Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCE
Further Mathematics (8FM0)
Paper 23 Further Statistics 1

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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. However, if a candidate read the question carefully it gave a lot of guidance as to what was required. A good example of this is part (c) in question 2.

Question 1

This was a generally welcoming first question as it had little wording and required skills that all candidates should immediately recognise. A large proportion of candidates were able to score full marks. Candidates not scoring full marks usually gained the B1 for $\mathrm{E}(X)$ and the first M1 for $\mathrm{E}(X^2)$, with many also gaining the final M1 for summing the probabilities.

The issue that proved most challenging for the candidates was forming an equation with their standard deviation and mean. There were a lot of algebraic errors, such as taking the square of terms individually. Candidates should be reminded of the importance of clearly labelling the expressions they find. Some candidates did not use the mean as $\mathrm{E}(X)$ or did not label their variance as such. Therefore, they were unable to gain method marks for using their expressions correctly as it was not clear they were equating their standard deviation to their $\mathrm{E}(X)$.

This question would have likely provided a helpful confidence boost early in the paper. Many candidates answered correctly, and most of those who made an error would have been unaware as most errors still gave plausible values of *k* and *r*.

Question 2

The vast majority of candidates were confident in calculating the expected frequencies, and as such were able to get off to a good start with this question. The vast majority of candidates then went on to use the correct degrees of freedom to find a correct critical value.

The final two marks were more challenging to obtain. The final mark of (b) required the candidates to mention ‘colour’ as well as ‘not independent’ (o.e.); a good number failed to meet both of these criteria. The B1 in (c) was seldom gained by candidates. Again, this required two criteria and most candidates only mentioned one, thus failing to gain this mark.

This was a very useful question as it was accessible to all, but the final two marks discriminated well and provided a high level of challenge.

The slightly unusual structure of this question was found to be challenging for many. Many candidates found all nine expected frequencies and/or the hypotheses. Neither of these were required and hence candidates finding these wasted a lot of their time, which may have had an impact on the rest of the paper.

Question 3

This was a lengthy question that was well broken down to be accessible to candidates. Most candidates gained twelve or more marks out of sixteen, which is a considerable amount on a paper such as this.
Part (a) was quite challenging and caused a good number of candidates to think. Few answered as the mark scheme described, with most opting for trial and error. However, the majority of candidates were able to arrive at the correct answer.
Many candidates were confused by which distributions to use throughout this question. The first instance of this was in part (b). A good number of students used a Poisson distribution instead of Binomial. Helpfully, the mark scheme awarded a mark for correct use of inequalities in the probability statement, and as such most candidates scored at least one mark on part (b).
Part (c) continued with the Binomial distribution. Candidates who correctly answered part (b) usually went on to gain the marks for part (c). Even those who used a Poisson distribution often managed to obtain the correct mean in (c). However, as the variances for these two distributions are different the final mark of (c) was gained less often.
Part (d) required the candidates to switch from Binomial to Poisson, and was usually answered correctly. The first M1 was very often awarded as an ft mark so most candidates were able to score some marks on this part. The fact that the question states 'use an approximation' meant that candidates were given a good chance to spot that they should have been using a Binomial distribution for the preceding parts. A fair few candidates did act on this hint and re-attempt parts (b) and (c).
Part (e) was a routine hypothesis test using the Poisson distribution and as such most candidates gained a lot of marks here. There was nothing out of the ordinary and candidates responded well, with a large number gaining all four marks. Most candidates gave a full contextual conclusion rather than commenting on the claim; this was perhaps poor exam technique as less was required in a comment relating to the claim compared to a full contextual comment.
Part (e) required the candidates to understand what a *p*-value was, and unfortunately a large number were unfamiliar with this aspect of the course. As such most answers to this part were guesses, the most common answer being 0.4 from the question.
Overall, this question was an excellent opportunity to pick up a large number of marks that could offset issues elsewhere in the paper. All parts were independent of one another except one mark in part (d), and as such gave the candidates lots of opportunities to recover from any errors.

Question 4

This was quite a challenging question, and whilst most candidates scored eight or more marks out of twelve many really struggled. The worded answers required were quite nuanced and specific, and if a candidate was unable to find a value of lambda they were only able to gain half the marks. This is not unreasonable for the final question of a paper, but it did put a distinct divide between higher and lower ability candidates.
Part (a) required the candidates to give hypotheses mentioning 'breakdowns' and 'Poisson'. A large number failed to meet both of these criteria. This is perhaps an issue of exam technique as if they read the question carefully it clearly mentions both of these points when describing Anya's belief and the direction in part (a) refers directly to Anya's belief. A further issue was that candidates gave the value of lambda in their hypotheses, which meant they did not gain the mark. This was unfortunate as often stating the value of a parameter is required. Once again, good exam technique dictates that this was not appropriate here as the candidate had not been asked to find a value of lambda at this stage of the question.
Part (b) was seldom answered correctly. Most candidates gave a contextual answer linking to the problem itself rather than the Poisson distribution. The question did not direct the candidates to such an answer, but this part was an excellent way to challenge the most able candidates.

Part (c) hinged on the candidate realising they had to find the value of lambda from the data, which is an entirely reasonable demand as it should be clear that this was needed to progress. Most candidates were able to gain the majority of the marks by finding a mean and using the Poisson distribution to calculate the frequencies. The final mark was often gained, showing candidates knew to calculate the final expected frequency in such a way to ensure the sum of the expected frequencies matched the sum of the observed frequencies. A fair few candidates obtained lambda by working backwards from a given expected frequency. Candidates who did this well could still gain three out of four marks for this question. Once a candidate did get started with part (c) the most common errors were failing to keep a suitable level of accuracy and consequently obtaining inaccurate expected frequencies, and not giving their answers to a level of accuracy matching the other expected frequencies.

Part (d) allowed candidates who had not attempted part (c) to gain one of the two marks. Most candidates therefore scored one mark if they had not completed part (c) or had done so with a low degree of accuracy. If a candidate had successfully completed part (c) they almost always gained both marks in (d).

Part (e) required the candidates to demonstrate a good understanding of the degrees of freedom used in chi-squared and also communicate this understanding accurately with a high level of specificity. Most candidates gained the first B1 for describing the need to merge columns, however, a good number failed to refer to expected frequencies specifically and fell short of this mark. The second mark was largely independent of the first and a large number of candidates were able to successfully describe the lost degree of freedom for estimating lambda to end up on three degrees of freedom. Again, a good number failed to be specific enough for this last mark – instead referring to estimating in general or estimating totals/probabilities.

Part (f) was able to be done fully independently of the rest of the question. As such, most candidates were able to give the correct critical value, though some failed to give it to the required level of accuracy. Many candidates failed to give an acceptable conclusion, usually by failing to mention ‘breakdowns’. As with part (e) of question 3, most candidates attempted to give a full contextual conclusion mentioning breakdowns and Poisson, perhaps missing the simpler approach of stating that we accept Anya’s belief.

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