A-LEVEL MATHS (EDEXCEL 9MA0) · STATISTICS YEAR 2 · CHAPTER 2: CONDITIONAL PROBABILITY · A* EXAM PRACTICE

Hints online, answers free with an account:
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Conditional probability: A* questions

82 marks

Date

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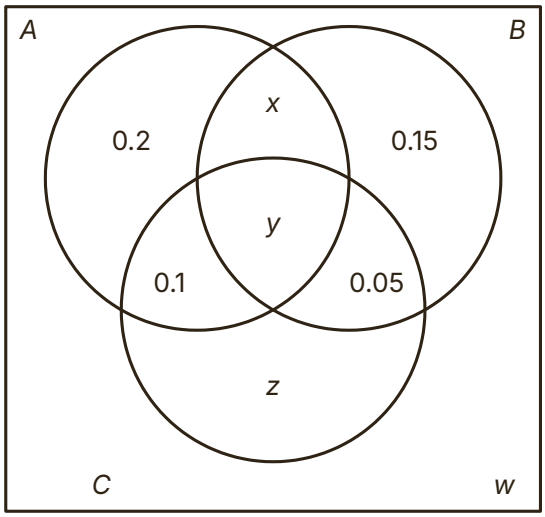
X A* exam questions

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 The Venn diagram shows the probabilities for three events A, B and C, where x, y, z and w are probabilities. $\mathrm{P}(A) = 0.5$, $\mathrm{P}(C \mid A) = 0.3$ and $\mathrm{P}(B \mid C) = 0.4$.

(a) Find y and x. [3 marks]



Answer .....

(b) Find z and w. [3 marks]

Answer .....

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(c) Use conditional probabilities to show that B and C are independent, and to determine whether A and C are independent. [3 marks]

Answer .....

(d) Find $\mathrm{P}(A \mid B \cup C)$. [2 marks]

Answer .....

(e) Find the probability that exactly one of the three events happens, given that at least one happens. [2 marks]

Answer .....

Total for X1: 13 marks

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X2 20% of the emails sent to a company are spam. A filter marks 95% of spam emails as spam, and marks a proportion q of genuine emails as spam. The company wants at least 95% of the emails that are marked as spam to be spam. Find the largest possible value of q. For this value of q, show that the proportion of all emails marked as spam is 0.2, and find the probability that an email that is not marked as spam is spam. A batch of 50 genuine emails passes through the filter, each independently. Find the probability that at least one of them is marked as spam. [9 marks]

Answer .....

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X3 On any day, it either rains or it is dry. If it rains on one day, the probability that it rains the next day is 0.6. If it is dry on one day, the probability that it rains the next day is 0.2. The probability that it rains on a day is the same, r, for every day.

(a) Show that $r = \frac{1}{3}$. [3 marks]

Answer .....

(b) Given that it rains on Tuesday, find the probability that it rained on Monday. [2 marks]

Answer .....

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(c) Given that it rains on both Monday and Wednesday, find the probability that it rains on Tuesday. [3 marks]

Answer .....

(d) Given that it rains on Wednesday, find the probability that it rained on Monday. [3 marks]

Answer .....

Total for X3: 11 marks

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X4 Ann and Bea take turns to toss a biased coin, starting with Ann. The probability of a head on each toss is p, where $0 < p < 1$, and the tosses are independent. The first person to toss a head wins, and they keep tossing until someone does. The probability that Ann wins is $\frac{5}{9}$. Find p. Given that Ann wins, find the probability that she wins on the first toss of the game. Given that Bea wins, find the probability that the game lasts more than 3 tosses. [10 marks]

Answer .....

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X5 A bag holds 4 red and 6 blue counters. A counter is taken at random. If it is red, it is put back together with one more red counter. If it is blue, it is not put back. A second counter is then taken at random.

(a) Find the probability that the second counter is red. [3 marks]

Answer .....

(b) Given that the second counter is red, find the probability that the first was red. [2 marks]

Answer .....

(c) Given that the second counter is blue, find the probability that both counters are the same colour. [3 marks]

Answer .....

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(d) Explain why the second counter is more likely to be red than the first. [2 marks]

Total for X5: 10 marks

X6 A bag holds three coins. One is fair, one lands heads with probability $\frac{3}{4}$, and one has a head on both sides. A coin is chosen at random and tossed twice.

(a) Find the probability that both tosses are heads. [2 marks]

Answer .....

(b) Given that both tosses are heads, find the probability that the coin has two heads. [2 marks]

Answer .....

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(c) Given that both tosses are heads, the same coin is tossed a third time. Find the probability that the third toss is a head. [3 marks]

Answer .....

(d) Given instead that exactly one of the first two tosses is a head, find the probability that the coin is the fair one. [3 marks]

Answer .....

Total for X6: 10 marks

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X7 The table shows the results of an operation at two hospitals, X and Y, for patients in a low-risk group and a high-risk group. A patient is chosen at random from the 1200 patients. Find $\mathrm{P}(\text{success} \mid X)$ and $\mathrm{P}(\text{success} \mid Y)$. Show that, within each risk group, the probability of success is higher at X. Explain why X has the lower overall probability of success. Find the probability that a patient who had a successful operation at X was in the high-risk group, and the probability that a high-risk patient with a successful operation was treated at X. [10 marks]

	Low risk: success	Low risk: fail	High risk: success	High risk: fail
X	180	20	240	160
Y	340	60	110	90

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X8 Each customer at a café buys a coffee with probability 0.3, independently. X is the number of the next 10 customers who buy a coffee.

(a) Find $\mathrm{P}(X \geqslant 2)$. [2 marks]

Answer .....

(b) Given that $X \geqslant 2$, find the probability that the first of the 10 customers buys a coffee. [4 marks]

Answer .....

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(c) Given that the first customer buys a coffee and $X \geqslant 2$, find the probability that $X = 2$. [3 marks]

Answer .....

Total for X8: 9 marks

F How did it go?

Colour one circle on each line.

	Not yet	Nearly	Yes
I can find unknowns in a Venn diagram from conditional probabilities and test independence.	○	○	○
I can reverse a tree to find P(first | later) and condition on more than one stage.	○	○	○
I can set up and solve an equation or inequality for an unknown probability from a conditional probability.	○	○	○
I can explain why a comparison within groups can reverse when the groups are combined.	○	○	○

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Hints

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

X1

Hint 1 $\mathrm{P}(C \mid A) = 0.3$ means the part of A that is also in C is $0.3 \times \mathrm{P}(A)$. That part is two regions of the diagram.

Hint 2 $\mathrm{P}(B \mid C)$ is the part of C inside B over the whole of C; only z is unknown in it. Then all eight regions add to 1.

Hint 3 For independence compare a conditional probability with the plain one: $\mathrm{P}(B \mid C)$ with $\mathrm{P}(B)$, and $\mathrm{P}(C \mid A)$ with $\mathrm{P}(C)$.

X2

Hint 1 Draw a tree: spam or genuine first, then marked or not. Add the two "marked" paths in terms of q.

Hint 2 $\mathrm{P}(\text{spam} \mid \text{marked})$ is the spam-and-marked path over all marked emails. Set it $\geqslant 0.95$; the denominator is positive, so you can multiply out.

Hint 3 For the batch, each genuine email is marked with probability q, independently. "At least one" is $1 - \mathrm{P}(\text{none})$.

X3

Hint 1 It rains tomorrow either after rain today or after a dry day. Write $\mathrm{P}(\text{rain tomorrow})$ in terms of r and set it equal to r.

Hint 2 For (b), the denominator is $\mathrm{P}(\text{rain Tue}) = r$, and the numerator is rain on Monday then rain on Tuesday.

Hint 3 For (c) and (d), list the two ways to get from Monday to Wednesday through Tuesday, and multiply along each.

X4

Hint 1 Ann wins on the first toss, or after two tails, or after four tails, and so on. This is a geometric series.

Hint 2 The series has first term p and common ratio $(1-p)^2$. Simplify $1 - (1-p)^2$ before solving.

Hint 3 "Given Bea wins, more than 3 tosses": Bea can only win on even tosses, so the only short way is a win on toss 2. Use the complement.

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X5

Hint 1 The second draw depends on the first: after a red the bag has 11 counters, 5 red; after a blue it has 9, 4 red.

Hint 2 "Given the second is red": the denominator is your answer to (a), the numerator is the red-then-red path.

Hint 3 For (c), list the two paths that end in blue. Only one of them has two counters of the same colour.

X6

Hint 1 A tree with three first branches, each $\frac{1}{3}$: the coin. On each branch, two heads has probability (head probability)^2.

Hint 2 For (c), the third toss uses the same coin, so you cannot use $\frac{29}{48}$ as a head probability. Find $\mathrm{P}(\text{three heads})$ and divide by $\mathrm{P}(\text{two heads})$.

Hint 3 "Exactly one head" in two tosses of a coin with head probability h is $2h(1-h)$. The two-headed coin cannot do it.

X7

Hint 1 "Given X": the denominator is all 600 patients at X. Then do the same within each risk group, where the denominator is that group at that hospital.

Hint 2 Look at how X's 600 patients split between the groups, and compare with Y. Which group has the lower success rate at both hospitals?

Hint 3 For the last two, the condition decides the denominator: "successful at X" is 420 patients; "high risk and successful" is $240 + 110$.

X8

Hint 1 $X \sim \mathrm{B}(10, 0.3)$. "At least 2" is 1 minus the probabilities of 0 and 1.

Hint 2 Split the 10 customers into the first and the other 9. If the first buys, $X \geqslant 2$ says at least one of the other 9 buys.

Hint 3 In (c), $X = 2$ with the first buying means exactly one of the other 9 buys: a $\mathrm{B}(9, 0.3)$ probability.

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