Two-Way Frequency Tables

Name: _____ Date: _____ Score: _____ / 31

Quick Review

A **two-way frequency table** crosses two categorical variables. Rows are one variable; columns are the other. The *cells* hold the **joint frequencies** (counts in both categories), while the right column and bottom row hold the **marginal frequencies** (totals for a single category). The bottom-right corner is the **grand total** – the whole sample size.

Joint probability. Divide a cell by the grand total. "P(boy and likes math)" uses the boy-likes-math cell over the grand total.

Marginal probability. Divide a marginal total by the grand total. "P(likes math)" uses the likes-math column total over the grand total.

Conditional probability. The word *given* tells you which margin becomes the new denominator. "P(likes math | girl)" restricts to girls only – the girl row total becomes the denominator, and you count girls who like math in the numerator.

Independence test (from tables). The two variables are independent in the sample exactly when $P(A \mid B) = P(A)$ for every row/column pair. Equivalently, the observed cell counts match what you'd expect from the row and column proportions alone.

Common slips. Putting the grand total in the denominator of a conditional probability (that gives joint, not conditional). Reversing the direction of conditioning ($P(A \mid B)$ vs. $P(B \mid A)$ – they're usually different). Confusing the row total with the grand total.

PRACTICE

Read each two-way table; compute the requested probability.

1. From the table: P(boy and likes math) _____

	Likes math	Dislikes math	Total
Boys	40	10	50
Girls	30	20	50
Total	70	30	100

2. From that same table: P(likes math) _____
3. From the same gender-math table: P(likes math|girl) _____
4. Same table: P(boy|likes math) _____
5. Same table: are gender and math preference independent? _____
6. From the table: P(exercise daily|full-time) _____

	Exercise	No exercise	Total
Full-time	50	50	100
Part-time	60	40	100
Total	110	90	200

7. From that employment table: P(exercise daily) _____
8. Same employment table: are work status and exercise independent? _____
9. In a 2×2 table, the bottom-right cell holds ... _____
10. A joint frequency is found in ... _____
11. Same employment table: P(part-time and exercise) _____
12. Same employment table: P(full-time|exercise) _____
13. Same gender-math table: P(girl and dislikes math) _____

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14. Same gender-math table: $P(\text{dislikes math}|\text{girl})$ _____

15. Conditional probability uses ... as denominator. _____

16. In a survey of $200,\ 80$ owned dogs, 60 of dog owners owned cats. $P(\text{cat}|\text{dog})$ _____

17. Same survey: 120 non-dog owners, of whom 40 owned cats. $P(\text{cat}|\text{no dog})$ _____

18. In the survey of $200,\ 100$ total cat owners. $P(\text{cat})$ _____

19. Same survey: are cat and dog ownership independent? _____

20. Sum of all interior cells in a two-way table equals ... _____

♦ Word Problems

21. A two-way frequency table records gender vs. math preference for 100 students: 40 boys like math, 10 boys dislike math, 30 girls like math, 20 girls dislike math. Find $P(\text{likes math} \mid \text{girl})$. _____

	Likes math	Dislikes math	Total
Boys	40	10	50
Girls	30	20	50
Total	70	30	100

22. From the same gender-math table, compute $P(\text{boy} \mid \text{likes math})$ and explain in words why it differs from $P(\text{likes math} \mid \text{boy})$. _____

23. A survey of 200 employees finds: 50 full-time workers exercise daily, 50 full-time workers don't; 60 part-time workers exercise daily, 40 don't. Find $P(\text{exercise daily} \mid \text{full-time})$ and decide whether work status and exercise look independent. _____

	Exercise	No exercise	Total
Full-time	50	50	100
Part-time	60	40	100
Total	110	90	200

24. In a survey of 200 people, 80 own dogs and 120 don't. Among dog owners, 60 own cats; among non-dog owners, 40 own cats. Are dog ownership and cat ownership independent in this sample? _____

Additional Practice

25. Probability of rolling an even number on a fair die. _____

26. Probability of drawing a heart from a standard deck. _____

27. Complement of $P(A) = 0.37$. _____

28. If events are independent, $P(A) = 0.4$, $P(B) = 0.5$, find $P(A \cap B)$. _____

29. Find $P(A \cup B)$ if $P(A) = 0.6$, $P(B) = 0.3$, $P(A \cap B) = 0.1$. _____

30. Choose 3 from 8. _____

31. Arrange 4 distinct books. _____

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Answer Keys

1. $\frac{40}{100} = 0.4$
2. $\frac{70}{100} = 0.7$
3. $\frac{30}{50} = 0.6$
4. $\frac{40}{70} \approx 0.571$
5. No
6. $\frac{50}{100} = 0.5$
7. $\frac{110}{200} = 0.55$
8. No
9. the grand total
10. an interior cell
11. $\frac{60}{200} = 0.3$
12. $\frac{50}{110} \approx 0.455$
13. $\frac{20}{100} = 0.2$
14. $\frac{20}{50} = 0.4$
15. the conditioning margin
16. 0.75
17. $\frac{40}{120} \approx 0.333$
18. 0.5
19. No
20. the grand total
21. $\frac{3}{5} = 0.6$
22. $P(\text{boy} \mid \text{likes math}) = \frac{4}{7} \approx 0.571$
23. $P = 0.5$; not independent
24. No

Additional Practice Answers

25. $\frac{1}{2}$
26. $\frac{1}{4}$
27. 0.63
28. 0.20
29. 0.8
30. 56
31. 24

Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

1. "Boy and likes math" is a joint event, so use the interior cell over the grand total. The boys-who-like-math cell is 40 and the grand total is 100: $\frac{40}{100} = 0.4$.

2. This is a marginal probability – it ignores gender. Use the "likes math" column total ($40 + 30 = 70$) over the grand total 100: $\frac{70}{100} = 0.7$.

3. "Given girl" restricts to the 50 girls. Of those, 30 like math: $\frac{30}{50} = 0.6$.

4. "Given likes math" restricts to the 70 math-likers. Of those, 40 are boys: $\frac{40}{70} = \frac{4}{7}$.

5. A careful way to see it: $P(\text{likes math} \mid \text{boy}) = \frac{40}{50} = 0.8$ but $P(\text{likes math}) = 0.7$. They don't match, so the variables are dependent in this sample. That gives a quick check on the answer.

6. "Given full-time" makes the full-time row total (100) the new denominator – not the grand total. Of those 100, the exercise cell is 50: $\frac{50}{100} = 0.5$.

7. Marginal probability across both work statuses: add the exercise column ($50 + 60 = 110$) and divide by the grand total 200. $\frac{110}{200} = 0.55$.

8. Start with the key idea: $P(\text{exercise} \mid \text{full-time}) = 0.5$ but $P(\text{exercise}) = 0.55$. The conditional and marginal differ, so the variables are dependent. That gives a quick check on the answer.

9. The bottom-right cell is always the grand total – it equals the total sample size and matches both row-margin and column-margin sums.

10. Joint frequencies (the count satisfying both row and column conditions) sit in the inner cells. Marginal totals sit on the edges.

11. "Part-time and exercise" is a joint event, so take that interior cell (60) over the grand total (200): $\frac{60}{200} = 0.3$. No conditioning here, so the denominator is the full sample.

12. Restrict to exercisers $(110$ total). Full-timers among them: 50. So $\frac{50}{110} = \frac{5}{11}$.

13. Joint event "girl and dislikes math": read the interior cell (20) and divide by the grand total (100). $\frac{20}{100} = 0.2$.

14. "Given girl" switches the denominator to the girl row total (50). Of those girls, 20 dislike math: $\frac{20}{50} = 0.4$. Using 100 here would wrongly give the joint probability.

15. One steady path is: $P(A \mid B)$ divides by $P(B)$. In a table that means divide by the row total or column total that matches the condition. That gives a quick check on the answer.

16. "Given dog" makes the 80 dog owners the denominator. Of those, 60 also own cats: $\frac{60}{80} = 0.75$. The full 200 never enters a conditional like this.

17. A careful way to see it: $\frac{40}{120} = \frac{1}{3} \approx 0.333$. Restrict to non-dog owners. This is the part to check before moving on, because it keeps the answer tied to the original question.

18. Marginal (no condition): all 100 cat owners over the full survey of 200. $\frac{100}{200} = 0.5$ – half the survey owns cats.

19. One steady path is: $P(\text{cat} \mid \text{dog}) = 0.75$ but $P(\text{cat}) = 0.5$. Knowing someone owns a dog changes the probability of cat ownership, so the variables are dependent. That gives a quick check on the answer.

20. Every observation falls in exactly one cell, so the cells partition the data set. Their sum is the total sample size.

21. The phrase "given the student is a girl" shrinks the universe to just the 50 girls. Of those, 30 like math, so $P(\text{likes math} \mid \text{girl}) = \frac{30}{50} = \frac{3}{5} = 0.6$. Common slip: writing $\frac{30}{100}$ – that would be the joint probability $P(\text{girl and likes math})$, not the conditional. The condition sets the denominator.

22. Restrict to the 70 students who like math. Among them, 40 are boys: $P(\text{boy} \mid \text{likes math}) = \frac{40}{70} = \frac{4}{7} \approx 0.571$. For comparison, $P(\text{likes math} \mid$

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boy) $= \frac{40}{50} = 0.8$. These are different because they're asking different questions: "what fraction of math-likers are boys" vs. "what fraction of boys like math." Same cell (40), different denominator.

23. Restrict to full-time workers $(100$ total). 50 of them exercise: $P(\text{exercise} \mid \text{full-time}) = \frac{50}{100} = 0.5$. Compare with the marginal: $P(\text{exercise}) = \frac{110}{200} = 0.55$. The two differ, so work status and exercise are *not* independent in this sample. (Part-time workers exercise more: $\frac{60}{100} = 0.6$ vs. 0.5 for full-timers. Maybe full-timers are too tired after work.)

24. Compute three probabilities: $P(\text{cat} \mid \text{dog}) = \frac{60}{80} = 0.75$, $P(\text{cat} \mid \text{no dog}) = \frac{40}{120} \approx 0.333$, $P(\text{cat}) = \frac{100}{200} = 0.5$. The conditional probabilities $(0.75$ vs. $0.333)$ are very different, and neither matches the marginal 0.5. So the variables are dependent – in fact, dog owners are about twice as likely to own cats as non-dog owners. (Real-world hunch: pet people tend to be pet people.)

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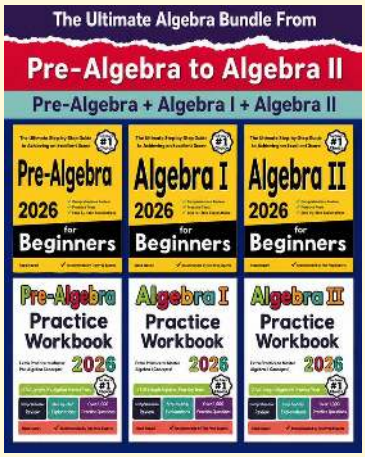

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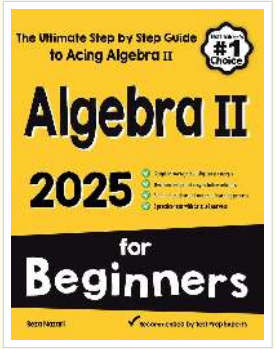

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