The working towards the interim answer of 17.6 to 17.7 suggests they have essentially solved the equation $2x^2 = 625$, where x is the dimension of the cube, and so scores M0M1A1. They have avoided the pitfall of premature rounding by getting back to 312.5 when they square 17.67 to find the area of one face. They then multiply by 6 to get the total surface area. The area work scores M1 and was often combined into one step.

It would have been preferable to see the equation $2x^2 = 625$ and to see that they are square rooting 312.5 to reach 17.67. For interim answers, it is also advisable to use surd form or the "Ans" button on their calculator.

Exemplar 3

2 marks



$a^2 + b^2 = 25^2$

$a^2 + b^2 = 625$

$20^2 + 15^2 = 625$

$\sqrt{625} = 25$

$15 \times 15 = 225$

$225 \times 6 = 1350$

1350 ..... cm^2 **[5]**

Examiner commentary

This was also a common response. The candidate has correctly drawn the diagonal across the cube but mistakenly thinks they have an enlargement of a 3, 4, 5 right-angled triangle. Thus, they believe the cube is of dimension 15. They score M1 for $[25^2 =]$ 625 and M1 for their total surface area, 6×15^2, here performed in two steps.

Question 15

15 Solve by factorisation.

$5x^2 + 7x + 2 = 0$

$x =$ ..... or $x =$ ..... **[3]**

Exemplar 1

2 marks

$5x^2+7x+2$

$(5x+2)(x+1)$

$x = -2$ or $x = -1$

~~$2+1=2$~~

~~$2\times(1\times5)+2=7$~~

$x = -1$ or $x = -2$ **[3]**

Examiner commentary

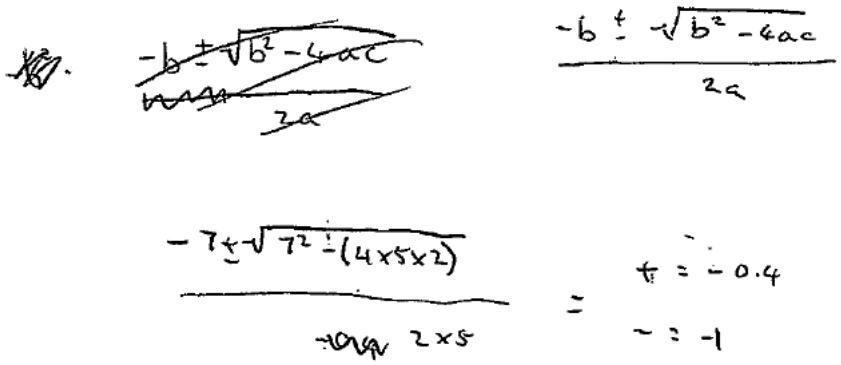
The factorisation is correct and scores M2.

M1 was given for two "factors" that give two correct terms when expanded, or for partial factorisation, such as $5x(x + 1) + 2(x + 1)$. In the latter case, candidates are advised to make sure they write the completed factorisation.

Exemplar 2

1 mark

$a \quad b \quad c$
$5x^2 + 7x + 2 = 0$



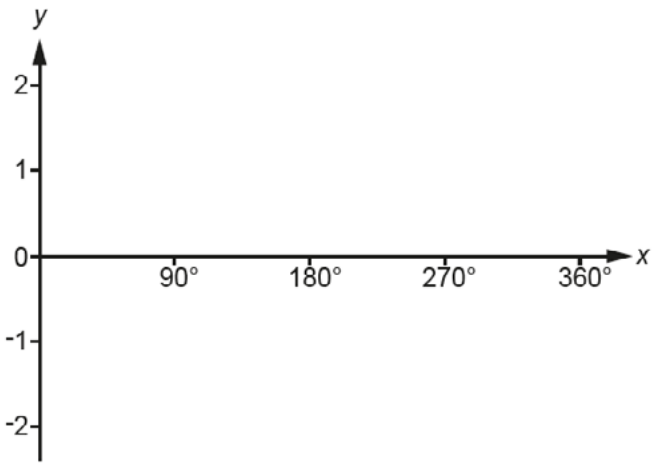
$x =$ -0.4 or $x =$ -1 **[3]**

Examiner commentary

The question requires the method of factorisation. On this paper in this series, B1 was given for the correct answers.

Question 16

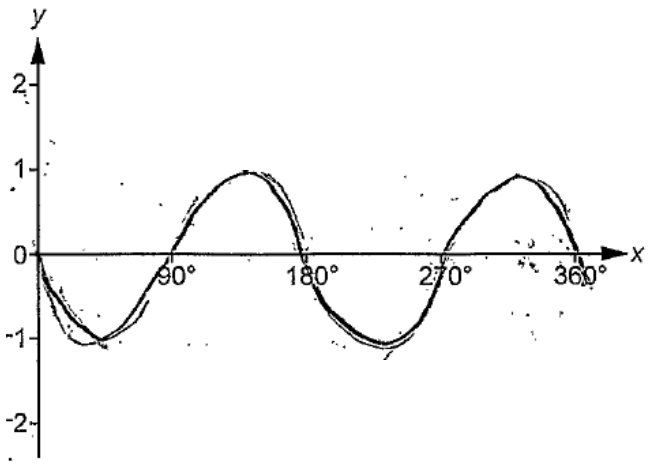
16 Sketch the graph of $y = -\sin x$ for $0° \leqslant x \leqslant 360°$.



[3]

Exemplar 1

2 marks



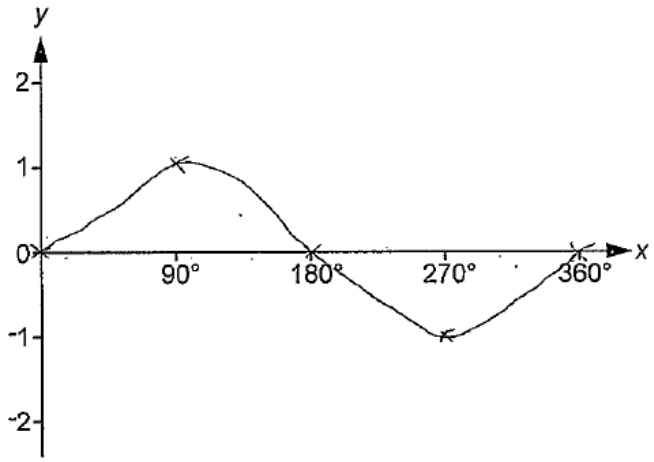
[3]

Examiner commentary

The graph is a negative sine curve starting at (0, 0), and the maximum and minimum values occur at $y = 1$ and $y = -1$. This scores B1B1. They do not score the final mark as the maximum and minimum values are not at $x = 270$ and $x = 90$, respectively.

Exemplar 2

2 marks



[3]

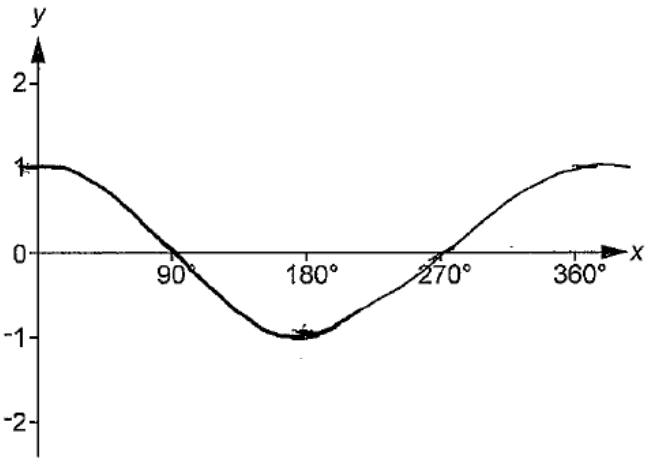
Examiner commentary

The graph is a positive sine curve starting at (0, 0), and the maximum and minimum values occur at $y = 1$ and $y = -1$. This scores B1B1. They do not score the final mark as the maximum and minimum values are not at $x = 270$ and $x = 90$, respectively.

A correctly drawn graph of $y = 2\sin x$ would score B1B0B0 as the maximum and minimum values would no longer occur at $y = 1$ and $y = -1$.

Exemplar 3

1 mark



[3]

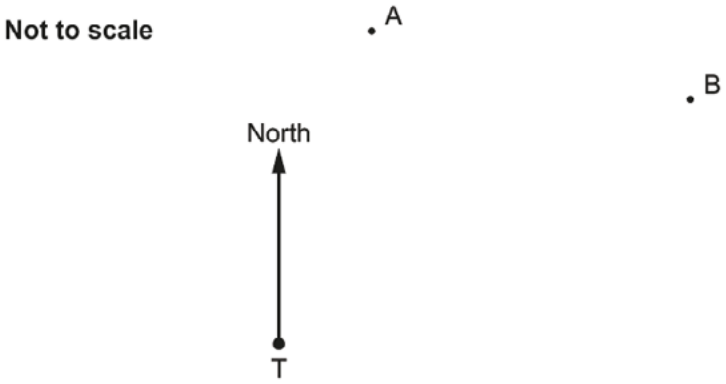
Examiner commentary

The graph is not a sine curve starting at (0, 0), but the maximum and minimum values occur at $y = 1$ and $y = -1$. This scores B0B1. They do not score the final mark as the maximum and minimum values are not at $x = 270$ and $x = 90$, respectively.

Question 17 (a)

17 T is a radar tower.
A and B are two aircraft.

At 3pm
- aircraft A is 3250 km from T on a bearing of 015°
- aircraft B is 4960 km from T on a bearing of 057°.



(a) Aircraft A flies directly towards radar tower T at a speed of 890 km/h.

At what time will the aircraft pass over radar tower T?
Give your answer to the nearest minute.

(a) ..... **[4]**

Exemplar 1

4 marks

3250 ÷ 890 = 3.65

60 x 0.65 = 39

3 h 39 mins

(a) 6:39 pm **[4]**

Examiner commentary

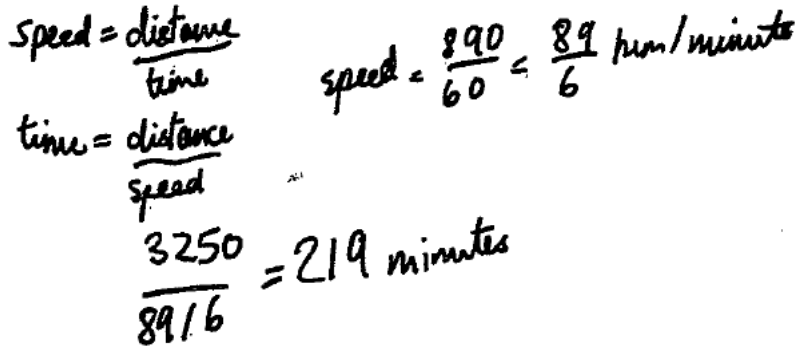
This is a concise, clear response that scores full marks.

B3 was given if they stopped at 39 or 3 h 39 mins.

For those not getting that far, performing distance ÷ time scored M1 and, if the method had not been shown, it was implied by 3.65(…). They could then score another M1 for converting the decimal part of their answer from hours into minutes.

Exemplar 2

3 marks



(a) 219 minutes [4]

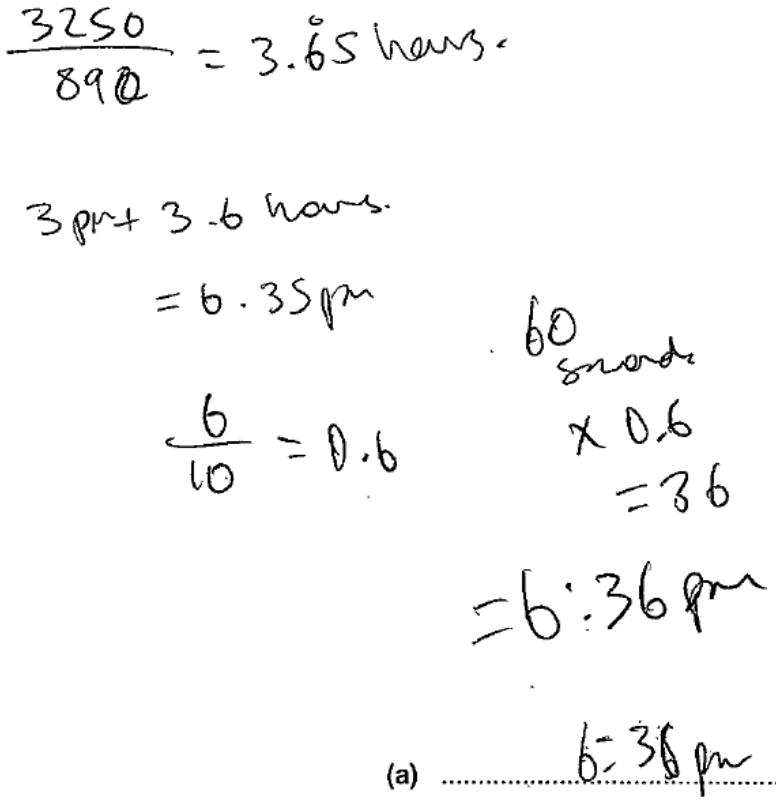
Examiner commentary

Candidates reaching 219 minutes were given B3.

219 was more frequently seen using the alternative method shown here. They first convert the speed from km/h to km/min (M1) before performing the distance/speed calculation (M1). They still needed to add 219 minutes to 3 pm to achieve full marks.

Exemplar 3

2 marks



(a) 6:38 pm [4]

Examiner commentary

The candidate correctly performs distance ÷ time, reaching 3.65, and so scores M1. They then convert the decimal part of their answer, which is in hours, into minutes by multiplying by 60. This scores another M1. The fact that they truncated their 0.65 to 0.6 causes them to lose accuracy marks but not method marks.

Many candidates were unable to convert 3.65… hours into hours and minutes, with 4 hours 5 minutes (which is what the candidate here probably intended) and 4 minutes being particularly common.

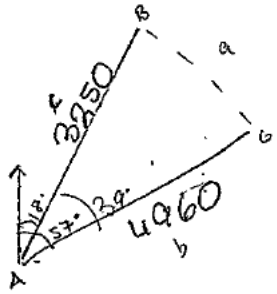
Question 17 (b)

(b) Calculate the distance that was between aircraft A and aircraft B at 3pm.

(b) ..... km **[4]**

Exemplar 1

2 marks



57 − 18 = 39

$\cos = a^2 = b^2 + c^2 - 2bc\cos A$

~~$= 4960^2 + 3250^2 - 2\times$~~

$4960^2 + 3250^2 - 2\times 4960 \times 3250 \times \cos 57°$

$35164100 - 17559162.5 = 17604937.5$

$a^2 = 17604937.5$

$a = 4195.823817$

(b) 4196 km **[4]**

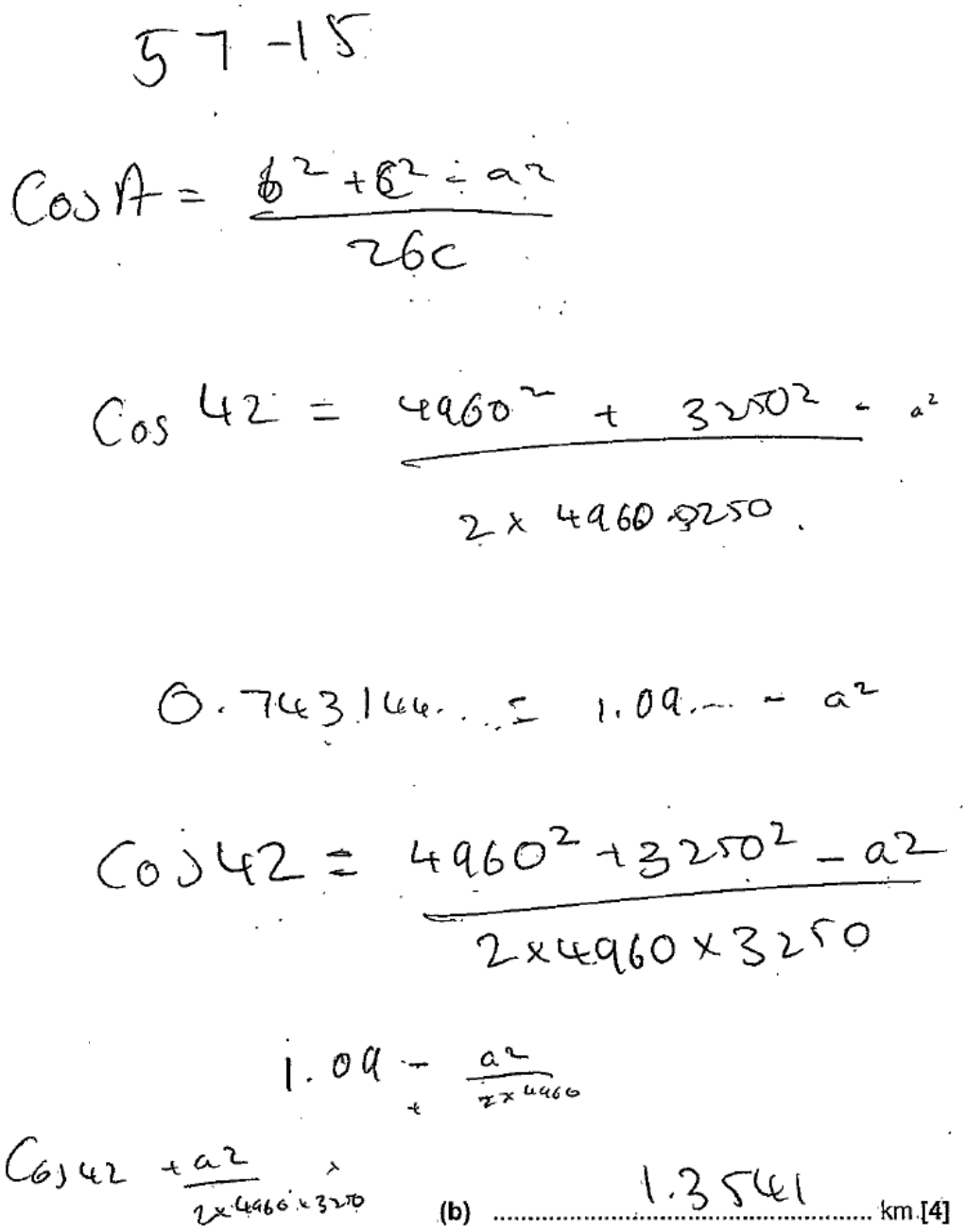
Examiner commentary

The candidate correctly identifies the need for the cosine rule but uses an angle of 57° instead of 42°. Therefore, only M2 is scored.

This form of the cosine rule, but with an angle of 42°, scored 3 marks. If the distance was then evaluated as 3345 to 3350 km then full marks were given.

Exemplar 2

2 marks

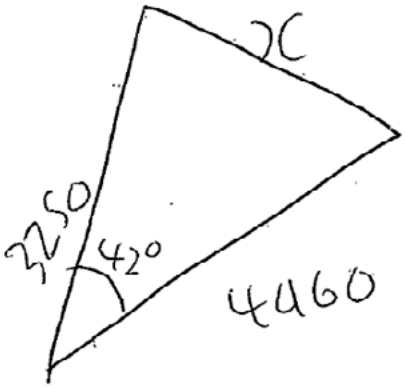


Examiner commentary

The candidate has used an angle of 42° in the cosine rule. However, rearrangement is needed to obtain the distance and so only B1M1 is given.

Exemplar 3

1 mark



$c^2 - b^2 = a^2$

$4460^2 - 3250^2 = 14039100$

$\sqrt{\text{ans}} = 3746.878701$

≈ 3746

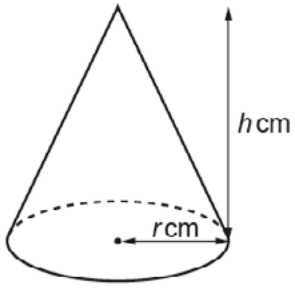
(b) 3747
~~3746~~ km **[4]**

Examiner commentary

Like many candidates, this candidate has incorrectly assumed a right-angled triangle and applied Pythagoras' theorem rather than the cosine rule. They score B1 for finding angle 42°.

Question 18

18 A cone has radius r cm and height h cm.



The height is three times the radius.
The volume of the cone is $2100\,\text{cm}^3$.

Calculate the radius of the cone.

[The volume V of a cone with radius r and height h is $V = \frac{1}{3}\pi r^2 h$.]

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

Exemplar 1

4 marks

$h = 3r$

$V = \frac{1}{3}\pi r^2 \times 3r$

$2100 = \frac{\pi r^2 \times 3r}{3}$

$6300 = \pi r^2 \times 3r$

$\frac{6300}{3\pi} = r^2 \times r$

$\sqrt[3]{\frac{6300}{3\pi}} = r$

$r = 8.7$

8.7 cm **[4]**

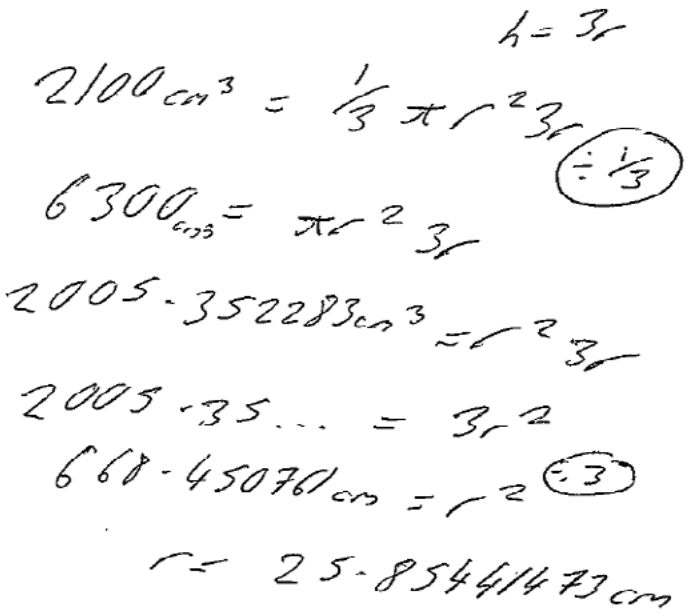
Examiner commentary

The candidate works efficiently and confidently in finding r and scores full marks. Most candidates switched to working in decimals, which is fine provided they do not round prematurely.

The expected answer was 8.74[…] but 8.7 was accepted if supported by full working. Candidates using trials needed to reach 8.74.

Exemplar 2

2 marks



25.85441473 cm [4]

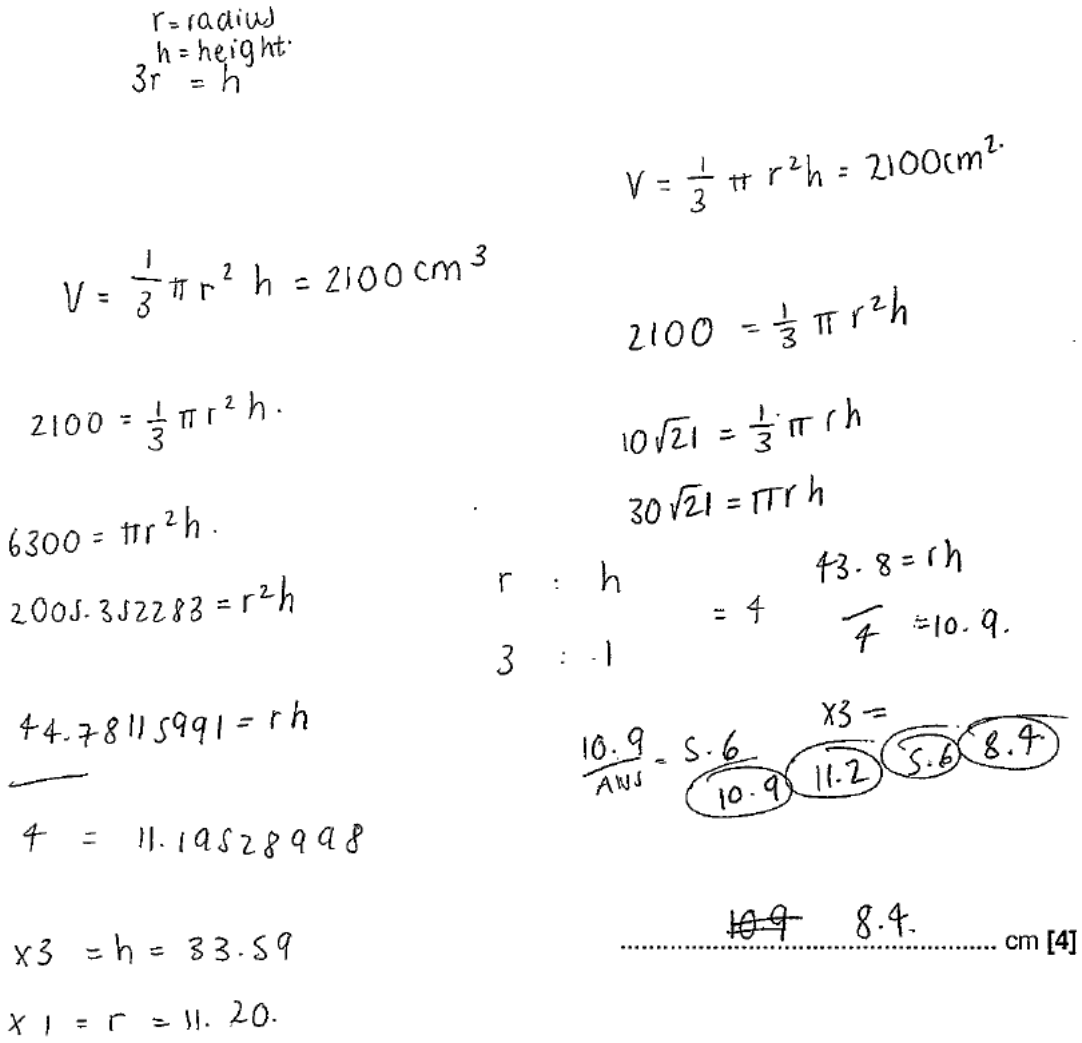
Examiner commentary

The candidate creates a correct equation in r, scoring M2.

Many candidates were subsequently unable to solve the resulting cubic equation. This candidate does not reach r^3 and so does not encounter the problem of needing to use a cube root.

Exemplar 3

0 marks



Examiner commentary

This candidate has two attempts but, working back from the answer line, it is the method on the right hand side of the page that is marked. In fact, both attempts score 0 and show two of the most common mistakes.

In the attempt on the left, they reach the correct 2005.35… = r^2h but, as yet, do not have an expression or equation in terms of just one variable. Therefore, no marks have been achieved. They then square root and make an error in the algebra. The rather unclear division by 4 is because they now think that $rh = 4r$ and so they finish by dividing 44.78…. in the ratio 1 : 3.

In the attempt on the right, they perform the square root at an earlier stage and go wrong, followed again by $rh = 4r$. No marks are achieved.

Question 19 (a)

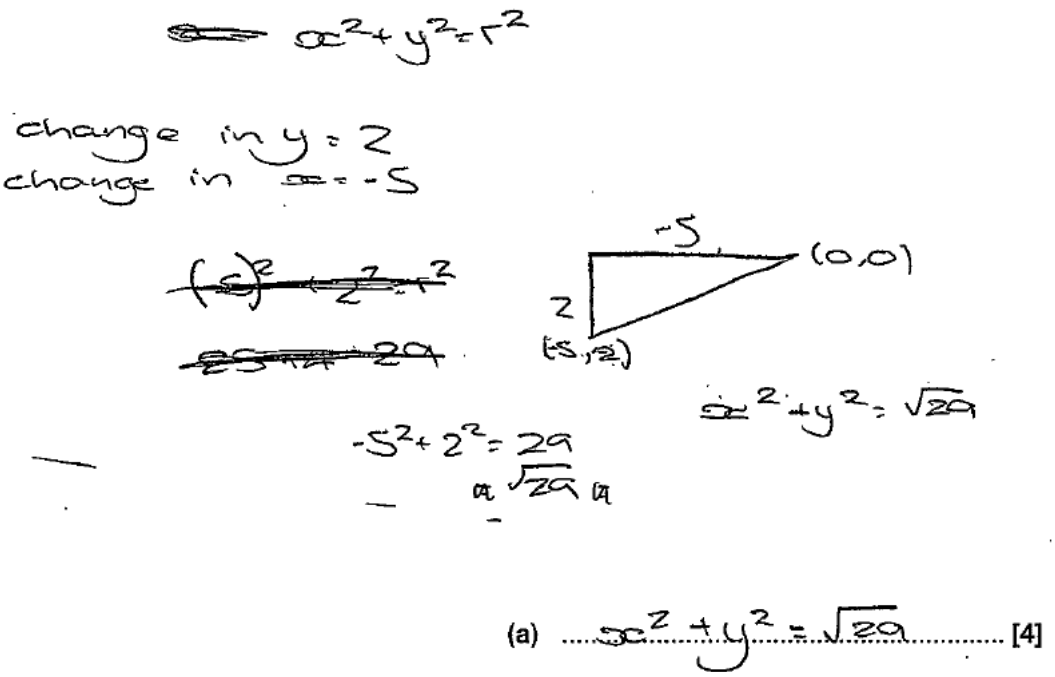
19 The point (-5, 2) lies on the circumference of a circle, centre (0, 0).

(a) Find the equation of the circle.

(a) ..... **[4]**

Exemplar 1

3 marks



(a) $x^2+y^2=\sqrt{29}$ **[4]**

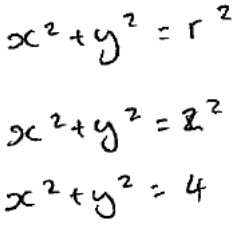
Examiner commentary

This response scores 3 marks. The candidate has used Pythagoras' theorem to obtain 29, scoring B2 ($\sqrt{29}$ or 5.38[5….] to 5.39 were also allowed for B2). The final answer is of the form $x^2 + y^2 = k$, where $k > 0$, and so another B1 is given.

$x^2 + y^2 = 5.38^2$ was often seen as the final answer. Although perhaps better than this exemplar, they have lost accuracy and so also scored 3 marks.

Exemplar 2

1 mark



Examiner commentary

There is no attempt to use Pythagoras' theorem to find the radius. The candidate scores B1 for the form $x^2 + y^2 = k$, where $k > 0$.

Question 19 (b)

(b) Work out the gradient of the tangent to the circle at $(-5, 2)$.

(b) ..... **[2]**

Exemplar 1

1 mark

radius of circle = 5

$-\frac{5}{2}$

$-2 \cdot 5 \times$ = gradient

neg. recip.

$y = \frac{2}{5}x + 2$ $y = mx + c$.

x y

$(-5, 2)$

$-5 \times \frac{2}{5} = -2 + 4 = 2$

(b) $y = \frac{2}{5}x + 2$ **[2]**

Examiner commentary

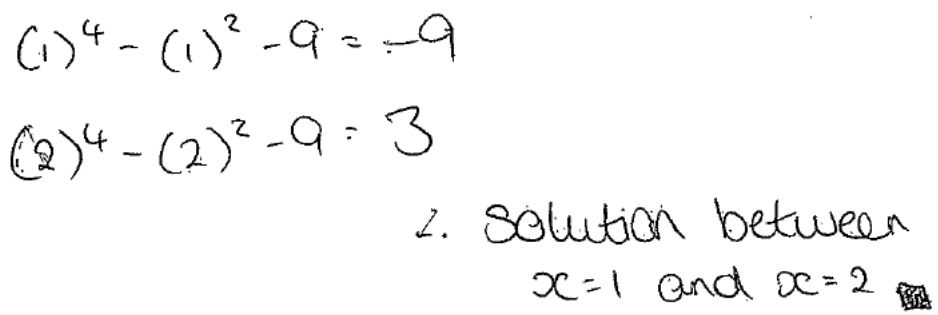
The candidate has the gradient of the radius inverted but correctly applies $m_1 m_2 = -1$ and so scores M1.

Question 20 (a)

20 (a) Show that the equation $x^4 - x^2 - 9 = 0$ has a solution between $x = 1$ and $x = 2$. **[3]**

Exemplar 1

2 marks



Examiner commentary

The candidate scores M1 for substitution of either $x = 1$ or $x = 2$ and another M1 for the correct evaluation of both.

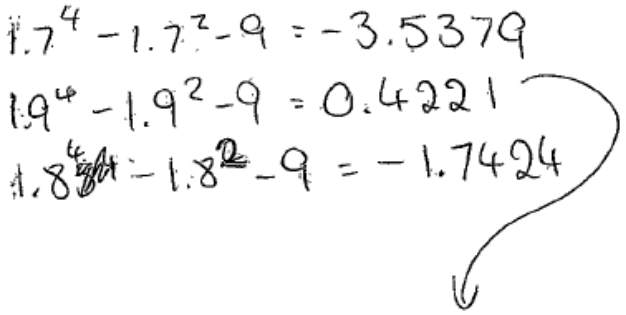
To receive full marks, they need to explain why this means x lies between 1 and 2. Acceptable explanations included "sign change" and "$-9 < 0 < 3$".

Question 20 (b)

(b) Find this solution correct to 1 decimal place.
Show your working.

(b) $x =$ ..... **[4]**

Exemplar 1 — 3 marks



Closest to 0

∴ solution correct to 1dp

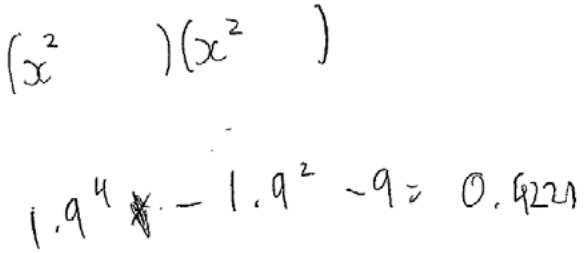
(b) $x =$ 1.9 **[4]**

Examiner commentary

The candidate has two correct evaluations for $1 < x < 2$, one which gives a positive value and the other giving a negative value. This scores M2. The A1 mark for the correct answer of 1.9 is dependent on at least M2 and so can be given.

For full marks, the two evaluations needed to be for $1.85 \leq x \leq 1.95$, one giving a positive value and the other a negative value. It was not sufficient to say "closest to 0".

Exemplar 2 — 1 mark



(b) $x =$ 1.9 **[4]**

Examiner commentary

Although the answer is correct, it is not justified by sufficient trials. It scores M1 for one correct evaluation for $1 < x < 2$. An award of A1 for the answer is dependent on M2 and, therefore, is not given.

Had there also been a correct trial for $1 < x < 1.85$ then M2A1 would have been scored. If that trial had used $x \geq 1.85$ and resulted in a negative answer, then M3A1 would have been scored.

In the absence of any working, an answer of 1.9 was given SC1.

Question 21

21 Toy building bricks are available in two sizes, small and large.
The small and large bricks are mathematically similar.

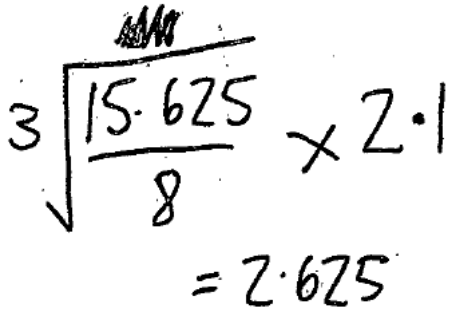
A small brick has volume $8\,cm^3$ and width 2.1 cm.
A large brick has volume $15.625\,cm^3$.

Calculate the width of a large brick.

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

Exemplar 1

4 marks



Examiner commentary

The candidate shows the full method in one statement and has the correct answer. They score full marks.

Most candidates did this processing in steps, sometimes making a rounding error. However, they could still score all the method marks. The volume scale factor $\frac{15.625}{8}$ scored M1. Cube rooting to find the length scale factor scored M1 and then multiplying the length factor by 2.1 scored M1.

The vast majority of candidates evaluated the volume factor as 1.95…., which is fine provided they do not round prematurely.

Exemplar 2

1 mark

$\frac{15.625}{8} = 1.953125$

$\times 2.1 = 4.1015625$

$\frac{8}{2.1} = 3.809523381.$

$\frac{15.625}{4.1015625} = 3.809523381.$

4.1 ..... cm [4]

Examiner commentary

This is a fairly typical, confused, response. The candidate scores M1 for finding the volume factor. The remaining work is probably a check.

Some candidates started with $\frac{8}{2.1}$, as seen in the check, followed by $\frac{15.625}{3.809...}$. This is equivalent to the method at the top and also scores M1 because the volume scale factor is embedded within the working.

If the method was absent or could not be identified, then an SC1 would have been given for the answer of 4.1, accepting 4.1 to 4.11.

Question 22 (a)

22 At the start of 2018, the population of a town was 17 150.
At the start of 2019, the population of the town was 16 807.

It is assumed that the population of the town is given by the formula

$$P = ar^t$$

where P is the population of the town t years after the start of 2018.

(a) Write down the value of a.

(a) ..... **[1]**

Exemplar 1

0 marks

17150 ÷ 0.98 = 17500

17500

(a) 16807 **[1]**

Examiner commentary

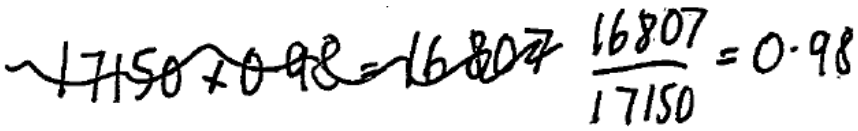
Most candidates wrote down the correct answer of 17150.

The demand "write down" suggests that no calculation should be needed. 17500 was the most common of the wrong answers, as shown in this exemplar, and some working was needed to obtain it. That should suggest to the candidate that they may have gone wrong.

Question 22 (b)

(b) Show that $r = 0.98$. **[1]**

Exemplar 1 1 mark



Examiner commentary

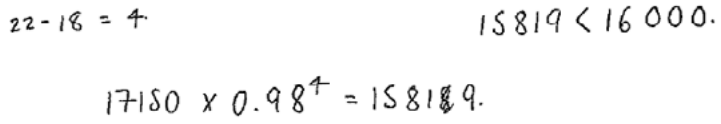
The candidate correctly settles on finding the multiplier from year 2018 to year 2019. This is preferable to the crossed-out embedded verification.

Crossing out replaced work is important. Here it does not matter as both responses would receive the mark, but normally the lower scoring attempt will count if the examiner is left with a choice.

Question 22 (c)

(c) Show that the population is predicted to be less than 16 000 at the start of 2022. **[2]**

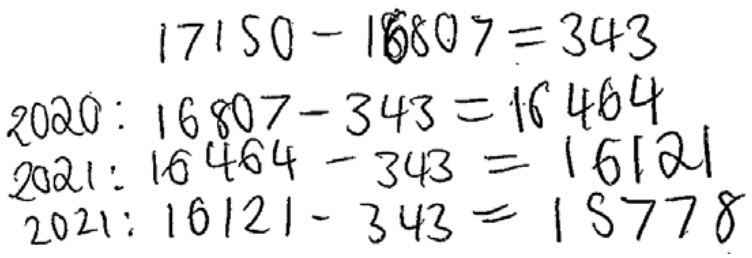
Exemplar 1 — 2 marks



Examiner commentary

The candidate shows the correct method of 17150×0.98^4 and evaluates it as 15 818 to 15 819 for 2 marks. For completeness, the candidate shows the comparison with 16 000. On another occasion, a comparison might be worth a mark in a "show" question and so it is best practice to always include it.

Exemplar 2 — 0 marks



Examiner commentary

The candidate has found the difference between the populations in 2019 and 2018 and then used this to produce an arithmetic sequence rather than using the given exponential formula. This response scores 0 marks.

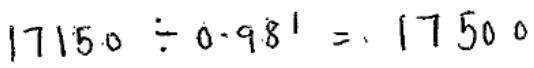
Question 22 (d)

(d) Use the formula to work out what the population might have been at the start of 2017.

(d) ..... [2]

Exemplar 1

2 marks



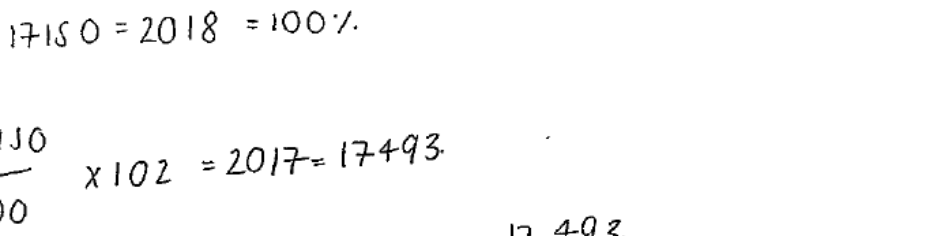
(d) 17500 [2]

Examiner commentary

The mark scheme states "17 150 × 0.98^{-1} oe" (or equivalent). The correct answer of 17 500, therefore, is from an equivalent method and 2 marks are given.

Exemplar 2

0 marks



(d) 17 493 [2]

Examiner commentary

This exemplar shows the most common wrong method where the candidate increases 17 150 by 2%. Even if they had rounded their answer to 17 500, the method is still invalid and would score 0 marks.

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