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GCE

Statistics (MEI)

Advanced Subsidiary GCE **AS H132**

Examiners' Reports

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H132/R/11

Oxford Cambridge and RSA Examinations

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Chief Examiner's Report

Attention is again drawn to issues of accuracy of numerical answers. As has been explained previously, while sufficient accuracy is of course essential, gross over-specification betrays a fundamental lack of understanding of statistical processes. For example, it is not useful to quote the value of a test statistic as, say, 1.8413879 merely because that is the number that happens to fall off a candidate's calculator. Such over-specification is now normally penalised on each occurrence by withholding the final accuracy mark. This also applies to probability calculations.

Hard-and-fast rules for specification of accuracy cannot be laid down. Any attempt to do so would often be misleading in individual circumstances and would be liable to cause many "hard cases", which is certainly not the intention. Rather, candidates are expected to act sensibly and intelligently in the light of the problem in hand. Thus in most cases 2 decimal places are likely to be appropriate for calculated values of test statistics. Probabilities however may need to be given to up to 5 significant figures, depending on the problem in hand. Other final numerical answers will probably rarely need to be given to more than 4 significant figures, if that.

It must be emphasised that these guidelines do not apply to intermediate stages of working. Candidates should be alert to the dangers of premature approximation, and always be sure to carry sufficient accuracy in intermediate stages to be confident in the final answer at the end. For example, values of the sample mean and standard deviation are required in the calculation of many test statistics, and these should certainly not be calculated, or reported, to only 2 decimal places. Another example is found in the contributions from individual cells to the usual statistic for a chi-squared test; these contributions may well need to be calculated, and reported, to at least 4 decimal places, even though the final value is reported to only two.

G241 Statistics 1

General Comments

The level of difficulty of the paper appeared to be appropriate for the candidates and there was no evidence of candidates being unable to complete the paper in the allocated time. On the whole, candidates appeared to be well prepared for the paper with relatively few unable to gain many marks. Most candidates supported their numerical answers with appropriate explanations and working. Most candidates had adequate space in the answer booklet without having to use additional sheets. Once again a few candidates over-specified some of their answers, despite recent Examiner's reports warning against this. Please see the comments about this in the Chief Examiner's report.

Many candidates struggled with the hypothesis testing in question 7 and there was still quite a lot of use of using point probabilities in their arguments. Candidates found the unfamiliar style of parts (iv) and (v) particularly challenging. Question 6 provided a valuable source of marks for most candidates, but a rather surprisingly large number of candidates did not score highly on the first three parts of question 8. However question 8(iv)A and B proved too difficult almost all candidates . There were few correct answers to question 1(iii), suggesting that 'midrange' is a measure of average which receives little attention. In question 4(ii) many candidates failed to understand what is required for a probability argument, despite this phrase having been used in past papers.

Comments on Individual Questions

1) In part (i) candidates were able to make a successful start to the paper by realising that the frequency was equal to the frequency density $\times$ class width. Most gained the expected answer of 13 but occasionally the examiners saw 14 (due to a misread of the vertical scale) or 130 (due to not being able to multiply by 1000 correctly).

   In part (ii), the vast majority of candidates recognised that the distribution was positively skewed but some still insist on using the unacceptable terms of 'right skew' or 'symmetrical skew'.

   Part (iii) defeated many candidates. Whilst many understood the idea of the mid-range, few were able to apply it in the context of the question. Very few appreciated that the maximum mid-range could only be found by averaging the highest value in the last class with highest value in the first class to give (4000 + 1000)/2 = 2500. Many wrote (4000 + 0)/2 = 2000 as their response here. Similarly, the minimum mid- range could only be found by averaging the lowest value in the last class with lowest value of the first class to yield (3000 + 0)/2 = 1500.

2) Part (i) was successfully answered by most candidates.

   Many candidates gained only 1 mark out of 3 in part (ii), giving an answer of (1/5) x (1/4) = 1/20, failing to realise that Austen could be picked first followed by Brontë, or vice versa, hence requiring their answer to be multiplied by 2.

3) Part (i) was usually answered correctly, the standard correct response being $(0.75)^6$ = 0.178. However a surprising number of candidates thought that the probability was just 0.75.

In part (ii) the expectation was usually found correctly by multiplication of 0.178 by 50 but occasionally some used 300 instead. Candidates should be reminded not to round their final answer in an expectation calculation. There were too many cases of 8.9 being rounded to 9 which lost the final mark. Candidates who had got the wrong answer to part (i) were allowed a full follow through in part (ii).

4) Part (i) was generally well answered. Candidates who used fractions (in multiples of 1/18) on their probability scale usually scored full marks. Candidates who used decimals made the question more difficult, which often led to inaccurate heights and a loss of one mark. Some candidates lost the first mark due to failure to label both axes.

In part (ii) parts A and B, a significant number of candidates failed to understand the questions by thinking that they had to use the probability distribution given, subtracting the other probabilities from 1, but there was no actual probability argument evident. Those who did begin to identify combinations with a difference of one often did not recognize that the order mattered and then claimed that there were only 18 possible outcomes in order to make the numbers fit the given answer. Most candidates who were successful compiled a two way table of all of the possibilities. A correct numerical method which lacked the essential explanation of where it had come from was fairly commonly seen.

In part (iii), a large majority used a correct method, but a surprising number did not realise that expectation and mean are interchangeable in this context and consequently they divided by 6 or some other number.

5) Many candidates got full marks for their Venn diagram in part (i). A minority failed to subtract 0.11 from 0.41 and 0.14 but even these usually produced two intersecting circles labelled correctly to get the first mark. A few candidates did not work out the probability for the fourth region (0.56).

Part (ii) was answered fairly well and showed that many candidates know how to test for independence, although surprisingly candidates often used the probabilities from their Venn diagram rather than those from the question. Some candidates failed to evaluate 0.14 x 0.41 and consequently lost the accuracy mark. A minority of candidates, having correctly completed the working, then got the conclusion the wrong way round. A small number of candidates used a conditional probability method, not always correctly.

Part (iii) was also answered fairly well, but again a significant number of candidates used the wrong figures from their Venn diagram. An impressively large proportion of candidates did get the correct explanation of what this probability represented but several missed out this mark because they did not explain the conditional probability in the context of the question.

6) In part (i) most candidates found the mean correctly and whilst decimal answers were frequently over-specified candidates gained the mark for giving the answer in fractional form, even if subsequently over-specified. Most candidates made a good attempt at the standard deviation; the main errors were the usual ones - calculating the rmsd instead of the standard deviation, incorrect squaring when calculating $\sum fx^2$ or using n=4 instead of n=70. The number of candidates who simply used the statistical functions on their calculator was fairly small, despite this being the easiest way to do the question.

In part (ii) many candidates found the mean correctly but thought that the standard deviation remained unchanged. Those candidates who understood that standard deviation is a measure of deviation were usually able to see clearly that the deviations would (tend to) be increased. Those who tried to reason their way through the formula usually came to the wrong conclusion. A very few very able candidates correctly said that if the number of gulls laying no eggs was very large (over around 500) then the standard deviation would decrease.

7) Part (i)A was generally answered correctly, although when using the binomial formula, a few candidates forgot to round off sensibly.

Part (i)B was found to be slightly more difficult. Most candidates used tables but some went wrong by calculating $1 - P(X < 1)$ or $1 - P(X \leq 2)$. A reasonable number of candidates first found $P(X = 0)$ and then usually went on to finish off the question correctly.

In part (ii) most candidates correctly stated their hypotheses in terms of p, but then often lost the available mark for defining p. Most were able to give an explanation of the reason for the nature of the alternative hypothesis.

In parts (iii), (iv) and (v), too many candidates forgot to state their conclusions in context. This is required in every exam and so teachers should be careful to instruct their students to do this.

Part (iii) was a relatively easy hypothesis test, since it was a lower tail test. However, many candidates (almost half of the candidature) used point probabilities and thus gained no marks. Of those who gained some credit, most either got full marks, or lost the final mark for conclusion in context.

In part (iv) some candidates wasted a lot of time for these 3 marks, testing out trial distributions for large n. Candidates should appreciate that, with only 3 marks at stake, there must be a more tractable solution. In fact all that was required was a comparison of the test statistic with the critical value, followed by a conclusion in context. In fact, only one third of the candidature gained any marks at all.

Part (v) was expecting candidates to give a valid reason for the critical region being empty. A number of fully correct solutions were seen, and the question was generously marked, so that candidates who got some way to an explanation gained one mark.

8) In part (i) most candidates scored at least three marks. Many did not explicitly write down their calculations for the cumulative frequency, preferring to plot their points directly on the graph, but still gained the mark. Scales were usually correct and sensible but some candidates used a linear horizontal scale starting from zero, which made a very cramped graph. Labels were often forgotten altogether and the vertical scale was often seen as just 'frequency', losing the mark. Points were usually plotted correctly at the right height but far too often were plotted at the mid-points i.e. 9.2, 9.4 etc. losing the final 2 marks. Only a few candidates used the lower class boundaries. Many candidates lost the final mark by not joining (9.3, 5) to (9.1, 0). Cumulative frequency bars were sometimes seen as were lines of best fit. Occasionally no attempt was made at a cumulative frequency graph at all, with some candidates just plotting frequency against midpoints or attempting to find frequency density.

Part (ii) was generally well answered often from a follow through from a 'sensible' graph. Some of the scales used in part (i) meant that it was very difficult to read the figures if they fell outside the allowed ranges. The 12th value was often used instead of the 12.5th value, perhaps because it was easier to read as there was a point plotted there. A few candidates failed to calculate the IQR even though both quartiles were found.

There were many correct answers to part (iii) (or correct ft answers) but many candidates tried to use the median or twice the IQR. A few candidates reverted to calculating and using the mean and standard deviation, gaining up to 2 marks out of 3 although they could not gain the last mark with this method because outliers could exist.

In part (iv)(A) only the better candidates obtained the correct answer. Many used $(38/50)^3$ scoring one mark only. Others candidates had more complicated incorrect versions of binomial probabilities. Occasionally the numerators decreased but the denominators didn't. Some candidates did not find the correct value of 38 from the table.

Part (iv)(B) was found very challenging and only about ten percent of candidates gained full credit. Many candidates scored one mark for adding their answer from part (A), but otherwise a common incorrect answer of 0.8549 was often seen, which scored SC2. Some candidates thought that they had to multiply only two probabilities when finding the probability of two being more than 9.5. Many candidates did not realise that there were three different ways of getting two more than 9.5. Those candidates who drew tree diagrams fared better here, and in realising that the probabilities diminished. Those candidates attempting 1 - (P(0) + P(1)) were on the whole not as successful, sometimes not including both probabilities or failing to include the factor of 3.

G242 Statistics 2

General Comments

The majority of candidates showed a good understanding of a variety of statistical techniques. There was little evidence of candidates being short of time to complete the paper.

Comments on Individual Questions

Q1 i Well answered.

Q1 ii Well answered. Some candidates used -1.175 (in place of +1.175) and others failed to find a *z*-value at all and were thus heavily penalised.

Q1 iii Poorly answered. Very few candidates knew how to handle this question involving the sum of Normal variables.

Q1 iv Following on from incorrect answers to part (iii) many candidates managed to carry out appropriate calculations with their incorrect values.

Q2 i Well answered. Commonly, candidates failed to include the word 'population' in their hypotheses and some used the symbol 'μ' which was deemed inappropriate. A few candidates failed to rank their 'differences', causing loss of several marks. Generally, conclusions were justified and set out clearly; it should be noted that it is preferable to comment on the suitability of the alternative hypothesis in conclusions to hypothesis tests, than to make an overly-assertive statement about H_0 such as "the evidence shows that the median number of scorched leaves is still 25".

Q2 ii Many candidates provided spurious comments here.

Q3 i Few candidates scored well here; the information that the given confidence interval was based on the *t* distribution was seemingly not noticed by many, as 1.96 was seen regularly. Few candidates realised that the sample mean could be deduced by taking the mid-point of the interval.

Q3 ii Though many candidates seemed to know what was required their answers were often unclear and in many cases incorrect.

Q3 iii Reasonably well answered. Commonly, marks were lost in calculating the sample standard deviation, using incorrect critical values and making incorrect conclusions despite having correct working.

Q4 i Well answered. Occasional errors occurred in calculating contributions to the test statistic and in determining the number of degrees of freedom. A few lost marks for failing to provide context in hypotheses and/or conclusions.

Q4ii Poorly answered. Despite the clear instruction in the question, most candidates failed to make any reference to 'contributions to the test statistic' in their answers.

Q5 i Well answered. A variety of acceptable approaches were seen.

Q5 ii Few candidates provided a convincing justification for using 0.25 as the value of p to use. The instruction 'Show that' was meant to encourage candidates to show some form of justification for the given answer – ideally in the form of an equation involving p.

Q5 iii Poorly answered. Many candidates understood the need to merge cells but did not provide the reason for this being necessary. Very few candidates understood that a further restriction was needed due to the parameter being estimated.

Q5 iv Poorly answered. Conclusions were often incorrect or poorly worded.

Q5 v Poorly answered. Many candidates used an incorrect mean in both parts of the question.

Q5 vi Many answers were not 'in context' and also not very clear in their meaning.

G243 Statistics 3

General Comments

The level of difficulty of the paper appeared to be appropriate for the candidates and there was no evidence of candidates being unable to complete the paper in the allocated time. Many candidates appeared to be well prepared for the paper although a significant number gained relatively few marks. In general, candidates supported their numerical answers with appropriate explanations and working, although in questions requiring discussion it was sometimes difficult to work out what the candidate meant.

Many candidates lost marks because they failed to mention 'population' in stating their hypotheses. Others lost marks because their answers were too assertive. Candidates should realise that they should express some doubt in the conclusion to a hypothesis using phrases such as 'there is sufficient (or insufficient) evidence to suggest that...'. Question 2 was found by most candidates to be rather easier than the other three questions, and in question 3(iii) it was disappointing to see the number of candidates who failed to rank the data. In question 4(iv) there were few good answers despite this being a straightforward question, simply requiring an explanation of how to select a random sample.

Comments on Individual Questions

1) Many candidates gained one mark in part (i), but few gave a fully correct response.

There were a good number of fully or almost fully correct responses to part (ii). However several candidates tried to carry out a two-sample test, gaining no marks. Other found the test statistic correctly but then got the critical value wrong. A very few candidates produced a fully correct solution other than their final conclusion.

In part (iii) most candidates mentioned 'Normal' in their answer but only a few mentioned 'population' and almost nobody mentioned 'differences'. All sorts of answers were seen for the reason for a *t* test being preferable, and many gained a generous mark, though none gave the actual response given in the mark scheme.

2) Part (i) was usually correct.

In part (ii) many candidates scored the mark which was allowed even for an answer such as *n* is large. However there was a variety of wrong answers, including 'samples random', 'Normally distributed', 'variances equal' etc.

In part (iii) there were few fully correct responses. Many candidates scored 2 marks out of 3 for the hypotheses, but missed the final mark for **'population** mean times'. It was pleasing to see that most candidates tried to carry out the correct test. The majority of candidates knew how to calculate the test statistic, although some squared the variances in the denominator. Most of these then went on to compare the test statistic with the correct critical value, but often missed the final mark because their conclusion was too assertive.

3) Part (i) was usually well answered, with most candidates gaining all 3 marks. However a significant number of candidates tried to plot a graph with 'country' on the horizontal axis and both of the other variables on the vertical axis.

In part (ii) many candidates mentioned 'an elliptical distribution' (or a non elliptical distribution) gaining one mark. Rather fewer mentioned 'bivariate Normality', also gaining one mark. Very few candidates mentioned both.

Part (iii) was reasonably well answered with many candidates ranking the data, although occasional slips in the ranking were seen. A number of candidates failed to rank the data and thus scored zero. Those candidates who got the ranks correct usually went on to get full marks for this part.

In part (iv) as in question 2, candidates often forgot to mention population and thus lost a mark. Some candidates gave a conclusion which was too assertive. Many candidates found the correct critical value but there was a wide variety of incorrect values.

4) Part (i) was generally well answered.

Many candidates gained the mark in part (ii), although the explanations differed in quality.

In part (iii) most candidates gained at least one mark, citing differences in fertility or difference in sunshine levels as possible confounding factors.

In part (iv), many candidates gave an explanation of systematic sampling, which gained no credit. Even those who tried to explain random sampling often only produced a partial explanation, often failing to mention repeats.

In part (v) many candidates realised that the populations need to be Normally distributed, but very few mentioned the need for equality of population variances. The hypotheses were usually stated correctly, although occasionally candidates gave two tailed hypotheses, but once again few mentioned population. Most candidates knew how to proceed with the hypothesis test, although a few made errors in the pooled variance or in calculating the test statistic. Most candidates who got this far were able to give the correct test statistic and complete the test, although a few tried to compare a negative test statistic to a positive critical value, thus losing the final two marks.

Candidates often omitted to mention 'median' in part (vi), thus losing a mark. Most then found the critical value correctly and usually went on to complete the test correctly, although a number thought that if the test statistic is greater than the critical value then the result is significant.

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