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Permutations and Combinations

Class 11 Notes | CBSE Maths

Chapter 6

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Permutations and Combinations Class 11 Notes | CBSE Maths Chapter 6

Permutations and Combinations is Chapter 6 of CBSE Class 11 Maths — the chapter that teaches you how to *count* cleverly without listing every possibility. Whether it is arranging books on a shelf, forming committees, or making number plates, this chapter gives you the tools to count huge possibilities in a single line of working.

By the end of these notes you will confidently use the fundamental principle of counting, handle factorials, apply nP_r and nC_r , solve arrangement problems with restrictions and circular cases, and tackle selection, division and distribution problems. This is a high-scoring chapter carrying roughly 6–8 marks in boards, and the foundation for Binomial Theorem and all of Probability.

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Key Concepts

1. Fundamental Principle of Counting

The whole chapter rests on two simple counting rules. They let you find the total number of outcomes without writing them all out.

Multiplication Principle

If one event can occur in m ways and, following it, a second event can occur in n ways, then the two events together occur in $m \times n$ ways. Use it when tasks happen one *after* another ("AND").

Example: A boy has 3 shirts and 2 pants. He can dress in $3 \times 2 = 6$ ways.

Addition Principle

If one event can occur in m ways and a separate, mutually exclusive event in n ways, then either one can occur in $m + n$ ways. Use it when you choose one task *or* the other ("OR").

Example: A student can travel by 2 buses or 3 trains, so they can travel in $2 + 3 = 5$ ways.

2. Factorial Notation

The **factorial** of a natural number n , written $n!$, is the product of all positive integers up to n .

$$n! = n \times (n - 1) \times (n - 2) \times \dots \times 3 \times 2 \times 1$$

- $0! = 1$ (by definition) and $1! = 1$.
- $n! = n \times (n - 1)!$ — the recursive relation used to simplify ratios.
- Factorials are defined only for whole numbers; $(\frac{1}{2})!$ is not defined here.

Example: $5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$, and $6!/4! = 6 \times 5 = 30$.

3. Permutations (Arrangements)

A **permutation** is an arrangement of objects in a definite order. Here *order matters* — AB and BA are counted as different.

The number of permutations of n distinct objects taken r at a time is:

$${}^n P_r = n! / (n - r)!, \text{ where } 0 \leq r \leq n$$

- ${}^n P_n = n!$ — arranging all n objects.
- ${}^n P_0 = 1$ and ${}^n P_1 = n$.

Example: The number of 3-letter words from the letters of WORLD is ${}^5 P_3 = 5!/2! = 60$.

4. Permutations with Repetition

When objects may be repeated, each of the r places can be filled in n ways.

Number of arrangements = n^r

Example: The number of 4-digit codes using digits 0–9 with repetition allowed is $10^4 = 10000$.

5. Permutations of Objects Not All Distinct

If among n objects, p are alike of one kind, q alike of a second kind and r alike of a third, the number of distinct arrangements is:

$$n! / (p! \times q! \times r!)$$

Example: The number of arrangements of the letters of the word MISSISSIPPI (where I appears 4 times, S 4 times, P 2 times, M once) is $11!/(4! 4! 2!) = 34650$.

6. Permutations with Restrictions

Many board questions add a condition — fix a position, keep some objects together, or keep them apart.

- **Objects together:** tie the group as a single unit, arrange the units, then arrange within the group.
- **Objects never together:** total arrangements – arrangements where they are together.
- **Fixed positions:** e.g. words beginning with a vowel — fix that place first, then fill the rest.

Example: In how many ways can 5 boys and 3 girls sit in a row so that all 3 girls are together? Treat the girls as one block:
 $6! \times 3! = 720 \times 6 = 4320$.

7. Circular Permutations

When objects are arranged in a circle there is no fixed "first" seat, so we fix one object and arrange the rest.

- Number of circular arrangements of n distinct objects = $(n - 1)!$
- If clockwise and anticlockwise arrangements are considered the same (e.g. a garland or necklace) = $(n - 1)!/2$

Example: 5 people can be seated around a round table in $(5 - 1)! = 4! = 24$ ways.

8. Combinations (Selections)

A **combination** is a selection of objects where *order does not matter* — AB and BA are the same selection.

The number of combinations of n distinct objects taken r at a time is:

$${}^nC_r = n! / [r! (n - r)!], \text{ where } 0 \leq r \leq n$$

- ${}^nC_0 = {}^nC_n = 1$ and ${}^nC_1 = n$.
- Use combinations for committees, teams, handshakes, and drawing cards.

Example: A committee of 3 from 8 people can be chosen in ${}^8C_3 = 8!/(3! 5!) = 56$ ways.

9. Relation Between Permutations and Combinations

A permutation is just a selection followed by an arrangement. So the two are linked by:

$${}^nP_r = {}^nC_r \times r!$$

This says: choose r objects (nC_r ways), then arrange them ($r!$ ways). Dividing a permutation count by $r!$ removes the ordering and gives the combination count.

10. Properties of nC_r

Property	Statement
Symmetry	${}^nC_r = {}^nC_{n-r}$
If ${}^nC_x = {}^nC_y$	then $x = y$ or $x + y = n$
Pascal's rule	${}^nC_r + {}^nC_{r-1} = {}^{n+1}C_r$
Sum of all	${}^nC_0 + {}^nC_1 + \dots + {}^nC_n = 2^n$
Relation	${}^nC_r / {}^nC_{r-1} = (n - r + 1)/r$

Note: The symmetry property ${}^nC_r = {}^nC_{n-r}$ saves work — ${}^{50}C_{48}$ is far easier to compute as ${}^{50}C_2$.

11. Division and Distribution of Objects

These are the trickiest exam problems — splitting items into groups or handing them to people.

- **Into groups of unequal size** (e.g. groups of p, q, r where $p + q + r = n$): $n!/(p! q! r!)$.
- **Into groups of equal size** (m groups of equal size, groups *not* named): divide further by $m!$ to remove the ordering of identical groups.
- **Distribution to named persons:** after dividing, multiply by the number of ways to assign the groups to the persons.

Example: The number of ways to divide 52 cards equally among 4 players is $52!/(13!)^4$. If the four players are distinct, no extra division by $4!$ is needed because the players are named.

12. Total Number of Combinations

Sometimes you select *any* number of objects (one or more), not a fixed count.

- Selecting some or all of n distinct objects (at least one) = $2^n - 1$.
- This comes from each object being either chosen or not chosen (2 options each), minus the empty selection.

Example: A person with 5 distinct fruits can make $2^5 - 1 = 31$ different non-empty selections.

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	6–8 marks	Counting principle, ${}^nP_r/{}^nC_r$, words with restrictions, committees
JEE Main / Advanced	1–2 questions (with Probability)	Distribution, circular, repeated letters, nC_r properties
CUET / Other	2–3 questions	Direct nP_r , nC_r formula application, factorial simplification

[TABLE: Question-type split — VSA (1 mark): factorial values, simple ${}^nP_r/{}^nC_r$; SA (2–3 marks): words with conditions, committees, circular; LA (5 marks): division/distribution, ${}^nP_r = {}^nC_r \times r!$ based proofs.]

Important Definitions & Formulas

Term	Definition / Formula
Multiplication principle	Events one after another: $m \times n$ ways
Addition principle	Mutually exclusive events: $m + n$ ways
Factorial	$n! = n(n-1)(n-2)\dots 2 \cdot 1$; $0! = 1$
Permutation	Ordered arrangement: ${}^nP_r = n!/(n-r)!$
Permutation with repetition	r places, n choices each: n^r
Like objects	$n!/(p! q! r!)$ distinct arrangements
Circular permutation	$(n-1)!$; necklace/garland: $(n-1)!/2$
Combination	Unordered selection: ${}^nC_r = n!/[r!(n-r)!]$
Relation	${}^nP_r = {}^nC_r \times r!$
Symmetry	${}^nC_r = {}^nC_{n-r}$; Pascal: ${}^nC_r + {}^nC_{r-1} = {}^{n+1}C_r$
Total selections	At least one of n objects: $2^n - 1$

Solved Examples

Example 1

How many 3-digit numbers can be formed using the digits 1, 2, 3, 4, 5 without repetition?

Answer: Order matters, so ${}^5P_3 = 5!/2! = 5 \times 4 \times 3 = \mathbf{60}$.

Example 2

In how many ways can the letters of the word EQUATION be arranged? (All 8 letters are distinct.)

Answer: $8! = \mathbf{40320}$.

Example 3

Find the number of arrangements of the letters of the word BALLOON.

Answer: 7 letters with L twice and O twice: $7!/(2! 2!) = 5040/4 = \mathbf{1260}$.

Example 4

A committee of 5 is to be formed from 6 men and 4 women so that it has exactly 3 men and 2 women. In how many ways?

Answer: ${}^6C_3 \times {}^4C_2 = 20 \times 6 = \mathbf{120}$.

Example 5

In how many ways can 6 people be seated around a round table?

Answer: Circular arrangement = $(6 - 1)! = 5! = \mathbf{120}$.

Example 6

If ${}^nC_8 = {}^nC_6$, find n and then nC_2 .

Answer: Since ${}^nC_x = {}^nC_y \Rightarrow x + y = n$, so $8 + 6 = n \Rightarrow n = 14$. Then ${}^{14}C_2 = (14 \times 13)/2 = \mathbf{91}$.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Evaluate $8!/(6! \times 2!)$.
2. Write the value of nP_0 and nP_n .

3. If ${}^nC_3 = {}^nC_7$, find n .
4. How many ways can 4 distinct objects be arranged in a circle?
5. State the difference between a permutation and a combination.

2–3-Mark Questions (SA)

1. How many words, with or without meaning, can be formed using all the letters of the word MONDAY? How many begin with M?
2. Find the number of arrangements of the letters of the word ASSASSINATION.
3. In how many ways can 5 boys and 4 girls be seated in a row so that no two girls sit together?
4. Prove that ${}^nP_r = {}^nC_r \times r!$.

5-Mark Questions (LA)

1. From a class of 25 students, 10 are to be chosen for an excursion. There are 3 students who decide that either all of them join or none. In how many ways can the excursion party be chosen?
 2. In how many ways can 52 playing cards be divided equally among 4 players? Among 4 groups (not named)?
 3. Find the number of triangles that can be formed by joining 12 points, of which 4 are collinear.
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Quick Revision Points

- Counting: multiplication for "AND" ($m \times n$), addition for "OR" ($m + n$)
 - $n! = n(n-1)!$; $0! = 1$; factorials defined for whole numbers only
 - Permutation (order matters): ${}^nP_r = n!/(n-r)!$; with repetition: n^r
 - Like objects: $n!/(p! q! r!)$
 - Circular: $(n-1)!$; necklace/garland: $(n-1)!/2$
 - Combination (order does not matter): ${}^nC_r = n!/[r!(n-r)!]$
 - Link: ${}^nP_r = {}^nC_r \times r!$
 - Properties: ${}^nC_r = {}^nC_{n-r}$; ${}^nC_r + {}^nC_{r-1} = {}^{n+1}C_r$; $\sum {}^nC_r = 2^n$
 - Selecting at least one of n objects: $2^n - 1$
 - Items together $\rightarrow$ bundle; never together $\rightarrow$ total – together
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Next Chapter: Chapter 7 — Binomial Theorem



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