

GCSE Higher Mathematics

Practice Test 8: Probability

Instructions:

Answer all questions. Show your working clearly.
Calculators may be used unless stated otherwise.

Time allowed: 90 minutes

Section A: Conditional Probability Fundamentals

1. A survey of 280 students shows:

- 175 study Psychology
- 142 study Sociology
- 89 study both Psychology and Sociology

- (a) Draw a Venn diagram
- (b) Find $P(\text{studies Psychology} \mid \text{studies Sociology})$
- (c) Find $P(\text{studies Sociology} \mid \text{studies Psychology})$
- (d) Find $P(\text{studies exactly one subject})$
- (e) Are studying Psychology and Sociology independent? Justify your answer

2. A box contains 14 lime balls and 16 magenta balls. Two balls are drawn without replacement.

- (a) Find $P(\text{second ball is lime} \mid \text{first ball is lime})$
- (b) Find $P(\text{second ball is magenta} \mid \text{first ball is lime})$
- (c) Find $P(\text{both balls are the same color})$
- (d) Find $P(\text{balls are different colors})$
- (e) Verify that your probabilities sum to 1

3. Events Q and R are such that:

- $P(Q) = 0.59$
- $P(R) = 0.46$
- $P(Q \cap R) = 0.31$

Calculate:

- (a) $P(Q \cap R)$
- (b) $P(Q')$
- (c) $P(Q \cap R)$
- (d) $P(R \cap Q)$

- (e) $P(Q' \cap R')$
(f) $P(Q \cap R')$
4. A card is drawn from a standard 52-card deck. Let Q = "card is an odd number" (3, 5, 7, 9) and R = "card is a Queen".
- (a) Find $P(Q)$, $P(R)$, and $P(Q \cap R)$
(b) Calculate $P(Q \cap R)$
(c) Calculate $P(R \cap Q)$
(d) Are events Q and R independent? Show your working
(e) Find $P(Q' \cap R')$

Section B: Tree Diagrams and Sequential Events

5. A bag contains 13 scarlet counters and 11 gold counters. A counter is drawn, its color noted, and then replaced. This process is repeated twice more.
- (a) Draw a tree diagram for all three draws
(b) Find $P(\text{all three counters are scarlet})$
(c) Find $P(\text{exactly two counters are gold})$
(d) Find $P(\text{at least one counter is scarlet})$
(e) Find $P(\text{first counter is gold} \cap \text{exactly two are gold})$
6. Box H contains 9 red balls and 1 white ball. Box I contains 2 red balls and 10 white balls. A fair coin is flipped to choose a box, then a ball is drawn.
- (a) Draw a tree diagram
(b) Find $P(\text{red ball})$
(c) Find $P(\text{white ball})$
(d) Given a red ball was drawn, find $P(\text{it came from Box H})$
(e) Given a white ball was drawn, find $P(\text{it came from Box I})$
7. Three machines produce components with different defect rates:
- Machine F: produces 61% of components, 7% defective
 - Machine G: produces 24% of components, 13% defective
 - Machine H: produces 15% of components, 19% defective
- (a) Find the overall probability of a defective component
(b) If a component is defective, find the probability it came from Machine F
(c) If a component is defective, find the probability it came from Machine H
(d) If a component is not defective, which machine most likely produced it?
8. A student takes three tests. The probability of passing each test is 0.86, and the tests are independent.
- (a) Find $P(\text{passes all three tests})$
(b) Find $P(\text{fails all three tests})$
(c) Find $P(\text{passes exactly two tests})$
(d) Find $P(\text{passes at least one test})$
(e) Given the student passed at least two tests, find $P(\text{passed all three})$

Section C: Bayes' Theorem Applications

9. A medical test for a condition has the following characteristics:

- If a person has the condition, the test is positive 79% of the time
- If a person doesn't have the condition, the test is negative 88% of the time
- 2.8% of the population has the condition

- (a) Find $P(\text{positive test})$
- (b) If someone tests positive, find $P(\text{they have the condition})$
- (c) If someone tests negative, find $P(\text{they don't have the condition})$
- (d) Comment on the reliability of a positive test result
- (e) How would the results change if 28% of the population had the condition?

10. A security system has three sensors. The probability each sensor detects an intruder is:

- Sensor F: 0.94
- Sensor G: 0.88
- Sensor H: 0.98

The sensors operate independently.

- (a) Find $P(\text{all three sensors detect an intruder})$
- (b) Find $P(\text{at least one sensor detects an intruder})$
- (c) Find $P(\text{exactly two sensors detect an intruder})$
- (d) If exactly two sensors detect an intruder, find $P(\text{Sensor G failed})$
- (e) Which single sensor is most reliable for detection?

11. A factory produces items using two processes. Process H is used 74% of the time and produces 10% defective items. Process I is used 26% of the time and produces 21% defective items.

- (a) A random item is selected and found to be defective. Use Bayes' theorem to find $P(\text{produced by Process H})$
- (b) If 1000 items are produced, how many would you expect to be defective?
- (c) How many of the defective items would come from each process?
- (d) To reduce overall defect rate to 9%, what should Process I's defect rate be?

12. Three weather forecasting models predict rain independently:

- Model F: 89% accurate when it will rain, 91% accurate when it won't rain
- Model G: 72% accurate when it will rain, 96% accurate when it won't rain
- Model H: 94% accurate when it will rain, 85% accurate when it won't rain

Historically, it rains 42% of days.

- (a) If all three models predict rain, find $P(\text{it actually rains})$
- (b) If Model F predicts rain but Models G and H predict no rain, find $P(\text{it rains})$
- (c) Which model would you trust most for a "rain" prediction?
- (d) Which model would you trust most for a "no rain" prediction?

Section D: Introduction to Binomial Distribution

13. A fair coin is flipped 22 times.
- (a) Find $P(\text{exactly 12 heads})$
 - (b) Find $P(\text{at most 9 heads})$
 - (c) Find $P(\text{at least 14 heads})$
 - (d) Find the expected number of heads
 - (e) Find the most likely number of heads
 - (f) Calculate the variance of the number of heads
14. A multiple choice test has 28 questions, each with 5 possible answers. A student guesses randomly on all questions.
- (a) State the distribution of the number of correct answers
 - (b) Find $P(\text{exactly 10 correct answers})$
 - (c) Find $P(\text{more than 12 correct answers})$
 - (d) Find the expected number of correct answers
 - (e) Find $P(\text{passes the test})$ if the pass mark is 30%
 - (f) Calculate the standard deviation of correct answers
15. The probability that a seed germinates is 0.68. A packet contains 26 seeds.
- (a) Find $P(\text{all seeds germinate})$
 - (b) Find $P(\text{exactly 19 seeds germinate})$
 - (c) Find $P(\text{fewer than 15 seeds germinate})$
 - (d) How many seeds would you expect to germinate?
 - (e) Find $P(\text{at least 65\% of seeds germinate})$
 - (f) What's the most likely number of seeds to germinate?
16. A manufacturing process produces 15% defective items. Quality control samples 32 items.
- (a) Find $P(\text{no defective items in the sample})$
 - (b) Find $P(\text{exactly 6 defective items})$
 - (c) Find $P(\text{more than 7 defective items})$
 - (d) Calculate the expected number of defective items
 - (e) Find $P(\text{defect rate in sample exceeds 22\%})$
 - (f) Calculate the probability that the sample defect rate is between 10% and 20%

Section E: Advanced Binomial Applications

17. A basketball player has a 84% free throw success rate. In a game, they attempt 34 free throws.
- (a) Model this situation and state any assumptions
 - (b) Find $P(\text{makes at least 30 free throws})$
 - (c) Find $P(\text{makes between 26 and 30 free throws inclusive})$
 - (d) Calculate the expected number of successful free throws
 - (e) Find the probability their success rate in this game is above 90%
 - (f) What's the minimum number of attempts needed for $P(\text{at least 1 success}) > 0.999999999$?

18. A quality control inspector checks 46 items per hour. The probability any item is defective is 0.16.
- (a) Find $P(\text{finds exactly 7 defective items in one hour})$
 - (b) Find $P(\text{finds no defective items in one hour})$
 - (c) Over a 5-hour shift, find the expected number of defective items found
 - (d) In what percentage of hours would you expect to find more than 10 defective items?
 - (e) If the inspector finds 13 defective items in one hour, comment on whether this is unusual
19. A pharmaceutical company claims their drug is effective for 92% of patients. A trial involves 31 patients.
- (a) If the claim is true, find $P(\text{drug works for exactly 28 patients})$
 - (b) Find $P(\text{drug works for at least 26 patients})$
 - (c) Calculate the expected number of patients for whom the drug works
 - (d) If the drug works for only 23 patients, test whether this supports the company's claim
 - (e) What's the minimum number of successes that would support the 92% claim at 5% significance?
20. A survey shows 57% of people support a proposal. A random sample of 42 people is surveyed.
- (a) Find $P(\text{exactly 24 people support the proposal})$
 - (b) Find $P(\text{fewer than 20 people support the proposal})$
 - (c) Calculate the expected number of supporters
 - (d) Find $P(\text{between 50\% and 70\% of the sample support the proposal})$
 - (e) If 29 people in the sample support the proposal, is this significantly different from expected?

Section F: Combined Probability Scenarios

21. An online retailer has two suppliers. Supplier H provides 78% of goods with 9% defect rate. Supplier I provides 22% of goods with 22% defect rate.
- (a) A customer receives 32 items. Find $P(\text{exactly 4 are defective})$
 - (b) If a customer complains about a defective item, find $P(\text{it came from Supplier I})$
 - (c) A batch of 350 items arrives. Find the expected number from each supplier
 - (d) Calculate the overall defect rate
 - (e) If the company wants to reduce defects to 8%, what should Supplier I's rate be?
22. A casino game involves drawing 10 cards from a standard deck without replacement. The player wins if all 10 cards are spades.
- (a) Calculate $P(\text{all 10 cards are spades})$
 - (b) Calculate $P(\text{all 10 cards are the same suit})$
 - (c) If 5000 people play this game, how many would you expect to win?
 - (d) What should be the payout ratio for this to be a fair game?
 - (e) How does the probability change if cards are replaced after each draw?
23. A communication system sends signals through 10 independent channels. Each channel has probability 0.83 of successful transmission.
- (a) Find $P(\text{message received successfully through all channels})$

- (b) Find $P(\text{message fails on exactly one channel})$
 - (c) The system works if at least 9 channels succeed. Find $P(\text{system works})$
 - (d) If the system sends 200 messages, find $P(\text{fewer than 170 are received successfully})$
 - (e) What should be the individual channel reliability for 99.999% system reliability?
24. A hospital emergency department sees an average of 31% critical cases. On a particular shift, 39 patients arrive.
- (a) Model the number of critical cases and state assumptions
 - (b) Find $P(\text{exactly 12 critical cases})$
 - (c) Find $P(\text{no critical cases})$
 - (d) Find $P(\text{more than 18 critical cases})$
 - (e) Calculate the expected number of critical cases
 - (f) If there are 21 critical cases in one shift, is this unusually high?

Section G: Advanced Problem Solving

25. A genetic disorder affects 1 in 480 births. A screening test is 81% accurate for positive cases and 99.7% accurate for negative cases.
- (a) Calculate the probability of testing positive
 - (b) If a baby tests positive, what's the probability they have the disorder?
 - (c) How many false positives occur per 48,000 births?
 - (d) Design a two-stage testing procedure to reduce false positives
 - (e) Comment on the ethical implications of these probabilities
26. A software company releases updates with bugs 37% of the time. They use a testing protocol that catches 68% of buggy updates but also flags 15% of good updates as potentially buggy.
- (a) If an update is flagged, find $P(\text{it actually has bugs})$
 - (b) If an update passes testing, find $P(\text{it's actually bug-free})$
 - (c) In 600 updates, how many false alarms would you expect?
 - (d) Suggest improvements to the testing protocol
 - (e) Calculate the overall accuracy of the testing system
27. A lottery has the following structure: pick 6 numbers from 1-28. You win the jackpot if all 6 match.
- (a) Calculate $P(\text{winning the jackpot})$
 - (b) Find $P(\text{matching exactly 5 numbers})$
 - (c) Find $P(\text{matching exactly 4 numbers})$
 - (d) If 25 million tickets are sold, find $P(\text{no one wins the jackpot})$
 - (e) Model the number of jackpot winners as a binomial distribution
28. A cybersecurity system monitors network traffic. It correctly identifies 83% of malicious attacks and incorrectly flags 9% of normal traffic. On average, 0.8% of traffic is malicious.
- (a) Find the probability of an alert
 - (b) If there's an alert, find $P(\text{it's a real attack})$
 - (c) In monitoring 1,500,000 data packets, how many false alarms occur?

- (d) Design a cost-benefit analysis for this system
 - (e) How would increasing the detection rate to 87% affect false alarms?
29. Design and analyze a probability model for a real-world scenario of your choice:
- (a) Define the scenario and identify random variables
 - (b) State all assumptions clearly
 - (c) Choose appropriate probability distributions
 - (d) Calculate relevant probabilities
 - (e) Discuss limitations and potential improvements
 - (f) Consider practical applications of your analysis

Answer Space

Use this space for your working and answers.

END OF TEST

Total marks: 100

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