Finding Probabilities of Compound Events

Apply the skill to decisions and designs

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QUICK REVIEW

Multiply independent stage chances for an AND event: $(1/4)(1/5) = 1/20$. Add disjoint winning paths, or subtract the losing chance from 1. Without replacement, update the remaining counts.

Worked example

Flip a fair coin and independently spin five equal sectors A, B, C, D, E. Find the chance of tails and either A or E.

1. Tails has chance $1/2$.
2. A or E takes 2 of 5 sectors, so its chance is $2/5$.
3. Both are needed and the stages are independent: $(1/2)(2/5) = 1/5$.
Answer: $1/5$.

Practice Problems

Show your thinking.

1. Game A spins a fair 1 to 4 spinner twice independently and wins on matching results. Game B wins on 1 or 2 on a fair six-sided die. Choose the more likely game and give the exact gap.

2. A booth rolls a fair six-sided die twice independently. It must win with chance no greater than $2/3$. Compare winning on at least one even roll with winning on exactly one even roll. Which rule fits?

3. With two independent fair six-sided dice, a booth pays a prize for sum at least 10. Estimate prizes in 180 plays. Will 25 prizes cover the estimate, and what is the margin?

4. Roll a fair six-sided die and independently spin equal sectors W, W, L. A rule must win with chance exactly $1/3$. Compare A: even and W, with B: roll 1 and W. Which works?

5. Draw two counters at random without replacement from 3 green and 3 orange. To win with probability $3/5$, should the rule require same colors or different colors? Find both chances.

6. Independent equal-sector spinners show $0, 1, 2$ and $1, 2$. A product below 3 wins. Product 0 pays two tickets and other wins pay one. Find the win chance and expected tickets in 30 plays.

7. A game draws twice at random from 2 red and 3 blue counters and wins on two reds. Which rule, with or without replacement, reaches a win chance of at least $3/20$? Find both chances.

8. A fair six-sided die and an independent equal-sector spinner H, H, H, T win on an even roll or H, including both. The target is at least $5/6$. Use the losing event to test the target and find the gap.

Answer Key

1. B is better: $1/3$ versus $1/4$, gap $1/12$.
2. Use exactly one even roll: $1/2$; at least one gives $3/4$, over the limit.
3. Expect 30 prizes; stock is short by 5.
4. A works: $1/3$. B gives $1/9$.
5. Different colors gives $3/5$; same colors gives $2/5$.
6. Win chance $5/6$; expect 35 tickets.
7. Use replacement: $4/25$ meets the target; without gives $1/10$.
8. Yes; win chance $7/8$ is $1/24$ above target.

Step-by-Step Solutions

Follow each calculation, then check your own work.

Problem 1

1. A matches in 4 of $4(4) = 16$ ordered results, so its chance is $4/16 = 1/4$.
2. B wins on 2 of 6 die faces, so its chance is $2/6 = 1/3$.
3. The difference is $1/3 - 1/4 = 1/12$ in favor of B.

Problem 2

1. At least one even has chance $1 - (3/6)(3/6) = 3/4$.
2. Exactly one even is even-odd or odd-even: $2(3/6)(3/6) = 1/2$.
3. $1/2 \le 2/3 < 3/4$, so only the exactly-one rule fits.

Problem 3

1. Sums 10, 11, and 12 have 3, 2, and 1 ordered pairs, respectively.
2. The chance is $(3 + 2 + 1)/36 = 1/6$.
3. Expected prizes: $180(1/6) = 30$, which is $30 - 25 = 5$ more than stock.

Problem 4

1. W has chance $2/3$ because two of the 3 sectors show W.
2. Rule A gives $(3/6)(2/3) = 1/3$.
3. Rule B gives $(1/6)(2/3) = 1/9$, so only A reaches $1/3$.

Problem 5

1. Green-green has chance $(3/6)(2/5) = 1/5$. Orange-orange has the same chance.
2. The same-color paths are disjoint: $1/5 + 1/5 = 2/5$.
3. Different colors is the complement: $1 - 2/5 = 3/5$, the target.

Problem 6

1. Of $3(2) = 6$ ordered outcomes, $(0, 1), (0, 2)$ give 0 and earn two tickets.
2. $(1, 1), (1, 2), (2, 1)$ earn one ticket; only $(2, 2)$ loses. Win chance $(2 + 3)/6 = 5/6$.
3. Expect $30(2/6) = 10$ two-ticket wins and $30(3/6) = 15$ one-ticket wins.
4. Ticket estimate: $2(10) + 15 = 35$.

Problem 7

1. With replacement: $(2/5)(2/5) = 4/25$.
2. Without replacement: $(2/5)(1/4) = 1/10$.
3. In hundredths, $10/100 < 15/100 \le 16/100$, so only replacement qualifies.

Problem 8

1. The only losing condition is odd and T, with chance $(3/6)(1/4) = 1/8$.
2. Win chance is $1 - 1/8 = 7/8$.
3. Compare: $7/8 - 5/6 = 21/24 - 20/24 = 1/24 > 0$.

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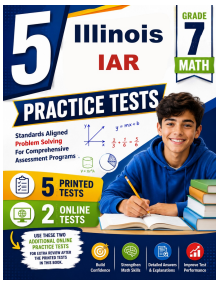

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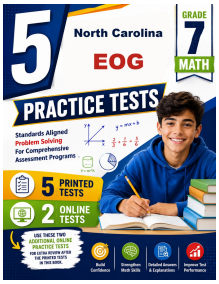

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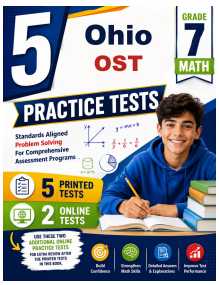

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