

# User's Manual

STAT

*Mathematical software:*

**STATOOL:**

Statistics and Probability Tools  
for Windows



[www.vaxasoftware.com](http://www.vaxasoftware.com)

Ref.: STAT

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## Introduction

StaTool is a Windows application for Statistics and Probability calculations.

**StaTool** performs 7 types of Statistics and Probability calculations:  
Hypothesis testing, Confidence interval estimation, Probability distributions,  
One variable statistics, Two variables statistics, Total Probability Law and Bayes' Theorem,  
Probability of A and B events

Please, read this manual carefully in order to learn all the capabilities of the application.

◆ **Note:**

Design, price and specifications are subject to changes without notice.

## Terms of use

In no event shall Vaxa Software be liable to anyone for direct, indirect, special, collateral, incidental, or consequential damages by the use or impossibility of use of this application, nor by the effects in the operation of other applications or the operating system.

Before the installation we recommended to make backup of your data and create a restoration point.

You will be able freely to evaluate the application shareware during the time that considers necessary. Passed this period of evaluation you would have or to register it or uninstall it.

In order to register the application, please see the option "REGISTER APPLICATION" in the help menu of the application.

After paying the registry rights you will receive by email the REGISTRATION KEY of the application. Once registered the application, it will be able to use the options that were disabled until that moment.

The REGISTRATION KEY is UNIQUE for EACH COMPUTER.

You cannot use the same REGISTRATION KEY for multiple computers.

You can freely distribute unaltered copies of the installation system of the application to other users.

You cannot decompile the application nor use no type of reverse engineer for its analysis or modification.

You cannot use part or the totality of the application to create a new application.

### **Conflicts of shared files:**

Vaxa Software assumes no liability for conflicts due to the incompatibility of shared files (\*.dll, \*.ocx and other files).

Vaxa Software applications use shared files (\*.dll, \*.ocx and other files).

It is possible that the shared file exists and whether or not previously replaced by a different version during the installation of the VaxaSoftware application.

This can cause the VaxaSoftware application not work and/or a third party application that shares the same file does not.

Also the installation of a third party application can cause the application of VaxaSoftware or third party application does not work.

Vaxa Software will try to resolve these conflicts in a reasonable manner, despite its satisfactory resolution is not guaranteed and in many cases may be impossible.

## Formats for input values

The numeric values can be entered in the following formats:

- Standard numbers: 0.24; 15.23
- Percentage: 90%; 12%
- Fractions: 2/3; 5/8
- Scientific notation: 2E-4 (equal to  $2 \times 10^{-4} = 0.0002$ )

The decimal separator is a POINT.

Even, if you enter a COMMA, a POINT is entered instead.

## Types of calculations

**StaTool** features 7 types of Statistics and Probability calculations:

- Hypothesis testing.
- Confidence interval estimation.
- Probability distributions.
- One variable statistics.
- Two variables statistics.
- Total Probability Law and Bayes' Theorem.
- Probability of A and B events.

We have to press the relevant label in the main window in order to access to each calculation type.

## Hypothesis testing

Allows us to test a population statistics using sample statistics.

Always, we have to enter the confidence level or the significance level.

Hypothesis testing can be two-sided, left side or right side.

StaTool has 9 types of Hypothesis testing:

### **One population:**

- 1) Mean of population (known population variance).
- 2) Mean of population (unknown population variance).
- 3) Variance of population.
- 4) Ratio of population.

### **Two populations:**

- 5) Mean difference of two populations (known population variances).
- 6) Mean difference of two populations (unknown and equal population variances).
- 7) Mean difference of two populations (unknown and different population variances).
- 8) Variance ratio of two populations.
- 9) Ratio difference of two populations.

## Confidence interval estimation

Allows us estimate the Confidence Interval of a population statistics using sample statistics.

Always, we have to enter the confidence level or the significance level.

StaTool has 9 types of Confidence Intervals:

### **One population:**

- 1) Mean of population (known population variance).
- 2) Mean of population (unknown population variance).
- 3) Variance of population.
- 4) Ratio of population.

### **Two populations:**

- 5) Mean difference of two populations (known population variances).
- 6) Mean difference of two populations (unknown and equal population variances).
- 7) Mean difference of two populations (unknown and different population variances).
- 8) Variance ratio of two populations.
- 9) Ratio difference of two populations.

## Probability distributions

For each probability distribution, we can calculate the percentage point or the probability (\*).

Probability can be left cumulative, right cumulative, interval, centered interval or point.

StaTool has 6 types of probability distribution:

- 1) Normal.
- 2) t-Student.
- 3) Chi-Square.
- 4) F-Snedecor.
- 5) Binomial.
- 6) Poisson.

### **Note:**

(\*) In the Binomial or Poisson distribution, we can calculate only the probability, not the percentage point.

## One variable statistics

Allows us to calculate statistical data for one numeric variable.

Data can be ungrouped or grouped (intervals or classes).

StaTool calculates the following statistical data:

- 1) Mean.
- 2) Median.
- 3) Mode.
- 4) Standard deviation.
- 5) Variance.
- 6) Coefficient of variation.
- 7) Skewness.
- 8) Kurtosis.
- 9) Moments (0th to 4th, about mean and origin).
- 10) Quartiles, deciles and percentiles and his inverses.
- 11) Graphic (bar and histogram chart) and printing.

- We can save and open data as a file (E1V extension).

- Also, we can print data and results.

## Two variables statistics

Allows us to calculate statistical data for two numeric variables X and Y.

We can calculate 5 types of functions for regression analysis using the least squared method:

- 1) Linear
- 2) Logarithmic
- 3) Exponential
- 4) Power
- 5) Quadratic

StaTool calculates the following statistical data:

- 1) Means of X and Y.
- 2) Standard deviations of X and Y.
- 3) Variances of X and Y.
- 4) Covariance.
- 5) Coefficient of correlation.
- 6) Formula of regression curve.
- 7) Estimation of X or Y.
- 8) Graphic (scatter plot and regression curve) and printing.

- We can save and open data as a file (E2V extension).

- Also, we can print data and results.

## Total Probability Law and Bayes' Theorem

We have a set of incompatible  $A_i$  events as a finite partition of the probability space.  
Also, we have the event B that is compatible with each  $A_i$ .

If we know the probabilities  $p(A_i)$  and  $p(B / A_i)$ , then StaTool calculates  $p(B)$  and  $p(A_i / B)$

## Probability of two events A and B

For A and B events, we can calculate some probability values when we know some other probability values:

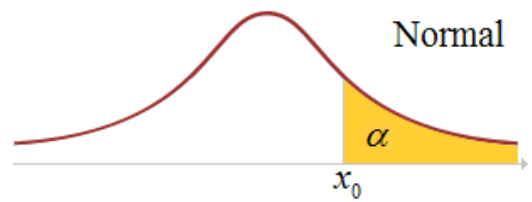
We have to know some of the following values of probability:

$p(A)$	$p(\bar{A})$
$p(B)$	$p(\bar{B})$
$p(A \cap B)$	$p(\overline{A \cap B})$
$p(A \cup B)$	$p(\overline{A \cup B})$
$p(\bar{A} \cap \bar{B})$	$p(\bar{A} \cup \bar{B})$
$p(A / B)$	$p(A - B)$
$p(B / A)$	$p(B - A)$

## Formulas of Probability distributions

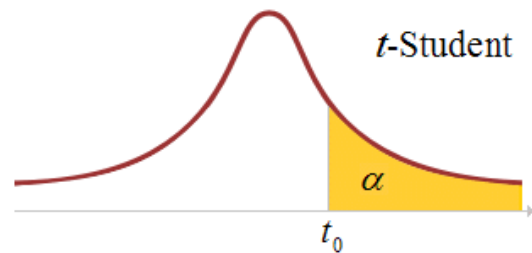
### Normal distribution (Gauss)

$$\alpha = p(x \geq x_0) = \int_{x_0}^{\infty} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx$$



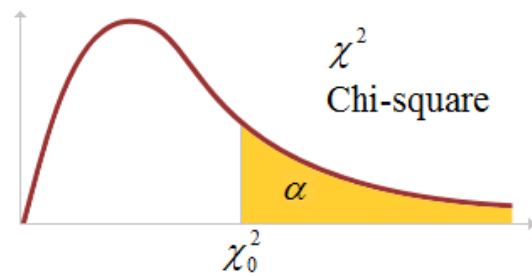
### t-Student distribution (Gosset)

$$\alpha = p(t \geq t_0) = \int_{t_0}^{\infty} \frac{\Gamma\left(\frac{n+1}{2}\right) \left(1 + \frac{t^2}{n}\right)^{-\frac{n+1}{2}}}{\Gamma\left(\frac{n}{2}\right) \sqrt{n\pi}} dt$$



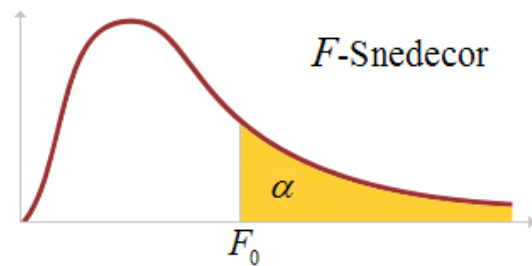
### Chi-square distribution (Pearson)

$$\alpha = p(\chi^2 \geq \chi_0^2) = \int_{\chi_0^2}^{\infty} \frac{e^{-x/2} x^{n/2-1}}{2^{n/2} \Gamma(n/2)} dx$$



### F distribution (Fisher-Snedecor)

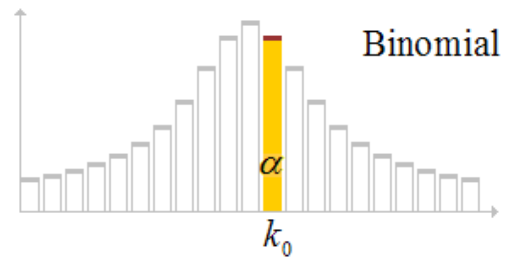
$$\alpha = p(F \geq F_0) = \int_{F_0}^{\infty} \frac{\Gamma\left(\frac{n_1+n_2}{2}\right) \left(\frac{n_1}{n_2}\right)^{\frac{n_1}{2}} F^{\frac{n_1}{2}-1}}{\Gamma\left(\frac{n_1}{2}\right) \Gamma\left(\frac{n_2}{2}\right) \left(1 + \frac{n_1}{n_2} F\right)^{\frac{n_1+n_2}{2}}} dF$$



**Binomial distribution**

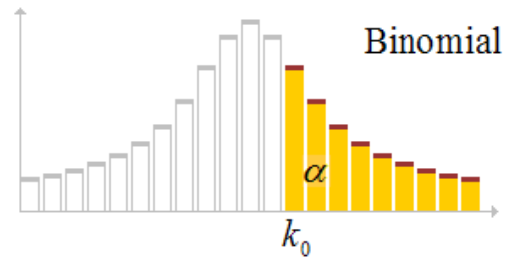
Probability at a point:

$$\alpha = p(x = k_0) = \binom{n}{k_0} p^{k_0} (1-p)^{n-k_0}$$



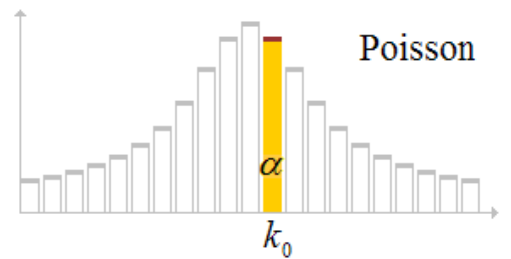
Upper cumulative probability:

$$\alpha = p(x \geq k_0) = \sum_{i=k_0}^n \binom{n}{i} p^i (1-p)^{n-i}$$

**Poisson distribution**

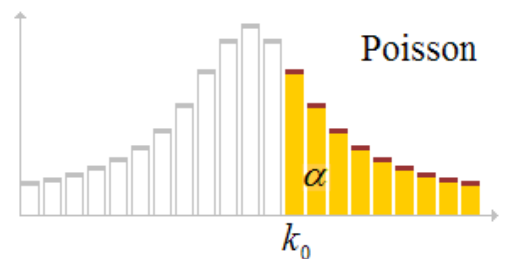
Probability at a point:

$$\alpha = p(x = k_0) = e^{-\lambda} \frac{\lambda^{k_0}}{k_0!}$$



Upper cumulative probability:

$$\alpha = p(x \geq k_0) = \sum_{n=k_0}^{\infty} e^{-\lambda} \frac{\lambda^n}{n!}$$



**Where:**

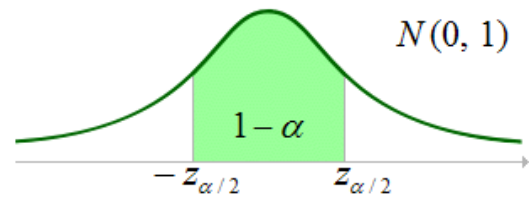
$\alpha$	Probability
$x$ $\mu$ $\sigma$ $x_0$	Random variable of Normal distribution Mean of Normal distribution Standard deviation of Normal distribution Percentage point of Normal distribution
$t$ $n$ $t_0$	Random variable of $t$ -Student distribution Degrees of freedom of $t$ -Student distribution Percentage point of $t$ -Student distribution
$\chi^2$ $n$ $\chi_0^2$	Random variable of Chi-square distribution Degrees of freedom of Chi-square distribution Percentage point of Chi-square distribution
$F$ $n_1$ $n_2$ $F_0$	Random variable of $F$ -Snedecor distribution Numerator degrees of freedom of $F$ -Snedecor distribution Denominator degrees of freedom of $F$ -Snedecor distribution Percentage point of $F$ -Snedecor distribution
$n$ $p$ $x$ $k_0$	Number of trials in Binomial distribution Probability of success for each alone event in Binomial distribution Random variable of Binomial distribution Percentage point of Binomial distribution
$\lambda$ $x$ $k_0$	(Lambda): Mean and standard deviation of Poisson distribution Random variable of Poisson distribution Percentage point of Poisson distribution

## Formulas of Confidence interval estimation

### Mean of population

(known population variance)

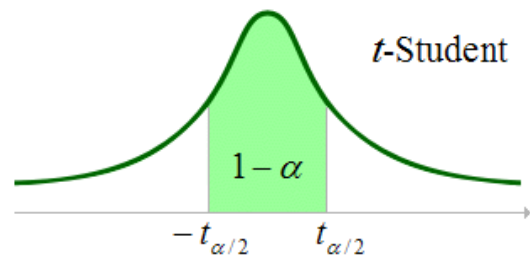
$$\mu \in \left( \bar{x} - z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}}, \bar{x} + z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}} \right)$$



### Mean of population

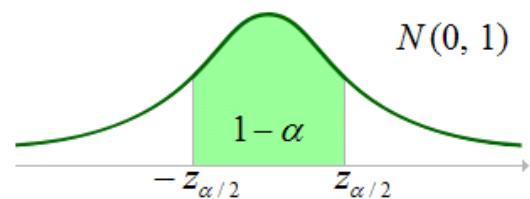
(unknown population variance)

$$\mu \in \left( \bar{x} - t_{\left(\frac{\alpha}{2}, n-1\right)} \frac{S}{\sqrt{n}}, \bar{x} + t_{\left(\frac{\alpha}{2}, n-1\right)} \frac{S}{\sqrt{n}} \right)$$



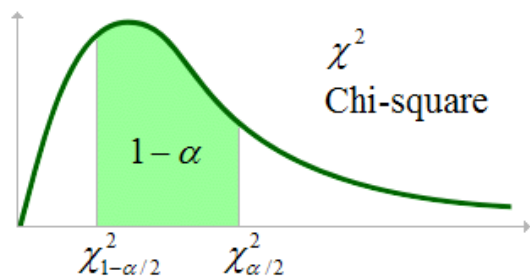
### Ratio of population

$$p \in \left( \hat{p} - z_{\frac{\alpha}{2}} \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}, \hat{p} + z_{\frac{\alpha}{2}} \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \right)$$



### Variance of population

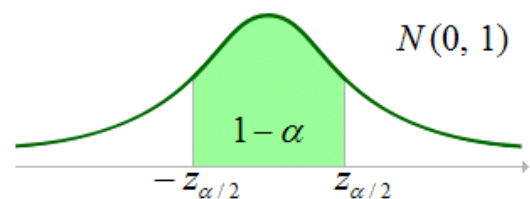
$$\sigma^2 \in \left( \frac{(n-1)S^2}{\chi^2_{\left(\frac{\alpha}{2}, n-1\right)}}, \frac{(n-1)S^2}{\chi^2_{\left(1-\frac{\alpha}{2}, n-1\right)}} \right)$$



### Mean difference of two populations

(known population variances)

$$\mu_1 - \mu_2 \in \left( \bar{x}_1 - \bar{x}_2 \pm z_{\frac{\alpha}{2}} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} \right)$$



### Mean difference of two populations

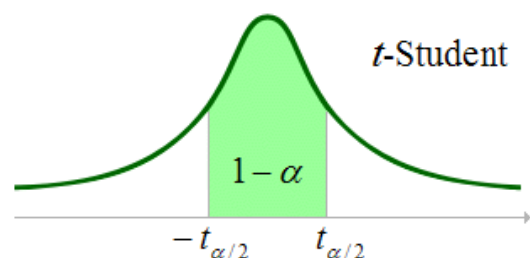
(unknown and equal population variances)

$$\mu_1 - \mu_2 \in \left( \bar{x}_1 - \bar{x}_2 \pm t_{\left(\frac{\alpha}{2}, n_1+n_2-2\right)} S_P \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \right)$$

Where: 
$$S_P^2 = \frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2}$$

(Pooled variance of the samples)

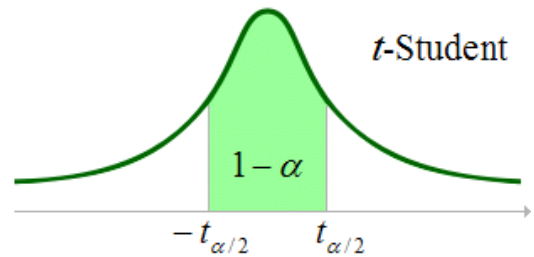
$$\sigma_1^2 = \sigma_2^2$$



**Mean difference of two populations**  
(unknown and different population variances)

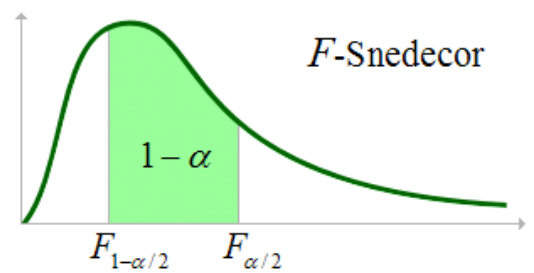
$$\mu_1 - \mu_2 \in \left( \bar{x}_1 - \bar{x}_2 \pm t_{\left(\frac{\alpha}{2}, \nu\right)} \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}} \right)$$

Where: 
$$\nu \approx \frac{(S_1^2/n_1 + S_2^2/n_2)^2}{\frac{(S_1^2/n_1)^2}{n_1 - 1} + \frac{(S_2^2/n_2)^2}{n_2 - 1}}, \quad \sigma_1^2 \neq \sigma_2^2$$
  
(Welch approximation)



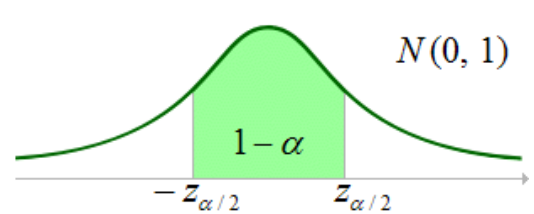
**Variance ratio of two populations**

$$\frac{\sigma_1^2}{\sigma_2^2} \in \left( \frac{S_1^2}{S_2^2} F_{\left(1 - \frac{\alpha}{2}, n_2 - 1, n_1 - 1\right)}, \frac{S_1^2}{S_2^2} F_{\left(\frac{\alpha}{2}, n_2 - 1, n_1 - 1\right)} \right)$$



**Ratio difference of two populations**

$$p_1 - p_2 \in \left( \hat{p}_1 - \hat{p}_2 \pm z_{\frac{\alpha}{2}} \sqrt{\frac{\hat{p}_1(1 - \hat{p}_1)}{n_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{n_2}} \right)$$

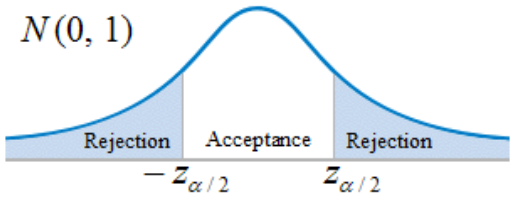
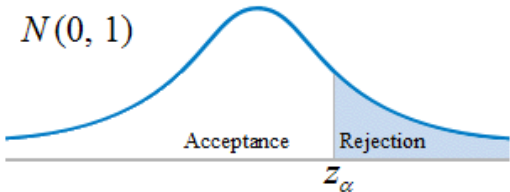
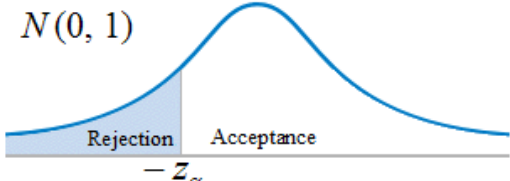


**Where:**

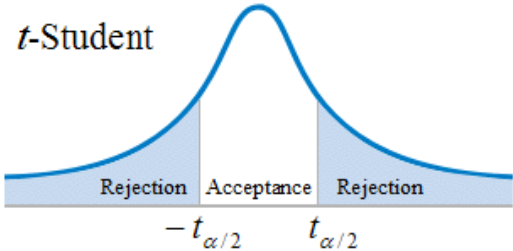
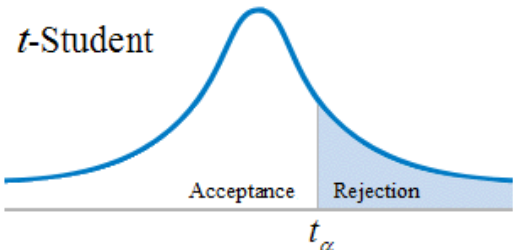
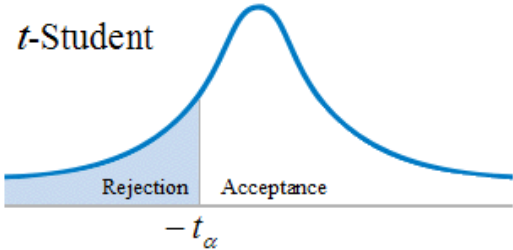
$\mu$	Mean of the population
$\bar{x}$	Mean of the sample
$\sigma$	Standard deviation of the population
$S$	Standard deviation of the sample
$p$	Ratio of the population
$\hat{p}$	Ratio of the sample
$n$	Sample size
$\alpha$	Significance level
$1 - \alpha$	Confidence level
$z_{\frac{\alpha}{2}}$	Percentage point of the Normal distribution with an upper cumulative probability of $\frac{\alpha}{2}$
$t_{(\alpha, \nu)}$	Percentage point of the t-Student distribution with an upper cumulative probability $\alpha$ and $\nu$ degrees of freedom.
$\chi^2_{(\alpha, \nu)}$	Percentage point of the Chi-square distribution with an upper cumulative probability $\alpha$ and $\nu$ degrees of freedom.
$F_{(\alpha, \nu_1, \nu_2)}$	Percentage point of F-Snedecor distribution with an upper cumulative probability $\alpha$ and $\nu_1$ and $\nu_2$ degrees of freedom

## Formulas of Hypothesis testing

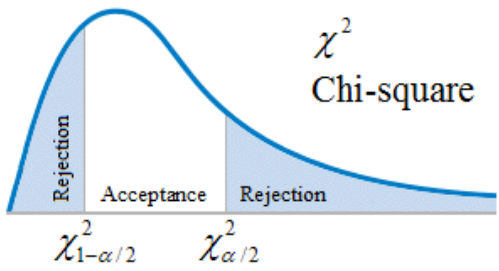
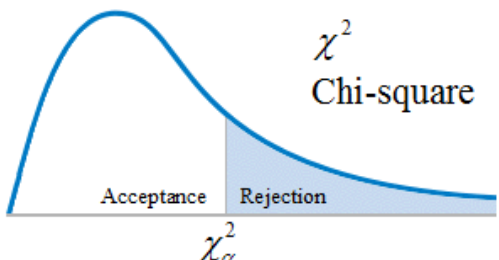
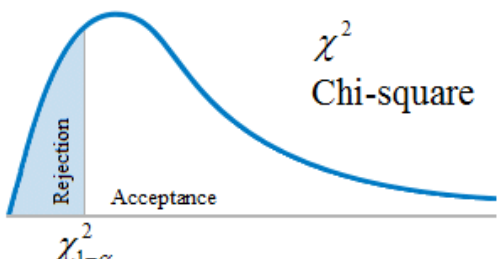
### Mean of population (known population variance)

<p><b>Two-sided:</b>  <math>H_0: \mu = \mu_0</math>  <math>H_1: \mu \neq \mu_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 \notin \left( -z_{\frac{\alpha}{2}}, z_{\frac{\alpha}{2}} \right)</math>            Where <math>z_0 = \frac{\bar{x} - \mu_0}{\sigma / \sqrt{n}}</math>            The statistic <math>z_0</math> follows a normal distribution <math>N(0, 1)</math>.</p>	
<p><b>Right side:</b>  <math>H_0: \mu \leq \mu_0</math>  <math>H_1: \mu &gt; \mu_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &gt; z_{\alpha}</math></p>	
<p><b>Left side:</b>  <math>H_0: \mu \geq \mu_0</math>  <math>H_1: \mu &lt; \mu_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &lt; -z_{\alpha}</math></p>	

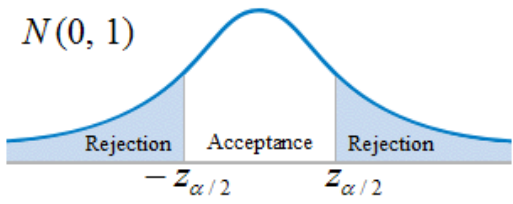
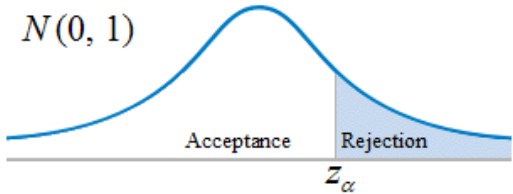
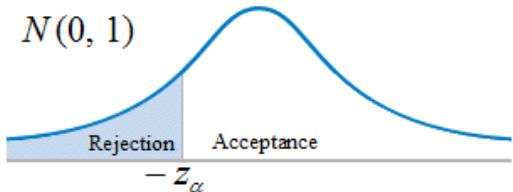
**Mean of population** (unknown population variance)

<p><b>Two-sided:</b>  <math>H_0: \mu = \mu_0</math>  <math>H_1: \mu \neq \mu_0</math></p>	<p>Reject <math>H_0</math> if:  <math display="block">t_0 \notin \left( -t_{\left(\frac{\alpha}{2}, n-1\right)}, t_{\left(\frac{\alpha}{2}, n-1\right)} \right)</math>           Where <math>t_0 = \frac{\bar{x} - \mu_0}{S/\sqrt{n}}</math></p> <p>The statistic <math>t_0</math> follows a <math>t</math>-Student distribution with <math>n-1</math> degrees of freedom.</p>	<p><b><math>t</math>-Student</b></p> 
<p><b>Right side:</b>  <math>H_0: \mu \leq \mu_0</math>  <math>H_1: \mu &gt; \mu_0</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 &gt; t_{(\alpha, n-1)}</math></p>	<p><b><math>t</math>-Student</b></p> 
<p><b>Left side:</b>  <math>H_0: \mu \geq \mu_0</math>  <math>H_1: \mu &lt; \mu_0</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 &lt; -t_{(\alpha, n-1)}</math></p>	<p><b><math>t</math>-Student</b></p> 

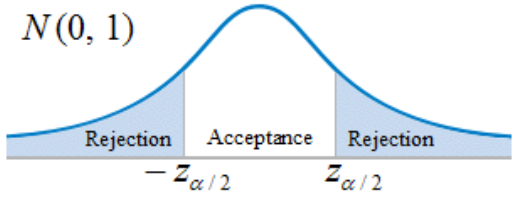
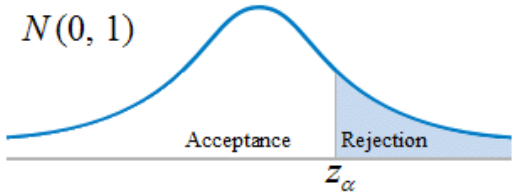
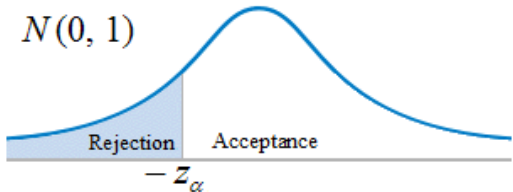
## Variance of population

<p><b>Two-sided:</b>  <math>H_0: \sigma^2 = \sigma_0^2</math>  <math>H_1: \sigma^2 \neq \sigma_0^2</math></p>	<p>Reject <math>H_0</math> if:  <math>\chi_0^2 \notin \left( \chi_{\left(1-\frac{\alpha}{2}, n-1\right)}^2, \chi_{\left(\frac{\alpha}{2}, n-1\right)}^2 \right)</math></p> <p>Where <math>\chi_0^2 = \frac{(n-1)S^2}{\sigma_0^2}</math></p> <p>The statistic <math>\chi_0^2</math> follows a Chi-square distribution with <math>n-1</math> degrees of freedom.</p>	 <p style="text-align: right;"><math>\chi^2</math> Chi-square</p>
<p><b>Right side:</b>  <math>H_0: \sigma^2 \leq \sigma_0^2</math>  <math>H_1: \sigma^2 &gt; \sigma_0^2</math></p>	<p>Reject <math>H_0</math> if:  <math>\chi_0^2 &gt; \chi_{(\alpha, n-1)}^2</math></p>	 <p style="text-align: right;"><math>\chi^2</math> Chi-square</p>
<p><b>Left side:</b>  <math>H_0: \sigma^2 \geq \sigma_0^2</math>  <math>H_1: \sigma^2 &lt; \sigma_0^2</math></p>	<p>Reject <math>H_0</math> if:  <math>\chi_0^2 &lt; \chi_{(1-\alpha, n-1)}^2</math></p>	 <p style="text-align: right;"><math>\chi^2</math> Chi-square</p>

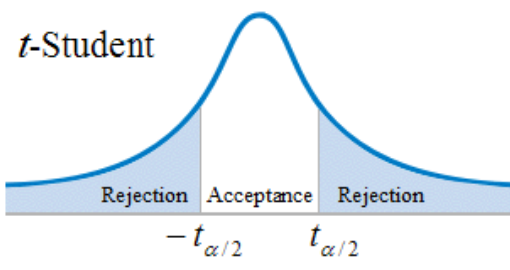
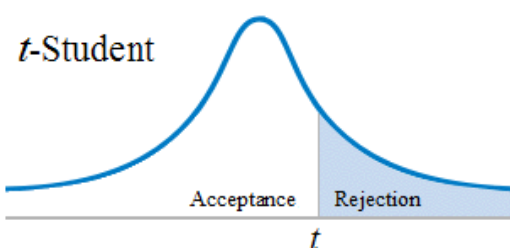
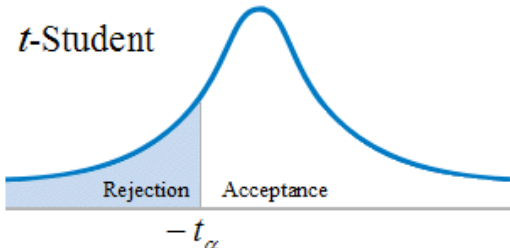
## Ratio of population

<p><b>Two-sided:</b>  <math>H_0: p = p_0</math>  <math>H_1: p \neq p_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 \notin \left( -z_{\frac{\alpha}{2}}, z_{\frac{\alpha}{2}} \right)</math></p> <p>Where <math>z_0 = \frac{n \hat{p} - n p_0}{\sqrt{n p_0 (1 - p_0)}}</math></p> <p>The statistic <math>z_0</math> follows a normal distribution <math>N(0, 1)</math>.</p>	
<p><b>Right side:</b>  <math>H_0: p \leq p_0</math>  <math>H_1: p &gt; p_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &gt; z_\alpha</math></p>	
<p><b>Left side:</b>  <math>H_0: p \geq p_0</math>  <math>H_1: p &lt; p_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &lt; -z_\alpha</math></p>	

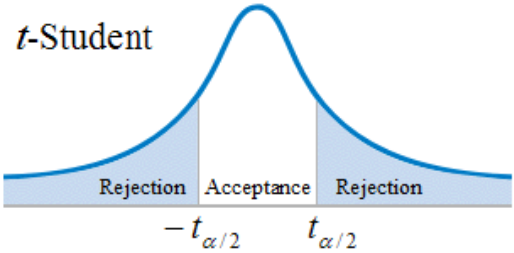
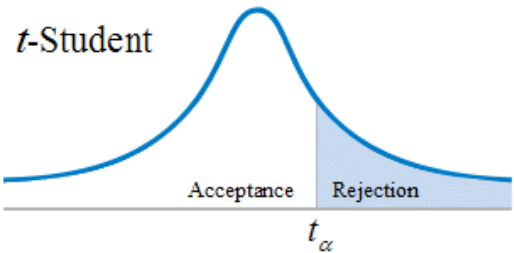
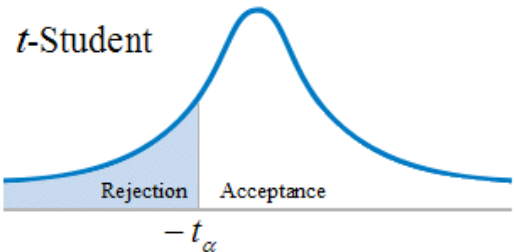
## Mean difference of two populations (known population variances)

<p><b>Two-sided:</b>  <math>H_0: \mu_1 - \mu_2 = \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 \neq \Delta_0</math></p> <p><math>(\sigma_1^2 \neq \sigma_2^2)</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 \notin \left( -z_{\frac{\alpha}{2}}, z_{\frac{\alpha}{2}} \right)</math></p> <p>Where <math>z_0 = \frac{\bar{x}_1 - \bar{x}_2 - \Delta_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}</math></p> <p>The statistic <math>z_0</math> follows a normal distribution <math>N(0, 1)</math>.</p>	
<p><b>Right side:</b>  <math>H_0: \mu_1 - \mu_2 \leq \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 &gt; \Delta_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &gt; z_\alpha</math></p>	
<p><b>Left side:</b>  <math>H_0: \mu_1 - \mu_2 \geq \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 &lt; \Delta_0</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &lt; -z_\alpha</math></p>	

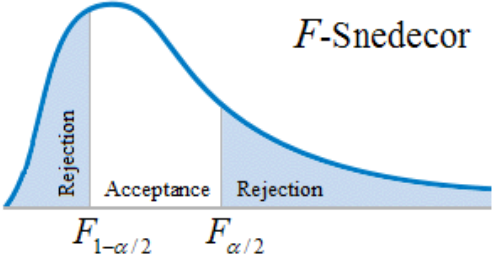
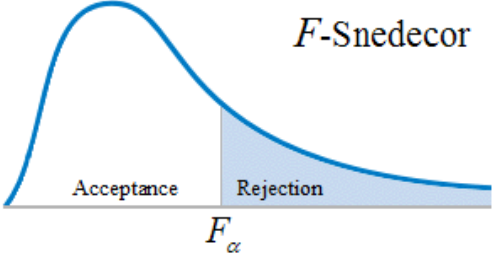
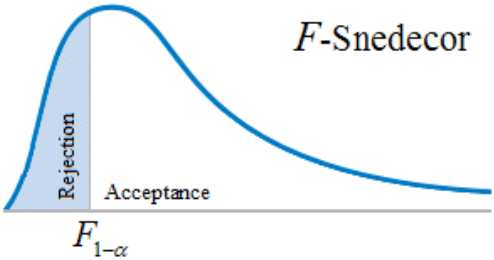
**Mean difference of two populations** (unknown and equal population variances)

<p><b>Two-sided:</b>  <math>H_0: \mu_1 - \mu_2 = \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 \neq \Delta_0</math>  <math>(\sigma_1^2 = \sigma_2^2)</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 \notin \left( -t_{\left(\frac{\alpha}{2}, n_1+n_2-2\right)}, t_{\left(\frac{\alpha}{2}, n_1+n_2-2\right)} \right)</math></p> <p>Where <math>t_0 = \frac{\bar{x}_1 - \bar{x}_2 - \Delta_0}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}</math></p> $S_p^2 = \frac{(n_1 - 1) S_1^2 + (n_2 - 1) S_2^2}{n_1 + n_2 - 2}$ <p>(Pooled variance of the samples)</p> <p>The statistic <math>t_0</math> follows a <math>t</math>-Student distribution with <math>n_1 + n_2 - 2</math> degrees of freedom.</p>	<p><b>t-Student</b></p> 
<p><b>Right side:</b>  <math>H_0: \mu_1 - \mu_2 \leq \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 &gt; \Delta_0</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 &gt; t_{(\alpha, n_1+n_2-2)}</math></p>	<p><b>t-Student</b></p> 
<p><b>Left side:</b>  <math>H_0: \mu_1 - \mu_2 \geq \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 &lt; \Delta_0</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 &lt; -t_{(\alpha, n_1+n_2-2)}</math></p>	<p><b>t-Student</b></p> 

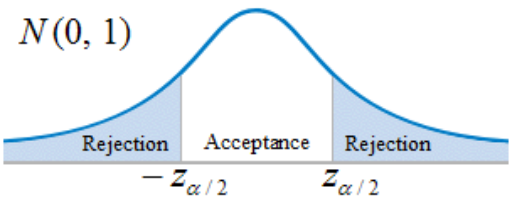
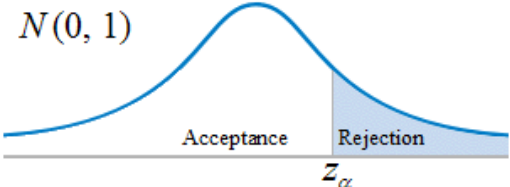
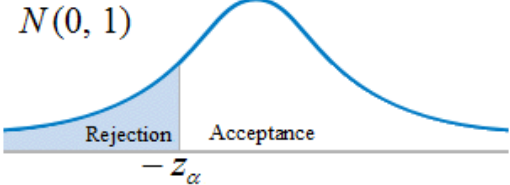
**Mean difference of two populations** (unknown and different population variances)

<p><b>Two-sided:</b>  <math>H_0: \mu_1 - \mu_2 = \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 \neq \Delta_0</math>    <math>(\sigma_1^2 \neq \sigma_2^2)</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 \notin \left( -t_{\left(\frac{\alpha}{2}, \nu\right)}, t_{\left(\frac{\alpha}{2}, \nu\right)} \right)</math>              Where <math>t_0 = \frac{\bar{x}_1 - \bar{x}_2 - \Delta_0}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}</math>    <math display="block">\nu = \frac{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)^2}{\frac{\left(\frac{S_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{S_2^2}{n_2}\right)^2}{n_2 - 1}}</math>           (Welch approximation)              The statistic <math>t_0</math> follows a <math>t</math>-Student distribution with <math>\nu</math> degrees of freedom.</p>	<p><b>t-Student</b></p> 
<p><b>Right side:</b>  <math>H_0: \mu_1 - \mu_2 \leq \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 &gt; \Delta_0</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 &gt; t_{(\alpha, \nu)}</math></p>	<p><b>t-Student</b></p> 
<p><b>Left side:</b>  <math>H_0: \mu_1 - \mu_2 \geq \Delta_0</math>  <math>H_1: \mu_1 - \mu_2 &lt; \Delta_0</math></p>	<p>Reject <math>H_0</math> if:  <math>t_0 &lt; -t_{(\alpha, \nu)}</math></p>	<p><b>t-Student</b></p> 

## Variance ratio of two populations

<p><b>Two-sided:</b>  <math>H_0: \sigma_1^2 = \sigma_2^2</math>  <math>H_1: \sigma_1^2 \neq \sigma_2^2</math></p>	<p>Reject <math>H_0</math> if:  <math display="block">F_0 \notin \left( F_{\left(1-\frac{\alpha}{2}, n_1-1, n_2-1\right)}, F_{\left(\frac{\alpha}{2}, n_1-1, n_2-1\right)} \right)</math></p> <p>Where <math>F_0 = \frac{S_1^2}{S_2^2}</math></p> <p>The statistic <math>F_0</math> follows a <math>F</math>-Snedecor distribution with <math>n_1-1</math> and <math>n_2-1</math> degrees of freedom.</p>	
<p><b>Right side:</b>  <math>H_0: \sigma_1^2 \leq \sigma_2^2</math>  <math>H_1: \sigma_1^2 &gt; \sigma_2^2</math></p>	<p>Reject <math>H_0</math> if:  <math display="block">F_0 &gt; F_{(\alpha, n_1-1, n_2-1)}</math></p>	
<p><b>Left side:</b>  <math>H_0: \sigma^2 \geq \sigma_0^2</math>  <math>H_1: \sigma^2 &lt; \sigma_0^2</math></p>	<p>Reject <math>H_0</math> if:  <math display="block">F_0 &lt; F_{(1-\alpha, n_1-1, n_2-1)}</math></p>	

## Ratio difference of two populations

<p><b>Two-sided:</b>  <math>H_0: p_1 = p_2</math>  <math>H_1: p_1 \neq p_2</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 \notin \left( -z_{\frac{\alpha}{2}}, z_{\frac{\alpha}{2}} \right)</math></p> <p>Where <math>z_0 = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}</math></p> $\hat{p} = \frac{n_1 \hat{p}_1 + n_2 \hat{p}_2}{n_1 + n_2}$ <p>The statistic <math>z_0</math> follows a normal distribution <math>N(0, 1)</math>.</p>	 <p><math>N(0, 1)</math></p> <p>Rejection Acceptance Rejection</p> <p><math>-z_{\alpha/2}</math> <math>z_{\alpha/2}</math></p>
<p><b>Right side:</b>  <math>H_0: p_1 \leq p_2</math>  <math>H_1: p_1 &gt; p_2</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &gt; z_{\alpha}</math></p>	 <p><math>N(0, 1)</math></p> <p>Acceptance Rejection</p> <p><math>z_{\alpha}</math></p>
<p><b>Left side:</b>  <math>H_0: p_1 \geq p_2</math>  <math>H_1: p_1 &lt; p_2</math></p>	<p>Reject <math>H_0</math> if:  <math>z_0 &lt; -z_{\alpha}</math></p>	 <p><math>N(0, 1)</math></p> <p>Rejection Acceptance</p> <p><math>-z_{\alpha}</math></p>

**Where:**

$1 - \alpha$	Confidence level
$\alpha$	Significance level
$H_0$	Null hypothesis
$H_1$	Alternative hypothesis
$\mu$	Mean of the population
$\bar{x}$	Mean of the sample
$\sigma$	Standard deviation of the population
$S$	Standard deviation of the sample
$p$	Ratio of the population
$\hat{p}$	Ratio of the sample
$n$	Sample size
$z_0$	Statistic that follows a normal distribution $N(0, 1)$
$t_0$	Statistic that follows a $t$ -Student distribution
$F_0$	Statistic that follows a $F$ -Snedecor distribution
$\chi_0^2$	Statistic that follows a Chi-square distribution
$z_\alpha$	Percentage point of the Normal distribution with an upper cumulative probability of $\alpha$
$t_{(\alpha, \nu)}$	Percentage point of the $t$ -Student distribution with an upper cumulative probability $\alpha$ and $\nu$ degrees of freedom.
$\chi_{(\alpha, \nu)}^2$	Percentage point of the Chi-square distribution with an upper cumulative probability $\alpha$ and $\nu$ degrees of freedom.
$F_{(\alpha, \nu_1, \nu_2)}$	Percentage point of $F$ -Snedecor distribution with an upper cumulative probability $\alpha$ and $\nu_1$ and $\nu_2$ degrees of freedom

## Formulas of One variable statistics

<b>Mean</b>	$\bar{x} = \frac{\sum x_i n_i}{N}$
<b>Variance (<math>s^2</math>) and standard deviation (<math>s</math>)</b>	$s^2 = \frac{\sum x_i^2 n_i}{N} - \bar{x}^2; \quad s = \sqrt{\frac{\sum x_i^2 n_i}{N} - \bar{x}^2}$
<b>Coefficient of variation</b>	$CV = \frac{s}{\bar{x}}$
<b>Percentiles</b>	$P_k = L + a \frac{\frac{k \cdot N}{100} - N_{i-1}}{n_i}$
<b>Deciles</b>	$D_k = L + a \frac{\frac{k \cdot N}{10} - N_{i-1}}{n_i}$
<b>Quartiles</b>	$Q_k = L + a \frac{\frac{k \cdot N}{4} - N_{i-1}}{n_i}$
<b>Median</b>	$Me = L + a \frac{\frac{N}{2} - N_{i-1}}{n_i}, \quad Me = P_{50} = D_5 = Q_2$
<b>Mode</b>	$Mo = L + a \frac{\Delta_1}{\Delta_1 + \Delta_2} \quad \Delta_1 = n_i - n_{i-1}, \quad \Delta_2 = n_i - n_{i+1}$ <p>If intervals aren't the same width, density of frequency is used instead frequency.</p>
<b>Moments</b>	<p>About the mean: <math display="block">m_k = \frac{\sum (x_i - \bar{x})^k n_i}{N}</math></p> <p>About the origin: <math display="block">a_k = \frac{\sum x_i^k n_i}{N}</math></p>
<b>Skewness</b>	$g_1 = \frac{m_3}{s^3}$
<b>Kurtosis</b>	$g_2 = \frac{m_4}{s^4} - 3$

**Where:**

$N$	Number of items (size of the sample)
$L$	Left endpoint of the relevant interval
$a$	Width of the relevant interval
$N_{i-1}$	Cumulative frequency of the previous interval
$n_i$	Frequency of the relevant interval
$n_{i-1}$	Frequency of the previous interval
$n_{i+1}$	Frequency of the next interval

## Formulas of Two variables statistics

<b>Means</b>	$\bar{x} = \frac{\sum x_i n_i}{N}; \quad \bar{y} = \frac{\sum y_i n_i}{N}$
<b>Variances</b>	$s_x^2 = \frac{\sum x_i^2 n_i}{N} - \bar{x}^2; \quad s_y^2 = \frac{\sum y_i^2 n_i}{N} - \bar{y}^2$
<b>Covariance</b>	$s_{xy}^2 = \frac{\sum x_i y_i n_i}{N} - \bar{x} \bar{y}$
<b>Pearson coefficient of correlation</b>	$r = \frac{s_{xy}}{s_x s_y}$
<b>LINEAR regression</b>	$y - \bar{y} = \frac{s_{xy}}{s_x^2} (x - \bar{x}) \quad \rightarrow \quad y = a + b x$
<b>LOGARITHMIC regression</b>	$y - \bar{y} = \frac{s_{\ln x y}}{s_{\ln x}^2} (\ln x - \overline{\ln x}) \quad \rightarrow \quad y = a + b \ln x$
<b>EXPONENTIAL regression</b>	$\ln y - \overline{\ln y} = \frac{s_{x \ln y}}{s_x^2} (x - \bar{x}) \quad \rightarrow \quad y = a b^x$
<b>POWER regression</b>	$\ln y - \overline{\ln y} = \frac{s_{\ln x \ln y}}{s_{\ln x}^2} (\ln x - \overline{\ln x}) \quad \rightarrow \quad y = a x^b$
<b>QUADRATIC regression</b>	$\rightarrow y = a x^2 + b x + c$

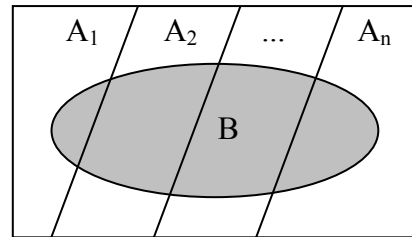
## Formulas of Total Probability Law and Bayes' Theorem

### Total Probability Law

$$P(B) = P(A_1) \cdot P(B / A_1) + P(A_2) \cdot P(B / A_2) + \dots + P(A_n) \cdot P(B / A_n)$$

### Bayes' Theorem

$$P(A_i / B) = \frac{P(A_i) \cdot P(B / A_i)}{P(B)}$$



## Formulas of probability of two events A and B

$$P(E)=1$$

$$P(\emptyset)=0$$

$$P(\bar{A})=1-P(A)$$

$$P(\bar{B})=1-P(B)$$

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

$$P(A \cap B) = P(A) \cdot P(B/A)$$

$$P(A \cap B) = P(B) \cdot P(A/B)$$

$$P(A - B) = P(A) - P(A \cap B)$$

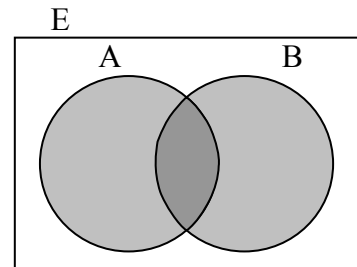
$$P(B - A) = P(B) - P(A \cap B)$$

$$P(\overline{A \cup B}) = P(\bar{A} \cap \bar{B})$$

$$P(\overline{A \cap B}) = P(\bar{A} \cup \bar{B})$$

$$P(A/B) = \frac{P(A \cap B)}{P(B)}$$

$$P(B/A) = \frac{P(A \cap B)}{P(A)}$$



## Specifications

<b>Description</b>	StaTool. Application for Windows with capabilities of statistics and probability calculations.
<b>Output precision</b>	From 8 to 10 digits
<b>Internal precision</b>	16 digits.
<b>Types of calculations:</b>	<b>7 types:</b> <ul style="list-style-type: none"><li>- Hypothesis testing</li><li>- Confidence interval estimation</li><li>- Probability distributions</li><li>- One variable statistics</li><li>- Two variables statistics</li><li>- Total Probability Law and Bayes' Theorem</li><li>- Probability of A and B events</li></ul>
<b>Size</b>	Width = 1024 pixels, height = 732 pixels.

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