Let $r, n \in \mathbb{N}$ with $0 \leq r \leq n$.

**Permutations**

A permutation of a set of $n$ DISTINCT objects is an ORDERED arrangement of them. The number of permutations of $n$ objects is $n!$.

An $r$-permutation of $n$ objects is a permutation of $r$ of the $n$ objects.

The number of $r$-permutations of $n$ objects is denoted $P(n, r)$.

For $n \geq 1$, the value $P(n, r)$ is defined by $P(n, 0) = 1$ and for $r > 0$,

$$P(n, r) = n(n-1)(n-2)\ldots(n-r+1) = \prod_{i=0}^{r-1} (n-i) = \frac{n!}{(n-r)!}$$

Suppose there are $r$ marbles, each of a DIFFERENT color, and $n$ NUMBERED boxes. The number of ways to place the $r$ marbles in the $n$ boxes (with at most one marble per box) is $P(n, r)$.

**Combinations**

A combination, or more precisely an $r$-combination, of a set of $n$ DISTINCT objects is an UNORDERED subset containing $r$ elements.

The number of $r$ combinations of $n$ objects is denoted ${n \choose r}$, which is read “$n$ choose $r$.”

The notation ${n \choose r}$ is also called a binomial coefficient. (More on this in Section 7.7.)

For $n \geq 0$, the value of $n$ choose $r$ is

$${n \choose r} = \frac{n!}{r!(n-r)!}.$$

Suppose there are $r$ marbles, of the SAME color, and $n$ NUMBERED boxes. The number of ways to place the $r$ marbles in the $n$ boxes (with at most one marble per box) is ${n \choose r}$.

Why does $n$ choose $r$ have the same value as $n$ choose $(n-r)$?