Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCE

In A Level Further Mathematics (9FM0)

Paper 4B Statistics 2

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The paper was accessible to all the students and there was little evidence that they could not complete it in the time allowed. Very few candidates left a question blank.

Overall, the paper was accessible to all candidates but still differentiated by outcome, with most questions containing some marks that were very hard to gain, allowing the top candidates a chance to distinguish themselves.

There were a lot of marks requiring the candidates to write a worded answer, many of which had fairly high requirements. Many of these marks were seldom gained by candidates.

Question 1

This was a generally welcoming first question as the first six marks were procedural and very straightforward, allowing candidates a gentle introduction to the paper.

Parts (a) and (b) were almost always done correctly.

Many candidates subtracted the real and estimated value backwards to obtain a positive residual in part (d), failing to gain the mark. However, this was almost the only error made.

The written answer required in part (d) was very high demand. As such, very few candidates answered correctly. The vast majority wrote something general about residuals along the line of most similar questions from previous years, perhaps indicating a lack of understanding of this element of the course.

Question 2

The vast majority of candidates were confident in finding a confidence interval using the normal distribution, as well as calculating a test statistic for the difference between independent normal population means. Therefore, this allowed many candidates to continue the good start a lot had made to the paper.

Part (a) was well done, with the method being familiar to almost all candidates. However, candidates should be reminded to state and use z-values to at least 4.s.f. as a good number carried out the calculation in (a) correctly but used a correct but inaccurate z-value.

Most candidates were able to state accurate hypotheses to gain the mark in (b).

Overall, part (c) was carried out largely successfully by most candidates. The most successful candidates stated their distribution in full before giving an expression for the test statistic. The most common errors were using a mean of -10 instead of 10 or having one element within the variance incorrect. If a candidate was able to reach the stage of a correct expression for the test statistic, the vast majority were able to convert this into a correct value of n. Additionally, they were also reliable at giving a suitably accurate contextual conclusion in (e).

Part (d) was one of the questions requiring a written answer that many candidates struggled with. It was clear that almost all candidates had a reasonably understanding of what the CLT is and how it is used. However, most were unable to describe the relevance of the CLT in sufficient detail to gain the mark in (d). That is, most did not hit the two requirements of mentioning a large sample size and the means being distributed normally, the most commonly lacking part being the latter.

Question 3

This was a fairly procedural question which was recognisable to most candidates and hence was answered very well on the whole.

A small minority of candidates failed to realise that a confidence interval for the variance requires the chi-squared distribution and gained at most 1 mark out of 4 in part (a). The vast majority did use the correct distribution and went on to gain all the marks in (a). Almost all candidates were able to gain the mark for a correct sample variance regardless of which distribution they used.

Almost all candidates stated correct hypotheses in (b). Most were familiar with the process of hypothesis testing for the variance, and as such gained all the marks here. A few candidates tested the lower tail; however, while this is an acceptable approach, candidates testing the upper tail appeared more likely to be able to execute their chosen method correctly.

Question 4

This was another fairly routine question. However, a surprisingly high number of students appeared to struggle to reach correct answers to both parts.

Almost all candidates understood the method for combining means to gain the first mark in (a), but a good number used an incorrect method to find the combined variance. The most common error was squaring the 6 and using 36 instead of 6 to multiply the variance for one egg. This error cost these candidates two marks in (a).

In part (b), candidates were required to carry out a similar task as in (a), but also be able to distinguish between the method for adding variables to that of comparing multiples of the same variable. Candidates who only scored one mark in (a) were often able to gain two more in (b) for combining means. However, those who had a limited understanding of how to combine variances continued to struggle.

This question produced a fairly polarised number of marks gained. A good number of candidates found the question routine and easily gained all marks. However, those that struggled with variances usually scored significantly fewer marks.

Question 5

This was perhaps the first really challenging question on the paper. The candidates' holistic knowledge of *t*-tests and when it is appropriate to use them was thoroughly tested.

Parts (a) and (b) were quite high demand as they required rigorous answers. Most of the candidates showed understanding of the premise of both parts, but were often unable to give sufficiently detailed and high-level answers worthy of both marks.

Most candidates were able to carry out the hypothesis test well, and hence gained the majority of the marks in (c). A good number made an error while finding their differences, costing them two marks.

A small minority of candidates carried out a test for two independent population means instead of a paired *t*-test. This limited such candidates to 3 marks out of the 7 available in (c). The question led candidates into the correct approach helpfully by asking candidates directly why a paired *t*-test is suitable for this situation. Therefore, candidates should be encouraged to read the question carefully to ensure they pick up on such direction.

Question 6

This was a fairly straightforward question on continuous random variables that all candidates would have been expecting. Consequently, the majority of candidates were able to produce good answers to this question.

Part (a) was helpfully posed, and most candidates were able to gain all the marks. Those who did struggle usually did so initially by failing to begin by stating both equations correctly. The mark scheme was well-crafted and allowed candidates to still gain 3 marks following such an error.

Part (b) was overall well done. Most candidates showed an understanding of the relationship between the cdf and pdf, and knew to differentiate. However, a good number of candidates did not state their pdf properly with an exhaustive domain.

Part (c) required the candidates to show understanding of how the mode of a distribution manifested in a pdf. This showed up misconceptions among a number of candidates who gave the mode as the value of f(x) rather than the value of x. Roughly equal numbers of candidates seemed to justify their mode with a sketch as with a written explanation. Both were acceptable.

Question 7

While the previous question tested the fundamentals of continuous random variables, this question tested the candidates' knowledge of this topic in more detail. As such, candidates often fared worse on this question than on the previous one.

As in the previous part (b), most candidates showed an understanding of pdfs, but with many missing the mark in (a) by failing to state a domain for their pdf or by using inconsistent notation.

Part (b) allowed two separate approaches. Candidates perhaps chose the integration approach most often, though it seemed the expectation approach was perhaps executed correctly more often.

Part (c) was more challenging, but a good number of candidates showed sufficient understanding to form a correct integral. Those that did this were usually able to go on to gain all the marks in (c).

This question somewhat polarised the results. The more able candidates did not seem to be troubled by the question and went on to gain full marks much of the time. However, a good number of candidates showed quite superficial knowledge of this topic and often only scored a minimum number of marks out of those available.

Question 8

This question was understandably quite challenging and did a good job of testing the candidates' knowledge and skill with estimators. There were a distinct minority of candidates who failed to realise a binomial distribution was required, and hence scored very few marks on this question.

Part (a) was usually done well, with most candidates using the binomial to good effect to find the bias for both estimators. However, a fair few of these candidates did not state a clear conclusion and lost the final mark in (a).

Part (b) required the candidates to be able to find the variance of a combination of random variables. Most were able to do this, though a good number were not able to do so accurately and scored only one of the two marks for (b).

Part (c) was well done on the whole. Most candidates knew to assess the relative validity of unbiased estimators by comparing the variance and seeking a low variance. As candidates were able to follow through their variance from (b) most scored both marks.

Part (d) was definitely the most challenging part of the paper. It required candidates to utilise two criteria for an estimator being valid. While a good number of candidates were able to complete this question well, a lot only used one criterion and hence were not able to form simultaneous equations. If candidates were able to form two equations in a and b there was still much to do. A decent amount of rigour was required to use a correct expression for the variance of the new estimator, combine it with a correct linear equation, form a 3TQ, solve this quadratic to state a range, and interpret the range correctly. This was an appropriate level of challenge to finish the paper, and this part of the question helped to discriminate between the differing ability levels of candidates.

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