# Candidate Style Answers

# Statistical Problem Solving

# Medium banded responses

### Introduction

This resource has been produced by a senior member of the Core Maths examining team to offer teachers an insight into how the assessment objectives are applied. It has taken questions from the sample question paper and used them to illustrate how the questions might be answered and provide some commentary on what factors contribute to overall levels.

As these responses have not been through full moderation, they are banded to give an indication of the level of each response. Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

The sample assessment material for these answers and commentary can be found on the Core Maths web page and accessed via the following link: <https://www.ocr.org.uk/qualifications/core-maths/b-mei-level-3-certificate-h869/assessment/>

### Question 1

A biologist is concerned about the possible decline in numbers of a type of bird in a wood. The bird eats insects and the biologist thinks that the use of insecticides on nearby fields may be one of the causes of the possible decline.

The biologist observes 12 female birds during the breeding season and counts the number of fledglings (young that leave their nests). The results are shown on this chart.

Question 1 graph

She applies the following modelling assumptions to this situation.

* Half of the fledglings are male and half are female.
* 75% of the fledglings will be taken by predators before they are old enough to breed.
* A female breeds three times in her lifetime.
* A female breeds once a year.

**(i)** Show that these observations and modelling assumptions lead to the conclusion that the birds will reduce in numbers.

**[4]**

**(ii)** Is there good evidence for the biologist to ask the farmer to stop using insecticides on the fields near the wood? Give three comments.

**[3]**

### Sample answer for Question 1

(i) At start, 12 females

New birds, (2 + 3 + 8 + 15) are females = 14

Only 25% of these will survive predators so 25% of 14 = 3.5 breeding females.

This is not enough to replace the 12 females at the start so the population will decline.

(ii) No, a sample size of 12 is quite small; a larger sample would provide stronger evidence.

There may be other factors which affect the number of fledglings which the biologist has not considered, such as climate that particular season.

### Commentary on the answer

(i) This answer has correctly used the information about birds lost to predators and has concentrated on the number of female birds to decide whether replacement takes place. However, the answer has not taken account of the assumption ‘a female breeds three times in her lifetime’.

(ii) This answer has two correct distinct comments; the reference to insufficient evidence and the realisation that other factors could be the cause. However, three comments were asked for so this gains two out of three marks.

### Question 2 (i)

The residents of a small town find the cost of their house insurance has gone up. The insurance companies say that their risk of flooding is high. A river flows through the town. If the river level rises by more than 2 metres above a given datum level, the town will flood.

Question 2 i image

The residents decide to investigate the situation so that either they can refute the insurance companies’ argument, or they can claim funding for flood defences.

The town’s archives have records going back 120 years giving the greatest height of the water above the datum level each year. The mean of these heights is 0.61 m with standard deviation 0.48 m. One of the residents tries using the Normal distribution to model this situation.

**(i)** Show that using the Normal distribution as a model suggests that the flood risk in this town means that the flood can be described as a ‘Once in 500 years event’.

**[7]**

### Sample answer for Question 2 (i)

(i) Level ~ N(0.61,0.482)





So probability of flood is .

### Commentary on the answer

This answer has used the information that flooding occurs when the water level rises above 2 metres and has made correct use of the Normal distribution to find the probability of this. However, the answer is not complete because it does not show how this relates to once in 500 years.

### Question 2 (ii)

Another resident points out that she has experienced three floods and she is not very old. She draws this frequency diagram using the records of the greatest heights above the datum level from the town’s archives.

Question 2 ii graph

**(ii)** Taking this new information into account, comment on the work the residents have done so far and advise them how they should proceed.

**[3]**

### Sample answer for Question 2 (ii)

(ii) The new information suggests that the model may not be accurate and may need to be refined. I would suggest that they use the data from more recent years only because there may have been changes in the surrounding area which has made flooding more likely, or changes in weather patterns over time.

### Commentary on the answer

This answer has correctly identified that the model may need to be refined and has also correctly suggested that more recent information would be best to use, with a reason. However, there is no reason given for suggesting that the model may need to be refined – “appropriate” would be better as a descriptor rather than “accurate”; models do not need to be accurate, they just need to be helpful. The skewness in the diagram is a strong indicator that a Normal model is not appropriate and this should have been identified and commented on.

### Question 3 (i) & (ii)

A psychology student has devised a test for how conformist people are. It places each person in one of three categories: C, D and N.

C People who will always do what they are told without questioning it.

D People who will only do what they are told without question if they respect the person asking them.

N People who will never do what they are told without first questioning it.

The student tried the test out on groups of rugby followers attending Six Nations matches. He wanted to know if there are differences between the nationalities involved. The test was carried out in bars near the matches and the student bought drinks for some of the participants to get them to take part.

The results are summarised in this table.

|  |  |  |  |
| --- | --- | --- | --- |
| Team supported | C | D | N |
| England | 0 | 0 | 20 |
| France | 6 | 8 | 6 |
| Ireland | 5 | 7 | 8 |
| Italy | 6 | 8 | 6 |
| Scotland | 3 | 11 | 6 |
| Wales | 10 | 5 | 5 |

**(i)** What sampling method did the student use?

**[1]**

**(ii)** The information for England is an outlier. Explain what this means?

**[1]**

### Sample answer for Question 3 (i) & (ii)

(i) Convenience sampling

(ii) England has no data in the C or D, everyone is N, all of the others have some data in C and D.

### Commentary on the answer

(i) Although this answer does not give one of the sampling methods listed in the specification, it is a recognised sampling method which fits the description in the question so this is a correct answer.

(ii) This answer describes the data in a way which is relevant to the question but does not go on to explain the term “outlier”.

### Question 3 (iii) & (iv)

**(iii)** Use the data, with the outlier excluded, to carry out a  test, using a 5% significance level. State clearly your null and alternative hypotheses.

**[9]**

**(iv)** Make two comments on the conduct of the experiment.

**[2]**

### Sample answer for Question 3 (iii) & (iv)

(iii)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Team supported | C | D | N | Totals |
| France | 6 | 8 | 6 | 20 |
| Ireland | 5 | 7 | 8 | 20 |
| Italy | 6 | 8 | 6 | 20 |
| Scotland | 3 | 11 | 6 | 20 |
| Wales | 10 | 5 | 5 | 20 |
| Totals | 30 | 39 | 31 | 100 |

P(C) =  P(D) =  P(N) = 

|  |  |  |  |
| --- | --- | --- | --- |
| Expected frequencies, | **C** | **D** | **N** |
| **France** | 6 | 7.8 | 6.2 |
| **Ireland** | 6 | 7.8 | 6.2 |
| **Italy** | 6 | 7.8 | 6.2 |
| **Scotland** | 6 | 7.8 | 6.2 |
| **Wales** | 6 | 7.8 | 6.2 |

|  |  |  |  |
| --- | --- | --- | --- |
| Contributions to | **C** | **D** | **N** |
| **France** | 0.000 | 0.005 | 0.006 |
| **Ireland** | 0.167 | 0.082 | 0.523 |
| **Italy** | 0.000 | 0.005 | 0.006 |
| **Scotland** | 1.500 | 1.313 | 0.006 |
| **Wales** | 2.667 | 1.005 | 0.232 |

Total of contributions = 7.52

Degrees of freedom = 2 × 5 = 10

5% significance from the chi-squared table for 10df = 18.31

As 7.52 < 18.31 we can assume that the events are independent.

(iv) A sample of 20 is quite small and the rugby fans are more likely to be male.

### Commentary on the answer

(iii) This answer is correct in terms of calculating the chi-squared statistic; this is then tested at 5% significance level. However, the degrees of freedom are not correct and the answer does not include a statement of the null and alternative hypotheses – they were explicitly asked for in the question but, even if they had not been, they should have been included. The conclusion is rather brief and refers to “events” – it is not clear what is meant by this. It is generally best to give the conclusion as a two stage process; first stating the decision whether to reject the null hypothesis or not and then giving this in terms of the original situation – this final statement should make it clear that the decision is made on the basis of the evidence available.

(iv) The second comment in this answer is relevant; the original question was about nationalities but the sample has been about rugby fans – it would be better to go on to say that the sample is unlikely to be representative of the population. The first comment in the answer is not relevant; the sample used was 120 rugby fans; there were 20 from each nation but that is not the sample size. There is quite a lot that could be said about the possible introduction of bias during the experiment.

### Question 4

**(a)** The figures in the column headed “Population” have been summed to give the total of

7 174 654 290. Give two reasons why this is not the present world population.

**[2]**

**(b)** Is it true or false that over a quarter of the world’s population lives in just two countries?

Justify your answer.

**[3]**

**(c)** Use the data provided to compare the number of births per year in Ghana and the UK.

**[4]**

### Sample answer for Question 4

(a) People will have been born since the data was collected, people will have died since the data was collected.

(b)  of 7 174 654 290 ≈ 1.79 bn

China and India

(c) The birth rate in Ghana is 31.4 per thousand compared with 12.22 in the United Kingdom.

### Commentary on the answer

(a) This answer is correct but incomplete; both statements are really the same point i.e. the population could have changed in the time since the data was collected.

(b) This answer correctly works out one quarter of the world’s population and identifies China and India as the two largest countries in terms of population. However, it does not show that the total population of China and India is over one quarter of the world’s population so the answer is not fully justified.

(c) This answer quotes the information in the table for births per thousand. However, it does not work out and compare the required quantities (the number of births per year).

Total = £33.65

### Question 5

In the accompanying data, GDP per capita is given by country.

Explain how you would use the spreadsheet containing the pre-release data to calculate an estimate of the mean GDP per capita for the whole world.

Explain what this figure represents.

Demonstrate your method using data from Japan, Nigeria and Sri Lanka.

**[8]**

### Sample answer for Question 5

I would use the spreadsheet to calculate the total wealth of the world and then divide this number by the population of the world.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| A | B | C | D |  |
| **Country** | **population** | **GDP per capita (US$)** |  |  |
| Niger | 17466172 | 800 | =b2\*c2 |  |
| Japan | 127103388 | 37100 | =b3\*c3 |  |
| Sri Lanka | 21866445 | 6500 | =b4\*c4 |  |
|  | 7174654290 |  | sum (d2:d4) | =d5/b5 |

### Commentary on the answer

The explanation of the method at the start of this answer is correct; however, it is not specific enough – the step taken to calculate the total wealth needs to be stated.

The answer goes on to show a correct method but it is incomplete and has used Niger instead of Nigeria. The answer for GDP per capita for these three countries taken together has not been worked out so the method is incomplete. There is also no statement of what the figure represents.

### Question 6 (i) & (ii)

A research student thinks that valuable insights can be obtained from the data in the tables.

In order to carry out a pilot investigation the student selects the following sample of countries.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Algeria | Brazil | Costa Rica | Poland | Tonga |
| Bangladesh | Cambodia | France | Syria | Zambia |
| Barbados | Canada | New Zealand | Tajikistan |  |

**(i)** Why might the student want to use a sample for a pilot investigation when the full data set is available?

**[1]**

**(ii)** Comment briefly on how it appears this sample was selected.

**[1]**

### Sample answer for Question 6 (i) & (ii)

(i) It would be quicker to work with a smaller set of data.

(ii) Random sample

### Commentary on the answer

(i) This answer is not complete; when calculations are done on a spreadsheet, there is little difference in time taken between 14 countries and all the countries in the data set. The essential point here is that the research student does not yet know what information will be helpful and so a smaller number of countries will be easier to work with to start with.

(ii) This answer is not complete – it misses the essential point that each country chosen is from a different sub-region.

### Question 6 (iii) & (iv)

The student uses this sample to investigate whether there is any association between the birth rate of a country and the life expectancy of its citizens.

**(iii)** Write down null and alternative hypotheses for a 2-tail test.

Carry out a hypothesis test, using Spearman’s rank correlation coefficient. Use a 5% significance level.

**[9]**

**(iv)** The student uses software to work out the product moment correlation coefficient for birth rate and life expectancy for all countries. The result is –0.84. Interpret this figure.

**[2]**

### Sample answer for Question 6 (iii) & (iv)

(iii) H0 = life expectancy and birth rate are not connected in any way

H1 = life expectancy and birth rate are connected in some way

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Country | **Birth rate** | **Life expectancy** | ***Rank(B)*** | ***Rank(L)*** | **d** | **d2** |
| **Algeria** | 23.99 | 76.39 | 63 | 80 | -17 | 289 |
| **Bangladesh** | 21.61 | 70.65 | 76 | 149 | -73 | 5329 |
| **Barbados** | 11.97 | 74.99 | 166 | 102 | 64 | 4096 |
| **Brazil** | 14.72 | 73.28 | 134 | 126 | 8 | 64 |
| **Cambodia** | 24.40 | 63.78 | 60 | 179 | -119 | 14161 |
| Canada | 10.29 | 81.67 | 188 | 14 | 174 | 30276 |
| **Costa Rica** | 16.08 | 78.23 | 123 | 58 | 65 | 4225 |
| **France** | 12.49 | 81.66 | 159 | 15 | 144 | 20736 |
| **New Zealand** | 13.40 | 80.93 | 151 | 26 | 125 | 15625 |
| **Poland** | 9.77 | 76.65 | 200 | 76 | 124 | 15376 |
| **Syria** | 22.76 | 68.41 | 74 | 161 | -87 | 7569 |
| **Tajikistan** | 24.99 | 67.06 | 56 | 166 | -110 | 12100 |
| **Tonga** | 23.55 | 75.82 | 66 | 88 | -22 | 484 |
| **Zambia** | 42.46 | 51.83 | 4 | 216 | -212 | 44944 |
|  |  |  |  |  | Σd2 | 175274 |

*rs* = 

The *rs* critical value for two tailed 5% = 0.5385

384.22 < 0.5385 so the value is significant.

(iv) The product moment result would imply that there is a strong negative correlation between the two variables.

### Commentary on the answer

(iii) In this answer, the hypotheses have not been stated correctly. The null hypothesis should be “There is no association between birth rate and life expectancy”.

Then the ranks from the population have been used instead of ranking the sample values from 1 to 14. The error should have been noticed when a value for the rank correlation coefficient was found that was not between -1 and 1. The correct critical value has been used and the incorrect value of the correlation coefficient has been correctly compared with it. However, having decided that the result is significant, the conclusion has not been expressed in relation to the original context.

(iv) The answer recognises that there is a strong negative correlation but it has not been related to the context.

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