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Examiners' report

QUANTITATIVE PROBLEM SOLVING (MEI)

H867
For first teaching in 2015

H867/01 Summer 2019 series

Version 1

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. 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 can be downloaded from OCR.

Paper 1 series overview

The great majority of candidates were able to attempt all the questions. Overall, candidates had the opportunity to show what they could achieve in this examination.

The mean omission rate this session is slightly higher than last session, but this was only marginally significant. Question 5(i)(D) had the highest omission rate and was not attempted by nearly 1 in 5 of all candidates. The mean mark for this paper is statistically significantly higher than the previous paper. By their very nature it is almost impossible to objectively compare the difficulty of these heavily contextualised questions.

Well over three quarters of candidates scored more than a half of the available credit while slightly more than 1 in a 100 gained less than a quarter of the marks available. There was no firm evidence that a significant proportion of candidates were denied credit by virtue of any literacy demands. The only question that might have had an unintentional interpretation was Question 3(iv)(C) in which a small minority of candidates appeared to interpret "How much interest in total" to mean "overall percentage interest" rather than the sum of money paid as interest.

In the main numbers were clearly written. Written explanations were usually understandable with only very occasional instances of almost illegible writing. Although the explanations required for Question 2(ii) and 2(iv)(C) were found challenging, candidates coped confidently with the literacy demands inherent in Question 1(iv).

Overall, the lowest attaining candidates found the questions in order of difficulty, easiest first (judged on facility) 4, 1, 3, 5, 2 and 6. For the highest attainers the corresponding order was 1, 4, 5 , 2, 3 and 6 – no significant difference.

Areas of content which were found most challenging included: using equations involving standard form and square roots Q6(i)(B), interpreting payback times within a context Q3(iv)(B), using a log/linear graph Q5(i)(C) and calculating weighted means Q2(iii).

Areas where candidates performed well were: extracting information from charts or tables and interpreting it Q3(i)(B), Q1(iv), Q3(i)(A), Q4(i)(A and B) and Q5(i)(A and B), working with percentages – both simple and compound Q1(ii) and Q3(i)(B), using and interpreting simple formulae Q4(iii)(A) and finding measures of statistical location Q5(ii)(B and C).

Looking at the paper as a whole there are several questions where credit could have been lost by incorrect rounding, even though in some instances the rounding mark was available as a follow through. In several cases there was a distinct command to round: Q1(i)(C), Q1(ii), Q1(iii)(A), Q2(iii) and Q3(iv)(A). In addition, there is a command to give an answer to a sensible accuracy: Q4(ii) and Q5(i)(C). There is also an expectation that money be given correct to two decimal places Q4(i)(C). Taking a really worst case, ignoring or not giving numerical answers to the correct accuracy, could have resulted in the loss of almost 10% of the total available marks.

Reflection on answers could prevent unnecessary loss of credit or at least flag to candidates that all may not be well. Wherever possible questions involve real-life situations and quantifies. While fully appreciating it is not possible that they always form part of candidates' life experience a critical attitude to the magnitudes of quantities can help. To quote some examples where wrong answers should have been picked up had candidates taken the time to reflect on the sensibleness of their answers:

- Probabilities greater than 1 are impossible; Q1(i)(B).
- Although compound interest does grow quickly, £1 000 invested at 2% compound for ten years is unlikely to grow to £6 000; Q1(ii).

- If £1 is equivalent to US$1.41, US$1.90 is unlikely to be worth £2.68; Q4(i)(C).
- The average wealth of a single human is unlikely to be anywhere near US$3 × 10^{-5}; Q4(ii).

Nevertheless questions like Q6 by their very nature (and design) force candidates to rely on their mathematics alone.

The other, all too obvious, strategy is to re-read both question and answer. This should pick up any missed rounding commands as well as ensuring that the question has in fact been answered , e.g. Q3(iv)(B), Q4(i)(D), Q4(ii).

Question 1 (i) (a)

1 **This question refers to the article A in the pre-release material, 'Making an investment'. You can find the article on the insert accompanying this paper.**

Andy wants to invest £1000 for 10 years for his grandchildren.

He considers these three ways.

- Buy £1000 worth of Premium Bonds.
- Put £1000 in a savings account.
- Buy £1000 worth of gold.

(i) (*A*) On average £1000 worth of Premium Bonds will win £120 over 10 years.

What percentage profit is this over the ten years? **[1]**

A well answered item with over three quarters of candidates successful. However, a small but noticeable proportion of candidates showed insecurities regarding percentages. Common wrong responses included 120% or 1.2%. Some of these errors may well have been the result of first question nerves.

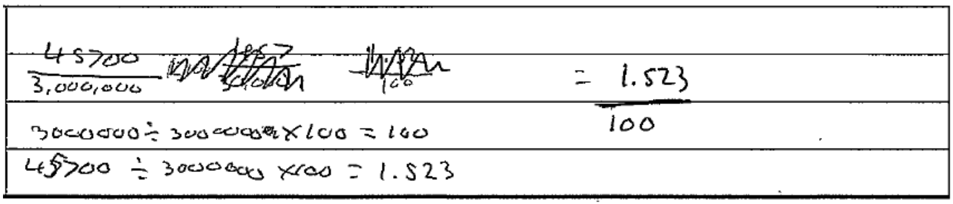
Question 1 (i) (b)

(*B*) There are currently a total of about 45 700 million Premium Bonds. Each month about 3 million Premium Bonds win a prize.

What is the probability of a particular bond winning a prize in a given month? **[2]**

Just over half the candidates gained full credit although about a fifth did not gain any credit. Problems appeared to originate in the fact that the units employed in the question were millions. There were instances where the millions were ignored for one of the quantities and not the other producing very large or very small final answers.

Exemplar 1



A common error involving confusion over large numbers coupled with a probability greater than 1, which the candidate may have realised and divided by 100 to disguise.

Question 1 (i) (c)

(*C*) One month 2 932 798 Premium Bonds win prizes.
The frequency of the different possible prizes is given in the pre-release material in Table A2.

A particular Premium Bond wins a prize.

What is the probability that the prize is more than £1000?
Write your answer in the form 1 in n.
Give n to the nearest 1000. **[2]**

This was a poorly answered question with just over half of candidates gaining any credit. It appeared that a significant proportion of candidates were not confident in working with probabilities expressed in the 1 in *n* form. A number appeared to understand the question as asking for the overall probability of winning a prize of more than £1 000, rather than the conditional probability demanded by the question.

Question 1 (ii)

(ii) £1000 is invested in a savings account paying 2% compound interest annually.

How much is it worth at the end of 10 years?
Give your answer to the nearest £. **[3]**

A well answered question; working was usually crisp and clear to follow. The great majority of candidates recognised that compound interest was involved – rather than simple interest. This was felt to be an improvement on previous years. There were a few instances of candidates working out the value piecemeal year by year, partial credit was available for these approaches providing the first few steps were correct.

Question 1 (iii) (a)

(iii) Andy obtains some figures for the annual average price of gold in £ per troy ounce.
In 2000 the cost of gold was £183.70 per troy ounce. This price was indexed as 100.

(*A*) In 2017 the price of gold was £980.50 per troy ounce.

What was the indexed price of gold in 2017?
Give your answer to the nearest whole number. **[3]**

A moderately well answered question, but one which was omitted by just less than 1 in 20 candidates. Most errors involved attempts based on using figures for 2016 from the graph in (iii)(B), rather than the information given in the question. A small but noticeable proportion of candidates did not respond to the request to round the final answer to the next whole number, thereby losing credit unnecessarily.

Question 1 (iii) (b)

The graph in Fig. 1.1 shows how the indexed price of gold changed from 2000 to 2016.

(*B*) Plot the point for 2017. **[1]**

1 (iii) (*B*)

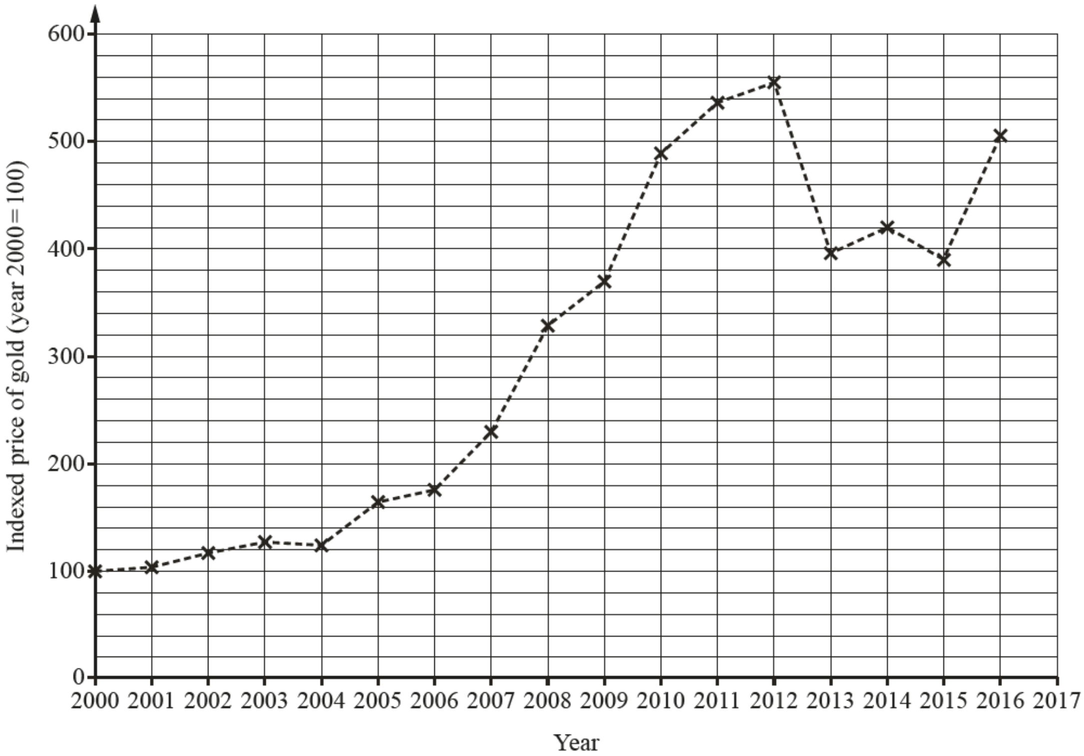


Fig. 1.1

Well answered with full follow through from the previous part. For some reason there were a few who did not attempt the question even though they had gained full credit on the previous question.

Question 1 (iv)

(iv) Tick the box of the investment you would advise Andy to choose.
Give an advantage for the investment you advised and a disadvantage for each of the other two investments. **[3]**

1 (iv)

Premium Bonds ☐

....

....

Savings account ☐

....

....

Buying gold ☐

....

....

A very well answered item which produced some quite thoughtful responses – a large majority gained full credit. This was probably because many used their own life experiences. Very few candidates did not gain any credit and there were very few contradictory comments.

Question 2 (i)

2 Janine has started to sell jewellery online.
Customers are asked to complete the online form shown in Fig. 2.1.

> Please rate your recent purchase experience from Janine's Jewels.
> Click on the number of stars you think it rates. ☆ ☆ ☆ ☆ ☆
> Thank you.

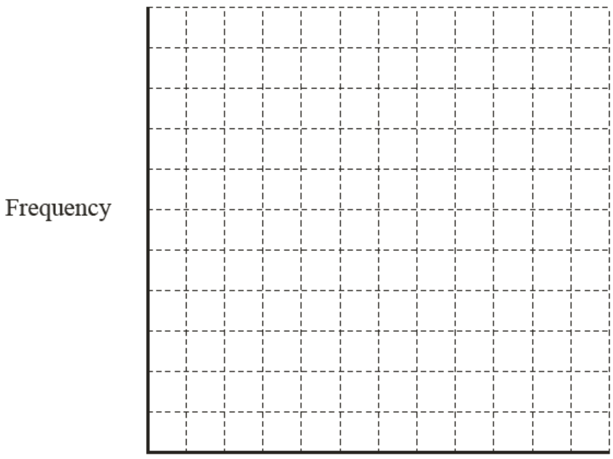
Fig. 2.1

(i) Janine records the number of stars. Here are the results for a week.

2	4	4	2	1	5	2	1	1	5
4	4	2	4	4	2	2	5	4	2

Use this grid to draw a dot plot of these figures. **[2]**

2 (i)



Somewhat surprisingly only a very small minority drew dot plots, although they are specifically mentioned in the specification. In order to reward partial understanding, bar charts and single point plots were condoned, but line graphs and histograms were not. Nevertheless, sensible axes scales were very largely chosen. Just over half gained full credit.

Question 2 (ii)

(ii) Give one reason why the mean number of stars for the data on the dot plot, which is 3, is not a useful figure for Janine. **[1]**

The large majority gained full credit for this item, possibly because any reference to the lack of a 3-star rating was condoned. Very few responded in as full a manner as expected, i.e. the mean is not representative because it is a bimodal distribution.

Question 2 (iii)

Janine thinks that rating a single feature does not give enough detailed information.
She wants to use the features in Table 2.2. She will combine the stars awarded for the three features to give a mean star score.

However not all features are equally important. She weights the different features as shown in Table 2.2.

Feature	**Weighting**
Jewellery matched the online pictures	4
Prompt delivery of jewellery	2
Quality of packaging	1

Table 2.2

(iii) The responses from a customer are shown in Table 2.3.

Calculate the mean star score, using Janine's weightings, for this customer.
Give your answer correct to 1 decimal place. **[3]**

Feature	**Stars awarded**
Jewellery matched the online pictures	★★★★★
Prompt delivery of jewellery	★★★☆☆
Quality of packaging	★★★★☆

Table 2.3

Only a small minority were completely successful. Although the majority were able to correctly apply the weighting to calculate the mean (5 × 4, 3 × 2 and 4 × 1), selecting the correct divisor was challenging with many choosing 3 rather than 7. Unfortunately, a very small minority did not round their final answer correct to 1 decimal place and thereby needlessly lost some credit.

Question 2 (iv) (a)

Some online shopping companies rank their sellers (vendors) on the mean number of stars they gain. Janine's friend Amber sets up a spreadsheet to find the mean number of stars particular vendors obtain. She uses two vendors to check her spreadsheet.

Chris Craft gained two 5-star ratings.

Jess Jewels gained ten 4-star ratings and thirty 5-star ratings.

(iv) The spreadsheet in Fig. 2.4 shows the results. There is an error somewhere.

	A	B	C	D	E	F	G	H
1	Vendor			Stars				
2		1	2	3	4	5	Total number of stars	Mean
3	Chris Craft	0	0	0	0	2	10	5
4	Jess Jewels	0	0	0	10	30	60	1.5

Fig. 2.4

Fig. 2.5 shows the spreadsheet after the 'Show Formulas' command.

	A	B	C	D	E	F	G	H
1	Vendor			Stars				
2		1	2	3	4	5	Total number of stars	Mean
3	Chris Craft	0	0	0	0	2	=B2*B3+C2*C3+D2*D3+E2*E3+F2*F3	=G3/SUM(B3:F3)
4	Jess Jewels	0	0	0	10	30	=B3*B4+C3*C4+D3*D4+E3*E4+F3*F4	=G4/SUM(B4:F4)

Fig. 2.5

(*A*) In which cell is the wrong formula? **[1]**

Only a very small minority experienced difficulties with this question. Although it is difficult to be certain, it appeared that candidates were more familiar with spreadsheet notation than in the previous sessions.

Question 2 (iv) (b)

(*B*) Write down the correct formula. **[2]**

The majority of responses were correct, but with a small minority omitting the "=" in an otherwise correct solution. In common with previous sessions correct spreadsheet notation was required i.e. "*" (asterisks) rather than "×" (multiplication symbol).

Question 2 (iv) (c)

(*C*) The spreadsheet formula is corrected.
Vendors are put in rank order based on their mean number of stars.
This is shown in Table 2.6.

Vendor	Stars					Mean number of stars	Ranking
	1	2	3	4	5		
R	0	0	0	0	1	5	1
T	0	0	0	65	65	4.5	2
W	0	0	1	1	2	4.25	3
S	0	0	0	250	0	4	4
U	0	0	25	13	2	3.425	5

Table 2.6

Janine and Amber do not think that ranking vendors by using the mean number of stars they gained is appropriate.

Use the results in Table 2.6 to suggest why they might think this. **[1]**

This proved too challenging for a significant minority of candidates. Some gave reasons based purely on the number of stars or responded with the stock phrase "sample size too small" without further amplification. In some cases credit might have been gained had candidates used numerical examples from the table to support or clarify their explanations.

Question 3 (i) (a)

3 This question refers to the articles A and E in the pre-release material, 'Making an investment' and 'Electrical energy'. You can find these articles on the insert accompanying this paper.

Amy lives in Glasgow. She is considering putting in solar panels and finds the information in Table 3.1 online.

Year	Megawatts of power generated by solar panels	Average cost (US$) to produce 1 watt of power from a solar panel
1975	0.4	100
1980	8	30
1985	100	10
1990	200	8
1995	700	5
2000	2000	3
2010	14 000	1.5
2015	300 000	0.4

Table 3.1

(i) **(*A*)** By how much did the average cost to produce 1 watt of power from a solar panel drop between 1975 and 1995? **[1]**

A large majority – of all capabilities – were successful.

Question 3 (i) (b)

(*B*) There is a rough rule called Swanson's Rule which states that:
'The average cost to produce 1 watt of power from a solar panel decreases by 20% when the total power generated by solar panels doubles'.

Find a pair of years in the table where this is true. **[1]**

Slightly better answered than the previous item with a very large majority of all capabilities gaining full credit.

Question 3 (ii) (a)

(ii) Amy decides to buy eight solar panels, but wonders if there is enough sunlight.
She finds the chart Fig. 3.2 online.
It shows the average daily solar energy per square metre for Glasgow for each month.

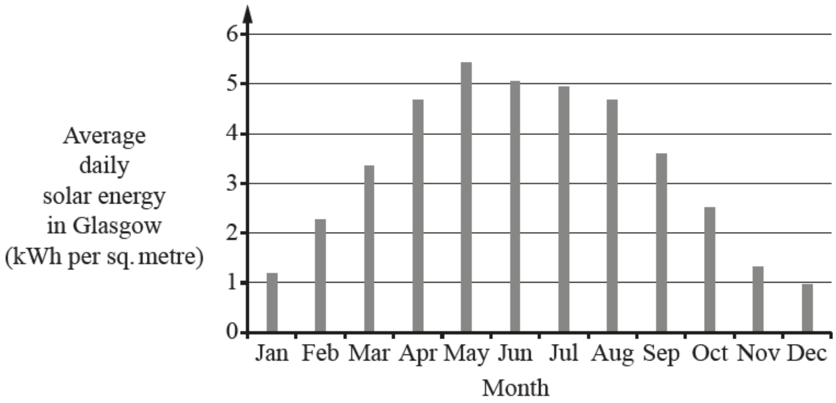


Fig. 3.2

(*A*) Use the chart and some **estimates** to work out a **rough figure** for the total yearly solar energy per square metre in Glasgow.

Show clearly any estimations or assumptions you make. **[3]**

Only about a fifth of candidates were completely successful with this item, a very small minority. The origin of this was almost certainly confusion between "average daily solar flux" for each month, as shown in the chart and the "average daily flux" which is multiplied by 365 to give the annual solar flux. The majority calculated in effect the average monthly solar flux (about 40 kW per sq. metre) and gained partial credit for this. It was expected that candidates would estimate an average daily solar flux of about 3 to 4 kW per square metre visually from the chart, and multiply this figure by 365, but this was rarely the case.

Exemplar 2

1.2 + 2.2 + 3.4 + 4.6 + 5.5 + 5 + 5 +
4.8 + 3.6 + 2.5 + 1.3 + 1 = 40 kWh
per sq metre

A typical example of confusion between daily/monthly/yearly rainfall; but still gaining a special case mark for "40"; very common.

Question 3 (ii) (b)

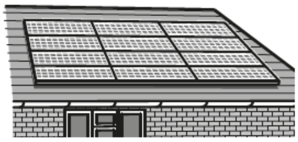
(*B*) Solar panels only convert 25% solar energy into electrical energy.

How much electrical energy would each square metre of solar panel in Glasgow produce in a year? **[1]**

This straightforward command to calculate 25% of the previous response was successfully done by the very large majority – as might have been expected. A large majority of the lowest attainers were successful. The most common error was to calculate 75% of the annual solar flux.

Question 3 (iii)

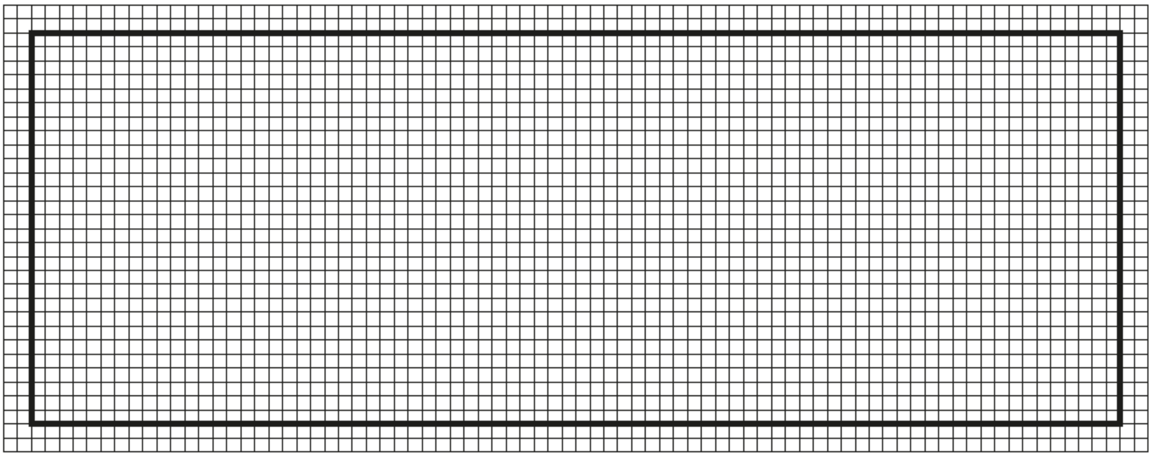
(iii) The solar panels are rectangular each measuring 1665 mm by 991 mm.
They must be at least 30 cm from the roof's edge.
This is to protect them from the wind.



Amy measures her roof. It is 2.8 m by 7.8 m.

Make a scale drawing showing how the eight solar panels could be arranged. **[3]**

3 (iii)



2 cm represents 1 m

Erratum notice

Turn to **page 12** of the **question paper** and look at the text below the scale drawing in **question 3(iii)**.

Cross out '2cm represents 1m' and replace with 'The side length of a small square represents 10cm'.

A noticeable minority of candidates very obviously sketched the solar panels – making the awarding of credit for use of a correct scale impossible. Nevertheless, the large majority gained at least partial credit or better for the whole item. Perhaps somewhat surprisingly, for what was considered to be a low demand question, about 1 in 50 candidates did not make any attempt at the question. There was no evidence that time was a contributory factor for this.

Question 3 (iv) (a)

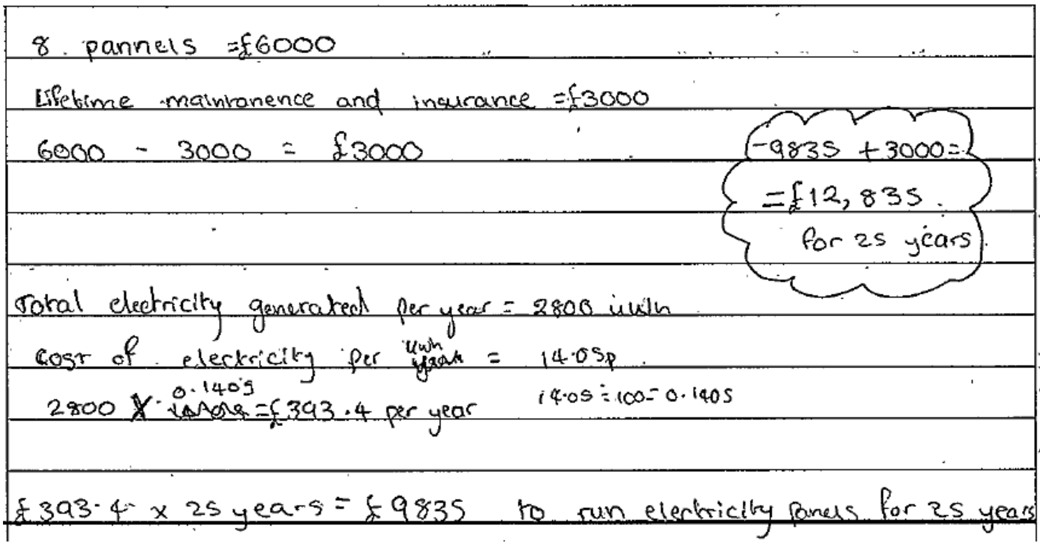
(iv) Amy makes these notes.

- Cost to buy and install 8 panels £6000.
- Special offer of one-off single payment at time of purchase for lifetime maintenance and insurance £3000.
- Lifetime of solar panels about 25 years.
- Total electrical energy generated by the panels a year 2800 kWh.
- Cost of electricity from electricity company 14.05p a kWh.
- Assume that all the electricity generated will be used.

(A) If Amy goes ahead and has the 8 solar panels fitted, what will her payback time be? Give your answer to the nearest year. **[4]**

It was evident from responses that candidates had used the pre-release materials and understood the concept of payback time. As a result, a very large majority gained partial credit or better. A small minority omitted to consider the one-off payment as a cost. The other common error was in calculating the overall saving in electricity cost by using solar panels. In common with some other items where a rounding request was asked, credit was needlessly lost by not giving the answer to the nearest year.

Exemplar 3


8 . pannels =£6000
Lifetime maintanence and insurance =£3000
6000 - 3000 = £3000
-9835 +3000= =£12,835. for 25 years
Total electricity generated per year = 2800 kwh
Cost of electricity per kwh year = 14.05p
2800 × 0.1405 = £393.4 per year 14.05 ÷ 100 = 0.1405
£393.4 × 25 years = £9835 to run electricity panels for 25 years

Confusion over costs involving maintenance but the working was clear enough to gain credit for calculating the saving in electricity costs.

Question 3 (iv) (b)

(B) Why may the payback time be less than your answer in part *(A)*? **[1]**

A number of candidates fell into the error of assuming lower electricity prices would decrease payback time. In fact, only a small minority were successful with this item. The other common error was to quote greatly increased solar flux due to global warming.

Question 3 (iv) (c)

(*C*) Amy decides to go ahead but she needs to borrow £2000.
She will have to make 12 monthly payments of £44.71 for 4 years.

How much interest in total will Amy have to pay? **[2]**

Unfortunately a very small minority interpreted this question as involving compound interest. Another common error was to interpret the question as being to calculate the percentage interest rather than the actual interest as a sum of money. Partial credit was possible when the later sums of money involved were evident in the working. A majority gained full credit.

Question 4 (i) (a)

4 **This question refers to article B in the pre-release material, 'Measuring poverty'. You can find the article on the insert accompanying this paper.**

(i) The poverty line is set by the World Bank at an income of US$ 1.90 per day.
Table 4.1 gives the percentage of the population of Indonesia who were living below this line. It covers the years between 2000 and 2016.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
% below poverty line	39.8	36.0	23.4	23.3	24.4	21.6	28.0	22.8	21.6

Year	2009	2010	2011	2012	2013	2014	2015	2016
% below poverty line	18.4	15.9	13.6	11.8	9.8	8.3	7.5	6.8

Table 4.1

(*A*) For how many of these years were more than 25% of the population of Indonesia living on US$ 1.90 a day or less? **[1]**

As might have been predicted a very large majority gained full credit.

Question 4 (i) (b)

(*B*) Make one comment about what the data in Table 4.1 show about the percentage of the population of Indonesia living below the poverty line. **[1]**

Initially it had been expected that a little more detail than a mere "decrease over time" or equivalent was needed – however in practice such responses were condoned and applied to the majority of candidates.

Question 4 (i) (c)

(*C*) The current rate of exchange is £1 for US$ 1.41.

How much money, in £, would the poverty line of US$ 1.90 a day be? **[2]**

In common with some other items credit was lost by not rounding the final answer. The actual calculation required was shown correctly by a very large majority.

Question 4 (i) (d)

(*D*) This is a headline from a newspaper.

> About 1 in 10 people in the world living on less than US$ 1.90 a day!

According to the World Bank 700 million people lived on less than US$ 1.90 a day at the time when the headline was printed.
At this time the world population was 7400 million.

Comment on whether the headline is giving a realistic summary of the situation, justifying your answer. **[2]**

Although well answered by a large majority, there was sometimes confusion between "the percentage on less than $1.90 a day" and this information expressed as "1 in so many million on less than $1.90 a day" – they are inversely proportional to each other.

Question 4 (ii)

(ii) According to some large banks the total wealth in the world is US$ 2.56×10^{14}.
The world population is 7.4×10^{9} people.

Use these figures to calculate the average wealth for one person in the world.
Give your answer to a sensible accuracy. **[3]**

The very great majority were confident in handling standard form in this situation. Although a very small minority found the inverse figure, what was perhaps most disappointing about this was that the incredibly low average wealth, about $3 × 10^{-5}, was not commented on or did not prompt the candidates to re-try the question. Unfortunately, sensible accuracy was sometimes interpreted as giving the mantissa to six or more significant figures. Although it was impossible to differentiate between a conscious response and ignoring the actual demand. A small minority gained full credit.

Question 4 (iii) (a)

(iii) Engel's coefficient is used to measure poverty.

$$\text{Engel's coefficient} = \frac{\text{Amount spent on food}}{\text{Total income}}.$$

(It can also be used to measure the poverty of a group of people.
The total amount of money the group spends on food and their total income are used.)

Table 4.2 shows the descriptions used by the United Nations to describe poverty and wealth using Engel's coefficient.

Engel's coefficient, *E*	**UN description**
$E < 0.2$	Extremely wealthy
$0.2 \leqslant E < 0.3$	Rich
$0.3 \leqslant E < 0.4$	Affluent
$0.4 \leqslant E < 0.5$	Moderate prosperity
$0.5 \leqslant E < 0.6$	Only basic needs met
$E \geqslant 0.6$	In poverty

Table 4.2

(*A*) These are the average figures, in Vietnamese dong, for a large sample of households in Vietnam in 2006.

Amount of money spent on food	**Total income**
14 000 000	28 700 000

What is the UN description of Vietnam's state of poverty or wealth? **[2]**

Only a very small minority did not gain any credit and calculating *E* presented no problems. However those candidates who rounded *E* to 0.5 were expected to give the corresponding UN description "only basic needs met". There were no observed cases of place value problems involving the large numbers.

Question 4 (iii) (b)

(*B*) In 2006 the average family in the Philippines spent 58 000 Philippine pesos on food.
In that year the Engel's coefficient was 0.50.

Calculate the average total income for a family in the Philippines in 2006. **[1]**

Accessible to the large majority, as might be expected 29 000 pesos was a common wrong response. The majority looked at the problem as one involving an equation, rather than working out the answer by inspection.

Question 5 (i) (a)

5 This question refers to article C in the pre-release material, 'Cloudiness in rivers, lakes and the sea'. You can find the article on the insert accompanying this paper.

(i) The intensity (brightness) of sunlight deceases as it travels through water.
The graph in Fig. 5.1 models how the intensity of sunlight varies with depth in unpolluted sea water.
The vertical scale is logarithmic.
The intensity at the surface is 100 units.

As a rough rule photosynthesis is not possible with light intensities 0.6 units or less.

(*A*) Plot the point on the graph which shows that the light intensity at a depth of 200 m is 0.6 units. **[1]**

5 (i)(*A*)/(*B*)

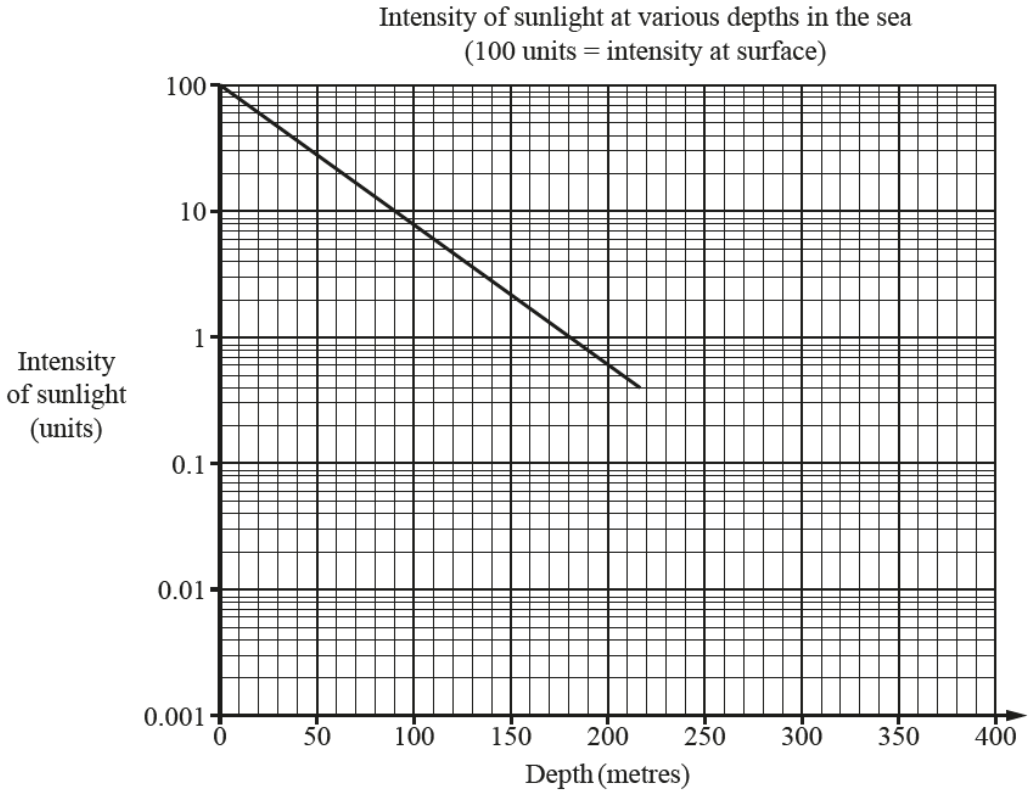


Fig. 5.1

Erratum notice

Now turn to **page 18** of the question paper and look at **question 5(i)**.

Cross out the word 'deceases' and replace it with 'decreases'.

The first line of the question should now read:

'The intensity (brightness) of sunlight decreases as it travels through water.'

Most candidates confidently indicated the correct point unambiguously, although slightly more than 1 in 100 did not attempt the question.

Question 5 (i) (b)

(*B*) Estimate the intensity of sunlight at a depth of 360 m.
Show on the graph how you arrived at your answer. **[2]**

The large majority were successful both in indicating the point and their method. However there was the odd instance of poorly connecting straight line extrapolating the given line and also free hand versions of the same.

Question 5 (i) (c)

(*C*) The extinction coefficient is defined in the pre-release material.

Use the graph in Fig. 5.1 to estimate the extinction coefficient for unpolluted sea water.
Give your answer to a sensible accuracy. **[2]**

A poorly answered question – almost a half of candidates did not gain any credit with 1 in 20 candidates not making any attempt at the question. Many seemed to confuse the unit, m^{-1}, with the actual reciprocal of the depth. Partial credit was available for the reciprocal of the candidate's depth – but only if the latter was clear from the working, which was not the case in many cases.

Question 5 (i) (d)

(*D*) A lake polluted by industrial waste has an extinction coefficient of $4\,m^{-1}$.

At what depth, in cm, in the lake would the intensity of sunlight be reduced to 37 units? **[1]**

A very large majority did not gain any credit. It was impossible to discern the logic behind many of the incorrect answers.

Question 5 (ii) (a)

(ii) The Secchi disc is a simple way to measure how clear water is, as detailed in the pre-release material.

(*A*) In an experiment a Secchi disc is lowered into a river.
The disc ceases to be visible at a depth of 4.5 m.
It becomes visible again at a depth of 4.3 m.

What is the Secchi depth for the river water? **[1]**

The majority were successful, the main source of credit loss was the omission of the correct units for the mean of the two Secchi depths.

Question 5 (ii) (b)

The graph in Fig. 5.2 shows the mean Secchi depths for the largest lakes in Maine, USA each year from 1975 to 2013.

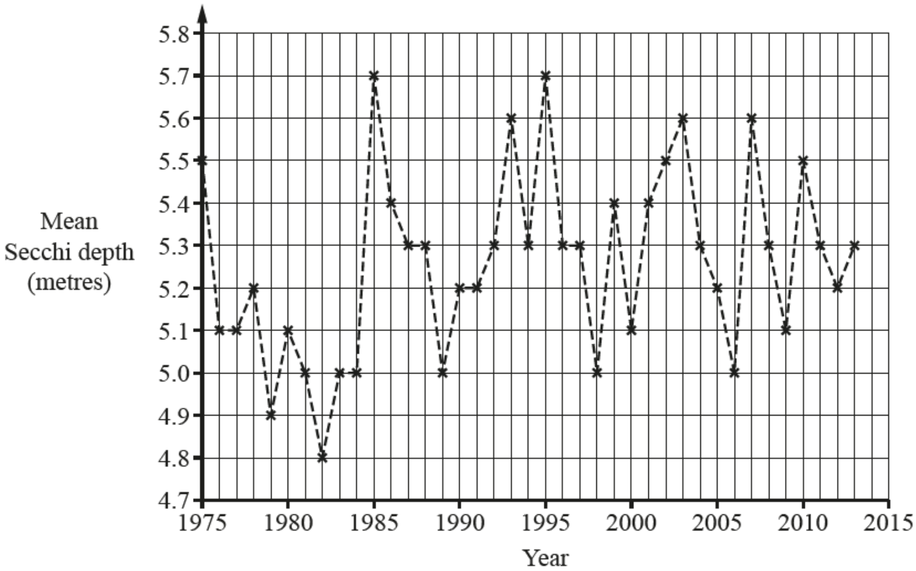


Fig. 5.2

(*B*) In how many years was the mean Secchi depth less than 5.0 metres? **[1]**

Confidently answered by the very large majority, most incorrect responses appeared to be the result of interpreting the question as meaning "Secchi depths of 5 or less metres".

Question 5 (ii) (c)

(*C*) What is the mode of the mean Secchi depths? **[1]**

A very large majority responded correctly, and there appeared to be no obvious reasons behind incorrect responses.

Question 5 (iii)

(iii) It is reasonable to suppose that the extinction coefficient, k, and the Secchi depth, d, are related.

Table 5.3 shows the values of k and d found at five locations.

Location	Crater Lake	Topaz Lake	Lake Superior	Lahontan Reservoir	Mississippi
Extinction coefficient *k* (per metre)	0.06	0.30	0.31	0.81	2.85
Secchi disc depth *d* (metres)	29.6	5.7	5.8	2.1	0.64

Table 5.3

An approximate rule connecting k and d is $kd = c$, where c is a constant.

Show that the rule is realistic for these data and find a suitable value of c. **[3]**

The majority gained full credit and most candidates showed an understanding of the underlying problem. Sets of values of *c* for the various given values of *k* and *d* were apparent as would be expected for a "show that" instruction.

Question 6 (i) (a)

6 **This question refers to article D in the pre-release material, 'The transit method (for detecting exoplanets)'. You can find the article on the insert accompanying this paper.**

(i) Astronomers suspected that a particular star was orbited by a planet. The scatter diagram in Fig. 6.1 shows readings of the brightness of the star at times close to the suspected transit.

(*A*) Draw a curve on the graph that best fits these points. **[1]**

6 (i)(*A*)

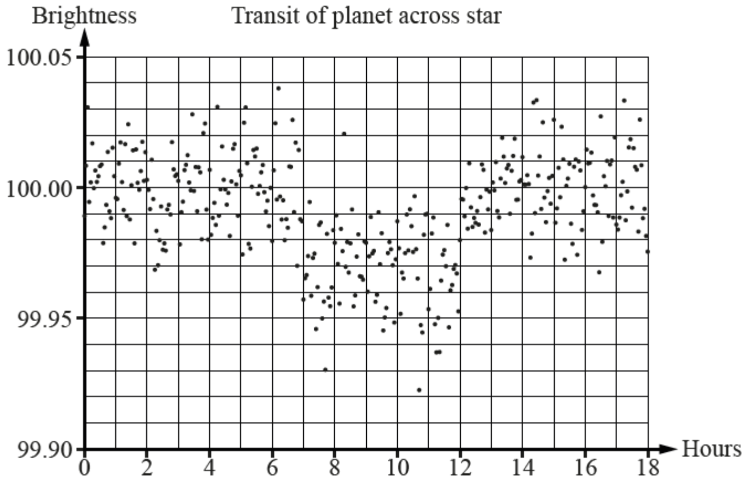


Fig. 6.1

Most candidates were able to draw a reasonable curve of best fit. Credit tended to be lost due to inaccuracy at the extremes, either going completely above or below values in the graph.

Question 6 (i) (b)

(B) Use the formula given in the pre-release material and the curve you drew on Fig. 6.1 to calculate an estimate of the radius of the planet.
The star has a radius of 3.8×10^5 km. **[3]**

This was one of the most challenging questions on the paper, not surprisingly given its arithmetic demands or the numbers involved. Perhaps the most common error was misinterpreting "dip in brightness". Many, despite the pre-release materials, assumed this meant absolute brightness. As a result the relative dip in brightness was something of the order of 0.999 rather than 0.0004. This made it difficult to follow through because many candidates truncated their values, and it was impossible to follow through on their initial values. Nevertheless, there were a minority of very clear and well laid out correct solutions. In addition, in some cases it was clear and pleasing to note that calculations were kept on the calculator and only rounded at the very end.

Exemplar 4

Dip in brightness = $\frac{0.06}{100}$ = $\sqrt{6 \times 10^{-4}}$ =
0.02449489743

$\frac{r}{3.8 \times 10^5}$ = 0.02449489743

$r = (3.8 \times 10^5) \times 0.02449489743 =$
9308.061023 km

An example of a well-executed solution – the candidate could have presented the final response rounded but lost no credit for this as it was not part of the demand. It was good to note the absence of any premature rounding.

Question 6 (i) (c)

(C) A nearly identical dip was observed about a thousand hours after the one above.

How many days does the planet take to orbit the star? **[1]**

Although a large majority were successful, it was somewhat surprising that a small minority could not recall the number of hours in a day correctly.

Question 6 (ii)

(ii) Fig. 6.2 shows the brightness graph of another star.
Observations were made each day for 75 days.

Use the brightness graph to make two deductions about any planets orbiting the star.
Do not do any calculations using the formula given in the pre-release material. **[2]**

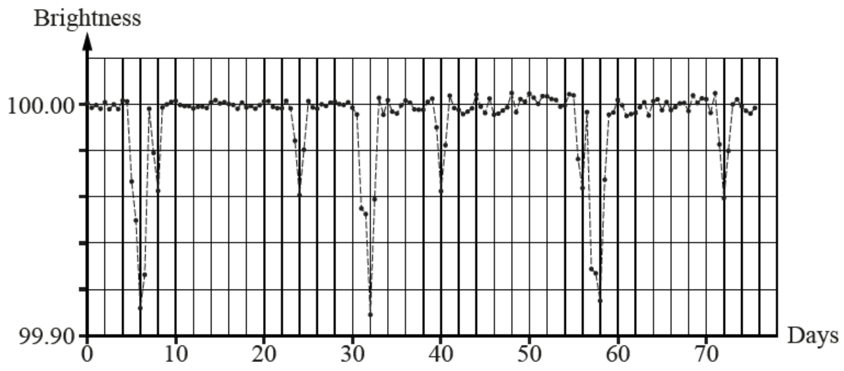


Fig. 6.2

Given the emphasis on making deductions as opposed to mere observations this question was quite well answered. About a third gained full credit but about a sixth of candidates did not attempt it.

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