Examiners' Report
Principal Examiner Feedback

Summer 2023

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

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Introduction

The paper was generally accessible with most students able to display good knowledge of the specification. All questions allowed students to get started, with questions 2(c), 5 and 6 providing some discrimination. Students are reminded to make their methods clear as well as stating which distribution they are using before carrying out probability calculations on their calculators.

Question 1

This was a good start to the paper for many. Parts (a) and (b) were very well attempted with virtually all scoring both marks in (a). In part (b), there are some students who confused $E(X^2)$ with $Var(X)$ and so set up $2a + 3.7 = 3.9$ leading to a common incorrect answer of $a = 0.1$. A follow through mark was available for those who went on to find a consistent but incorrect value of b.

Part (c) was more demanding. Many identified at least one combination of X_1 and X_2 that would lead to the sum being greater than 3, but often only went on to obtain two of the three correct products of probabilities. Some believed there were two ways of obtaining $X_1 = 3$ and $X_2 = 3$. Another common mistake was by those who believed the distribution of $X_1 + X_2$ was the same as the distribution of $2X_1$ and these responses often scored 0 marks.

Question 2

On the whole, this question proved to be one of the more demanding on the paper particularly due to part (c). Students had little difficulty in accessing the marks in part (a) and most were able to secure all 4. Most students choose hypotheses involving $\lambda = 17$ (rather than $\lambda = 1.7$) and most chose a correct two-tailed alternative. Most students successfully navigated their calculators to obtain the correct probability for P(X … 25). Most also chose to find the probability, rather than the critical region, though a typical mistake was to compare the probability to 5% rather than the required 2.5%. Nevertheless the vast majority of students completed the test accurately and were able to give a sufficiently contextual conclusion involving the rate of calls. The most typical errors in failing to secure the final mark was a non-contextual conclusion or one involving the ‘number’, rather than the rate, of calls.

Almost all students were able to identify the required binomial distribution in part (b) and of these the majority successfully calculated the required probability to the necessary level of accuracy. Some students failed to read the requirement for greater than 2 and so a typical mistake was to find $1 – P(T \leqslant 1)$.

Part (c) was a very good question for differentiating between the highest achievers on the paper. This part created more difficulties for the students and interpreting the information to obtain a Binomial distribution in terms of p. Many plugged in values for p. Of those students working with $X \sim B(900,p)$ who went on to find a Poisson approximation almost all were able to correctly solve $e^{-900p} = 0.05$. The most typical misconception was students using $p = 0.05$ and using a Poisson distribution of $Po(900 \times 0.05)$. Most were uncertain what to do with this. A few students used their calculators with a Poisson distribution or tables to find that $\lambda = 3$ was the closest parameter to give $P(X = 0) = 0.05$ and then calculated 3/900 to obtain an answer of 0.003333...

Question 3

There were a large number of accessible marks on this question for all students but the written expression required in part (e) allowed higher achieving pupils to shine.

Part (a) was answered extremely well, with the vast majority of candidates scoring full marks by multiplying the required probabilities by 170. Some slips saw students multiplying by 100 instead.

In (b) the majority of students correctly stated both the null and alternative hypotheses, although some forgot to mention the parameters of the model B(5,0.5). The value of the test statistic was generally calculated accurately, with $\sum \frac{(O_i - E_i)^2}{E_i}$ seen more commonly than $\sum \frac{O_i^2}{E_i} - 170$. Occasionally, the first two columns were pooled, leading to an incorrect value of the test statistic. The value of ν was usually taken to be 5 and a correct critical value found. A well expressed contextual conclusion meant that most students earned all marks on part (b).

In (c), the majority of students were able to calculate the correct estimate for *p*, although some rounded prematurely, giving an answer of 0.59. An answer of 0.6, without any working, was also regularly seen.

In part (d)(i), nearly all students referred to the necessity of combining the first two columns as the first expected frequency < 5. However, the constraint of the value of *p* being estimated was less frequently noted. Writing down the critical value for $\nu = 3$ presented no problems to students; students who had stated that $\nu = 4$ were able to obtain follow through credit for a critical value of 9.488. On rare occasions students gave a critical value to 1 or 2 decimal places and lost the mark as a result.

A large majority of students were able to make an attempt at both parts (e)(i) and (e)(ii). Some were hampered by a lack of clarity of thought. Those students who recognised that Nima's model was a good fit for the data usually were able to give convincing explanations in each case. Many thought that because *p* was greater than 0.5 (as demonstrated by Nima’s model) that independence no longer held. Examiners noted that poor handwriting in part (e) made it very difficult to decipher some students’ responses.

Question 4

This proved to be the most accessible question on the paper and it was quite common to see students earning full marks. Most correctly identified the Negative Binomial distribution and correctly calculated its mean and variance. The vast majority went on to identify the correct normal distribution for the mean and obtain the required probability.

Question 5

Though there were some good attempts seen here, premature rounding was the main issue.

Part (a) was a standard request to find the critical region for the test statistic $\bar{X}$, and presented few difficulties to students. The hypotheses, when written, were nearly always correct, with candidates invariably using a N(330, 8^2/25) distribution. The critical value of 327.368... was usually obtained from a calculator, but a small minority then forgot to state the critical region as an inequality. Occasionally, for those showing a standardisation, some equated it to –1.96 instead of –1.6449.

The concept of a Type I error was well known in part (b) and examiners frequently saw a correct answer of 0.063. Premature approximation did cause a sizeable number of candidates to lose the accuracy mark, writing 2×0.0319 = 0.0638

Although the concept of a Type II error was well known, there was an approximately equal split between those candidates who found P(Type II error) for part (a) and those who found this probability for the test in part (b). Of those who chose the requested option, premature rounding of 327.368... often spoilt an otherwise good solution. Occasionally, students mistakenly calculated the power of the test in part (a).

Question 6

This question worked well at this stage of the paper and parts (a), (b) and (d) were more discriminating.

In part (a) many students were able to use the formula sheet to identify this as a negative binomial PGF and having done so to recognise that r = 2 and p = 1/3. Some students did not include any parameters in their response. A handful of students opted for a Geometric distribution.

Part (b) was less well answered and was occasionally not answered at all. Although contextual answers were usually given, a minority of students gave a scenario with a probability of a sixth instead of a third. Some by this stage had resorted to a fixed number of trials rather than successes despite recognising it as a negative binomial distribution.

Students were very comfortable with what was required in part (c) and were almost, without fail, aware of where to find the formulae for the mean and variance. The vast majority had a suitable method to deal with the differentiation. Students opted as equally for the product rule as the quotient rule with both having a high success rate. On rare occasions, no calculus was seen and no marks were therefore awarded to these students.

Part (d) presented more of a challenge and while almost all students seemed aware of the need to find the coefficient of the t^{19} term many were not anticipating the need for the binomial expansion. Those who did rearrange their PGF in order to apply the binomial expansion were almost always able to achieve the required probability. A smaller number of students recognised a linear relationship between Y and X to find $Y = 3X + 4$. Not all of these students managed to calculate the resulting P(X = 5) successfully. A few students wrongly identified the relationship as $Y = 4X + 3$. The most typical wrong answer was to conclude P(X=19) = 0.

Question 7

There was a strong finish to the paper with many students achieving full marks on this question.

In part (a)(i), virtually all candidates successfully used a Geo(0.2) distribution accurately. Part (ii) was nearly as well answered using a NB(3,0.2) distribution, although a few students only gave 2 significant figure accuracy or miscopied the answer from their calculator as 0.551.

As expected, an excellent response was seen in part (iii) using a B(10, 0.2) distribution; occasionally, similar errors in accuracy to those in part (ii) were seen.

The calculation of P(R) was generally performed accurately using a Geo(0.2) distribution, although a relatively small number of candidates chose to use a B(4,0.2) or Geo(0.4) distribution instead. However, the calculation of P(Y) posed more problems, and numerous different errors were made. The most common was to use NB(3,0.2) rather than NB(3,0.4). In both cases, the nCr factors were sometimes omitted when listing the required terms. Fewer used a B(7,0.4) distribution, but these usually resulted in an accurate answer. For those who obtained correct probabilities, virtually all concluded that R had the greater probability.

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