

# Counting Principle and Permutations

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Score: \_\_\_\_\_ / 24

## Q Quick Review

The **Fundamental Counting Principle** says: if one choice can happen in  $m$  ways and a second *independent* choice in  $n$  ways, then together they can happen in  $m \times n$  ways — just multiply the options at each step. A **permutation** is an arrangement where *order matters*. The number of ways to arrange all  $n$  different items is  $n! = n \times (n - 1) \times \dots \times 2 \times 1$  (read “ $n$  factorial”). To arrange  $r$  of  $n$  items, use  $P(n, r) = \frac{n!}{(n - r)!}$ , which is the product of the first  $r$  factors counting down from  $n$ . Remember  $0! = 1$ .

◇ **Example:** A deli offers 3 breads, 4 fillings, and 2 sauces. How many different sandwiches are possible? Also, in how many orders can 5 friends line up?  
 ⇒ For the sandwich, use the counting principle: multiply the choices at each step.  $3 \text{ breads} \times 4 \text{ fillings} \times 2 \text{ sauces} = 24$  sandwiches. For the line-up, order matters and we are arranging all 5 friends, so we use a factorial:  $5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$  different orders. Notice how fast the factorial grows — arrangements pile up quickly!

**Answer:** 24 sandwiches, 120 line-ups

## PRACTICE

Use the counting principle or permutations. Give a whole-number answer.

- |                          |       |                |       |
|--------------------------|-------|----------------|-------|
| 1. $3 \times 4$          | _____ | 11. $P(4, 2)$  | _____ |
| 2. $2 \times 3 \times 5$ | _____ | 12. $P(5, 2)$  | _____ |
| 3. $3 \times 4 \times 2$ | _____ | 13. $P(5, 3)$  | _____ |
| 4. $4 \times 4 \times 4$ | _____ | 14. $P(6, 2)$  | _____ |
| 5. $5 \times 6$          | _____ | 15. $P(6, 3)$  | _____ |
| 6. $3!$                  | _____ | 16. $P(7, 2)$  | _____ |
| 7. $4!$                  | _____ | 17. $P(7, 3)$  | _____ |
| 8. $5!$                  | _____ | 18. $P(8, 2)$  | _____ |
| 9. $6!$                  | _____ | 19. $P(8, 3)$  | _____ |
| 10. $7!$                 | _____ | 20. $P(10, 3)$ | _____ |

### ◆ Word Problems

21. A school uniform has 3 shirt colors, 2 pant colors, and 4 shoe styles. How many different uniform combinations are possible?  
 \_\_\_\_\_
22. Six runners finish a race. In how many different orders can they cross the finish line (no ties)? \_\_\_\_\_
23. A club of 8 members must choose a president and a vice president (different people). How many ways can this be done?  
 \_\_\_\_\_
24. A lock code uses 4 digits, and each digit can be 0 through 9, with repeats allowed. How many codes are possible? \_\_\_\_\_



## Answer Keys

- |          |   |
|----------|---|
| 1. 12    | 13. 60  |
| 2. 30    | 14. 30  |
| 3. 24    | 15. 120   |
| 4. 64    | 16. 42  |
| 5. 30    | 17. 210   |
| 6. 6     | 18. 56  |
| 7. 24    | 19. 336   |
| 8. 120   | 20. 720   |
| 9. 720   | 21. $3 \times 2 \times 4 = 24$ combinations           |
| 10. 5040 | 22. $6! = 720$ orders                                 |
| 11. 12   | 23. $P(8, 2) = 8 \times 7 = 56$ ways                  |
| 12. 20   | 24. $10 \times 10 \times 10 \times 10 = 10,000$ codes |

### Step-by-Step Explanations

- |   |  |
|---|--|
| <p>1. Counting principle: 3 choices then 4 choices give <math>3 \times 4 = 12</math>.</p> <p>2. Multiply the options at each step: <math>2 \times 3 \times 5 = 30</math>.</p> <p>3. Multiply across all three stages: <math>3 \times 4 \times 2 = 24</math>.</p> <p>4. Four options at each of three stages: <math>4 \times 4 \times 4 = 64</math>.</p> <p>5. Two independent choices: <math>5 \times 6 = 30</math> combinations.</p> <p>6. <math>3! = 3 \times 2 \times 1 = 6</math>.</p> <p>7. <math>4! = 4 \times 3 \times 2 \times 1 = 24</math>.</p> <p>8. <math>5! = 5 \times 4 \times 3 \times 2 \times 1 = 120</math>.</p> <p>9. <math>6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 720</math>.</p> <p>10. <math>7! = 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 5040</math>.</p> <p>11. <math>P(4, 2) = 4 \times 3 = 12</math> (the first 2 factors counting down from 4).</p> <p>12. <math>P(5, 2) = 5 \times 4 = 20</math>.</p> <p>13. <math>P(5, 3) = 5 \times 4 \times 3 = 60</math>.</p> <p>14. <math>P(6, 2) = 6 \times 5 = 30</math>.</p> | <p>15. <math>P(6, 3) = 6 \times 5 \times 4 = 120</math>.</p> <p>16. <math>P(7, 2) = 7 \times 6 = 42</math>.</p> <p>17. <math>P(7, 3) = 7 \times 6 \times 5 = 210</math>.</p> <p>18. <math>P(8, 2) = 8 \times 7 = 56</math>.</p> <p>19. <math>P(8, 3) = 8 \times 7 \times 6 = 336</math>.</p> <p>20. <math>P(10, 3) = 10 \times 9 \times 8 = 720</math>.</p> <p>21. By the counting principle, multiply the choices at each step: <math>3 \times 2 \times 4 = 24</math> different uniforms.</p> <p>22. All 6 runners are being arranged and order matters, so it is <math>6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 720</math> possible finishing orders.</p> <p>23. Order matters — president and vice president are different roles — so use <math>P(8, 2) = 8 \times 7 = 56</math> ways.</p> <p>24. Each of the 4 positions has 10 choices and repeats are allowed, so by the counting principle there are <math>10^4 = 10,000</math> codes.</p> |
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