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# Combinatorics For Computer Science

***Permutations & Combinations and more exciting things …***

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# Table of Content



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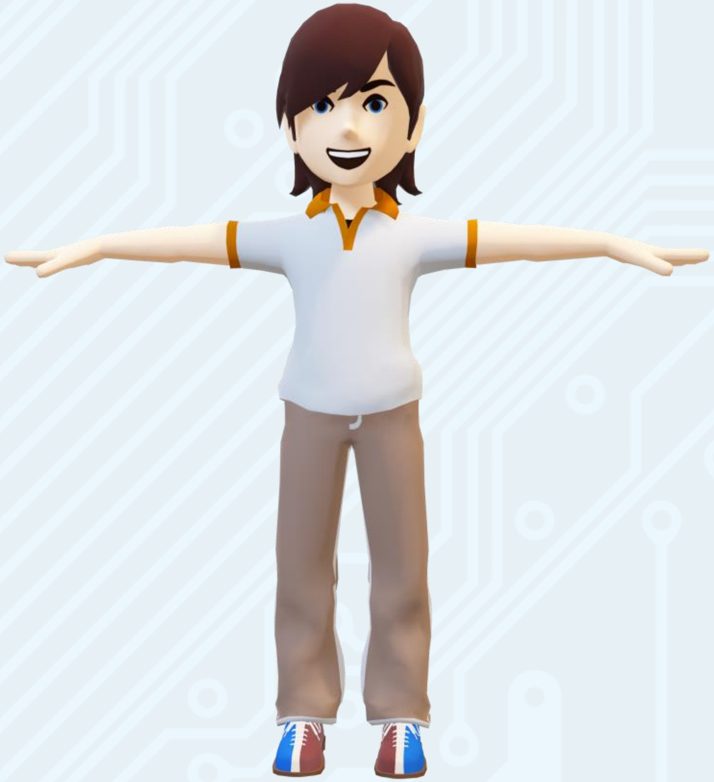
# Permutations & Combinations

# Rule of product and sum

## *1- Rule of sum:*

If there are m ways to arrange something, and n ways to arrange something else then the number of ways to arrange either of those things is $m + n$

# 1- Rule of sum:



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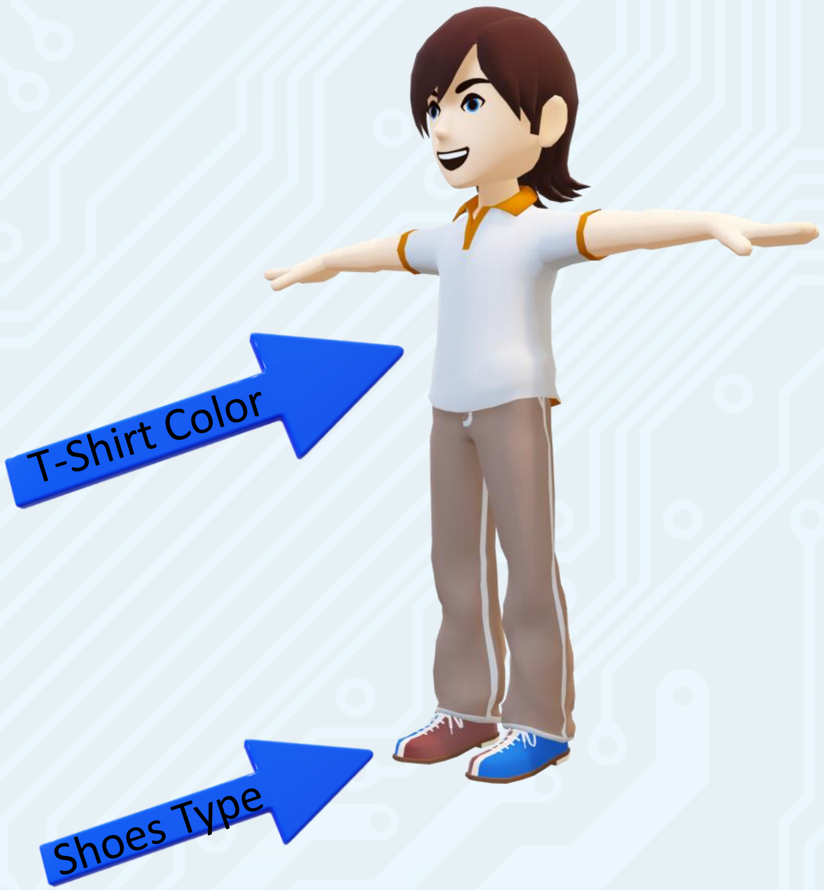
# 1- Rule of sum:



# 1- Rule of sum:

T-Shirt Color

Shoes Type

Classic – Sport

# 1- Rule of sum:

Shoes Type

Classic – Sport

T-Shirt Color

$$2 \quad + \quad 4 \quad = \quad 6$$

# Rule of product and sum

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## *1- Rule of sum:*

If there are m ways to arrange something, and n ways to arrange something else then the number of ways to arrange either of those things is $m + n$

## *2- Rule of product:*

If there are m ways to arrange something, and n ways to arrange something else then the number of ways to arrange both of those things is $m \times n$

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# Rule of product and sum

## *1- Rule of sum:*

If there are m ways to arrange something, and n ways to arrange something else then the number of ways to arrange either of those things is $m + n$

## *2- Rule of product:*

If there are m ways to arrange something, and n ways to arrange something else then the number of ways to arrange both of those things is $m \times n$

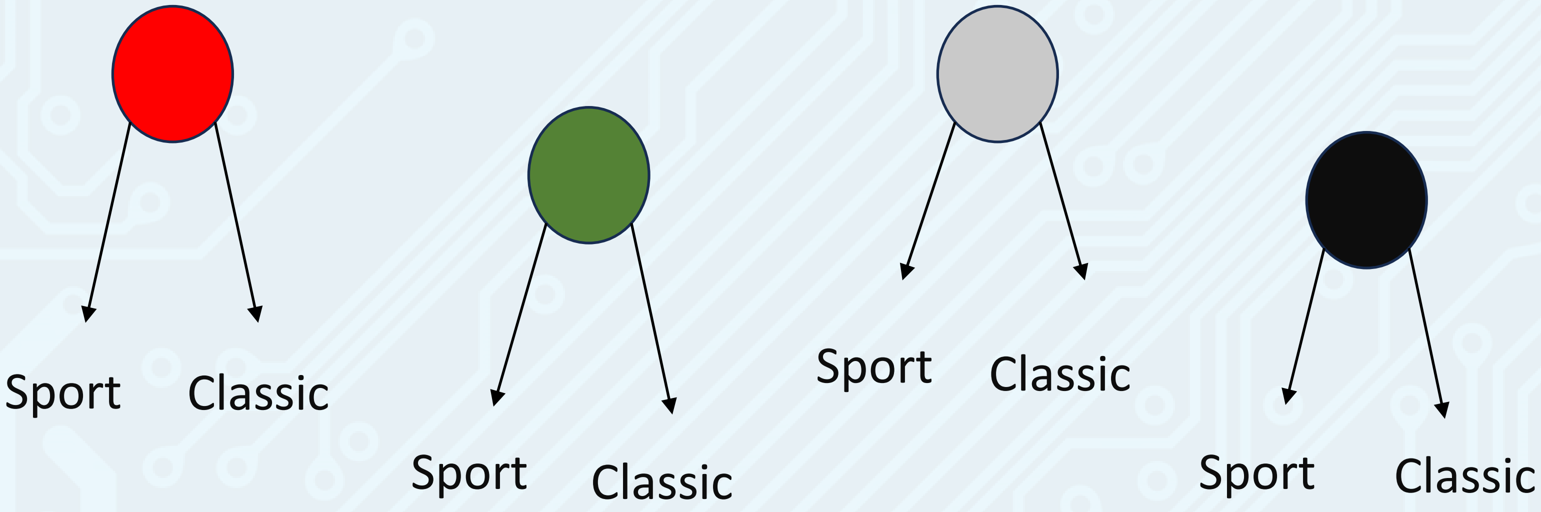
# 2- Rule of product:

T-Shirt Color

Shoes Type

Classic – Sport

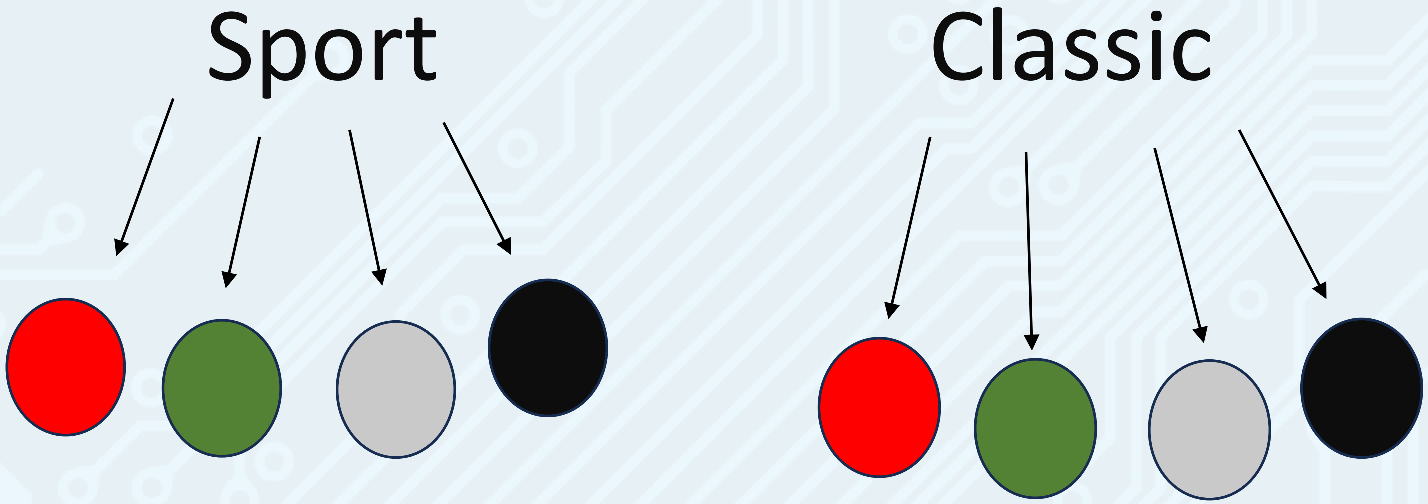
# 2- Rule of product:




Count the number of leaves

N x M

# 2- Rule of product:




Count the number of leaves

Also N x M

# Question

What about wearing pants this time?

If he will choose his outfit from
4 T-Shirts 2 shoes 3 pants

The answer is 4 x 2 x 3 = 22 Really?

# *Question*

What about wearing pants this time?

If he will choose his outfit from
4 T-Shirts 2 shoes 3 pants

The answer is $4 \times 2 \times 3 = 24$

# Question

If he will choose 3 pants from supermarket and this supermarket have 5 colors for pants find the result

The answer is $5 \times 5 \times 5 = 125$

# *Question*

If he will choose 3 pants from supermarket and this supermarket have 5 colors for pants find the result

$$5^3 = 125$$

# Application

In the truth table to find the number of rows we use the same way

$$2^N$$

$$N \text{ is the number of inputs}$$

| $a$ | $b$ | $c$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |
| 1 | 1 | 1 |

# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain those 5 numbers in how many ways I can?***

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# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain those 5 numbers in how many ways I can?***

$$\underline{5} \times \underline{4} \times \underline{3} \times \underline{2} \times \underline{1}$$

# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain those 5 numbers in how many ways I can?***

$$5!$$

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# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain only 3 digits in how many ways I can?***

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# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain only 3 digits in how many ways I can?***

$$\underline{5} \times \underline{4} \times \underline{3}$$

# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain only 3 digits in how many ways I can?***

$$\frac{5 * 4 * 3 \cancel{* 2 * 1}}{\cancel{2 * 1}}$$

# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain only 3 digits in how many ways I can?***

$$\frac{5!}{(5-3)!}$$

# What if I will choose the elements without repetition

***I have 5 numbers and want to make number contain only 3 digits in how many ways I can?***

$$\frac{n!}{(n-r)!}$$

# Permutations (nPr):

$$n_{P_r} = \frac{n!}{(n-r)!}$$

***n: Total number of distinct elements***

***r: Number of elements you want to select***

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# How many permutations are there of 2 letters from ABCD ?

*Question*

| | | |
|---|---|---|
| AB | AD | BD |
| BA | DA | DB |
| AC | BC | CD |
| CA | CB | DC. |

$$\frac{4!}{(4-2)!} = 12$$

# What if the order of selection does not matter

***I need to remove the excess probabilities***

$$\frac{5!}{(5-3)!}$$

3 x 2 x 1

$$\frac{5!}{(5-3)!}$$

$3!$

$$\frac{5!}{3!\,(5-3)!}$$

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# Combinations (nCr):

$$n_{C_r} = \frac{n!}{r!\,(n-r)!}$$

***n: Total number of distinct elements***

***r: Number of elements you want to select***

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# Combinations (nCr):

$$n_{C_r} = \binom{n}{r} = \frac{n!}{r!\ (n-r)!}$$

***n: Total number of distinct elements***

***r: Number of elements you want to select***

## *Question*

How many distinct triangles can be formed from 10 points on a plane?

$$\binom{10}{3} = \frac{10!}{3!\,(10-3)!} = 120$$

# Why $0! = 1$ ?

# Why 0! = 1 ?

To simplify mathematical formulas and combinatorial expressions

If I have zero numbers how many ways to arrange it? I have one way to arrange it

# Why 0! = 1 ?

To simplify mathematical formulas and combinatorial expressions

$$n_{P_r} = \frac{n!}{(n-r)!}$$

# Why $0! = 1$ ?

To simplify mathematical formulas and combinatorial expressions

$$\frac{n!}{(n-r)!}$$

# Why $0! = 1$ ?

To simplify mathematical formulas and combinatorial expressions

$$\frac{5!}{(5-5)!}$$

# Why 0! = 1 ?

To simplify mathematical formulas and combinatorial expressions

$$\frac{5!}{(0)!}$$

# Why $0! = 1$ ?

To simplify mathematical formulas and combinatorial expressions

Imaginary number $\sqrt{-1}$

# Binomial Theorem

# Binomial Theorem

$$(a+b)^0 = 1$$

$$(a+b)^1 = a+b$$

$$(a+b)^2 = (a+b)(a+b) = a^2+2ab+b^2$$

$$(a+b)^{20} = \ ?$$

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# Binomial Theorem

$$(a+b)^n = \sum_{k=0}^{n} \binom{n}{k} a^{n-k} b^k$$

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# Binomial Theorem

$$(a+b)^n = \sum_{k=0}^{n} \binom{n}{k} a^{n-k} b^k$$

$$(a+b)^3 = \binom{3}{0} a^3 b^0 + \binom{3}{1} a^2 b^1 + \binom{3}{2} a^1 b^2 + \binom{3}{3} a^0 b^3$$

$$= (1)a^3 b^0 + (3)a^2 b^1 + (3)a^1 b^2 + (1)a^0 b^3$$

$$= a^3 + 3a^2 b + 3ab^2 + b^3$$

# Binomial Theorem



$$(a+b)^0 = 1$$

$$(a+b)^1 = a+b$$

$$(a+b)^2 = a^2+2ab+b^2$$

$$(a+b)^3 = a^3+3a^2b+3ab^2+b^3$$

# Binomial Theorem

$$(a+b)^0 = 1$$

$$(a+b)^1 = 1a + 1b$$

$$(a+b)^2 = 1a^2 + 2ab + 1b^2$$

$$(a+b)^3 = 1a^3 + 3a^2b + 3ab^2 + 1b^3$$

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# Binomial Theorem

$$(a+b)^0 = \qquad 1$$

$$(a+b)^1 = \qquad 1 \quad 1$$

$$(a+b)^2 = \qquad 1 \quad 2 \quad 1$$

$$(a+b)^3 = \qquad 1 \quad 3 \quad 3 \quad 1$$

# Pascal's triangle

1

1 1

1 2 1

1 3 3 1

1 4 6 4 1

# Pascal's triangle

$$
\begin{array}{ccccccccc}
 & & & & 1 & & & & \\
 & & & 1 & & 1 & & & \\
 & & 1 & & 2 & & 1 & & \\
 & 1 & & 3 & & 3 & & 1 & \\
1 & & 4 & & 6 & & 4 & & 1
\end{array}
$$

$$(a+b)^4 = a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$$

# Bell Number

# Coding

# Practice

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# Contest

# For session Materials

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# Any Questions?

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# Thank You

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