A-LEVEL MATHS (EDEXCEL 9MA0) · STATISTICS YEAR 1 · CHAPTER 7: HYPOTHESIS TESTING · A* EXAM PRACTICE

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Hypothesis testing: A* questions

74 marks

Date

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X A* exam questions

A to A*

Extended Edexcel-style questions. Show every step. The hints are at the end of the sheet. Use one at a time.

X1 A cereal company states that 35% of its boxes contain a voucher. A consumer group believes that the proportion has changed. It buys 55 boxes and counts the number, X, that contain a voucher.

(a) State two conditions needed for X to be modelled by a binomial distribution, in context. The group bought all 55 boxes from one shop on one morning. Explain why the conditions might not hold. [3 marks]

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(b) Using a 10% level of significance, find the critical region for a test of the group's belief. The probability in each tail should be as close as possible to 5%. [4 marks]

Answer .....

(c) Find the actual significance level of the test. [2 marks]

Answer .....

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(d) 14 of the 55 boxes contain a voucher. Complete the test. [3 marks]

(e) Ben, a member of the group, notices that 14 is below the expected number, 19.25. He says: "Then the test should be one-tailed, $\mathrm{H}_1 : p < 0.35$, at the 10% level." Explain why Ben is wrong, and whether his test would give a different conclusion. [3 marks]

Total for X1: 15 marks

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X2 A spinner gives a score Y. The maker says that $\mathrm{P}(Y = y) = k(y + 1)$ for $y = 0, 1, 2, 3$, where k is a constant. Kofi believes that the spinner gives a score of 2 or more less often than the maker's model says. He spins it 40 times, and the score is 2 or more on 22 spins. Find k, and test Kofi's belief at the 5% level of significance. [9 marks]

Answer .....

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X3 A theatre says that 25% of the people who see its advert buy a ticket. A new manager will test, at the 5% level, whether a new advert gives a higher proportion, using a random sample of 30 people who see the new advert. Find the critical region for the test. In fact 40% of the people who see the new advert buy a ticket. Find the probability that the test leads the manager to conclude that the proportion is higher than 25%, and comment on the size of the sample. [9 marks]

Answer .....

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X4 A factory says that 20% of its batteries last less than 100 hours. A buyer believes that the proportion is higher, and tests $\mathrm{H}_0 : p = 0.2$ against $\mathrm{H}_1 : p > 0.2$ with this two-stage plan. Test 15 batteries. If 7 or more last less than 100 hours, reject H_0. If 3 or fewer do, do not reject H_0. Otherwise test a second 15 batteries, and reject H_0 if the total number of the 30 that last less than 100 hours is k or more. Assume that H_0 is true in parts (a) to (c).

(a) Find the probability that H_0 is rejected at the first stage. [2 marks]

Answer .....

(b) Find the probability that a second sample is needed. [2 marks]

Answer .....

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(c) The probability of rejecting H_0 when it is true must be at most 5%. Find the smallest possible value of k. [5 marks]

Answer .....

(d) A single test of 30 batteries at the 5% level would have critical region $X \geqslant 11$. Show this, and give one advantage of the two-stage plan and one advantage of the single test. [3 marks]

Total for X4: 12 marks

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X5 An office printer jams on 10% of print jobs. After a service, a technician believes that the proportion of jobs that jam is lower. She tests $\mathrm{H}_0 : p = 0.1$ against $\mathrm{H}_1 : p < 0.1$, where p is the proportion of jobs that jam. Jobs are independent, each jamming with the same probability. Plan A: send jobs one at a time, and reject H_0 if the first m jobs all print without a jam. Plan B: send a random sample of 50 jobs, and reject H_0 if the number that jam is in the critical region at the 5% level.

(a) Find the smallest value of m for which the probability that plan A rejects a true H_0 is at most 5%. [3 marks]

Answer .....

(b) For plan B, find the critical region and its actual significance level. [3 marks]

Answer .....

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(c) The technician uses plan A with the value of m from part (a). The first job that jams is the 17th job sent. State the conclusion, and find the p-value of this result. [3 marks]

Answer .....

Total for X5: 9 marks

X6 In a town, 60% of adults own a car and 30% own a bike. A planner models owning a car and owning a bike as independent.

(a) Show that, under the planner's model, the probability that an adult owns both is 0.18. [2 marks]

Answer .....

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(b) A researcher believes that the proportion of adults who own both is higher than the model gives. In a random sample of 50 adults, 15 own both. Test the researcher's belief at the 5% level of significance. [6 marks]

Answer .....

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(c) Sana says: "If only 14 had owned both, the test would not be significant, and that would prove that owning a car and owning a bike are independent." Comment on Sana's statement. [3 marks]

Total for X6: 11 marks

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X7 A website says that 45% of its visitors use a phone. Two students each test this claim with the same random sample of 40 visitors, at the 5% level. Amir tests $\mathrm{H}_1 : p > 0.45$. Bea tests $\mathrm{H}_1 : p \neq 0.45$, with the probability in each tail at most 2.5%. Find all the values of the number of visitors using a phone for which Amir and Bea reach different conclusions. [9 marks]

Answer .....

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F How did it go?

Colour one circle on each line.

	Not yet	Nearly	Yes
I can carry out a one-tailed or two-tailed binomial test in six steps, with the null value found from another part of the question.	○	○	○
I can find a critical region and its actual significance level, and the probability that a test rejects the null hypothesis for a given true value of p.	○	○	○
I can find the probability of rejecting a true null hypothesis for a two-stage plan or for several tests at once.	○	○	○
I can explain what a test result does and does not show, in context.	○	○	○

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Hints

Use one hint at a time. Cover the ones below it with a sheet of paper.

X1	**Hint 1**	For (b), "changed" gives $\mathrm{H}_1 : p \neq 0.35$. Put about 5% in each tail and compare the probabilities on both sides of each boundary.
	Hint 2	The actual significance level is the sum of the two tail probabilities of the region you chose.
	Hint 3	For (e), work out what Ben's test would decide, then ask when the tail is meant to be chosen.
X2	**Hint 1**	The four probabilities add to 1.
	Hint 2	Each spin either scores 2 or more or does not, so the number of such spins is binomial with $p = \mathrm{P}(Y \geqslant 2)$.
	Hint 3	"Less often" gives a lower tail: find $\mathrm{P}(X \leqslant 22)$, not $\mathrm{P}(X = 22)$.
X3	**Hint 1**	$\mathrm{P}(X \geqslant 12)$ is just over 0.05, so 12 is not in the critical region.
	Hint 2	The manager concludes "higher" exactly when the observed value is in the critical region.
	Hint 3	Now the true proportion is 0.4: find the probability of the critical region using $\mathrm{B}(30, 0.4)$.
X4	**Hint 1**	At the first stage, $X_1 \sim \mathrm{B}(15, 0.2)$.
	Hint 2	H_0 is rejected either at stage one, or after $X_1 = 4, 5$ or 6 when the second 15 give at least $k - X_1$. Add the three cases.
	Hint 3	Try $k = 10$ and $k = 11$ and compare each total with 0.05.
X5	**Hint 1**	If H_0 is true, each job prints without a jam with probability 0.9, independently. Write down the probability that the first m jobs all print.
	Hint 2	For plan B, $\mathrm{H}_1 : p < 0.1$ puts the critical region in the lower tail of $\mathrm{B}(50, 0.1)$.
	Hint 3	For (c), a result at least as extreme as the one seen is a run of printed jobs at least as long. Write that as an event about the first few jobs.

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X6

Hint 1 For independent events, $\mathrm{P}(A \cap B) = \mathrm{P}(A) \times \mathrm{P}(B)$.

Hint 2 "Higher than the model gives" is an upper tail with $p = 0.18$ in H_0.

Hint 3 For (c), find $\mathrm{P}(X \geqslant 14)$, then think about what "not significant" can and cannot show.

X7

Hint 1 Find each student's critical region first. Bea's has two tails, each with at most 0.025.

Hint 2 They reach different conclusions when one of them rejects H_0 and the other does not.

Hint 3 Amir's test has no lower tail, so a small number of phone users never makes him reject.

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