Examiners' Report

Principal Examiner Feedback

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Pearson Edexcel International A-Level
Statistics S2 (WST02)

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General introduction

This paper proved to be a good test of Statistics 2 material and discriminated well across candidates of all abilities. Written expressions remain an area of concern for many candidates on this paper as questions 4(c) and 5(b) were poorly answered. It is important for candidates to give answers in context rather than simply repeating stock/textbook responses. Work with conditional probability was, in general, poor on this paper. This is required knowledge from WST01 and candidates at this level are expected to be sufficiently prepared to deal with conditional probabilities.

In summary, Q1(b), Q2, Q3(e), Q4(a), Q4(b), Q7(c), Q7(d) were a good source of marks for the average candidate, mainly testing standard ideas and techniques and Q1(c), Q3(b), Q3(e), Q5(a), Q6, Q7(e) and Q7(f) were discriminating at the higher grades. Q4(c), Q4(d) and Q5(b) proved to be the most challenging questions on the paper.

Report on Individual Questions

Question 1

Part (a) of the first question on the paper already proved challenging for many candidates as they ignored the instruction 'write down' which should have been a sign that no working was required. The fact that there was only 1 mark available for this part should have been another clue for candidates. There were a significant number of attempts to standardise and evaluate P($W < 36$) instead of P($W = 36$).

Part (b) was answered well by the majority of candidates. Both approaches of using the tables and using the formula were seen. On occasions, candidates subtracted the wrong probabilities, e.g. P($X \leq 9$) – P($X \leq 8$).

Part (c) proved to be a little more challenging but the majority of candidates were able to score at least 2 marks. E(X) = 9 was usually seen or implied, yet the square root was sometimes omitted from 4.95 when candidates attempted to find the standard deviation. A lack of understanding of the phrase 'within one standard deviation of its mean' meant that many candidates were unable to come up with the required probability, P($\mu - \sigma < X < \mu + \sigma$). A common misinterpretation was P($\sigma < X < \mu$), i.e. P($2.22 < X < 9$)in this case. Others incorrectly attempted P($7 \leq X \leq 11$) as P($X \leq 11$) – P($X \leq 7$). Overall, just fewer than 20% of candidates successfully earned full marks on this question.

Question 2

Question 2 was the most successfully answered question on the entire paper with more than half of candidates achieving full marks. Virtually all candidates were able to write down a correct equation in part (a). The majority then went on to set up a second correct equation in part (b). Occasional minor slips when solving the simultaneous equations meant that some candidates lost the accuracy marks in part (c). Even when this occurred, most were still able to pick up a follow through mark in part (c) for evaluating the variance, with most using the formula $\frac{(b-a)^2}{12}$ though some attempted the less efficient method involving integration.

Part (d) proved problematical for a significant proportion of candidates. Many failed to realise that, in this context, the number 35 was larger than their value of β. Such candidates therefore wrote $\frac{35-5}{20.5+4.5}$ to obtain a 'probability' of 1.2. The fact that this was greater than 1 was often not enough to alert candidates to the possibility that there might be a mistake in their working. They then appeared unsurprised by a final probability greater than 1. Another error was to use $P(X \leq 20.5) - P(X \leq 4)$ treating the distribution as if it were discrete.

Question 3

Candidates at all levels were able to access parts of this question whilst it did well to discriminate the most able, particularly parts (b) and (d). Only around 20% of candidates scored 14 or more marks here out of a possible 16. In part (a) many candidates were able to give a condition under which a normal distribution may be used as an approximation to the Poisson distribution. Many stated λ was large or $\lambda > 10$. However some candidates gave incorrect answers such as 'mean = variance' or 'n is large and p is small' or stated the assumptions required for a Poisson distribution to be valid.

The response to part (b) was disappointing. Those candidates who stated the mode was 3 either gave no justification or incomplete justification, e.g. $P(Y = 3) = 0.2158$ on its own. A common incorrect answer was 3.5 with the misconceived justification that the mean is equal to the mode for a Poisson distribution.

Part (c) was a good source of marks for almost all candidates. Candidates are finding this type of calculation routine and it is pleasing to see evidence of confident and accurate work. Common errors included use of Po(3.5) instead of Po(7) and evaluating $P(X > 5)$ as $1 - P(X \leq 4)$.

Part (d) stands out as being the most demanding part of this question. Despite it being a topic required for S1, a majority of candidates on S2 were unable to tackle the conditional probability that is signalled at the start of the question by "Given that...". . Many candidates did not use conditional probability at all and merely subtracted, added or multiplied two probabilities to obtain their answer. Common errors included calculating $\frac{P(Y=4) \times P(Y=6)}{P(Y=6)}$ or not realising that numerator used Po(3.5). A few candidates rounded early and this cost them the final accuracy mark.

It appears that candidates are well rehearsed in performing normal approximation calculations and many were able to score full marks in part (e). Candidates should be advised that they need to write down their distribution at the start of their calculation, e.g. N(140, 140), as this may help them to gain method marks if they make a subsequent error. Common errors in standardising included no continuity correction or dividing by 140 rather than $\sqrt{140}$. A few candidates spoiled their answer by incorrectly subtracting from 1 to give 0.0418.

Question 4

The calculus required in question 4 was completed correctly by the vast majority of candidates with more than 50% picking up 7 of the first 8 marks. It is important for candidates to pay close attention to the context of the question as many scored only three marks out of four in part (a) for failing to give their answer 2.4 in thousands of hours.

The calculation of the standard deviation in part (b) was relatively straightforward, but nevertheless required a fair amount of work and attention to detail so it was pleasing to see a large number of correct solutions here. The most common errors seen were omitting the subtraction of the square of the expected value and forgetting to square root the answer.

There was limited success on parts (c) and (d) with less than 1 in 20 candidates appreciating that the components could last longer than 4000 hours. In part (c) the majority of answers focused on the skewness of the distribution and did not make reference to the suitability of the model. There were many blank responses to part (d), but for those who did make an attempt, a sketch of the normal distribution was popular. Some sketches would have scored the mark had they properly labelled the 4 on the horizontal axis.

Question 5

Question 5 was the second most demanding question on the paper as many struggled to express their thoughts clearly in part (b) and with 30% of candidates achieving 4 or fewer marks. In most cases in part (a), Po(6) was identified and used, although not all candidates found 0.744 for $P(X \leq 7)$. About half went on to complete the calculation by using their probability with the binomial distribution. Occasionally, 0.744 was given as the final answer and some candidates merely calculated $(0.744)^6$. A number of incorrect attempts using the Normal distribution were also seen here.

The overall response to part (b) was poor, particularly parts (ii) and (iii), as it was clear that many candidates were relying on memorised textbook definitions but were unable to apply them in the given context. Part (i) had more success but a number of candidates only gave a null hypothesis whilst some used p rather than λ or μ. It was apparent that not all candidates understood the demand in part (ii) with many blank or irrelevant responses seen. 'Rate of defects' was often referred to and partially correct responses not referring to all the necessary terms were most common amongst the better responses. Similarly in part (iii), candidates also failed to move beyond the textbook definition and explain what the critical region meant 'for this test'. Candidates should avoid using the word 'region' in their definition of a critical region.

Part (c) was generally answered well and many candidates scored at least 3 marks. To ensure method marks are scored, candidates should make it explicitly clear which distribution they are working from when finding probabilities for the critical region. In most cases, Po(10) was seen or implied, although a few used the Normal distribution. Problems in notation are not uncommon and even when one or more of the required probabilities were found correctly, the critical region was still sometimes incorrect, with either one or both of the tails wrongly stated. $X \geq 17$ was the most common error seen. When the two tails of the critical region were identified, these were occasionally combined incorrectly into a false inequality, or simply left written as probabilities.

Candidates should be encouraged to show their working including the values from tables as $P(X \leq c) < 0.025$ is not sufficient to score the method mark.

Part (d) was answered well and most candidates generally attempted to combine two relevant probabilities to find the actual significance level for the test. Even those who were unable to correctly notate the critical region in part (c) were still able to recover to give the required probability here.

Question 6

The hypothesis test in question 6 proved to be the most challenging on the paper with 20% of candidates making no progress at all. Few candidates scored more than four out of seven as most made the mistake of using a Normal approximation to $X \sim B(75, 0.96)$. This was not appropriate as p was not close to 0.5 and, in this case, a probability of 0.96 should have rung alarm bells. Those candidates who considered the number of seeds that do **not** germinate were more successful dealing with $Y \sim B(75, 0.04)$ so that a Poisson approximation is suitable (since n is large and p is small). Setting up the hypotheses correctly was already a challenge for many as they often interpreted 'overstating the probability' to mean that the alternative hypothesis should be H_1: $p > 0.96$. It was pleasing to see some good attempts at the calculation of the test statistic and most conclusions were given in context.

Question 7

The final question on the paper provided a good source of marks at all levels of ability and nearly 20% of candidates were able to achieve full marks on this question. In part (a) many candidates scored full marks for a correct sketch of $f(x)$. When marks were lost it was usually for the first part of the graph not having the correct shape (often drawn as a straight line or the curvature of the curved section reversed) or labels being omitted. Some candidates attempted to plot the graph using a 'table of values' but this method did not always produce a graph with correct curvature.

Most candidates were able to identify 2 as the mode of the distribution in part (b). However, an incorrect answer of 0.4 was not uncommon.

There were many fully correct solutions given to part (c) with both an integration method and an area of a triangle method equally being used.

There was a generally good response to part (d) with most candidates able to correctly identify at least 3 of the 4 lines of the cumulative distribution function correctly. The third line of the cumulative distribution function caused trouble for some with the most common error being forgetting to include the probability below $x = 2$. Those using a '+ c' approach tended to have more success. A few lost marks for not defining the cdf fully either omitting 0 for $x < 0$ or 1 for $x > 6$.

Only the most able candidates were able to persevere with parts (e) and (f) of this question. The response to part (e) was, in general, poor. Many candidates again struggled with the conditional probability and very few correct attempts were seen. The most common incorrect answers seen were $F(a) = 0.5$ or $F(a) = \frac{5}{8}$.

In part (f), many candidates were able to select the correct line of their cumulative distribution function and equate it to their F(a) to score the first method mark here. Candidates are once again advised that when solving quadratic equations, a method (factorising (if appropriate)/completing the square/quadratic equation) must be shown to ensure method marks are scored. The rubric on the front of the paper is clear that: "You should show sufficient working to make your methods clear. Answers without working may not gain full credit."

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