



The binomial distribution

About 55 minutes Calculator allowed 42 marks

Date _____

A Do Now

The first question is what today's lesson needs. The others bring back earlier topics.

- A1** Needed today [2 marks]

The probability that the morning train is late is 0.55. The probability that the evening train is late is 0.45. The two events are independent. Find the probability that exactly one of the trains is late.

A2 From chapter 7 [2 marks]

The waiting times, in minutes, of some callers to a help line have mean 55 and median 46. Ben wants one figure for a typical waiting time. Which average should Ben use? Give a reason.

Answer

- A3** From chapter 10 [2 marks]

Two judges rank 6 dogs at a show, A to F. Judge 1 ranks them in order: A is 1st, B is 2nd, and so on. Judge 2 gives A, B, C, D, E, F the ranks 2, 1, 3, 6, 4, 5. Work out Spearman's rank correlation coefficient, to 3 decimal places.

A4 From chapter 2 [2 marks]

A guide book says there are about 50 deer in a forest. A survey marks 31 deer. A second catch of 63 has 14 marked. Does the survey's estimate support the figure of 50? Give a reason.

Answer

B Example, then your turn

Your teacher works through each example with you. Then try the one beside it.

EXAMPLE 1

A fair dice is rolled 10 times. X is the number of sixes. Explain why X can be modelled by a binomial distribution.

Hint Four conditions: a fixed number of trials, two outcomes, the same probability each time, and trials that do not affect each other. Say each one about the dice.

- B1** Each of 12 seeds in a tray grows with probability 0.8. Y is the number of seeds that grow. Give two reasons, in context, why a binomial model could be suitable for Y . [2 marks]

EXAMPLE 2

$X \sim B(5, 0.3)$. Work out $P(X = 2)$.

Hint Count the arrangements of 2 successes in 5 trials, then multiply by $0.3^2 \times 0.7^3$.

B2 $X \sim B(6, 0.15)$. Work out [2 marks]
 $P(X = 1)$. Give your answer to 3 decimal places.

Answer

EXAMPLE 3

$X \sim B(4, 0.2)$. Work out (a) $P(X \geq 1)$, (b) $P(X \leq 1)$.

Hint "At least 1" is everything except $X = 0$. "At most 1" is $X = 0$ plus $X = 1$.

B3 $X \sim B(5, 0.2)$. Work out [3 marks]
 $P(X \leq 2)$. Give your answer to 3 decimal places.

Answer

EXAMPLE 4

(a) $X \sim B(20, 0.35)$. Work out the mean of X .
 (b) $Y \sim B(8, p)$ and the mean of Y is 2.4. Work out p .

Hint The mean of $B(n, p)$ is np .

B4 $W \sim B(15, p)$ and the mean of [3 marks]
 W is 6. Work out $P(W = 15)$.
 Give your answer in standard form to 3 significant figures.

Answer

EXAMPLE 5

Mo records whether it rains on each of the 7 days of a week in January. He models the number of rainy days as $B(7, 0.3)$. Give a reason why this model may not be suitable.

Hint Check the conditions: is the probability the same each day, and does one day affect the next?

B5 A bag has 6 green and 4 white [1 mark]
 counters. Sara takes 3
 counters, one at a time, and
 does not put them back.
 Explain why $B(3, 0.6)$ is not a
 suitable model for the number
 of green counters she takes.

EXAMPLE 6

Lin catches 2 buses each day. She models the number of late buses each day as $B(2, 0.2)$. Over 100 days, she had 0 late buses on 50 days, 1 on 38 days and 2 on 12 days. Is the model good? Give a reason.

Hint Expected number of days = $100 \times P(X = r)$.
 Compare with what happened.

B6 Ola models the number of her [2 marks]
 two alarms that fail each
 morning as $B(2, 0.3)$. Work out
 the expected number of
 mornings, out of 50, with 0, 1
 and 2 failures.

C Practice

- C1** $X \sim B(7, 0.4)$. Work out $P(X = 3)$. Give your answer to 3 decimal places. [2 marks]
- Answer
- C2** 3% of the phone cases a factory makes are faulty. A shop buys 10 cases. Work out the probability that at least one case is faulty. Give your answer to 3 decimal places. [2 marks]
- Answer

- C3** Leon counts the number of cars that pass his house in one hour. Explain why a binomial distribution cannot model this number. [1 mark]
- C4** $X \sim B(4, 0.4)$. Show that $P(X = 2) = 0.3456$. [2 marks]

D Exam-style questions

- D1** A fair coin is thrown 4 times. Joe says, "The probability of exactly 2 heads is $0.5^4 = 0.0625$." [2 marks]
- Is Joe correct? You must show your working.

- D2** Kemi takes 6 penalty kicks. She scores with each kick with probability 0.35. X is the number of kicks she scores.
- (a) State two conditions needed for X to have a binomial distribution. Give your conditions in context. [2 marks]

- (b) Work out the probability that Kemi scores with exactly one kick. Give your answer to 3 decimal places. [2 marks]

Answer

- (c) Kemi says, "I am more likely to score exactly twice than exactly once." Is she right? Show how you decide. [2 marks]

Total for D2: 6 marks

D3 Raj plays 3 games of chess against a computer each day. He thinks he wins each game with probability 0.7, independently. The table shows the number of games he won each day, over 200 days.

Wins in a day	0	1	2	3
Days	6	39	86	69

- (a)

Use $B(3,0.7)$ to work out the expected number of days with 0, 1, 2 and 3 wins.

[2 marks]
- (b)

Is $B(3,0.7)$ a good model for Raj's results? Give a reason.

[1 mark]

Total for D3: 3 marks

E Extension

No route is given. The hints are at the end of the sheet. Use one at a time.

E1

10% of the tickets in a game win a prize, independently. What is the smallest number of tickets you must buy for the probability of winning at least one prize to be more than 0.9?

[3 marks]

Answer

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Extension hints

Cover these with paper. Uncover one at a time.

- E1

Hint 1

$P(\text{at least one prize}) = 1 - P(\text{no prizes}).$

Hint 2

You need $1 - 0.9^n > 0.9$, so $0.9^n < 0.1$.

Hint 3

$0.9^{21} = 0.109$ and $0.9^{22} = 0.0985$, so $n = 22$.
- How did it go?**
- Colour one circle on each line: not yet, nearly, yes.
- I can state the conditions for a binomial model in context, and say when it is not suitable.

I can work out binomial probabilities, including at least and at most.

I can use the mean np and compare a binomial model with observed data.
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