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A **factorial** is a mathematical operation that multiplies a number by all the positive integers less than itself. It is denoted by an exclamation mark $n!$.

Definition

The factorial of a non-negative integer n is defined as:

$$n! = n \times (n-1) \times (n-2) \times \cdots \times 1$$

For $n = 0$, the factorial is defined as:

$$0! = 1$$

Examples

1. **Calculate $5!$:**

$$5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$$

2. **Calculate $3!$:**

$$3! = 3 \times 2 \times 1 = 6$$

3. **Calculate $0!$:** By definition:

$$0! = 1$$

4. **Calculate $7!$:**

$$7! = 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 5040$$

Applications of Factorial

Factorials are used in:

- **Permutations and combinations**: For arranging or selecting items.
  - Example: The number of ways to arrange n items is $n!$.
- **Probability**: For computing outcomes.
- **Mathematical series**: Such as Taylor and Maclaurin series.
- **Binomial theorem**: Factorials are part of binomial coefficients.

Visual Example

Suppose you have 4 books and you want to arrange them on a shelf. The total number of arrangements is $4!$:

$$4! = 4 \times 3 \times 2 \times 1 = 24$$

This means there are 24 different ways to arrange the 4 books.

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