# Candidate Style Answers

# Statistical Problem Solving

# High 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.

3.5 × 3 years gives 10.5 new 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 something peculiar about that year; the farmer may need evidence from more than one year. The birds may catch their insects beyond the farmer’s field. It may not be the pesticides that are to blame something else may have caused the problem.

### 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. It has also made correct use of the information that a female breeds three times to calculate the number of new females that will result.

(ii) This answer has three correct distinct comments; the reference to insufficient evidence, the realisation that other factors could be the cause and that there is no evidence that the birds are eating insects from the fields with pesticide.

### 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 2i 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 .

0.019 ≈  so about once in 500 years

### 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. The answer then shows 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.

Q2ii 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 shows 4 floods in 120 years which suggests that the model may need to be refined. I would 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. The data in the diagram is not symmetrical like the normal distribution, it is skewed.

### 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. The skewness in the diagram is a strong indicator that a Normal model is not appropriate and this has been identified.

### 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) Opportunity sampling

(ii) It is not consistent with the rest of the data.

### 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 sufficiently explains 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) H0 The proportions in each category are independent of nationality

H1 The proportions in each category are not independent of nationality.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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 × 4 = 8

5% significance from the chi-squared table for 8df = 15.51

As 7.52 < 15.51, there is insufficient evidence to reject H0

There is insufficient evidence that there are differences between the nationalities.

(iv) The sample is not representative of the nationalities; rugby fans are more likely to be male, plus as the sample was taken in bars some of the fans may have had alcohol or they may be sat with a group of friends and their answers could have been affected by this.

### Commentary on the answer

(iii) This answer includes a statement of the null and alternative hypothesis and is correct in terms of conducting a chi-squared test at 5% significance level. The conclusion states that there is insufficient evidence to accept the alternate hypothesis relating this back to the original context.

(iv) This answer gives two correct comments, as required. It recognises that the sample may not be representative and that a bar is not ideal for this 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) The figures are given to the nearest person but most population figures are not given as accurately so the data may not be as accurate as it claims to be also the population will have changed since the data were collected.

(b)  of 7 174 654 290 ≈ 1.79 bn

China and India make 1 236 344 631 + 1 355 692 576 = 2 592 037 207

This is more than of the population.

(c) Ghana 25 758 108 × 31.40 ÷ 1000 = 808 804

UK 63 742 977 × 12.22 ÷ 1000 = 778 939

So the numbers are very close.

### Commentary on the answer

(a) This answer is correct and gives two reasons – the possibility of change and also the unreasonable level of accuracy given.

(b) This answer correctly works out one quarter of the world’s population and identifies that China and India together are over one quarter of the world’s population.

(c) This answer works out and compares the required quantities (the number of births per year) in both countries and gives a conclusion related to the answer.

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 make a column for Population × GDP” then sum it and divide by the population of the world.

The figure would be what each person would get if the entire world’s wealth was shared out.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| A | B | C | D |  |
| **Country** | **population** | **GDP per capita (US$)** |  |  |
| Nigeria | 177155754 | 2800 | 4.960 × 1011 |  |
| Japan | 127103388 | 37100 | 4.7155 × 1012 |  |
| Sri Lanka | 21866445 | 6500 | 1.421 ×1011 |  |
|  | 326125587 |  | 5.3537 × 1012 |  |

GDP = 5.3537 × 1012 ÷ 326 125 587 = $16 416

### Commentary on the answer

The explanation of the method at the start of this answer is correct, as is the interpretation of what the answer represents.

The answer goes on to show a correct method for GDP per capita for these three countries together.

### 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) Spotting patterns may be easier with a smaller set of data.

(ii) The sample takes one country from each sub-region.

### Commentary on the answer

(i) The answer gives a valid reason for working with a small data set.

(ii) The answer correctly identifies the sampling method.

### 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 = There is no association between life expectancy and birth rate

H1 = There is an association between life expectancy and birth rate

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Country | **Birth rate** | **Life expectancy** | ***Rank(B)*** | ***Rank(L)*** | **d** | **d2** |
| **Algeria** | 23.99 | 76.39 | 4 | 6 | -2 | 4 |
| **Bangladesh** | 21.61 | 70.65 | 7 | 10 | -3 | 9 |
| **Barbados** | 11.97 | 74.99 | 12 | 8 | 4 | 16 |
| **Brazil** | 14.72 | 73.28 | 9 | 9 | 0 | 0 |
| **Cambodia** | 24.40 | 63.78 | 3 | 13 | -10 | 100 |
| Canada | 10.29 | 81.67 | 13 | 1 | 12 | 144 |
| **Costa Rica** | 16.08 | 78.23 | 8 | 4 | 4 | 16 |
| **France** | 12.49 | 81.66 | 11 | 2 | 9 | 81 |
| **New Zealand** | 13.40 | 80.93 | 10 | 3 | 7 | 49 |
| **Poland** | 9.77 | 76.65 | 14 | 5 | 9 | 81 |
| **Syria** | 22.76 | 68.41 | 6 | 11 | -5 | 25 |
| **Tajikistan** | 24.99 | 67.06 | 2 | 12 | -10 | 100 |
| **Tonga** | 23.55 | 75.82 | 5 | 7 | -2 | 4 |
| **Zambia** | 42.46 | 51.83 | 1 | 14 | -13 | 169 |
|  |  |  |  |  | Σd2 | 798 |

*rs* = 

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

0.754 < 0.5385 so the value is significant.

So reject H0 and accept H1

There is some evidence that birth rate and life expectancy are associated.

(iv) The product moment result would imply that there is a strong negative correlation between the two variables. This suggests that a high birth rate is associated with a low life expectancy.

### Commentary on the answer

(iii) In this answer, the hypotheses are stated correctly.

The correct critical value has been used; the value of the correlation coefficient has been correctly calculated and compared with the critical value. Having decided that the result is significant, the conclusion has been expressed in relation to the original context in a way which recognises that a hypothesis test can never give a definite result.

(iv) The answer recognises that there is a strong negative correlation and has related this to the context.

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