

Cheatsheet - Probability

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1. Intro

Some events are impossible, while others are quite certain to happen. When something is impossible, we say that the probability is **0**. If something is very likely going to happen, we say the probability is **1**. We use the letter **P** to indicate a probability of something occurring.

$$P(\text{a human will live for 1'000 years}) = 0$$

$$P(\text{all of us will die someday}) = 1$$

No probabilities are outside the range of 0 to 1.

We say that two events are **complementary** if they exclude each other, for example something can either exist or not exist, but not exist and not exist at the same time. The sum of the probabilities of the two complementary events must always equal 1, also known as the **total probability**.

2. Calculating Theoretical Probabilities

If the odds of some event occurring is the same for all possible events (e.g. when rolling a dice), the probability is **unbiased**. This **theoretical probability** is calculated the following way:

$$P(\text{obtaining our chosen event}) = \left(\frac{\text{number of ways the chosen event can occur}}{\text{total number of possibilities}} \right)$$

For example, the probability of rolling 4 on a dice is:

$$P(\text{rolling 4}) = \frac{1}{6} = 0.1666...$$

Or, the probability of rolling above 4 (by rolling 5 or 6):

$$P(\text{rolling above 4}) = \frac{2}{6} = \frac{1}{3} = 0.333...$$

3. Calculating Experimental Probabilities

If we don't have the necessary information to calculate a theoretical probability, ... TODO

TODO: Combinatorics

4. Combinatorics

4.1. Permutations

A **permutations** of n different elements is an ordering of the elements such that one element is first, one is second, one is third, and so on. In order to calculate the number of different permutations of n elements we use the **factorial** of n , respectively $n!$:

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

For example:

$$6! = 1 \times 2 \times 3 \times 4 \times 5 \times 6 = 720$$

Additionally, there are $3! = 6$ permutations of the letters X , Y and Z :

XYZ

YXZ

XZY

ZYX

ZXY

YZX

4.2. Permutations of n Elements Taken r at the Time

The number of permutations of n elements taken r at a time:

$$P_r^n = \frac{n!}{n-r}! = n(n-1)(n-2)...(n-r+1)$$

For example, consider the question:

“There are 8 horses running in a race. In how many different ways can these horses come in first, second and third (ties excluded)?

We can calculate:

$$P_3^8 = \frac{8!}{(8-3)!} = \frac{8!}{5!} = 336$$

4.3. Distinguishable Permutations

TODO

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