2.Tests (TEST)

The Z **Test** provides a variety of different standardization-based tests. They make it possible to test whether or not a sample accurately represents the population when the standard deviation of a population (such as the entire population of a country) is known from previous tests. Z testing is used for market research and public opinion research that need to be performed repeatedly.

1-Sample Z Test tests for unknown population mean when the population standard deviation is known.

2-Sample Z Test tests the equality of the means of two populations based on independent samples when both population standard deviations are known.

1-Prop Z Test tests for an unknown proportion of successes.

2-Prop Z Test tests to compare the propotion of successes from two populations.

The ***t*** **Test** tests the hypothesis when the population standard deviation is unknown. The hypothesis that is the opposite of the hypothesis being proven is called the *null hypothesis*, while the hypothesis being proved is called the *alternative hypothesis*. The t-test is normally applied to test the null hypothesis. Then a determination is made whether the null hypothesis or alternative hypothesis will be adopted.

1-Sample *t* Test tests the hypothesis for a single unknown population mean when the population standard deviation is unknown.

2-Sample *t* Test compares the population means when standard deviations are unknown.

Linear Reg *t* Test calculates the strength of the linear association of paired data.

χ^2 **Test** tests hypothesis concerning the proportion of samples included in each of a number of independent groups. Mainly, it generates cross-tabulation of two categorical variables (such as yes, no) and evaluates the independence of these variables. It could be used, for example, to evaluate the relationship between whether or not a driver has ever been involved in a traffic accident and that person's knowledge of traffic regulations.

2-Sample F Test tests the hypothesis for the ratio of sample variances. It could be used, for example, to test the carcinogenic effects of multiple suspected factors such as tobacco use, alcohol, vitamin deficiency, high coffee intake, inactivity, poor living habits, etc.

ANOVA tests the hypothesis that the population means of the samples are equal when there are multiple samples. It could be used, for example, to test whether or not different combinations of materials have an effect on the quality and life of a final product.

One-Way ANOVA is used when there is one independent variable and one dependent variable.

Two-Way ANOVA is used when there here are two independent variables and one dependent variable.

The following pages explain various statistical calculation methods based on the principles described above. Full details concerning statistical principles and terminology can be found in any standard general statistics textbook.

On the initial STAT2 Mode screen, press [F3] (TEST) to display the test menu, which contains the following items.

■ *Z* Tests

• *Z* Test Common Functions

You can use the following graph analysis functions after drawing a graph.

- [F1] (Z) ... Displays *z* score.

Pressing [F1] (Z) displays the *z* score at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).
Two points are displayed in the case of a two-tail test. Use ◀ and ▶ to move the pointer.
Press [ESC] to clear the *z* score.

- [F2] (P) ... Displays p-value.

Pressing [F2] (P) displays the p-value at the bottom of the display without displaying the pointer.
Press [ESC] to clear the p-value.

• 1-Sample *Z* Test

This test is used when the sample standard deviation for a population is known to test the hypothesis. The **1-Sample *Z* Test** is applied to normal distribution.

$$Z = \frac{\bar{x} - \mu_0}{\frac{\sigma}{\sqrt{n}}}$$

$\bar{x}$: mean of sample
μ_0 : assumed population mean
σ : population standard deviation
n : size of sample

The following V-Window settings are used for drawing the graph. *Xmin* = –3.2, *Xmax* = 3.2, *Xscale* = 1, *Ymin* = –0.1, *Ymax* = 0.45, *Yscale* =0.1

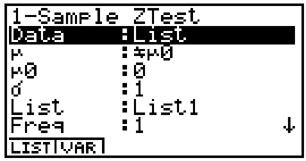
Executing an analysis function automatically stores the z and p values in alpha variables Z and P, respectively.

Perform the following key operation from the statistical data list.

[F3] (TEST)

[1] (Z)

[1] (1-Smpl)



The following shows the meaning of each item in the case of list data specification.

Data .... data type

μ .... population mean value test conditions ("≠ μ_0" specifies two-tail test, "< μ_0" specifies lower one-tail test, "> μ_0" specifies upper one-tail test.)

μ_0 .... assumed population mean

σ .... population standard deviation ($\sigma > 0$)

List .... list whose contents you want to use as data (List 1 to 20)

Freq .... frequency (1 or List 1 to 20)

Save Res .... list for storage of calculation results (None or List 1 to 20)

Execute .... executes a calculation or draws a graph

The following shows the meaning of parameter data specification items that are different from list data specification.

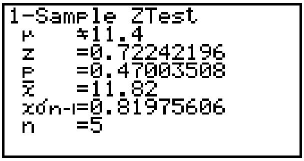
$\bar{x}$ .... mean of sample

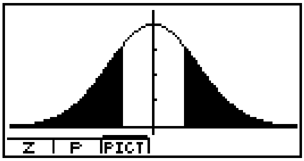
n .... size of sample (positive integer)

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1 (CALC) ... Performs the calculation.
- F6 (DRAW) ... Draws the graph.

Calculation Result Output Example





$\mu \neq 11.4$ .... direction of test

z .... Z score

p .... p-value

$\bar{x}$ .... mean of sample

$x\sigma_{n-1}$ .... sample standard deviation
(Displayed only for Data: List setting)

n .... size of sample

[Save Res] does not save the μ condition in line 2.

•2-Sample Z Test

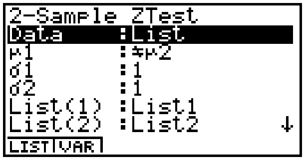
This test is used when the sample standard deviations for two populations are known to test the hypothesis. The **2-Sample Z Test** is applied to normal distribution.

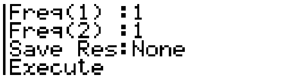
$$Z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sigma_1^{\,2}}{n_1} + \frac{\sigma_2^{\,2}}{n_2}}}$$

$\bar{x}_1$: mean of sample 1
$\bar{x}_2$: mean of sample 2
σ_1 : population standard deviation of sample 1
σ_2 : population standard deviation of sample 2
n_1 : size of sample 1
n_2 : size of sample 2

Perform the following key operation from the statistical data list.

[F3] (TEST)
[1] (Z)
[2] (2-Smpl)

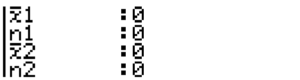




The following shows the meaning of each item in the case of list data specification.

Data .... data type
μ_1 .... population mean value test conditions ("$\neq \mu_2$" specifies two-tail test, "$< \mu_2$" specifies one-tail test where sample 1 is smaller than sample 2, "$> \mu_2$" specifies one-tail test where sample 1 is greater than sample 2.)
σ_1 .... population standard deviation of sample 1 ($\sigma_1 > 0$)
σ_2 .... population standard deviation of sample 2 ($\sigma_2 > 0$)
List(1) .... list whose contents you want to use as sample 1 data
List(2) .... list whose contents you want to use as sample 2 data
Freq(1) .... frequency of sample 1 (positive integer)
Freq(2) .... frequency of sample 2 (positive integer)
Save Res .... list for storage of calculation results (None or List 1 to 20)
Execute .... executes a calculation or draws a graph

The following shows the meaning of parameter data specification items that are different from list data specification.



$\bar{x}_1$ .... mean of sample 1

n_1 .... size (positive integer) of sample 1

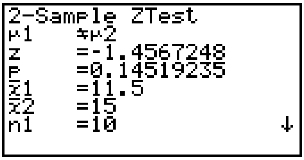
$\bar{x}_2$ .... mean of sample 2

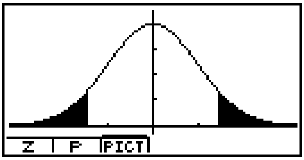
n_2 .... size (positive integer) of sample 2

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1 (CALC) ... Performs the calculation.
- F6 (DRAW) ... Draws the graph.

Calculation Result Output Example





$\mu_1 \neq \mu_2$ .... direction of test

z .... Z score

p .... p-value

$\bar{x}_1$ .... mean of sample 1

$\bar{x}_2$ .... mean of sample 2

$x_1\sigma_{n-1}$ .... standard deviation of sample 1 (Displayed only for Data: List Setting)

$x_2\sigma_{n-1}$ .... standard deviation of sample 2 (Displayed only for Data: List Setting.)

n_1 .... size of sample 1

n_2 .... size of sample 2

[Save Res] does not save the μ_1 condition in line 2.

•1-Prop Z Test

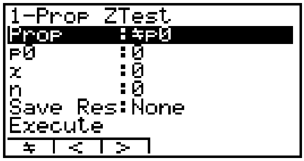
This test is used to test for an unknown proportion of successes. The **1-Prop Z Test** is applied to normal distribution.

$$Z = \frac{\frac{x}{n} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$$

p_0 : expected sample proportion
n : size of sample

Perform the following key operation from the statistical data list.

[F3](TEST)
[1](Z)
[3](1-Prop)



Prop .... sample proportion test conditions ("≠ p_0" specifies two-tail test, "< p_0" specifies lower one-tail test, "> p_0" specifies upper one-tail test.)

p_0 .... expected sample proportion ($0 < p_0 < 1$)

x .... sample value ($x \geqq 0$ integer)

n .... size of sample (positive integer)

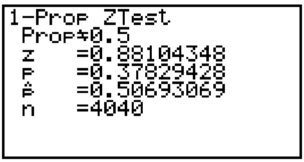
Save Res .... list for storage of calculation results (None or List 1 to 20)

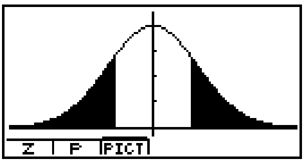
Execute .... executes a calculation or draws a graph

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- [F1](CALC) ... Performs the calculation.
- [F6](DRAW) ... Draws the graph.

Calculation Result Output Example





Prop≠0.5 .... direction of test

z .... Z score

p .... p-value

$\hat{p}$ .... estimated sample proportion

n .... size of sample

[Save Res] does not save the Prop condition in line 2.

●2-Prop *Z* Test

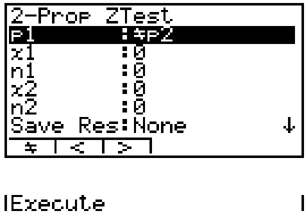
This test is used to compare the proportion of successes. The **2-Prop *Z* Test** is applied to normal distribution.

$$Z = \frac{\dfrac{x_1}{n_1} - \dfrac{x_2}{n_2}}{\sqrt{\hat{p}(1-\hat{p})\left(\dfrac{1}{n_1} + \dfrac{1}{n_2}\right)}}$$

x_1 : data value of sample 1
x_2 : data value of sample 2
n_1 : size of sample 1
n_2 : size of sample 2
$\hat{p}$: estimated sample proportion

Perform the following key operation from the statistical data list.

F3 (TEST)
1 (Z)
4 (2-Prop)



p_1 .... sample proportion test conditions ("≠ p_2" specifies two-tail test, "< p_2" specifies one-tail test where sample 1 is less than sample 2, "> p_2" specifies upper one-tail test where sample 1 is greater than sample 2.)

x_1 .... data value ($x_1 \geqq 0$ integer) of sample 1

n_1 .... size (positive integer) of sample 2

x_2 .... data value ($x_2 \geqq 0$ integer) of sample 1

n_2 .... size (positive integer) of sample 2

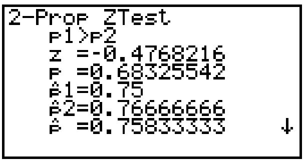
Save Res .... list for storage of calculation results (None or List 1 to 20)

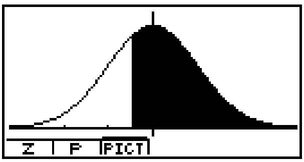
Execute .... executes a calculation or draws a graph

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1 (CALC) ... Performs the calculation.
- F6 (DRAW) ... Draws the graph.

Calculation Result Output Example





$p_1 > p_2$ .... direction of test
z .... Z score
p .... p-value
$\hat{p}_1$ .... estimated proportion of sample 1
$\hat{p}_2$ .... estimated proportion of sample 2
$\hat{p}$ .... estimated sample proportion
n_1 .... size of sample 1
n_2 .... size of sample 2

[Save Res] does not save the p_1 condition in line 2.

■ *t* Tests

• *t* Test Common Functions

You can use the following graph analysis functions after drawing a graph.

- F1 (T) ... Displays *t* score.

Pressing F1 (T) displays the *t* score at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).

Two points are displayed in the case of a two-tail test. Use ◀ and ▶ to move the pointer.

Press ESC to clear the *t* score.

- F2 (P) ... Displays p-value.

Pressing F2 (P) displays the p-value at the bottom of the display without displaying the pointer.

Press ESC to clear the p-value.

The following V-Window settings are used for drawing the graph. *Xmin* = –3.2, *Xmax* = 3.2, *Xscale* = 1, *Ymin* = –0.1, *Ymax* = 0.45, *Yscale* =0.1

Executing an analysis function automatically stores the t and p values in alpha variables T and P, respectively.

•1-Sample *t* Test

This test uses the hypothesis test for a single unknown population mean when the population standard deviation is unknown. The **1-Sample *t* Test** is applied to t-distribution.

$$t = \frac{\bar{x} - \mu_0}{\frac{x\sigma_{n-1}}{\sqrt{n}}}$$

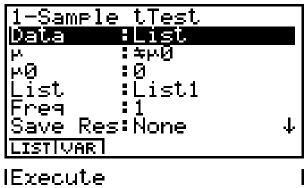
$\bar{x}$: mean of sample
μ_0 : assumed population mean
$x\sigma_{n-1}$: sample standard deviation
n : size of sample

Perform the following key operation from the statistical data list.

F3 (TEST)

2 (T)

1 (1-Smpl)



The following shows the meaning of each item in the case of list data specification.

Data .... data type

μ .... population mean value test conditions ("$\neq \mu_0$" specifies two-tail test, "$< \mu_0$" specifies lower one-tail test, "$> \mu_0$" specifies upper one-tail test.)

μ_0 .... assumed population mean

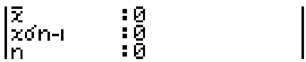
List .... list whose contents you want to use as data

Freq .... frequency

Save Res .... list for storage of calculation results (None or List 1 to 20)

Execute .... executes a calculation or draws a graph

The following shows the meaning of parameter data specification items that are different from list data specification.



$\bar{x}$ .... mean of sample

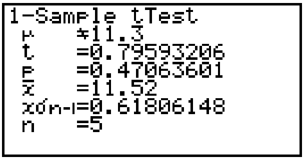
$x\sigma_{n-1}$ .... sample standard deviation ($x\sigma_{n-1} > 0$)

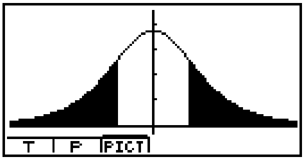
n .... size of sample (positive integer)

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1 (CALC) ... Performs the calculation.
- F6 (DRAW) ... Draws the graph.

Calculation Result Output Example





$\mu \neq 11.3$ .... direction of test

t .... t score

p .... p-value

$\bar{x}$ .... mean of sample

$x\sigma_{n-1}$ .... Sample standard deviation

n .... size of sample

[Save Res] does not save the μ condition in line 2.

•2-Sample *t* Test

2-Sample *t* Test compares the population means when standard deviations are unknown. The **2-Sample *t* Test** is applied to t-distribution.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\dfrac{x_1\sigma_{n-1}{}^2}{n_1} + \dfrac{x_2\sigma_{n-1}{}^2}{n_2}}}$$

$\bar{x}_1$: mean of sample 1
$\bar{x}_2$: mean of sample 2
$x_1\sigma_{n-1}$: standard deviation of sample 1
$x_2\sigma_{n-1}$: standard deviation of sample 2
n_1 : size of sample 1
n_2 : size of sample 2

This formula is applicable when the sample is not pooled, and the denominator is different when the sample is pooled.

Degrees of freedom df and $x_p\sigma_{n-1}$ differs according to whether or not pooling is in effect.

The following applies when pooling is in effect.

$$df = n_1 + n_2 - 2$$

$$x_p\sigma_{n-1} = \sqrt{\frac{(n_1-1)x_1\sigma_{n-1}{}^2 + (n_2-1)x_2\sigma_{n-1}{}^2}{n_1 + n_2 - 2}}$$

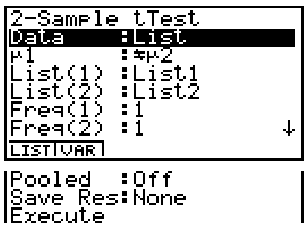
The following applies when pooling is not in effect.

$$df = \frac{1}{\dfrac{C^2}{n_1-1} + \dfrac{(1-C)^2}{n_2-1}}$$

$$C = \frac{\dfrac{x_1\sigma_{n-1}{}^2}{n_1}}{\left(\dfrac{x_1\sigma_{n-1}{}^2}{n_1} + \dfrac{x_2\sigma_{n-1}{}^2}{n_2}\right)}$$

Perform the following key operation from the statistical data list.

F3 (TEST)
2 (T)
2 (2-Smpl)



The following shows the meaning of each item in the case of list data specification.

Data .... data type

μ_1 .... sample mean value test conditions ("$\neq \mu_2$" specifies two-tail test, "< μ_2" specifies one-tail test where sample 1 is smaller than sample 2, "> μ_2" specifies one-tail test where sample 1 is greater than sample 2.)

List(1) .... list whose contents you want to use as data of sample 1

List(2) .... list whose contents you want to use as data of sample 2

Freq(1) .... frequency of sample 1 (positive integer)

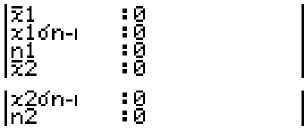
Freq(2) .... frequency of sample 2 (positive integer)

Pooled .... pooling On (in effect) or Off (not in effect)

Save Res .... list for storage of calculation results (None or List 1 to 20)

Execute .... executes a calculation or draws a graph

The following shows the meaning of parameter data specification items that are different from list data specification.



$\bar{x}_1$ .... mean of sample 1

$x_1\sigma_{n-1}$ .... standard deviation ($x_1\sigma_{n-1} > 0$) of sample 1

n_1 .... size (positive integer) of sample 2

$\bar{x}_2$ .... mean of sample 2

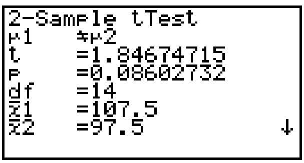
$x_2\sigma_{n-1}$ .... standard deviation ($x_2\sigma_{n-1} > 0$) of sample 2

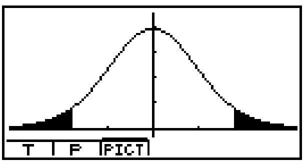
n_2 .... size (positive integer) of sample 2

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1 (CALC) ... Performs the calculation.
- F6 (DRAW) ... Draws the graph.

Calculation Result Output Example





$\mu_1 \neq \mu_2$ .... direction of test

t .... t score

p .... p-value
df .... degrees of freedom
$\bar{x}_1$ .... mean of sample 1
$\bar{x}_2$ .... mean of sample 2
$x_1\sigma_{n-1}$ .... standard deviation of sample 1
$x_2\sigma_{n-1}$ .... standard deviation of sample 2
$x_p\sigma_{n-1}$ .... pooled sample standard deviation (Displayed only when Pooled: On Setting.)
n_1 .... size of sample 1
n_2 .... size of sample 2

[Save Res] does not save the μ_1 condition in line 2.

•LinearReg *t* Test

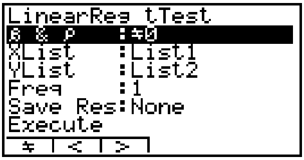
LinearReg *t* Test treats paired-variable data sets as (x, y) pairs and plots all data on a graph. Next, a straight line ($y = a + bx$) is drawn through the area where the greatest number of plots are located and the degree to which a relationship exists is calculated.

$$b = \frac{\sum_{i=1}^{n}(x-\bar{x})(y-\bar{y})}{\sum_{i=1}^{n}(x-\bar{x})^2} \qquad a = \bar{y} - b\bar{x} \qquad t = r\sqrt{\frac{n-2}{1-r^2}}$$

a : intercept
b : slope of the line
n : size of sample (n≧3)
r : correlation coefficient
r^2 : coefficient of determination

Perform the following key operation from the statistical data list.

F3 (TEST)
2 (T)
3 (LinReg)



The following shows the meaning of each item in the case of list data specification.

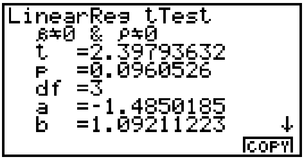
β & ρ .... p-value test conditions ("≠ 0" specifies two-tail test, "< 0" specifies lower one-tail test, "> 0" specifies upper one-tail test.)
XList .... list for x-axis data
YList .... list for y-axis data
Freq .... frequency
Save Res .... list for storage of calculation results (None or List 1 to 20)
Execute .... executes a calculation

After setting all the parameters, align the cursor with [Execute] and then press the function key shown below to perform the calculation.

- F1 (CALC) ... Performs the calculation.

You cannot draw a graph for LinearReg *t* Test.

Calculation Result Output Example



$\beta \neq 0$ & $\rho \neq 0$ .... direction of test

t .... t score

p .... p-value

df .... degrees of freedom

a .... constant term

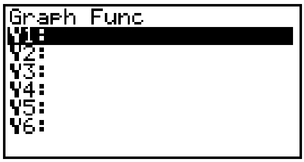
b .... coefficient

s .... standard error

r .... correlation coefficient

r^2 .... coefficient of determination

Pressing F6 (COPY) while a calculation result is on the display copies the regression formula to the graph formula editor.



When there is a list specified for the [Resid List] item on the SET UP screen, regression formula residual data is automatically saved to the specified list after the calculation is finished.

[Save Res] does not save the β & ρ conditions in line 2.

When the list specified by [Save Res] is the same list specified by the [Resid List] item on the SET UP screen, only[Resid List] data is saved in the list.

■ χ^2 Test

χ^2 **Test** sets up a number of independent groups and tests hypothesis related to the proportion of the sample included in each group. The χ^2 Test is applied to dichotomous variables (variable with two possible values, such as yes/no).

expected counts

$$F_{ij} = \frac{\sum_{i=1}^{k} x_{ij} \times \sum_{j=1}^{\ell} x_{ij}}{\sum n}$$

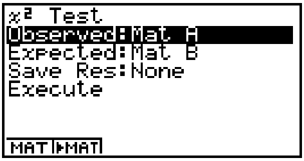
n : all data values

$$\chi^2 = \sum_{i=1}^{k} \sum_{j=1}^{\ell} \frac{(x_{ij} - F_{ij})^2}{F_{ij}}$$

Perform the following key operation from the statistical data list.

F3 (TEST)

3 (χ^2)



Next, specify the matrix that contains the data. The following shows the meaning of the above item.

- Observed .... name of matrix (A to Z) that contains observed counts (all cells positive integers)
- Expected .... name of matrix (A to Z) that is for saving expected frequency
- Save Res .... list for storage of calculation results (None or List 1 to 20)
- Execute .... executes a calculation or draws a graph

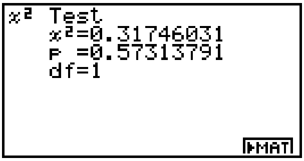
The matrix must be at least two lines by two columns. An error occurs if the matrix has only one line or one column.

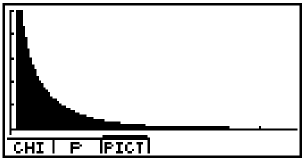
Pressing F2 (▶MAT) while setting parameters enters the MATRIX editor, which you can use to edit and view the contents of matrices.

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- F1(CALC) ... Performs the calculation.
- F6(DRAW) ... Draws the graph.

Calculation Result Output Example





χ^2 .... χ^2 value
p .... p-value
df .... degrees of freedom

You can use the following graph analysis functions after drawing a graph.

- F1(CHI) ... Displays χ^2 value.

Pressing F1 (CHI) displays the χ^2 value at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).

Press ESC to clear the χ^2 value.

- F2(P) ... Displays p-value.

Pressing F2 (P) displays the p-value at the bottom of the display without displaying the pointer.

Press ESC to clear the p-value.

Pressing F6 ((▶MAT) while a calculation result is displayed enters the MATRIX editor, which you can use to edit and view the contents of matrices.

The following V-Window settings are used for drawing the graph. $Xmin$ = 0, $Xmax$ = 11.5, $Xscale$ = 2, $Ymin$ = –0.1, $Ymax$ = 0.5, $Yscale$ =0.1

Executing an analysis function automatically stores the χ^2 and p values in alpha variables C and P, respectively.

■ 2-Sample *F* Test

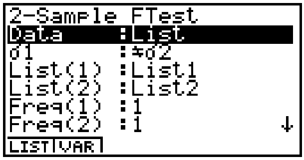
2-Sample *F* Test tests the hypothesis for the ratio of sample variances. The *F* Test is applied to *F* distribution.

$$F = \frac{x_1\sigma_{n-1}{}^2}{x_2\sigma_{n-1}{}^2}$$

Perform the following key operation from the statistical data list.

[F3] (TEST)

[4] (F)



The following is the meaning of each item in the case of list data specification.

Data .... data type

σ_1 .... population standard deviation test conditions ("≠ σ_2" specifies two-tail test, "< σ_2" specifies one-tail test where sample 1 is smaller than sample 2, "> σ_2" specifies one-tail test where sample 1 is greater than sample 2.)

List(1) .... list whose contents you want to use as data of sample 1

List(2) .... list whose contents you want to use as data of sample 2

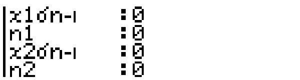
Freq(1) .... frequency of sample 1

Freq(2) .... frequency of sample 2

Save Res .... list for storage of calculation results (None or List 1 to 20)

Execute .... executes a calculation or draws a graph

The following shows the meaning of parameter data specification items that are different from list data specification.



$x_1\sigma_{n-1}$ .... standard deviation ($x_1\sigma_{n-1} > 0$) of sample 1

n_1 .... size (positive integer) of sample 1

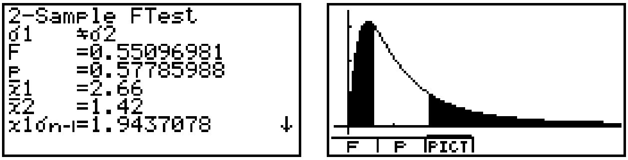
$x_2\sigma_{n-1}$ .... standard deviation ($x_2\sigma_{n-1} > 0$) of sample 2

n_2 .... size (positive integer) of sample 2

After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

- [F1] (CALC) ... Performs the calculation.
- [F6] (DRAW) ... Draws the graph.

Calculation Result Output Example



$\sigma_1 \neq \sigma_2$ .... direction of test

F .... F value

p .... p-value

$\bar{x}_1$ .... mean of sample 1 (Displayed only for Data: List Setting)

$\bar{x}_2$ .... mean of sample 2 (Displayed only for Data: List Setting)

$x_1\sigma_{n-1}$ .... standard deviation of sample 1

$x_2\sigma_{n-1}$ .... standard deviation of sample 2

n_1 .... size of sample 1

n_2 .... size of sample 2

You can use the following graph analysis functions after drawing a graph.

- F1 (F) ... Displays F value.

Pressing F1 (F) displays the F value at the bottom of the display, and displays the pointer at the corresponding location in the graph (unless the location is off the graph screen).

Two points are displayed in the case of a two-tail test. Use ◀ and ▶ to move the pointer.

Press ESC to clear the F value.

- F2 (P) ... Displays p-value.

Pressing F2 (P) displays the p-value at the bottom of the display without displaying the pointer.

Press ESC to clear the p-value.

[Save Res] does not save the σ_1 condition in line 2.

V-Window settings are automatically optimized for drawing the graph.

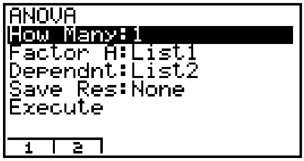
Executing an analysis function automatically stores the F and p values in alpha variables F and P, respectively

■ ANOVA

ANOVA tests the hypothesis that the population means of the samples are equal when there are multiple samples.
One-Way ANOVA is used when there is one independent variable and one dependent variable.
Two-Way ANOVA is used when there here are two independent variables and one dependent variable.
This **Two-Way ANOVA** calculation is available under the condition that is to prepare more than two experimental data as each dependent data.

Perform the following key operation from the statistical data list.

[F3](TEST)
[5](ANOVA)



The following is the meaning of each item in the case of list data specification.

How Many .... selects One-Way ANOVA or Two-Way ANOVA (number of levels).
Factor A .... category list.
Dependnt .... list to be used for sample data.
Save Res .... first list for storage of calculation results.
Execute .... executes a calculation or draws a graph (Two-Way ANOVA only)

The following item appears in the case of Two-Way ANOVA only.

Factor B .... category list.

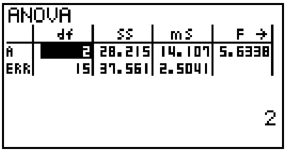
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

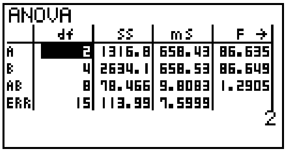
- [F1](CALC) ... Performs the calculation.
- [F6](DRAW) ... Draws the graph (Two-Way ANOVA only).

Calculation results are displayed in table form, just as they appear in science books.

[Save Res] saves each vertical column of the table into its own list. The leftmost column is saved in the specified list, and each subsequent column to the right is saved in the next sequentially numbered list. Up to five lists can be used for storing columns. You can specify an first list number in the range of 1 to 16.

Calculation Result Output Example





One-Way ANOVA

Line 1 (A) .... Factor A *df* value, *SS* value, *MS* value, *F* value, p-value

Line 2 (ERR) .... Error *df* value, *SS* value, *MS* value

Two-Way ANOVA

Line 1 (A) .... Factor A *df* value, *SS* value, *MS* value, *F* value, p-value

Line 2 (B) .... Factor B *df* value, *SS* value, *MS* value, *F* value, p-value

Line 3 (AB) .... Factor A x Factor B *df* value, *SS* value, *MS* value, *F* value, p-value

Line 4 (ERR) .... Error *df* value, *SS* value, *MS* value

F .... *F* value

p .... p-value

df .... degrees of freedom

SS .... sum of squares

MS .... mean squares

With Two-Way ANOVA, you can draw Interaction Plot graphs. The number of graphs depends on Factor B, while the number of X-axis data depends on the Factor A. The Y-axis is the average value of each category.

You can use the following graph analysis function after drawing a graph.

- F1 (TRACE) ... Trace function

Pressing ◀ or ▶ moves the pointer on the graph in the corresponding direction. When there are multiple graphs, you can move between graphs by pressing ▲ and ▼.

Press ESC to clear the pointer from the display.

Graphing is available with Two-Way ANOVA only. V-Window settings are performed automatically, regardless of SET UP screen settings.

Using the TRACE function automatically stores the number of conditions to alpha variable A and the mean value to variable M, respectively.

■ ANOVA (Two-Way)

•Description

The nearby table shows measurement results for a metal product produced by a heat treatment process based on two treatment levels: time (A) and temperature (B). The experiments were repeated twice each under identical conditions.

B (Heat Treatment Temperature) A (Time)	B1	B2
A1	113 , 116	139 , 132
A2	133 , 131	126 , 122

Perform analysis of variance on the following null hypothesis, using a significance level of 5%.

H_0 : No change in strength due to time
H_0 : No change in strength due to heat treatment temperature
H_0 : No change in strength due to interaction of time and heat treatment temperature

•Solution

Use two-way ANOVA to test the above hypothesis.
Input the above data as shown below.

List1={1,1,1,1,2,2,2,2}
List2={1,1,2,2,1,1,2,2}
List3={113,116,139,132,133,131,126,122}

Define List 3 (the data for each group) as Dependent. Define List 1 and List 2 (the factor numbers for each data item in List 3) as Factor A and Factor B respectively.
Executing the test produces the following results.

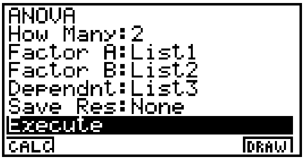
- Time differential (A) level of significance P = 0.2458019517
  The level of significance (p = 0.2458019517) is greater than the significance level (0.05), so the hypothesis does not reject.

- Temperature differential (B) level of significance P = 0.04222398836
  The level of significance (p = 0.04222398836) is less than the significance level (0.05), so the hypothesis rejects.

- Interaction (A × B) level of significance P = 2.78169946e-3
  The level of significance (p = 2.78169946e-3) is less than the significance level (0.05), so the hypothesis rejects.

  The above test indicates that the time differential is not significant, the temperature differential is significant, and interaction is highly significant.

●Input Example



●Results