Examiners' Report
Principal Examiner Feedback

Summer 2024

Pearson Edexcel GCE
In A Level Further Mathematics (9FM0)
Paper 3B Further Statistics 1

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Introduction

This paper was very accessible to candidates until the latter two questions. Candidates seemed to have sufficient time to complete the paper.

The questions allowed candidates to make a decent start to each one, with all but the final question keeping the majority of the candidates in the fight.

The first six questions tested relatively routine methods and skills and did so in a manner most candidates seemed accustomed to. The discriminating factor throughout these questions tended to be the candidates' accuracy and ability to execute methods they were familiar with successfully.

Candidates showed a good level of ability in interpreting contextual situations and selecting appropriate models to use in the questions. Candidates who are not adept at this scored poorly in comparison to their peers.

To ensure candidates are best prepared for a paper such as this they should be reminded to: state the distribution they are using clearly before carrying out calculations, retain a large number of significant figures of accuracy throughout their calculations, convert probability statements to the form $\mathrm{P}(X \leq a)$ to lock in method marks, not to use their calculators without detailing clearly their methodology, and use proper notation throughout their working.

While the first six questions largely tested the candidates' knowledge and competency with standard skills, the final question tested their problem-solving ability and their deeper understanding of variables and expectation. The highly challenging nature of this question reinforces the importance of gaining a high number of marks in the proceeding questions, as very few candidates were able to gain most of the marks in the final question.

Question 1

This was a nice opening question with little text to read and demands which were very familiar to the candidates. As such, almost all candidates scored full marks on Question 1.

Those who lost marks did so most commonly through arithmetic errors ($8.9 – 4 = 5.9$ was surprisingly common). The need for candidates to show their working was highlighted here, as the mark scheme was most forgiving of errors if a candidate showed their working.

Question 2

This question covered some familiar topics. Since the question did not require candidates to give the tail probabilities explicitly, almost all candidates gained full marks on this question as they tended to use their calculators to find the critical region and stating this was sufficient for part (b).

Candidates understood how to state a distribution clearly, they tended to use good notation throughout. The only common exception to this was that many often did not connect the two pieces of their critical region properly. However, in many cases a less than precise presentation was condoned, and candidates did not lose marks for poor notation here. While poor notation was condoned here, candidates should aim to use rigorous notation when giving critical regions in general.

Candidates appeared to know what was required for the P(Type I error), though some might have been making an educated guess that this was equivalent to the actual significance level – as this is a common thing to be asked to give after a hypothesis test such as this.

Barely any candidates were unfamiliar with the methods required for this question. The discriminating factor tended to be the execution of these methods. To ensure full marks on questions such as these, candidates should be sure to retain a high level of accuracy in their tail probabilities, define their distribution clearly, show their working on the way to finding their critical values, and use rigorous notation throughout.

Question 3

This question was perhaps the one that caused candidates the most issues of all the early questions in the paper.

Some candidates were not able to state the hypotheses correctly. The most common error being to give H_0 as ‘association’ instead of ‘no association’. This is not an error usually seen. Association was used most, but independence was also seen a lot – both scoring the mark in (a).

Part (b) did make the candidates think a little. Most still gave the correct answer, perhaps through understanding or perhaps through calculating the expected frequencies and choosing the lowest. Most also gave an acceptable reason. The most common incorrect answer was to select ‘Black’ and ‘1 – 5’, as the observed frequency is lowest. Almost all candidates were able to correctly find the value of an expected frequency, therefore, if they selected the correct cell candidates tended to gain the second mark in (b) as well.

Almost all candidates gave the correct degrees of freedom and critical value. The few that gave incorrect degrees of freedom tended to state 14 (using $15 – 1 = 14$). However, the vast majority still gained the second B1 for following through to give a correct critical value.

The final B1 did not depend on anything previous. That is, it was independent of the candidate's hypotheses, and followed through their critical value. As all incorrect critical values seen still led to the same conclusion, this allowed candidates to recover from any errors and to show their knowledge. The majority of candidates were able to give a suitable conclusion and score the final mark, showing that candidates are in general practised and adept at giving conclusions in context.

Question 4

Candidates did surprisingly well on this question. It tested their understanding of different distributions, but candidates were able to connect the contextual situation with the most appropriate distribution well.

Part (a) was almost always answered correctly, though a small number of candidates did not realise a parameter was required. Part (b) was almost always answered correctly as well. Many candidates used the formulae for the Geometric distribution, but a good number reached the answer by summing P($X = 1$), P($X = 2$), and P($X = 3$).

The high level of success the candidates had with part (c) was most encouraging. Again, most candidates realised that the central limit theorem was required and were able to correctly reach the required answer. On the whole the candidates' working was clear, showed good notation, and was concise.

Part (d) was answered well in general. Most candidates gave the hypotheses correctly – though some gave them in words and hence did not gain the mark.

A few candidates used P($X = 16$), but the majority were able to reach the correct probability, going on to conclude correctly and gain all the marks in (d). A small number chose a critical region approach, and these candidates did so correctly in general. However, overall, it seemed that the critical region approach was less likely to lead to a correct answer, since some candidates gave a critical value of 17 rather than 18 due to not solving the inequality correctly.

A small number of candidates chose to compare 0.935 with 0.95, but again, those that did generally did so successfully.

Overall, candidates showed a lot of skill when answering Question 5. They showed they were generally adept at modelling with different distributions (including the more challenging aspects such as use of CLT) and were able to conduct a Geometric hypothesis test correctly in the majority of cases.

Question 5

This question was the first on the paper to cause any real issues to most candidates. It covered an aspect of the specification which tends to not be as well answered as others: Quality of Tests.

Part (a) was very routine. A nice beginning to the question, and almost all candidates gained the mark.

Part (b) was also quite straightforward. Candidates tended to gain the marks on this part, showing that most do understand what is meant by the size of a test.

Part (c) was more challenging but candidates still coped well in general, with most gaining the marks. The importance of showing their working was brought to the fore, as a good number of candidates struggled to retain accuracy until their final answer – but those that showed their method clearly gained 2/3 marks. Overall, the candidates were generally able to

understand the context of the question, use the correct distribution, and have a good attempt at completing the question. Marks tended to be lost through poor execution rather than lack of understanding.

Part (d)(i) was answered correctly in general, again showing that candidates understand what is meant by power and size. However, part (d)(ii) caused candidates problems. It appeared that many did not perhaps think deeply enough, saw 'expected value', and immediately used $E(X) = np$ – gaining them no marks. Candidates did tend to use the correct distribution, but they needed to find a correct probability to gain any marks. Therefore, most candidates scored zero on this part of the question.

Part (e) was very demanding, and really tested the candidate's knowledge of the implications of size and power on the quality of a test. Most candidates, perhaps superficially, saw that the power of Test **A** was higher and concluded that therefore this test was the best to use. A more nuanced approach was required, either looking at size and power to conclude Test **A**, or to also consider number of components sampled to conclude Test **B**. Almost no candidates chose to conclude using the latter reasoning, most who answered correctly chose Test **A**.

A small number of candidates used a Poisson approximation - those who did tended to follow this method correctly. They could gain 6/8 marks using this approach, but since most candidates in general were not gaining the marks in (d)(ii) the use of a Poisson Approximation tended to effectively just lose a candidate one extra mark.

Question 6

Most candidates were able to access most of the question and gain a good number of marks, with some parts challenging the more able candidates.

Part (a) tested the core skills relating to PGFs, and the vast majority of candidates were able to gain full marks in (a). Candidates had no difficulty in recognising the approach needed and almost invariably found an acceptable form for $G'_X(t)$ and the correct value for $E(X)$ to follow. A small minority of candidates appeared unable to recognise the use of the chain rule to be the most appropriate method for their differentiation, and while some successfully applied the quotient rule most errors in forming $G''_X(t)$ came from those candidates who could not efficiently differentiate. Candidates were clearly aware of the fact that the formula for the variance was given and had no difficulty in applying this.

The question ascended nicely in difficulty, with part (b) being more challenging than part (a). Almost all candidates understood what was required to obtain probabilities from a PGF, however, there was a reasonable variation in how well candidates were able to execute their chosen method. The majority of candidates chose to use a binomial expansion, with a good degree of success in most cases, though some, despite having written it, forgot to multiply by $\frac{1}{2}$. The same error was made by candidates using a Maclaurin approach, also forgetting to divide by 2 despite having written it in their formula. Most candidates successfully got their values for $P(X = 0)$ and $P(X = 1)$. Those candidates following the binomial approach this time remembering the factor of $\frac{1}{2}$ but the odd error was made by those using the Maclaurin approach when substituting 0 into their expressions for $G_X(t)$ and $G'_X(t)$. Some candidates needlessly put their final fractional answer into their calculator to give a rounded decimal, showing that they misunderstand the meaning of an 'exact' answer. Some lost the final mark by only giving a decimal answer.

Part (c) showed that a good many candidates were not clear how to form the

PGF of $X_1 + X_2 + 1$. Many realised the need to multiply the PGF of *X* by itself, and many realised the '+1' required multiplying the PGF by *t*. However, not many candidates realised the need for both of these things. Those that did reach a correct PGF for *Y* tended to realise their PGF was Geometric(0.25) without converting to the formula book style, which still scored full marks. Many did not realise a parameter was required in (c) but gave it in (d) instead – which was condoned. Overall, a good proportion of candidates scored 4/4 on (c), but scoring 1-3 marks was more common.

A surprisingly large number of candidates who had successfully negotiated part (c) were unable to spot the link between *Y* and the required probability statement. A lot of candidates made quite basic errors, such as rearranging $P(X_1 + X_2 > 5)$ to $P(X_1 + X_2 + 1 > 4)$ rather than $P(X_1 + X_2 + 1 > 6)$, or setting $P(Y > 6)$ equal to $1 - P(Y \leq 5)$.

A reasonable number of candidates tried to form a new PGF for $X_1 + X_2$ and use that. However, very few who tried this did so successfully as it required a lot of work, and usually an error was made. Candidates who spotted the link to *Y* and used a Geo(0.25) were able to reach the correct answer successfully on the whole.

Overall, this question worked very well. Most candidates scored over half the marks, but then petering out a little towards the end of the question – allowing the most able students to distinguish themselves.

Question 7

Candidates understandably found this question very challenging. It started off very easily in parts (a) and (b) but stepped up in difficulty considerably in part (c). The demand and nuance of (c) was beyond almost all candidates.

Parts (a) and (b) were very routine, and the vast majority of candidates scored full marks on both parts. Candidates showed they are adept at modelling contextual situations with appropriate distributions – as they did throughout the paper.

In part (c), candidates needed to set up a random variable for the number of wins, then use an arithmetic sum to reach an expression for profit. They then needed to find the expectation of their expression, after modelling their random variable using the correct binomial distribution, to reach the given answer. This approach was not a familiar one to the majority of candidates. Most changed their random variable to an expected number of wins at the start of their solution, which led to the candidates working in terms of *n*. This is incorrect, and candidates who did this tended to score just 1 mark for stating the distribution of their random variable.

Candidates often realised that they needed to use an arithmetic sum. However, they did so after converting to $0.2n$, which meant they were no longer working with a random variable and hence could not evaluate the expectation correctly.

Part (d) was more accessible. However, as the answer to (c) was 'show that', many candidates thought they needed to use the answer to (c) to answer (d), which was not the case. Candidates should be reminded to look out for instructional words such as 'hence' to direct them to use a previous answer and be open to other approaches.

There were two methods used to answer (d). The first being to use the expression for profit in terms of the number of wins hopefully generated as part of the solution to (c), the second being a listing approach to find the minimum number of wins required to be in profit. Very few candidates used the first method, mostly because very few had a suitable expression from (c). The candidates using the listing method usually did so successfully and gained all the marks in (d).

Part (e) required a similar approach to (c). Very few candidates answered (c) correctly, but a cohort were able to form an expression for the revenue in (e) by using an arithmetic sum. Those that did often went on to gain full marks. However, in general candidates gained no marks for (e), or only the initial mark for stating the distribution correctly.

Question 7 was certainly a very challenging question. To prepare to answer questions such as these successfully, candidates should be encouraged to: define the variable they are working with, state the distribution of that variable, and consider taking the expectation of a random variable or an expression in terms of a random variable properly when directed to by the word 'expected' in the question.

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