# Simulating Compound Events

Apply the skill to decisions and designs

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**QUICK REVIEW**

Each practice entry is an ordered pair of independent uniform digits from $0$ to $9$. Match each chance with the right number of digit labels; for $1/10$, use one label. Count whole trials, not separate digits.

**Worked example**

Model independent stage chances $1/2$ and $1/5$. Using separate digits, how can both stages pass? Find the model chance.

1. Use $5$ of $10$ labels for the first chance: $5/10 = 1/2$.
2. Use $2$ of $10$ labels for the second chance: $2/10 = 1/5$.
3. With independent digits, both pass with chance $(5/10)(2/10) = 1/10$.

**Answer:** First $0$ to $4$, second $0$ to $1$; both $1/10$.

## Practice Problems

Show your thinking.

**1.** Check 1 detects a defect if the first digit is $0$ to $3$; check 2 if the second is $7$ to $9$. Rule A flags one or both defects; B flags only both. Which flags $2$ to $5$ trials here?

| Trial number: (first digit, second digit) | | | | |
|---|---|---|---|---|
| $1:(6,6)$ | $2:(8,9)$ | $3:(7,3)$ | $4:(4,6)$ | $5:(2,8)$ |
| $6:(8,5)$ | $7:(3,4)$ | $8:(5,6)$ | $9:(6,1)$ | $10:(6,2)$ |
| $11:(7,9)$ | $12:(1,9)$ | $13:(3,7)$ | $14:(7,7)$ | $15:(5,9)$ |
| $16:(9,2)$ | $17:(3,8)$ | $18:(6,4)$ | $19:(3,4)$ | $20:(0,5)$ |

**2.** Independent sensors respond with chances $3/10$ and $8/10$. Assign each a consecutive success range starting at $0$, one digit per sensor. If both must respond, find the model chance and this run rate.

| Trial number: (first digit, second digit) | | | | |
|---|---|---|---|---|
| $1:(0,8)$ | $2:(7,3)$ | $3:(3,1)$ | $4:(3,4)$ | $5:(5,1)$ |
| $6:(9,2)$ | $7:(4,5)$ | $8:(3,5)$ | $9:(6,2)$ | $10:(6,3)$ |
| $11:(2,4)$ | $12:(8,2)$ | $13:(3,6)$ | $14:(3,5)$ | $15:(5,9)$ |
| $16:(0,6)$ | $17:(9,4)$ | $18:(2,7)$ | $19:(5,9)$ | $20:(9,1)$ |

**3.** Signal 1 fires if the first digit is at least $7$; signal 2 if the second is at most $4$. Pay one ticket for exactly one signal, two for both. Use the table to forecast tickets for $100$ trials. Will $80$ suffice, and by what margin?

| Trial number: (first digit, second digit) | | | | |
|---|---|---|---|---|
| $1:(7,2)$ | $2:(9,5)$ | $3:(8,9)$ | $4:(0,6)$ | $5:(1,1)$ |
| $6:(7,7)$ | $7:(3,7)$ | $8:(3,9)$ | $9:(1,6)$ | $10:(7,7)$ |
| $11:(7,0)$ | $12:(8,0)$ | $13:(1,8)$ | $14:(9,3)$ | $15:(1,7)$ |
| $16:(0,9)$ | $17:(2,2)$ | $18:(4,0)$ | $19:(4,7)$ | $20:(2,7)$ |

**4.** A game needs model win chance at most $1/5$. Rule A wins when digits have the same parity; B wins when they differ by $1$. Compare the model chances, choose a rule, and find its observed rate.

| Trial number: (first digit, second digit) | | | | |
|---|---|---|---|---|
| $1:(8,9)$ | $2:(2,8)$ | $3:(8,0)$ | $4:(1,9)$ | $5:(3,2)$ |
| $6:(5,5)$ | $7:(1,0)$ | $8:(8,6)$ | $9:(0,8)$ | $10:(0,2)$ |
| $11:(6,8)$ | $12:(6,9)$ | $13:(2,2)$ | $14:(6,6)$ | $15:(3,3)$ |
| $16:(9,3)$ | $17:(2,2)$ | $18:(6,4)$ | $19:(6,5)$ | $20:(6,4)$ |

**5.** A trial must pass both stages. The first uses digits $0$ to $4$. Choose a consecutive success range from $0$ for the second to make the model chance $3/20$. Apply it to the table and give the observed rate.

| Trial number: (first digit, second digit) | | | | |
|---|---|---|---|---|
| $1:(1,0)$ | $2:(4,6)$ | $3:(0,4)$ | $4:(2,9)$ | $5:(1,1)$ |
| $6:(8,6)$ | $7:(0,6)$ | $8:(7,1)$ | $9:(9,7)$ | $10:(3,9)$ |
| $11:(0,3)$ | $12:(1,5)$ | $13:(4,5)$ | $14:(0,4)$ | $15:(5,9)$ |
| $16:(6,6)$ | $17:(8,2)$ | $18:(5,1)$ | $19:(1,0)$ | $20:(5,9)$ |

**6.** A prize needs a digit of $8$ or $9$. Normally use the first digit. A new rule uses the second instead only if the first is $0$ to $3$. Does it add at least $2$ winners here? Give both counts and added trials.

| Trial number: (first digit, second digit) | | | | |
|---|---|---|---|---|
| $1:(7,6)$ | $2:(0,5)$ | $3:(2,8)$ | $4:(4,7)$ | $5:(6,7)$ |
| $6:(6,9)$ | $7:(7,7)$ | $8:(2,9)$ | $9:(3,3)$ | $10:(0,2)$ |
| $11:(5,1)$ | $12:(8,6)$ | $13:(7,7)$ | $14:(1,6)$ | $15:(8,4)$ |
| $16:(1,6)$ | $17:(4,9)$ | $18:(1,0)$ | $19:(8,3)$ | $20:(5,7)$ |

# Answer Key

1. Choose B: A flags $11$; B flags $4$.
2. Use $0$ to $2$ and $0$ to $7$; model $\frac{6}{25}$, observed $\frac{3}{20}$.
3. Yes; expect $75$ tickets, $5$ spare.
4. Choose B: model $\frac{9}{50}$ (A is $1/2$); observed $\frac{1}{5}$.
5. Second uses $0$ to $2$; observed $\frac{3}{20}$.
6. Yes. Old $3$, new $5$; added trials $3, 8$.

## Step-by-Step Solutions

Follow each calculation, then check your own work.

### Problem 1

1. A flags trials $2, 5, 7, 11, 12, 13, 14, 15, 17, 19, 20$, a count of $11$.
2. B flags trials $5, 12, 13, 17$, a count of $4$.
3. $2 \le 4 \le 5$, while $11 > 5$. Only B fits the limit.

### Problem 2

1. Use $3$ labels for the first sensor ($0$ to $2$) and $8$ for the second ($0$ to $7$).
2. Model chance: $(3/10)(8/10) = \frac{6}{25}$.
3. Winning trials: $11, 16, 18$; count $3$ of $20$.
4. Observed rate: $3/20 = \frac{3}{20}$.

### Problem 3

1. One-ticket trials: $2, 3, 5, 6, 10, 17, 18$; count $7$.
2. Two-ticket trials: $1, 11, 12, 14$; count $4$.
3. Run total: $7 + 2(4) = 15$ tickets. Five times this is $5(15) = 75$.
4. Stock minus forecast is $80 - 75 = 5$ tickets, so yes.

### Problem 4

1. A wins on even-even or odd-odd: $(5/10)^2 + (5/10)^2 = 1/2$.
2. B has $9$ adjacent digit pairs in either order: $2(9)/100 = \frac{9}{50}$.
3. $9/50 \le 1/5 < 1/2$, so choose B.
4. Winning trials: $1, 5, 7, 19$; count $4$ of $20$.
5. Observed rate: $4/20 = \frac{1}{5}$.

### Problem 5

1. The first chance is $5/10 = 1/2$. If $s$ labels pass the second, then $(1/2)(s/10) = 3/20$.
2. Solve $s/20 = 3/20$: $s = 3$ labels, namely $0, 1, 2$.
3. Winning trials: $1, 5, 19$; count $3$ of $20$.
4. Observed rate: $3/20 = \frac{3}{20}$.

### Problem 6

1. The original winners are $12, 15, 19$, a count of $3$.
2. A second chance adds $3, 8$: first below $4$, second at least $8$. That adds $2$.
3. New count: $3 + 2 = 5$. The required increase is $2$, so yes.

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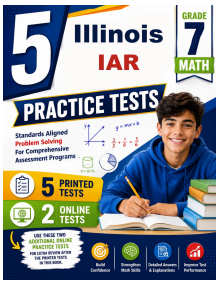


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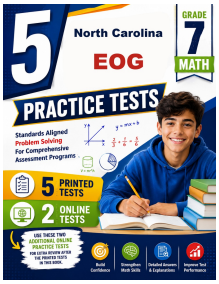


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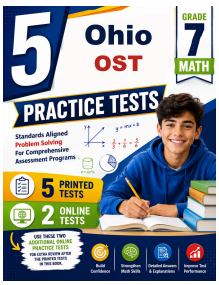


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