

# Cheatsheet for Math Exercises

## Probability and Conditional Probability

Notation	Value	Formula
$P(A)$	Probability of event A occurring.	$P(A) = \frac{\text{Number of favorable outcomes for } A}{\text{Total number of possible outcomes}}$
$P(A \mid B)$	Conditional probability of event A occurring, given that event B has occurred.	$P(A \mid B) = \frac{P(A \cap B)}{P(B)}$
$P(A \cap B)$	Probability of both events A and B occurring.	In general: $P(A \cap B) = P(A) \cdot P(B \mid A)$ If A and B are independent events, then: $P(A \cap B) = P(A) \cdot P(B)$
$P(A \cup B)$	Probability that event A or event B (or both) occur.	$P(A \cup B) = P(A) + P(B) - P(A \cap B)$

## Information Theory

Notation	Value	Formula
$I(A)$	Information content or self-information of an event A.	$I(A) = -\log_2 P(A) = \log_2 \frac{1}{P(A)}$ [bits]
$H(X)$	Entropy, which measures the average amount of information (or uncertainty) in a random variable X.	$H(X) = -\sum_{x \in X} P(x) \log_2 P(x) = \sum_{x \in X} P(x) \log_2 \frac{1}{P(x)}$ [bits]
$H_{\max}$	Maximum possible entropy (when all outcomes are equally likely).	$H_{\max} = \log_2  \mathcal{X} $   $\mathcal{X}$   is the number of possible outcomes in the set $\mathcal{X}$
$R(X)$	Redundancy, which measures the portion of duplicative information within a message.	$R(X) = 1 - \frac{H(X)}{\log_2  X }$ In terms of maximum entropy: $R = \frac{H_{\max} - H}{H_{\max}}$

## Combinatorics

	without repetition	with repetition
<b>Permutations</b> number of all possible arrangements of $n$ elements	$P_n = n!$	$P_{n^{k_1, k_2, \dots, k_r}} = \frac{n!}{k_1! \cdot k_2! \cdot \dots \cdot k_r!}$
<b>Variations</b> the number of all possible arrangements of any $k$ elements from $n$ elements	$V_n^k = \frac{n!}{(n-k)!}$	$\overline{V}_n^k = n^k$

	without repetition	with repetition
<b>Combinations</b> number of ways to choose $k$ items from $n$ items, regardless of order	$C_n^k = \binom{n}{k} = \frac{n!}{k! \cdot (n-k)!}$	$\overline{C}_n^k = \binom{n+k-1}{k}$

**What formula to use?**

		Repetition	
		<i>Not possible</i>	<i>Possible</i>
<b>Order</b>	<i>Matters</i>	$V_n^k$ (variation without repetition)	$\overline{V}_n^k$ (variation with repetition)
	<i>Doesn't matter</i>	$C_n^k$ (combination without repetition)	$\overline{C}_n^k$ (combination with repetition)

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