Chapter 18

18

Statistical Graphs and Calculations

This chapter describes how to input statistical data into lists, how to calculate the mean, maximum and other statistical values, how to perform various statistical tests, how to determine the confidence interval, and how to produce a distribution of statistical data. It also tells you how to perform regression calculations.

Important!

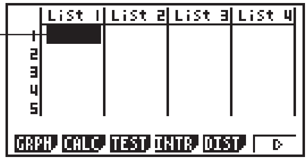
- This chapter contains a number of graph screen shots. In each case, new data values were input in order to highlight the particular characteristics of the graph being drawn. Note that when you try to draw a similar graph, the unit uses data values that you have input using the List function. Because of this, the graphs that appears on the screen when you perform a graphing operation will probably differ somewhat from those shown in this manual.

18-1 Before Performing Statistical Calculations

In the Main Menu, select the **STAT** icon to enter the STAT Mode and display the statistical data lists.

Use the statistical data lists to input data and to perform statistical calculations.

Use ▲, ▼, ◀ and ▶ to move the highlighting around the lists.



P.251 • {**GRPH**} ... {graph menu}
P.269 • {**CALC**} ... {statistical calculation menu}
P.276 • {**TEST**} ... {test menu}
P.293 • {**INTR**} ... {confidence interval menu}
P.303 • {**DIST**} ... {distribution menu}
P.234 • {**SRT·A**}**/**{**SRT·D**} ... {ascending}/{descending} sort
P.233 • {**DEL**}**/**{**DEL·A**} ... deletes {highlighted data}/{all data}
P.234 • {**INS**} ... {inserts new cell at highlighted cell}

• The procedures you should use for data editing are identical to those you use with the list function. For details, see "17. List Function". P.229

18-2 Paired-Variable Statistical Calculation Examples

Once you input data, you can use it to produce a graph and check for tendencies. You can also use a variety of different regression calculations to analyze the data.

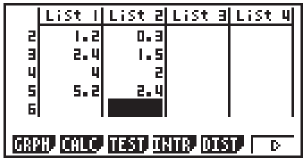
Example **To input the following two data groups and perform statistical calculations**

0.5, 1.2, 2.4, 4.0, 5.2
–2.1, 0.3, 1.5, 2.0, 2.4

■ Inputting Data into Lists

Input the two groups of data into List 1 and List 2.

[0] [•] [5] [EXE] [1] [•] [2] [EXE]
[2] [•] [4] [EXE] [4] [EXE] [5] [•] [2] [EXE]
[▶]
[(–)] [2] [•] [1] [EXE] [0] [•] [3] [EXE]
[1] [•] [5] [EXE] [2] [EXE] [2] [•] [4] [EXE]



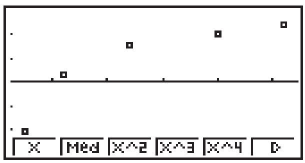
Once data is input, you can use it for graphing and statistical calculations.

- Input values can be up to 10 digits long.
- You can use the [▲], [▼], [◀] and [▶] keys to move the highlighting to any cell in the lists for data input.

■ Plotting a Scatter Diagram

Use the data input above to plot a scatter diagram.

[F1](GRPH)[F1](GPH1)



- To return to the statistical data list, press [EXIT] or [SHIFT] [QUIT].

- View Window parameters are normally set automatically for statistical graphing. If you want to set View Window parameters manually, you must change the Stat Wind item to "Manual".

  Note that View Window parameters are set automatically for the following types of graphs regardless of whether or not the Stat Wind item is set to "Manual".

  1-Sample Z Test, 2-Sample Z Test, 1-Prop Z Test, 2-Prop Z Test, 1-Sample t Test, 2-Sample t Test, χ^2 Test, 2-Sample F Test (x-axis only disregarded).

While the statistical data list is on the display, perform the following procedure.

[SHIFT] [SETUP] [F2] (Man)

[EXIT] (Returns to previous menu.)

- It is often difficult to spot the relationship between two sets of data (such as height and shoe size) by simply looking at the numbers. Such relationship become clear, however, when we plot the data on a graph, using one set of values as *x*-data and the other set as *y*-data.

The default setting automatically uses List 1 data as *x*-axis (horizontal) values and List 2 data as *y*-axis (vertical) values. Each set of *x*/*y* data is a point on the scatter diagram.

■ Changing Graph Parameters

Use the following procedures to specify the graph draw/non-draw status, the graph type, and other general settings for each of the graphs in the graph menu (GPH1, GPH2, GPH3).

While the statistical data list is on the display, press [F1] (GRPH) to display the graph menu, which contains the following items.

- {**GPH1**}/{**GPH2**}/{**GPH3**} ... only one graph {1}/{2}/{3} drawing

- The initial default graph type setting for all the graphs (Graph 1 through Graph 3) is scatter diagram, but you can change to one of a number of other graph types.

P.252
- {**SEL**} ... {simultaneous graph (GPH1, GPH2, GPH3) selection}

P.254
- {**SET**} ... {graph settings (graph type, list assignments)}

- You can specify the graph draw/non-draw status, the graph type, and other general settings for each of the graphs in the graph menu (GPH1, GPH2, GPH3).

- You can press any function key ([F1], [F2], [F3]) to draw a graph regardless of the current location of the highlighting in the statistical data list.

1. Graph draw/non-draw status [GRPH]-[SEL]

The following procedure can be used to specify the draw (On)/non-draw (Off) status of each of the graphs in the graph menu.

●To specify the draw/non-draw status of a graph

1. Pressing [F4] (SEL) displays the graph On/Off screen.

- Note that the StatGraph1 setting is for Graph 1 (GPH1 of the graph menu), StatGraph2 is for Graph 2, and StatGraph3 is for Graph 3.

2. Use the cursor keys to move the highlighting to the graph whose status you want to change, and press the applicable function key to change the status.

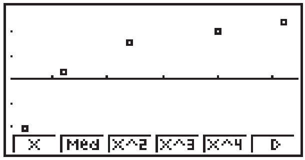
- {**On**}/{**Off**} ... setting {On (draw)}/{Off (non-draw)}
- {**DRAW**} ... {draws all On graphs}

3. To return to the graph menu, press [EXIT].

●To draw a graph

Example **To draw a scatter diagram of Graph 3 only**

[F1](GRPH)[F4](SEL) [F2](Off)
[▼][▼][F1](On)
[F6](DRAW)



2. General graph settings **[GRPH]-[SET]**

This section describes how to use the general graph settings screen to make the following settings for each graph (GPH1, GPH2, GPH3).

• Graph Type

The initial default graph type setting for all the graphs is scatter graph. You can select one of a variety of other statistical graph types for each graph.

• List

The initial default statistical data is List 1 for single-variable data, and List 1 and List 2 for paired-variable data. You can specify which statistical data list you want to use for x-data and y-data.

• Frequency

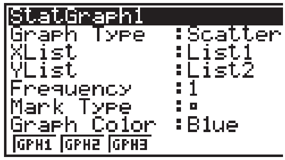
Normally, each data item or data pair in the statistical data list is represented on a graph as a point. When you are working with a large number of data items however, this can cause problems because of the number of plot points on the graph. When this happens, you can specify a frequency list that contains values indicating the number of instances (the frequency) of the data items in the corresponding cells of the lists you are using for x-data and y-data. Once you do this, only one point is plotted for the multiple data items, which makes the graph easier to read.

• Mark Type

This setting lets you specify the shape of the plot points on the graph.

•To display the general graph settings screen [GRPH]-[SET]

Pressing F6 (SET) displays the general graph settings screen.



- The settings shown here are examples only. The settings on your general graph settings screen may differ.

•StatGraph (statistical graph specification)

- {**GPH1**}/{**GPH2**}/{**GPH3**} ... graph {1}/{2}/{3}

•Graph Type (graph type specification)

- {**Scat**}/{***xy***}/{**NPP**} ... {scatter diagram}/{*xy* line graph}/{normal probability plot}
- {**Hist**}/{**Box**}/{**$\overline{\text{Box}}$**}/{**N·Dis**}/{**Brkn**} ... {histogram}/{med-box graph}/{mean-box graph}/{normal distribution curve}/{line graph}
- {**X**}/{**Med**}/{**X^2**}/{**X^3**}/{**X^4**} ... {linear regression graph}/{Med-Med graph}/{quadratic regression graph}/{cubic regression graph}/{quartic regression graph}
- {**Log**}/{**Exp**}/{**Pwr**}/{**Sin**} ... {logarithmic regression graph}/{exponential regression graph}/{power regression graph}/{sine regression graph}

•XList (*x*-axis data list)

- {**List1**}/{**List2**}/{**List3**}/{**List4**}/{**List5**}/{**List6**} ... {List 1}/{List 2}/{List 3}/{List 4}/{List 5}/{List 6}

•YList (*y*-axis data list)

- {**List1**}/{**List2**}/{**List3**}/{**List4**}/{**List5**}/{**List6**} ... {List 1}/{List 2}/{List 3}/{List 4}/{List 5}/{List 6}

•Frequency (number of data items)

- {**1**} ... {1-to-1 plot}
- {**List1**}/{**List2**}/{**List3**}/{**List4**}/{**List5**}/{**List6**} ... frequency data in {List 1}/{List 2}/{List 3}/{List 4}/{List 5}/{List 6}

•Mark Type (plot mark type)

- {□}/{×}/{•} ... plot points: {□}/{×}/{•}

●Graph Color (graph color specification)

- {**Blue**}/{**Orng**}/{**Grn**} ... {blue}/{orange}/{green}

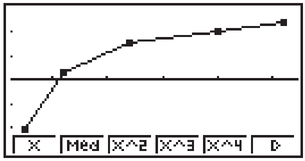
●Outliers (outliers specification)

- {**On**}/{**Off**} ... {display}/{non-display}

P.254
(Graph Type)
(*xy*)

■ Drawing an *xy* Line Graph

Paired data items can be used to plot a scatter diagram. A scatter diagram where the points are linked is an *xy* line graph.

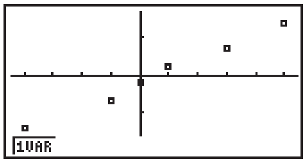


Press [EXIT] or [SHIFT] [QUIT] to return to the statistical data list.

P.254
(Graph Type)
(NPP)

■ Drawing a Normal Probability Plot

Normal probability plot contrasts the cumulative proportion of variables with the cumulative proportion of a normal distribution and plots the result. The expected values of the normal distribution are used as the vertical axis, while the observed values of the variable being tested are on the horizontal axis.



Press [EXIT] or [SHIFT] [QUIT] to return to the statistical data list.

■ Selecting the Regression Type

After you graph paired-variable statistical data, you can use the function menu at the bottom of the display to select from a variety of different types of regression.

- {**X**}/{**Med**}/{**X^2**}/{**X^3**}/{**X^4**}/{**Log**}/{**Exp**}/{**Pwr**}/{**Sin**} ... {linear regression}/{Med-Med}/{quadratic regression}/{cubic regression}/{quartic regression}/{logarithmic regression}/{exponential regression}/{power regression}/{sine regression} calculation and graphing
- {**2VAR**} ... {paired-variable statistical results}

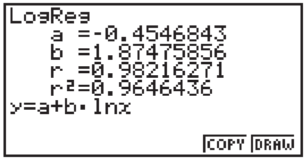
Displaying Statistical Calculation Results

Whenever you perform a regression calculation, the regression formula parameter (such as a and b in the linear regression $y = ax + b$) calculation results appear on the display. You can use these to obtain statistical calculation results.

Regression parameters are calculated as soon as you press a function key to select a regression type while a graph is on the display.

Example **To display logarithmic regression parameter calculation results while a scatter diagram is on the display**

F6(▷)F1(Log)



Graphing Statistical Calculation Results

You can use the parameter calculation result menu to graph the displayed regression formula.

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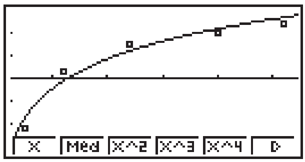
- {**COPY**} ... {stores the displayed regression formula as a graph function}
- {**DRAW**} ... {graphs the displayed regression formula}

Example **To graph a logarithmic regression**

While logarithmic regression parameter calculation results are on the display, press F6 (DRAW).



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For details on the meanings of function menu items at the bottom of the display, see "Selecting the Regression Type".

18-3 Calculating and Graphing Single-Variable Statistical Data

Single-variable data is data with only a single variable. If you are calculating the average height of the members of a class for example, there is only one variable (height).

Single-variable statistics include distribution and sum. The following types of graphs are available for single-variable statistics.

■ Drawing a Histogram (Bar Graph)

From the statistical data list, press [F1] (GRPH) to display the graph menu, press [F6] (SET), and then change the graph type of the graph you want to use (GPH1, GPH2, GPH3) to histogram (bar graph).

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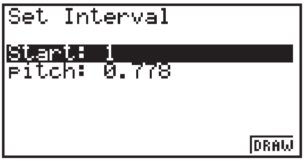
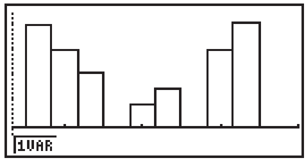
Data should already be input in the statistical data list (see “Inputting Data into Lists”). Draw the graph using the procedure described under “Changing Graph Parameters”.

P.254
(Graph Type)
(Hist)



[F6]

⇒
[F6] (DRAW)



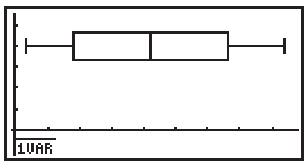
The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and pitch values.

■ Med-box Graph (Med-Box)

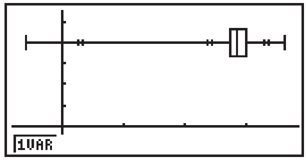
P.254
(Graph Type)
(Box)

This type of graph lets you see how a large number of data items are grouped within specific ranges. A box encloses all the data in an area from the 25th percentile to the 75th percentile, with a line drawn at the 50th percentile. Lines (called whiskers) extend from either end of the box up to the minimum and maximum of the data.

From the statistical data list, press [F1] (GRPH) to display the graph menu, press [F6] (SET), and then change the graph type of the graph you want to use (GPH1, GPH2, GPH3) to med-box graph.



To plot the data that falls outside the box, first specify "**MedBox**" as the graph type. Then, on the same screen you use to specify the graph type, turn the outliers item "**On**", and draw the graph.



P.254 (Graph Type) (Box)

Mean-box Graph

This type of graph shows the distribution around the mean when there is a large number of data items. A line is drawn at the point where the mean is located, and then a box is drawn so that it extends below the mean up to the standard deviation and above the mean up to the standard deviation. Lines (called whiskers) extend from either end of the box up to the minimum and maximum of the data.

From the statistical data list, press F1 (GRPH) to display the graph menu, press F6 (SET), and then change the graph type of the graph you want to use (GPH1, GPH2, GPH3) to mean-box graph.

Note :

This function is not usually used in the classrooms in U.S. Please use Med-box Graph, instead.

P.254 (Graph Type) (N·Dis)

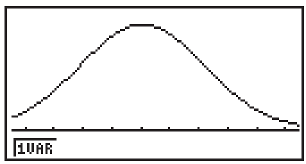
Normal Distribution Curve

The normal distribution curve is graphed using the following normal distribution function.

$$y = \frac{1}{\sqrt{(2\pi)}\, x\sigma_n} e^{-\frac{(x-\bar{x})^2}{2x\sigma_n{}^2}}$$

The distribution of characteristics of items manufactured according to some fixed standard (such as component length) fall within normal distribution. The more data items there are, the closer the distribution is to normal distribution.

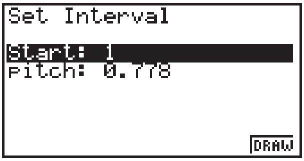
From the statistical data list, press F1 (GRPH) to display the graph menu, press F6 (SET), and then change the graph type of the graph you want to use (GPH1, GPH2, GPH3) to normal distribution.



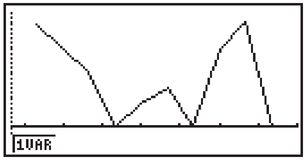
P.254
(Graph Type)
(Brkn)

Line Graph

A line graph is formed by plotting the data in one list against the frequency of each data item in another list and connecting the points with straight lines.
Calling up the graph menu from the statistical data list, pressing F6 (SET), changing the settings to drawing of a line graph, and then drawing a graph creates a line graph.



⇒
F6 (DRAW)



F6

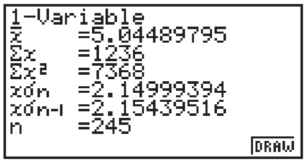
The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and pitch values.

Displaying Single-Variable Statistical Results

Single-variable statistics can be expressed as both graphs and parameter values. When these graphs are displayed, the menu at the bottom of the screen appears as below.

- {**1VAR**} ... {single-variable calculation result menu}

Pressing F1 (1VAR) displays the following screen.



- Use ⏷ to scroll the list so you can view the items that run off the bottom of the screen.

The following describes the meaning of each of the parameters.

$\bar{x}$ .... mean of data
Σx .... sum of data
Σx^2 .... sum of squares
$x\sigma_n$ .... population standard deviation
$x\sigma_{n-1}$ .... sample standard deviation
n .... number of data items

minX .... minimum
Q1 .... first quartile
Med .... median
Q3 .... third quartile
$\overline{x}-x\sigma_n$ .... data mean – population standard deviation
$\overline{x}+x\sigma_n$ .... data mean + population standard deviation
maxX .... maximum
Mod .... mode

- Press F6 (DRAW) to return to the original single-variable statistical graph.

18-4 Calculating and Graphing Paired-Variable Statistical Data

Under “Plotting a Scatter Diagram,” we displayed a scatter diagram and then performed a logarithmic regression calculation. Let’s use the same procedure to look at the various regression functions.

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■ Linear Regression Graph

Linear regression plots a straight line that passes close to as many data points as possible, and returns values for the slope and y-intercept (y-coordinate when x = 0) of the line.

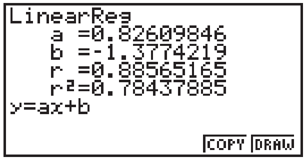
The graphic representation of this relationship is a linear regression graph.

(Graph Type) SHIFT QUIT F1(GRPH) F6(SET) ▼

(Scatter) F1(Scat)

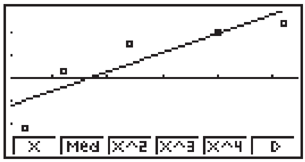
(GPH1) SHIFT QUIT F1(GRPH) F1(GPH1)

(X) F1(X)



F6

F6(DRAW)



a ...... regression coefficient (slope)

b ...... regression constant term (intercept)

r .... correlation coefficient

r^2 ...... coefficient of determination

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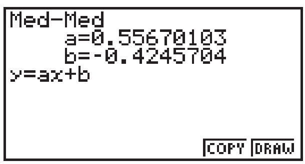
■ Med-Med Graph

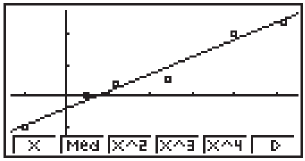
When it is suspected that there are a number of extreme values, a Med-Med graph can be used in place of the least squares method. This is also a type of linear regression, but it minimizes the effects of extreme values. It is especially useful in producing highly reliable linear regression from data that includes irregular fluctuations, such as seasonal surveys.

F2(Med)



F6

F6 (DRAW)



a ...... Med-Med graph slope

b ...... Med-Med graph intercept

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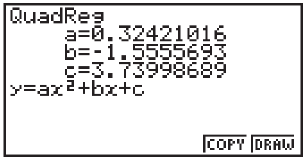
Quadratic/Cubic/Quartic Regression Graph

A quadratic/cubic/quartic regression graph represents connection of the data points of a scatter diagram. It actually is a scattering of so many points that are close enough together to be connected. The formula that represents this is quadratic/cubic/quartic regression.

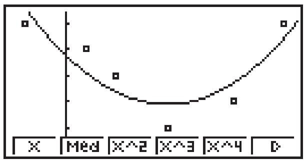
Ex. Quadratic regression

F3 (X^ 2)



F6

F6 (DRAW)



Quadratic regression

a ...... regression second coefficient

b ...... regression first coefficient

c ...... regression constant term (intercept)

Cubic regression

a ...... regression third coefficient

b ...... regression second coefficient

c ...... regression first coefficient

d ...... regression constant term (intercept)

Quartic regression

a ...... regression fourth coefficient

b ...... regression third coefficient

c ...... regression second coefficient

d ...... regression first coefficient

e ...... regression constant term (intercept)

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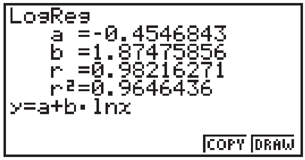
■ Logarithmic Regression Graph

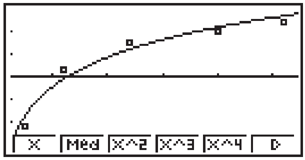
Logarithmic regression expresses y as a logarithmic function of x. The standard logarithmic regression formula is $y = a + b \times \ln x$, so if we say that $X = \ln x$, the formula corresponds to linear regression formula $y = a + bX$.

F6(▷)F1(Log)



F6

F6(DRAW)



a ...... regression constant term (intercept)

b ...... regression coefficient (slope)

r ...... correlation coefficient

r^2 ..... coefficient of determination

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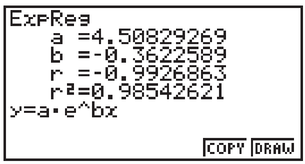
■ Exponential Regression Graph

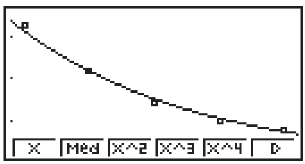
Exponential regression expresses y as a proportion of the exponential function of x. The standard exponential regression formula is $y = a \times e^{bx}$, so if we take the logarithms of both sides we get $\ln y = \ln a + bx$. Next, if we say $Y = \ln y$, and $a = \ln a$, the formula corresponds to linear regression formula $Y = a + bx$.

F6(▷)F2(Exp)



F6

F6(DRAW)



a ...... regression coefficient

b ...... regression constant term

r ...... correlation coefficient

r^2 ..... coefficient of determination

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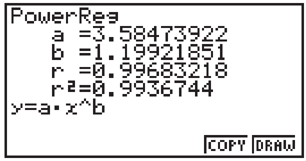
Power Regression Graph

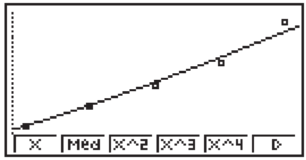
Exponential regression expresses y as a proportion of the power of x. The standard power regression formula is $y = a \times x^b$, so if we take the logarithms of both sides we get $\ln y = \ln a + b \times \ln x$. Next, if we say $X = \ln x$, $Y = \ln y$, and $a = \ln a$, the formula corresponds to linear regression formula $Y = a + bX$.

F6 (▷) F3 (Pwr)



F6

F6 (DRAW)



a ...... regression coefficient

b ...... regression power

r ...... correlation coefficient

r^2 ..... coefficient of determination

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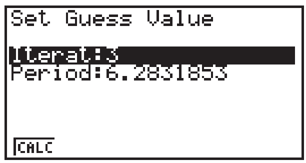
Sine Regression Graph

Sine regression expresses the relationship between specific pair of data (variables) as a trigonometric function. Residual mean square partial differentiation is expressed in the form of a matrix, and the iteration method is used to determine the coefficient that minimizes the residual mean square.

$$y = a\cdot\sin(bx + c) + d$$

While the statistical data list is on the display, perform the following key operation.

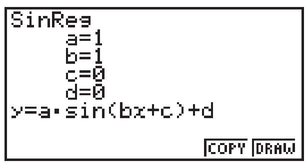
F6 (▷) F5 (Sin)



Iterat .... number of iterations (Specify in the range of 1 to 16.)

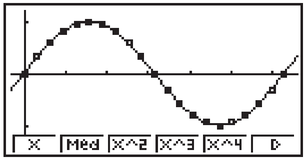
Period ...... domain

F1 (CALC)



F6

F6(DRAW)



Gas bills, for example, tend to be higher during the winter when heater use is more frequent. Periodic data, such as gas usage, is suitable for application of sine regression.

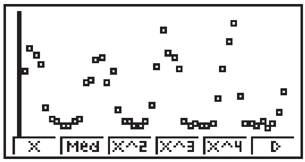
Example **To perform sine regression using the gas usage data shown below**

List 1 (Month Data)
{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48}

List 2 (Gas Usage Meter Reading)
{130, 171, 159, 144, 66, 46, 40, 32, 32, 39, 44, 112, 116, 152, 157, 109, 130, 59, 40, 42, 33, 32, 40, 71, 138, 203, 162, 154, 136, 39, 32, 35, 32, 31, 35, 80, 134, 184, 219, 87, 38, 36, 33, 40, 30, 36, 55, 94}

Input the above data and plot a scatter diagram.

F1(GRPH)F1(GPH1)

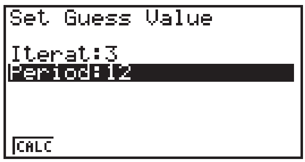


Since this example involves monthly billing, we will assume a period of 12.

- You can also estimate the period by using Trace to manually count the number of plots between high points or low points of the graph, or you can simply view the data in the list to see if there is any apparent trend.

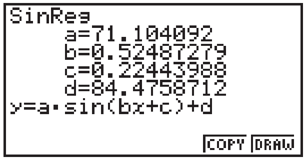
Press F6(▷)F5(Sin) to start sine regression analysis.

F6(▷)F5(Sin) ▼ 1 2 EXE



Execute the calculation and produce sine regression analysis results.

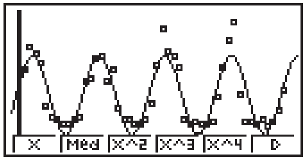
F1(CALC)



F6

Display a sine regression graph based on the analysis results.

F6(DRAW)



■ Residual Calculation

Actual plot points (y-coordinates) and regression model distance can be calculated during regression calculations.

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While the statistical data list is on the display, recall the set up screen to specify a list (“**List 1**” through “**List 6**”) for “Resid List”. Calculated residual data is stored in the specified list.

The vertical distance from the plots to the regression model will be stored.

Plots that are higher than the regression model are positive, while those that are lower are negative.

Residual calculation can be performed and saved for all regression models.

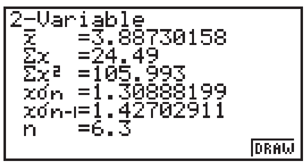
Any data already existing in the selected list is cleared. The residual of each plot is stored in the same precedence as the data used as the model.

■ Displaying Paired-Variable Statistical Results

Paired-variable statistics can be expressed as both graphs and parameter values. When these graphs are displayed, the menu at the bottom of the screen appears as below.

- {**2VAR**} ... {paired-variable calculation result menu}

Pressing F4 (2VAR) displays the following screen.



- Use ⏷ to scroll the list so you can view the items that run off the bottom of the screen.

$\bar{x}$ .... mean of *x*List data
Σx .... sum of *x*List data
Σx^2 .... sum of squares of *x*List data
$x\sigma_n$ .... population standard deviation of *x*List data
$x\sigma_{n-1}$ .... sample standard deviation of *x*List data
n .... number of *x*List data items
$\bar{y}$ .... mean of *y*List data
Σy .... sum of *y*List data
Σy^2 .... sum of squares of *y*List data
$y\sigma_n$ .... population standard deviation of *y*List data
$y\sigma_{n-1}$ .... sample standard deviation of *y*List data
Σxy .... sum of *x*List and *y*List data
minX .... minimum of *x*List data
maxX .... maximum of *x*List data
minY .... minimum of *y*List data
maxY .... maximum of *y*List data

Copying a Regression Graph Formula to the Graph Mode

After you perform a regression calculation, you can copy its formula to the **GRAPH Mode**.

The following are the functions that are available in the function menu at the bottom of the display while regression calculation results are on the screen.

- {**COPY**} ... {stores the displayed regression formula to the **GRAPH Mode**}
- {**DRAW**} ... {graphs the displayed regression formula}

1. Press [F5] (COPY) to copy the regression formula that produced the displayed data to the **GRAPH Mode**.

Note that you cannot edit regression formulas for graph formulas in the **GRAPH Mode**.

2. Press [EXE] to save the copied graph formula and return to the previous regression calculation result display.

■ Multiple Graphs

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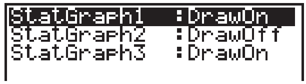
You can draw more than one graph on the same display by using the procedure under "Changing Graph Parameters" to set the graph draw (On)/non-draw (Off) status of two or all three of the graphs to draw "**On**", and then pressing F6 (DRAW). After drawing the graphs, you can select which graph formula to use when performing single-variable statistic or regression calculations.



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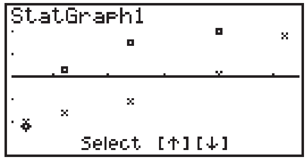
F6(DRAW)

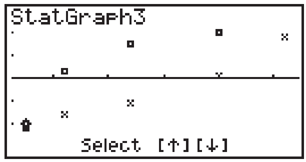
F1(X)



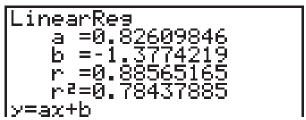
- The text at the top of the screen indicates the currently selected graph (StatGraph1 = Graph 1, StatGraph2 = Graph 2, StatGraph3 = Graph 3).

1. Use ⏶ and ⏷ to change the currently selected graph. The graph name at the top of the screen changes when you do.

⏷



2. When graph you want to use is selected, press EXE.



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Now you can use the procedures under "Displaying Single-Variable Statistical Results" and "Displaying Paired-Variable Statistical Results" to perform statistical calculations.

18-5 Performing Statistical Calculations

All of the statistical calculations up to this point were performed after displaying a graph. The following procedures can be used to perform statistical calculations alone.

•To specify statistical calculation data lists

You have to input the statistical data for the calculation you want to perform and specify where it is located before you start a calculation. Display the statistical data and then press F2(CALC)F6 (SET).

The following is the meaning for each item.

1Var XList .... specifies list where single-variable statistic x values (XList) are located

1Var Freq .... specifies list where single-variable frequency values (Frequency) are located

2Var XList .... specifies list where paired-variable statistic x values (XList) are located

2Var YList .... specifies list where paired-variable statistic y values (YList) are located

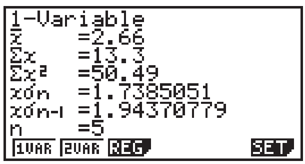
2Var Freq .... specifies list where paired-variable frequency values (Frequency) are located

- Calculations in this section are performed based on the above specifications.

■ Single-Variable Statistical Calculations

In the previous examples from “Drawing a Normal Probability Plot” and “Histogram (Bar Graph)” to “Line Graph,” statistical calculation results were displayed after the graph was drawn. These were numeric expressions of the characteristics of variables used in the graphic display.

These values can also be directly obtained by displaying the statistical data list and pressing F2 (CALC) F1 (1VAR).



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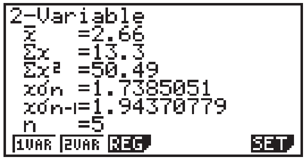
Now you can use the cursor keys to view the characteristics of the variables.

For details on the meanings of these statistical values, see “Displaying Single-Variable Statistical Results”.

■ Paired-Variable Statistical Calculations

In the previous examples from “Linear Regression Graph” to “Sine Regression Graph,” statistical calculation results were displayed after the graph was drawn. These were numeric expressions of the characteristics of variables used in the graphic display.

These values can also be directly obtained by displaying the statistical data list and pressing F2 (CALC) F2 (2VAR).



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Now you can use the cursor keys to view the characteristics of the variables.

For details on the meanings of these statistical values, see “Displaying Paired-Variable Statistical Results”.

■ Regression Calculation

In the explanations from “Linear Regression Graph” to “Sine Regression Graph,” regression calculation results were displayed after the graph was drawn. Here, the regression line and regression curve is represented by mathematical expressions.

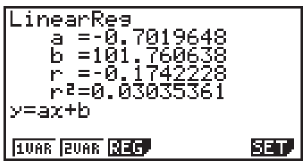
You can directly determine the same expression from the data input screen.

Pressing F2 (CALC) F3 (REG) displays a function menu, which contains the following items.

- {**X**}/{**Med**}/{**X^2**}/{**X^3**}/{**X^4**}/{**Log**}/{**Exp**}/{**Pwr**}/{**Sin**} ... {linear regression}/{Med-Med}/{quadratic regression}/{cubic regression}/{quartic regression}/{logarithmic regression}/{exponential regression}/{power regression}/{sine regression} parameters

Example **To display single-variable regression parameters**

F2(CALC) F3(REG) F1(X)



The meanings of the parameters that appear on this screen are the same as those for “Linear Regression Graph” to “Sine Regression Graph”.

Estimated Value Calculation ($\hat{x}$, $\hat{y}$)

After drawing a regression graph with the **STAT Mode**, you can use the **RUN Mode** to calculate estimated values for the regression graph's *x* and *y* parameters.

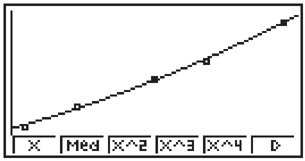
- Note that you cannot obtain estimated value for a Med-Med, quadratic regression, cubic regression, quartic regression, or sine regression graph.

Example **To perform power regression using the nearby data and estimate the values of $\hat{y}$ and $\hat{x}$ when xi = 40 and yi = 1000**

xi	*yi*
28	2410
30	3033
33	3895
35	4491
38	5717

1. In the Main Menu, select the **STAT** icon and enter the STAT Mode.

2. Input data into the list and draw the power regression graph*.



3. In the Main Menu, select the **RUN** icon and enter the RUN Mode.

4. Press the keys as follows.

[4] [0] (value of *xi*)
[OPTN] [F5] (STAT) [F2] ($\hat{y}$) [EXE]

```
40ŷ
           6587.674589
```

The estimated value $\hat{y}$ is displayed for xi = 40.

[1] [0] [0] [0] (value of *yi*)
[F1] ($\hat{x}$) [EXE]

```
40ŷ
           6587.674589
1000x̂
           20.26225681
```

The estimated value $\hat{x}$ is displayed for yi = 1000.

*

(Graph Type)	[F1] (GRPH) [F6] (SET) [▼]
(Scatter)	[F1] (Scat) [▼]
(XList)	[F1] (List1) [▼]
(YList)	[F2] (List2) [▼]
(Frequency)	[F1] (1) [▼]
(Mark Type)	[F1] (□) [EXIT]
(Auto)	[SHIFT] [SET UP] [F1] (Auto) [EXIT] [F1] (GRPH) [F1] (GPH1) [F6] (▷)
(Pwr)	[F3] (Pwr) [F6] (DRAW)

Probability Distribution Calculation and Graphing

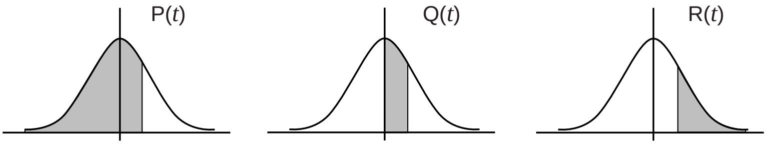
You can calculate and graph probability distributions for single-variable statistics.

•Probability distribution calculations

Use the **RUN Mode** to perform probability distribution calculations. Press OPTN in the RUN Mode to display the option number and then press F6 (▷) F3 (PROB) F6 (▷) to display a function menu, which contains the following items.

- {**P(**}/{**Q(**}/{**R(**} ... obtains probability {P(*t*)}/{Q(*t*)}/{R(*t*)} value
- {***t*(**} ... {obtains normalized variate *t*(*x*) value}

- Probability P(*t*), Q(*t*), and R(*t*), and normalized variate *t*(*x*) are calculated using the following formulas.



$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{t} e^{-\frac{t^2}{2}}dt \qquad \frac{1}{\sqrt{2\pi}}\int_{0}^{t} e^{-\frac{t^2}{2}}dt \qquad \frac{1}{\sqrt{2\pi}}\int_{t}^{+\infty} e^{-\frac{t^2}{2}}dt$$

$t(x)$

$$t = \frac{x - \bar{x}}{\sigma n}$$

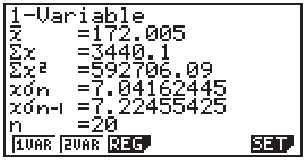
Example **The following table shows the results of measurements of the height of 20 college students. Determine what percentage of the students fall in the range 160.5 cm to 175.5 cm. Also, in what percentile does the 175.5 cm tall student fall?**

Class no.	Height (cm)	Frequency
1	158.5	1
2	160.5	1
3	163.3	2
4	167.5	2
5	170.2	3
6	173.3	4
7	175.5	2
8	178.6	2
9	180.4	2
10	186.7	1

1. In the **STAT Mode**, input the height data into List 1 and the frequency data into List 2.

2. Use the **STAT Mode** to perform the single-variable statistical calculations.

   F2 (CALC) F6 (SET)
   ▼ F3 (List2) EXIT F1 (1VAR)



3. Press MENU to display the Main Menu, and then enter the **RUN Mode**. Next, press OPTN to display the option menu and then F6 (▷) F3 (PROB) F6 (▷).

- You obtain the normalized variate immediately after performing single-variable statistical calculations only.

F4 (t() 1 6 0 • 5) EXE
(Normalized variate t for 160.5cm) Result: –1.633855948
(≒ –1.634)

F4 (t() 1 7 5 • 5) EXE
(Normalized variate t for 175.5cm) Result: 0.4963343361
(≒ 0.496)

F1 (P() 0 • 4 9 6) −
F1 (P() (−) 1 • 6 3 4) EXE
(Percentage of total) Result: 0.638921
(63.9% of total)

F3 (R() 0 • 4 9 6) EXE
(Percentile) Result: 0.30995
(31.0 percentile)

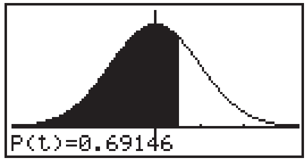
Probability Graphing

You can graph a probability distribution with Graph Y = in the Sketch Mode.

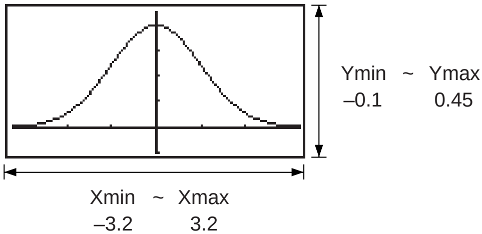
Example **To graph probability P(0.5)**

Perform the following operation in the **RUN Mode**.

SHIFT F4(Sketch) F1(Cls) EXE
F5(GRPH) F1(Y=) OPTN F6(▷) F3(PROB)
F6(▷) F1(P() 0 • 5) EXE



The following shows the View Window settings for the graph.



18-6 Tests

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 the population mean when the standard deviation is known.

2-Sample *Z* Test compares two population means when standard deviations are known.

1-Prop *Z* Test tests whether or not data that satisfies certain criteria reaches a specific proportion.

2-Prop *Z* Test compares the proportions of data from two samples that satisfy certain criteria.

The ***t*** **Test** uses the sample size and obtained data to test the hypothesis that the sample is taken from a particular population. 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.

When the sample shows a trend, the probability of the trend (and to what extent it applies to the population) is tested based on the sample size and variance size. Inversely, expressions related to the *t* test are also used to calculate the sample size required to improve probability. The *t* test can be used even when the population standard deviation is not known, so it is useful in cases where there is only a single survey.

1-Sample *t* Test tests the hypothesis that a sample is taken from the population.

2-Sample *t* Test tests the hypothesis that two samples are taken from the same population.

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

In addition to the above, a number of other functions are provided to check the relationship between samples and populations.

χ^2 **Test** tests hypotheses 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 that there will be no change in the result for a population when a result of a sample is composed of multiple factors and one or more of the factors is removed. 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.

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.

While the statistical data list is on the display, press F3 (TEST) to display the test menu, which contains the following items.

- {***Z***}/{***t***}/{**CHI**}/{***F***} ... {*Z*}/{*t*}/{χ^2}/{*F*} test
- {**ANOV**} ... {analysis of variance (ANOVA)}

About data type specification

For some types of tests you can select data type using the following menu.

- {**List**}/{**Var**} ... specifies {list data}/{parameter data}

■ *Z* Test

You can use the following menu to select from different types of *Z* Test.

- {**1-S**}/{**2-S**}/{**1-P**}/{**2-P**} ... {1-Sample}/{2-Sample}/{1-Prop}/{2-Prop} *Z* Test

●1-Sample *Z* Test

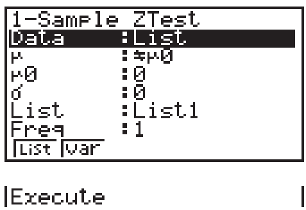
This test is used when the sample standard deviation for a population is known to test the hypothesis that the population mean value is equal to the sample mean value. The **1-Sample *Z* Test** is applied to standard normal distribution.

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

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

Perform the following key operation from the statistical data list.

F3 (TEST)
F1 (Z)
F1 (1-S)



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

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

List .... list whose contents you want to use as data (List 1 to 6)

Freq .... frequency (1 or List 1 to 6)

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.

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

n .... sample size (positive integer)

Example **To perform a 1-Sample Z Test for one list of data**

For this example, we will perform a $\mu < \mu_0$ test for the data List1 = {11.2, 10.9, 12.5, 11.3, 11.7}, when μ_0 = 11.5 and σ = 3.

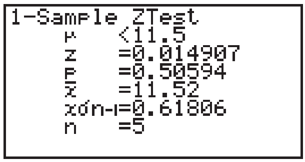
[F1](List) ▼ [F2](<) ▼

[1] [1] [•] [5] [EXE]

[3] [EXE]

[F1](List1) ▼ [F1](1) ▼

[F1](CALC)



μ<11.5 .... assumed population mean and direction of test

z .... Z score

p .... p-value

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

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

n .... sample size

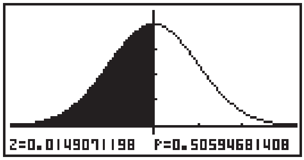
[F6](DRAW) can be used in place of [F1](CALC) in the final Execute line to draw a graph.

Perform the following key operation from the statistical result screen.

[EXIT] (To data input screen)

[▼] [▼] [▼] [▼] [▼] [▼] (To Execute line)

[F6] (DRAW)



•2-Sample *Z* Test

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

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

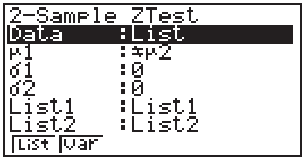
$\bar{x}_1$: sample 1 mean
$\bar{x}_2$: sample 2 mean
σ_1 : population standard deviation of sample 1
σ_2 : population standard deviation of sample 2
n_1 : sample 1 size
n_2 : sample 2 size

Perform the following key operation from the statistical data list.

[F3] (TEST)

[F1] (Z)

[F2] (2-S)



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 ($\sigma_2 > 0$)

List1 .... list whose contents you want to use as sample 1 data

List2 .... list whose contents you want to use as sample 2 data

Freq1 .... frequency of sample 1 (positive integer)

Freq2 .... frequency of sample 2 (positive integer)

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.

```
x̄1       :0
n1       :0
x̄2       :0
n2       :0
```

$\bar{x}_1$ .... sample 1 mean
n_1 .... sample 1 size (positive integer)
$\bar{x}_2$ .... sample 2 mean
n_2 .... sample 2 size (positive integer)

Example **To perform a 2-Sample Z Test when two lists of data are input**

For this example, we will perform a $\mu_1 < \mu_2$ test for the data List1 = {11.2, 10.9, 12.5, 11.3, 11.7} and List2 = {0.84, 0.9, 0.14, –0.75, –0.95}, when σ_1 = 15.5 and σ_2 = 13.5.

[F1](List) [▼]
[F2](<) [▼]
[1] [5] [•] [5] [EXE]
[1] [3] [•] [5] [EXE]
[F1](List1) [▼] [F2](List2) [▼]
[F1](1) [▼] [F1](1) [▼]
[F1](CALC)

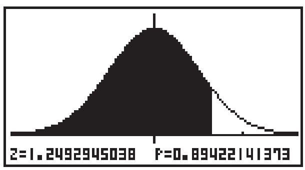
```
2-Sample ZTest
   μ1    <μ2
   z     =1.2492
   p     =0.89422
   x̄1    =11.52
   x̄2    =0.036
   x1σn-1=0.61806
```

```
   x2σn-1=0.86511
   n1    =5
   n2    =5
```

$\mu_1<\mu_2$ .... direction of test
z .... Z score
p .... p-value
$\bar{x}_1$ .... sample 1 mean
$\bar{x}_2$ .... sample 2 mean
$x_1\sigma_{n-1}$ .... sample 1 standard deviation
$x_2\sigma_{n-1}$ .... sample 2 standard deviation
n_1 .... sample 1 size
n_2 .... sample 2 size

Perform the following key operation to display a graph.

[EXIT]
[▼] [▼] [▼] [▼] [▼] [▼] [▼] [▼]
[F6](DRAW)



•1-Prop Z Test

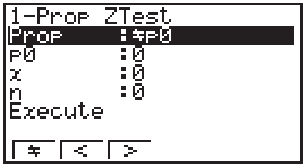
This test is used to test whether data that satisfies certain criteria reaches a specific proportion. It tests the hypothesis when sample size and the number of data satisfying the criteria are specified. The **1-Prop Z Test** is applied to standard normal distribution.

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

p_0 : expected sample proportion
n : sample size

Perform the following key operation from the statistical data list.

F3(TEST)
F1(Z)
F3(1-P)

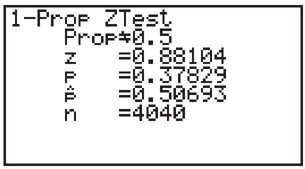


Prop .... sample proportion test conditions ("≠ p_0" specifies two-tail test, "< p_0" specifies lower one-tail test, "> p_0" specifies upper one-tail test.)
p_0 .... expected sample proportion ($0 < p_0 < 1$)
x .... sample value ($x \geqq 0$ integer)
n .... sample size (positive integer)
Execute .... executes a calculation or draws a graph

Example **To perform a 1-Prop Z Test for specific expected sample proportion, data value, and sample size**

Perform the calculation using: p_0 = 0.5, x = 2048, n = 4040.

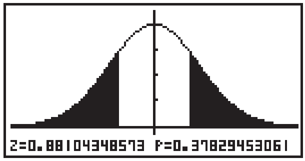
F1(≠)▼
0 • 5 EXE
2 0 4 8 EXE
4 0 4 0 EXE
F1(CALC)



Prop≠0.5 .... direction of test
z .... Z score
p .... p-value
$\hat{p}$ .... estimated sample proportion
n .... sample size

The following key operation can be used to draw a graph.

EXIT
▼▼▼▼
F6 (DRAW)



•2-Prop Z Test

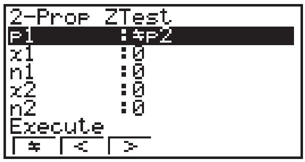
This test is used to compare the proportions of two samples that satisfy certain criteria. It tests the hypothesis that the size and the number of data of two samples that satisfy the criteria are as specified. The **2-Prop Z Test** is applied to standard normal distribution.

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

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

Perform the following key operation from the statistical data list.

F3 (TEST)
F1 (Z)
F4 (2-P)

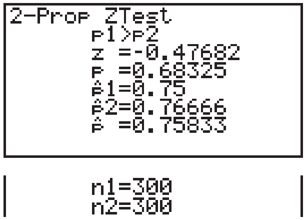


p_1 .... sample proportion test conditions ("≠ p_2" specifies two-tail test, "< p_2" specifies one-tail test where sample 1 is less than sample 2, "> p_2" specifies upper one-tail test where sample 1 is greater than sample 2.)
x_1 .... sample 1 data value ($x_1 \geqq 0$ integer)
n_1 .... sample 1 size (positive integer)
x_2 .... sample 2 data value ($x_2 \geqq 0$ integer)
n_2 .... sample 2 size (positive integer)
Execute .... executes a calculation or draws a graph

Example **To perform a $p_1 > p_2$ 2-Prop Z Test for expected sample proportions, data values, and sample sizes**

Perform a $p_1 > p_2$ test using: $x_1 = 225$, $n_1 = 300$, $x_2 = 230$, $n_2 = 300$.

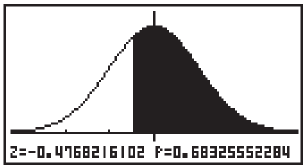
F3(>) ▼
2 2 5 EXE
3 0 0 EXE
2 3 0 EXE
3 0 0 EXE
F1(CALC)



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

The following key operation can be used to draw a graph.

EXIT
▼ ▼ ▼ ▼ ▼
F6(DRAW)



■ *t* Test

You can use the following menu to select a *t* test type.

- {**1-S**}/{**2-S**}/{**REG**} ... {1-Sample}/{2-Sample}/{LinearReg} *t* Test

•1-Sample *t* Test

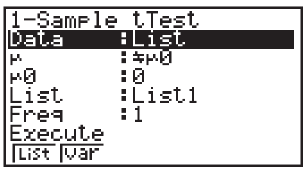
This test uses the sample size and population mean value to test the hypothesis that the sample is taken from the population. The **1-Sample *t* Test** is applied to standard normal distribution.

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

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

Perform the following key operation from the statistical data list.

F3(TEST)
F2(*t*)
F1(1-S)



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.)

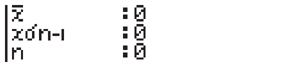
μ_0 .... assumed population mean

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

Freq .... frequency

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.



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

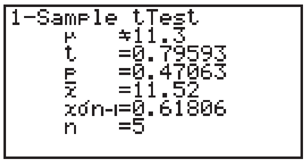
$x\sigma_{n-1}$ .... sample standard deviation ($x\sigma_{n-1}$ > 0)

n .... sample size (positive integer)

Example **To perform a 1-Sample *t* Test for one list of data**

For this example, we will perform a $\mu \neq \mu_0$ test for the data List1 = {11.2, 10.9, 12.5, 11.3, 11.7}, when μ_0 = 11.3.

[F1](List) [▼]
[F1](≠) [▼]
[1] [1] [•] [3] [EXE]
[F1](List1) [▼] [F1](1) [▼]
[F1](CALC)



$\mu \neq 11.3$ .... assumed population mean and direction of test

t .... t-value

p .... p-value

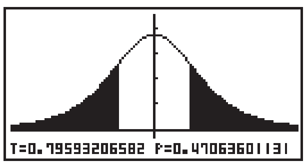
$\bar{x}$ .... sample mean

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

n .... sample size

The following key operation can be used to draw a graph.

[EXIT]
[▼] [▼] [▼] [▼] [▼]
[F6](DRAW)



•2-Sample *t* Test

2-Sample *t* Test uses the sample means, variance, and sample sizes when the sample standard deviations for two populations are unknown to test the hypothesis that the two samples were taken from the same population. The 2-Sample *t* Test is applied to standard normal distribution.

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

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

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.

$$df = n_1 + n_2 - 2$$

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

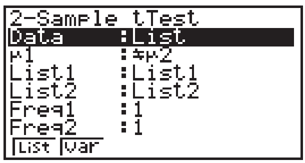
The following applies when pooling is not in effect.

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

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

Perform the following key operation from the statistical data list.

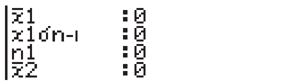
F3(TEST)
F2(t)
F2(2-S)

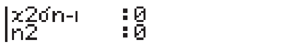


The following shows the meaning of each item in the case of list data specification.

- Data .... data type
- μ_1 .... sample mean value test conditions ("≠ μ_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.)
- List1 .... list whose contents you want to use as sample 1 data
- List2 .... list whose contents you want to use as sample 2 data
- Freq1 .... frequency of sample 1 (positive integer)
- Freq2 .... frequency of sample 2 (positive integer)
- Pooled .... pooling On or Off
- 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.



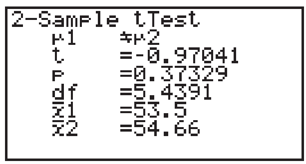


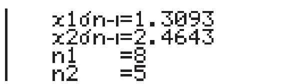
- $\bar{x}_1$ .... sample 1 mean
- $x_1\sigma_{n-1}$ .... sample 1 standard deviation ($x_1\sigma_{n-1} > 0$)
- n_1 .... sample 1 size (positive integer)
- $\bar{x}_2$ .... sample 2 mean
- $x_2\sigma_{n-1}$ .... sample 2 standard deviation ($x_2\sigma_{n-1} > 0$)
- n_2 .... sample 2 size (positive integer)

Example **To perform a 2-Sample *t* Test when two lists of data are input**

For this example, we will perform a $\mu_1 \neq \mu_2$ test for the data List1 = {55, 54, 51, 55, 53, 53, 54, 53} and List2 = {55.5, 52.3, 51.8, 57.2, 56.5}.

F1(List) ▼ F1(≠) ▼
F1(List1) ▼ F2(List2) ▼
F1(1) ▼ F1(1)
▼ F2(Off) ▼
F1(CALC)

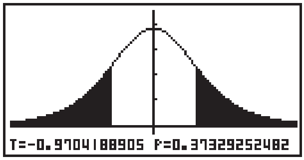




$\mu_1 \neq \mu_2$ .... direction of test
t .... t-value
p .... p-value
df .... degrees of freedom
$\bar{x}_1$ .... sample 1 mean
$\bar{x}_2$ .... sample 2 mean
$x_1\sigma_{n-1}$ .... sample 1 standard deviation
$x_2\sigma_{n-1}$ .... sample 2 standard deviation
n_1 .... sample 1 size
n_2 .... sample 2 size

Perform the following key operation to display a graph.

EXIT
▼ ▼ ▼ ▼ ▼ ▼ ▼
F6(DRAW)



The following item is also shown when Pooled = On.

xpσn-1=1.8163

$x_p\sigma_{n-1}$ .... pooled sample standard deviation

●LinearReg *t* Test

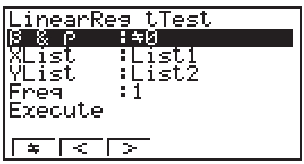
LinearReg *t* Test treats paired-variable data sets as (x, y) pairs and plots all data on a graph. Next, a straight line ($y = a + bx$) is drawn through the area where the greatest number of plots are located and the degree to which a relationship exists is calculated.

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

a : intercept
b : slope of the line

Perform the following key operation from the statistical data list.

F3(TEST)
F2(t)
F3(REG)



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

Execute .... executes a calculation

Example **To perform a LinearReg *t* Test when two lists of data are input**

For this example, we will perform a LinearReg *t* Test for *x*-axis data {0.5, 1.2, 2.4, 4, 5.2} and *y*-axis data {–2.1, 0.3, 1.5, 5, 2.4}.

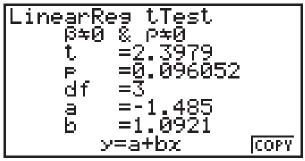
F1(≠)▼

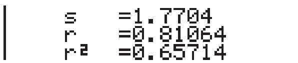
F1(List1)▼

F2(List2)▼

F1(1)▼

F1(CALC)





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

t .... t-value

p .... p-value

df .... degrees of freedom

a .... constant term

b .... coefficient

s .... standard error

r .... correlation coefficient

r^2 .... coefficient of determination

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The following key operation can be used to copy the regression formula.

F6(COPY)

Other Tests

•χ^2 Test

χ^2 **Test** sets up a number of independent groups and tests hypotheses 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

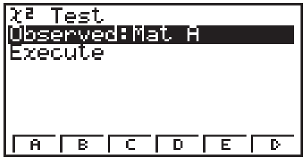
$$\chi^2 = \sum_{i=1}^{k} \sum_{j=1}^{\ell} \frac{(x_{ij} - F_{ij})^2}{F_{ij}}$$

For the above, data must already be input in a matrix using the **MAT Mode**.

Perform the following key operation from the statistical data list.

F3(TEST)

F3(CHI)



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)

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.

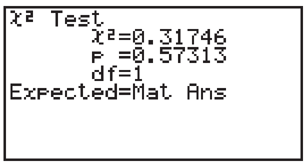
Example **To perform a χ^2 Test on a specific matrix cell**

For this example, we will perform a χ^2 Test for Mat A, which contains the following data.

Mat A = $\begin{bmatrix} 1 & 4 \\ 5 & 10 \end{bmatrix}$

F1(Mat A)▼

F1(CALC)



χ^2 .... χ^2 value

p .... p-value

df .... degrees of freedom

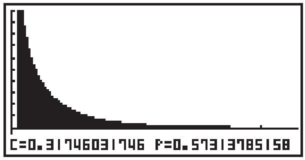
Expected .... expected counts (Result is always stored in MatAns.)

The following key operation can be used to display the graph.

[EXIT]

[▼]

[F6](DRAW)



●2-Sample *F* Test

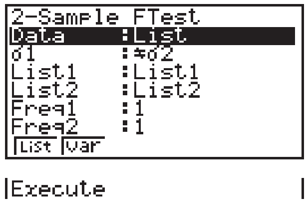
2-Sample *F* Test tests the hypothesis that when a sample result is composed of multiple factors, the population result will be unchanged when one or some of the factors are removed. The *F* Test is applied to *F* distribution.

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

Perform the following key operation from the statistical data list.

[F3](TEST)

[F4](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.)

List1 .... list whose contents you want to use as sample 1 data

List2 .... list whose contents you want to use as sample 2 data

Freq1 .... frequency of sample 1

Freq2 .... frequency of sample 2

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.

```
x1σn-1   :0
n1       :0
x2σn-1   :0
n2       :0
```

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

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

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

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

Example **To perform a 2-Sample *F* Test when two lists of data are input**

For this example, we will perform a 2-Sample *F* Test for the data List1 = {0.5, 1.2, 2.4, 4, 5.2} and List2 = {–2.1, 0.3, 1.5, 5, 2.4}.

[F1] (List) [▼] [F1] (≠) [▼]
[F1] (List1) [▼] [F2] (List2) [▼]
[F1] (1) [▼] [F1] (1) [▼]
[F1] (CALC)

```
2-Sample FTest
   σ1    ≠σ2
   F     =0.55096
   p     =0.57785
   x1σn-1=1.9437
   x2σn-1=2.6185
   x̄1    =2.66
```

```
   x̄2    =1.42
   n1    =5
   n2    =5
```

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

F .... F value

p .... p-value

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

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

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

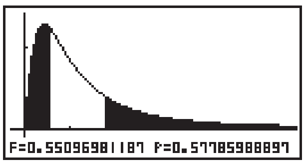
$\bar{x}_2$ .... sample 2 mean

n_1 .... sample 1 size

n_2 .... sample 2 size

Perform the following key operation to display a graph.

[EXIT]
[▼] [▼] [▼] [▼] [▼] [▼]
[F6] (DRAW)



•Analysis of Variance (ANOVA)

ANOVA tests the hypothesis that when there are multiple samples, the means of the populations of the samples are all equal.

$$F = \frac{M1}{Me}$$

$$MS = \frac{SS}{Fdf}$$

$$MSe = \frac{SSe}{Edf}$$

$$SS = \sum_{i=1}^{k} n_i (\bar{x}_i - \bar{x})^2$$

$$SSe = \sum_{i=1}^{k} (n_i - 1) x_i\sigma_{n-1}{}^2$$

$$Fdf = k - 1$$

$$Edf = \sum_{i=1}^{k} (n_i - 1)$$

k : number of populations
$\bar{x}_i$: mean of each list
$x_i\sigma_{n-1}$: standard deviation of each list
n_i : size of each list
$\bar{x}$: mean of all lists

Perform the following key operation from the statistical data list.

F3 (TEST)
F5 (ANOV)

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

How Many ...... number of samples
List1 .... list whose contents you want to use as sample 1 data
List2 .... list whose contents you want to use as sample 2 data
Execute .... executes a calculation

A value from 2 through 6 can be specified in the How Many line, so up to six samples can be used.

Example **To perform one-way ANOVA (analysis of variance) when three lists of data are input**

For this example, we will perform analysis of variance for the data List1 = {6, 7, 8, 6, 7}, List2 = {0, 3, 4, 3, 5, 4, 7} and List3 = {4, 5, 4, 6, 6, 7}.

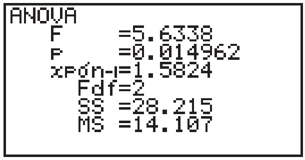
F2(3) ▼

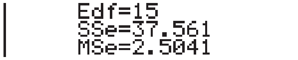
F1(List1) ▼

F2(List2) ▼

F3(List3) ▼

F1(CALC)





F .... *F* value

p .... p-value

$x_p\sigma_{n-1}$ .... pooled sample standard deviation

Fdf .... numerator degrees of freedom

SS .... factor sum of squares

MS .... factor mean squares

Edf .... denominator degrees of freedom

SSe .... error sum of squares

MSe .... error mean squares

18-7 Confidence Interval

A confidence interval is a range (interval) that includes the population mean value.

A confidence interval that is too broad makes it difficult to get an idea of where the population value (true value) is located. A narrow confidence interval, on the other hand, limits the population value and makes it possible to obtain reliable results. The most commonly used confidence levels are 95% and 99%. Raising the confidence level broadens the confidence interval, while lowering the confidence level narrows the confidence level, but it also increases the chance of accidently overlooking the population value. With a 95% confidence interval, for example, the population value is not included within the resulting intervals 5% of the time.

When you plan to conduct a survey and then t test and Z test the data, you must also consider the sample size, confidence interval width, and confidence level. The confidence level changes in accordance with the application.

1-Sample *Z* Interval calculates the confidence interval when standard deviation is known.

2-Sample *Z* Interval calculates the confidence interval when the standard deviations of two samples are known.

1-Prop *Z* Interval uses the number of data to calculate the confidence interval when the proportion is not known.

2-Prop *Z* Interval calculates the confidence interval when the proportions of two samples are known.

1-Sample *t* Interval calculates the confidence interval when the mean value of the sample is known.

2-Sample *t* Interval calculates the confidence interval when the difference between the means of two samples is known.

While the statistical data list is on the display, press F4 (INTR) to display the confidence interval menu, which contains the following items.

- {***Z***}/{***t***} ... {*Z*}/{*t*} confidence interval calculation

About data type specification

For some types of confidence interval calculation you can select data type using the following menu.

- {**List**}/{**Var**} ... specifies {List data}/{parameter data}

■ Z Confidence Interval

You can use the following menu to select from the different types of Z confidence interval.

- {**1-S**}/{**2-S**}/{**1-P**}/{**2-P**} ... {1-Sample}/{2-Sample}/{1-Prop}/{2-Prop} Z Interval

●1-Sample Z Interval

1-Sample Z Interval calculates the confidence interval when standard deviation is known. Z Interval is applied to normal distribution.

The following is the confidence interval.

$$Left = \bar{x} - Z\left(\frac{\alpha}{2}\right)\frac{\sigma}{\sqrt{n}}$$

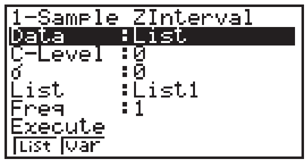
$$Right = \bar{x} + Z\left(\frac{\alpha}{2}\right)\frac{\sigma}{\sqrt{n}}$$

However, α is not the confidence level itself.

When the confidence level is 95%, for example, inputting 0.95 produces 1 – 0.95 = 0.05 = α.

Perform the following key operation from the statistical data list.

F4(INTR)
F1(Z)
F1(1-S)



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

Data .... data type
C-Level .... confidence level (0 ≦ C-Level < 1)
σ .... population standard deviation (σ > 0)
List .... list whose contents you want to use as sample data
Freq .... sample frequency
Execute .... executes a calculation

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

$\bar{x}$ .... sample mean
n .... sample size (positive integer)

Example **To calculate the 1-Sample Z Interval for one list of data**

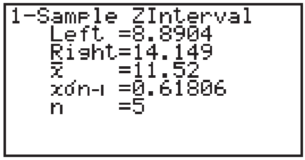
For this example, we will obtain the Z Interval for the data {11.2, 10.9, 12.5, 11.3, 11.7}, when C-Level = 0.95 (95% confidence level) and σ = 3.

F1 (List) ▼

0 • 9 5 EXE

3 EXE

F1 (List1) ▼ F1 (1) ▼ F1 (CALC)



Left .... interval lower limit (left edge)
Right .... interval upper limit (right edge)
$\bar{x}$ .... sample mean
$x\sigma_{n-1}$ .... sample standard deviation
n .... sample size

●2-Sample Z Interval

2-Sample Z Interval calculates the confidence interval when the standard deviations of two samples are known.

$$Left = (\bar{x}_1 - \bar{x}_2) - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

$$Right = (\bar{x}_1 - \bar{x}_2) + Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

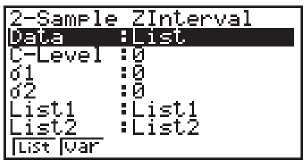
$\bar{x}_1$: sample 1 mean
$\bar{x}_2$: sample 2 mean
σ_1 : population standard deviation of sample 1
σ_2 : population standard deviation of sample 2
n_1 : sample 1 size
n_2 : sample 2 size

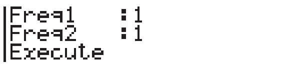
Perform the following key operation from the statistical data list.

F4 (INTR)

F1 (Z)

F2 (2-S)





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

Data .... data type
C-Level .... confidence level (0 ≦ C-Level < 1)

σ_1 .... population standard deviation of sample 1 ($\sigma_1 > 0$)

σ_2 .... population standard deviation of sample 2 ($\sigma_2 > 0$)

List1 .... list whose contents you want to use as sample 1 data

List2 .... list whose contents you want to use as sample 2 data

Freq1 .... frequency of sample 1

Freq2 .... frequency of sample 2

Execute .... executes a calculation

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

```
x̄1        :0
n1        :0
x̄2        :0
n2        :0
```

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

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

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

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

Example **To calculate the 2-Sample Z Interval when two lists of data are input**

For this example, we will obtain the 2-Sample Z Interval for the data 1 = {55, 54, 51, 55, 53, 53, 54, 53} and data 2 = {55.5, 52.3, 51.8, 57.2, 56.5} when C-Level = 0.95 (95% confidence level), σ_1 = 15.5, and σ_2 = 13.5.

[F1](List) ▼

[0] [•] [9] [5] [EXE]

[1] [5] [•] [5] [EXE]

[1] [3] [•] [5] [EXE]

[F1](List1) ▼ [F2](List2) ▼ [F1](1) ▼

[F1](1) ▼ [F1](CALC)

```
2-Sample ZInterval
   Left =-17.14
   Right=14.82
   x̄1    =53.5
   x̄2    =54.66
   x1σn-1=1.3093
   x2σn-1=2.4643
```

```
   n1    =8
   n2    =5
```

Left .... interval lower limit (left edge)

Right .... interval upper limit (right edge)

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

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

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

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

n_1 .... sample 1 size

n_2 .... sample 2 size

•1-Prop Z Interval

1-Prop Z Interval uses the number of data to calculate the confidence interval when the proportion is not known. The 1-Prop Z Interval is applied to standard normal distribution.

The following is the confidence interval.

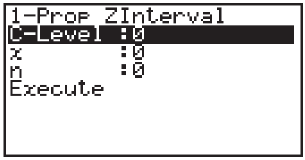
$$Left = \frac{x}{n} - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{1}{n}\left(\frac{x}{n}\left(1-\frac{x}{n}\right)\right)}$$

$$Right = \frac{x}{n} + Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{1}{n}\left(\frac{x}{n}\left(1-\frac{x}{n}\right)\right)}$$

n : sample size
x : data

Perform the following key operation from the statistical data list.

[F4](INTR)
[F1](Z)
[F3](1-P)



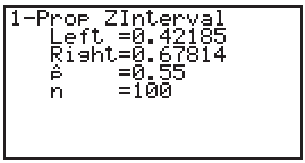
Data is specified using parameter specification. The following shows the meaning of each item.

C-Level .... confidence level (0 ≦ C-Level < 1)
x .... data (0 or positive integer)
n .... sample size (positive integer)
Execute .... executes a calculation

Example **To calculate the 1-Prop Z Interval using parameter value specification**

For this example, we will obtain the 1-Prop Z Interval when C-Level = 0.99, x = 55, and n = 100.

[0] [•] [9] [9] [EXE]
[5] [5] [EXE]
[1] [0] [0] [EXE]
[F1](CALC)



Left .... interval lower limit (left edge)
Right .... interval upper limit (right edge)
$\hat{p}$ .... expected p-value
n .... sample size

•2-Prop *Z* Interval

2-Prop *Z* Interval calculates the confidence interval when the proportions of two samples are known. The 2-Prop *Z* Interval is applied to standard normal distribution.

The following is the confidence interval.

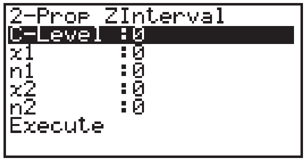
$$Left = \frac{x_1}{n_1} - \frac{x_2}{n_2} - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{\frac{x_1}{n_1}\left(1-\frac{x_1}{n_1}\right)}{n_1} + \frac{\frac{x_2}{n_2}\left(1-\frac{x_2}{n_2}\right)}{n_2}}$$

$$Right = \frac{x_1}{n_1} - \frac{x_2}{n_2} + Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{\frac{x_1}{n_1}\left(1-\frac{x_1}{n_1}\right)}{n_1} + \frac{\frac{x_2}{n_2}\left(1-\frac{x_2}{n_2}\right)}{n_2}}$$

n_1, n_2 : sample size
x_1, x_2 : data

Perform the following key operation from the statistical data list.

F4 (INTR)
F1 (Z)
F4 (2-P)



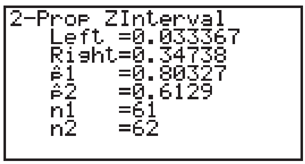
Data is specified using parameter specification. The following shows the meaning of each item.

C-Level .... confidence level ($0 \leqq$ C-Level < 1)
x_1 .... sample 1 data value ($x_1 \geqq 0$)
n_1 .... sample 1 size (positive integer)
x_2 .... sample 2 data value ($x_2 \geqq 0$)
n_2 .... sample 2 size (positive integer)
Execute .... Executes a calculation

Example **To calculate the 2-Prop *Z* Interval using parameter value specification**

For this example, we will obtain the 2-Prop *Z* Interval when C-Level = 0.95, x_1 = 49, n_1 = 61, x_2 = 38 and n_2 = 62.

0 • 9 5 EXE
4 9 EXE 6 1 EXE
3 8 EXE 6 2 EXE
F1 (CALC)



Left .... interval lower limit (left edge)
Right .... interval upper limit (right edge)

$\hat{p}_1$ .... expected p-value 1

$\hat{p}_2$ .... expected p-value 2

n_1 .... sample 1 size

n_2 .... sample 2 size

■ *t* Confidence Interval

You can use the following menu to select from two types of *t* confidence interval.

- {**1-S**}/{**2-S**} ... {1-Sample}/{2-Sample} *t* Interval

●1-Sample *t* Interval

1-Sample *t* Interval calculates the confidence interval when the mean value of the sample is known. The *t* Interval is applied to *t* distribution.

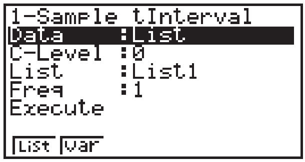
The following is the confidence interval.

$$Left = \bar{x} - t_{n-1}\left(\frac{\alpha}{2}\right)\frac{x\sigma_{n-1}}{\sqrt{n}}$$

$$Right = \bar{x} + t_{n-1}\left(\frac{\alpha}{2}\right)\frac{x\sigma_{n-1}}{\sqrt{n}}$$

Perform the following key operation from the statistical data list.

F4(INTR)
F2(*t*)
F1(1-S)



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

Data .... data type

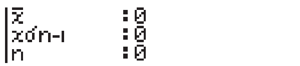
C-Level .... confidence level ($0 \leqq$ C-Level < 1)

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

Freq .... sample frequency

Execute .... execute a calculation

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



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

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

n .... sample size (positive integer)

Example **To calculate the 1-Sample *t* Interval for one list of data**

For this example, we will obtain the 1-Sample *t* Interval for data = {11.2, 10.9, 12.5, 11.3, 11.7} when C-Level = 0.95.

[F1](List)[▼]
[0][.][9][5][EXE]
[F1](List1)[▼]
[F1](1)[▼]
[F1](CALC)

```
1-Sample tInterval
   Left =10.752
   Right=12.287
   x̄    =11.52
   xσn-1 =0.61806
   n    =5
```

Left .... interval lower limit (left edge)
Right .... interval upper limit (right edge)
$\bar{x}$ .... sample mean
$x\sigma_{n\text{-}1}$ .... sample standard deviation
n .... sample size

●2-Sample *t* Interval

2-Sample *t* Interval calculates the confidence interval when the difference between the means of two samples is known. The *t* Interval is applied to *t* distribution.

The following confidence interval applies when pooling is in effect.

$$Left = (\bar{x}_1 - \bar{x}_2) - t_{n_1+n_2-2}\left(\frac{\alpha}{2}\right)\sqrt{x_p\sigma_{n-1}{}^2\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$$

$$Right = (\bar{x}_1 - \bar{x}_2) + t_{n_1+n_2-2}\left(\frac{\alpha}{2}\right)\sqrt{x_p\sigma_{n-1}{}^2\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$$

The following confidence interval applies when pooling is not in effect.

$$Left = (\bar{x}_1 - \bar{x}_2) - t_{df}\left(\frac{\alpha}{2}\right)\sqrt{\left(\frac{x_1\sigma_{n-1}{}^2}{n_1}+\frac{x_2\sigma_{n-1}{}^2}{n_2}\right)}$$

$$Right = (\bar{x}_1 - \bar{x}_2) + t_{df}\left(\frac{\alpha}{2}\right)\sqrt{\left(\frac{x_1\sigma_{n-1}{}^2}{n_1}+\frac{x_2\sigma_{n-1}{}^2}{n_2}\right)}$$

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

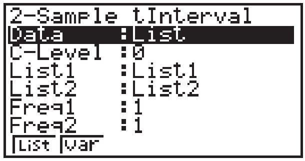
$$C = \frac{\dfrac{x_1\sigma_{n-1}{}^2}{n_1}}{\left(\dfrac{x_1\sigma_{n-1}{}^2}{n_1}+\dfrac{x_2\sigma_{n-1}{}^2}{n_2}\right)}$$

Perform the following key operation from the statistical data list.

F4(INTR)

F2(*t*)

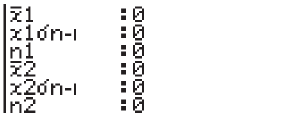
F2(2-S)



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

Data .... data type
C-Level .... confidence level ($0 \leqq$ C-Level < 1)
List1 .... list whose contents you want to use as sample 1 data
List2 .... list whose contents you want to use as sample 2 data
Freq1 .... frequency of sample 1
Freq2 .... frequency of sample 2
Pooled .... pooling On or Off
Execute .... executes a calculation

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



$\bar{x}_1$ .... sample 1 mean
$x_1\sigma_{n-1}$ .... sample 1 standard deviation ($x_1\sigma_{n-1} \geqq 0$)
n_1 .... sample 1 size (positive integer)
$\bar{x}_2$ .... sample 2 mean
$x_2\sigma_{n-1}$ .... sample 2 standard deviation ($x_2\sigma_{n-1} \geqq 0$)
n_2 .... sample 2 size (positive integer)

Example **To calculate the 2-Sample *t* Interval when two lists of data are input**

For this example, we will obtain the 2-Sample *t* Interval for data 1 = {55, 54, 51, 55, 53, 53, 54, 53} and data 2 = {55.5, 52.3, 51.8, 57.2, 56.5} without pooling when C-Level = 0.95.

[F1](List) [▼]
[0] [.] [9] [5] [EXE]
[F1](List1) [▼] [F2](List2) [▼] [F1](1) [▼]
[F1](1) [▼] [F2](Off) [▼] [F1](CALC)

```
2-Sample tInterval
   Left =-4.1576
   Right=1.8376
   df   =5.4391
   x̄1   =53.5
   x̄2   =54.66
   x1σn-1=1.3093
```

```
   x2σn-1=2.4643
   n1   =8
   n2   =5
```

Left .... interval lower limit (left edge)
Right .... interval upper limit (right edge)
df .... degrees of freedom
$\bar{x}_1$ .... sample 1 mean
$\bar{x}_2$ .... sample 2 mean
$x_1\sigma_{n-1}$ .... sample 1 standard deviation
$x_2\sigma_{n-1}$ .... sample 2 standard deviation
n_1 .... sample 1 size
n_2 .... sample 2 size

The following item is also shown when Pooled = On.

```
   xpσn-1=1.8163
```

$x_p\sigma_{n-1}$ .... pooled sample standard deviation

18-8 Distribution

There is a variety of different types of distribution, but the most well-known is "normal distribution," which is essential for performing statistical calculations. Normal distribution is a symmetrical distribution centered on the greatest occurrences of mean data (highest frequency), with the frequency decreasing as you move away from the center. Poisson distribution, geometric distribution, and various other distribution shapes are also used, depending on the data type.

Certain trends can be determined once the distribution shape is determined. You can calculate the probability of data taken from a distribution being less than a specific value.

For example, distribution can be used to calculate the yield rate when manufacturing some product. Once a value is established as the criteria, you can calculate normal probability density when estimating what percent of the products meet the criteria. Conversely, a success rate target (80% for example) is set up as the hypothesis, and normal distribution is used to estimate the proportion of the products will reach this value.

Normal probability density calculates the probability that data taken from a normal distribution is less than a specific value.

Normal distribution probability calculates the probability of normal distribution data falling between two specific values.

Inverse cumulative normal distribution calculates a value that represents the location within a normal distribution for a specific cumulative probability.

Student- *t* probability density calculates the probability that data taken from a *t* distribution is less than a specific value.

Student- *t* distribution probability calculates the probability of *t* distribution data falling between two specific values.

Like *t* distribution, distribution probability can also be calculated for **chi-square**, ***F***, **binomial**, **Poisson**, and **geometric** distributions.

While the statistical data list is on the display, press F5 (DIST) to display the distribution menu, which contains the following items.

- {**NORM**}/{*t*}/{**CHI**}/{*F*}/{**BINM**}/{**POISN**}/{**GEO**} ... {normal}/{*t*}/{χ^2}/{*F*}/{binomial}/{Poisson}/{geometric} distribution

About data type specification

For some types of distribution you can select data type using the following menu.

- {**List**}/{**Var**} ... specifies {list data}/{parameter data}

Normal Distribution

You can use the following menu to select from the different types of calculation.

- **{Npd}/{Ncd}/{InvN}** ... {normal probability density}/{normal distribution probability}/{inverse cumulative normal distribution} calculation

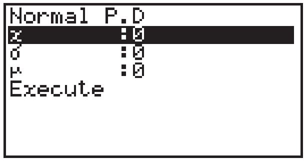
•Normal probability density

Normal probability density calculates the probability that data taken from a normal distribution is less than a specific value. Normal probability density is applied to standard normal distribution.

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (\sigma > 0)$$

Perform the following key operation from the statistical data list.

F5(DIST)
F1(NORM)
F1(Npd)



Data is specified using parameter specification. The following shows the meaning of each item.

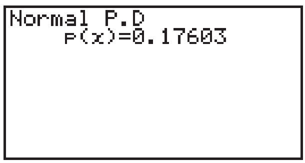
x .... data
σ .... population standard deviation ($\sigma > 0$)
μ .... population mean
Execute .... executes a calculation or draws a graph

- Specifying $\sigma = 1$ and $\mu = 0$ specifies standard normal distribution.

Example **To calculate the normal probability density for a specific parameter value**

For this example, we will calculate the normal probability density when $x = 36$, $\sigma = 2$ and $\mu = 35$.

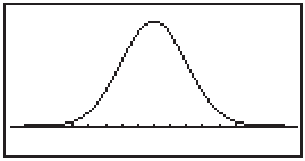
3 6 EXE
2 EXE
3 5 EXE
F1(CALC)



$p(x)$ .... normal probability density

Perform the following key operation to display a graph.

[EXIT]
[▼][▼][▼]
[F6](DRAW)



●Normal distribution probability

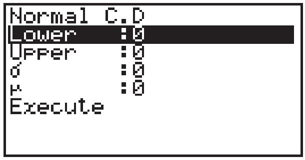
Normal distribution probability calculates the probability of normal distribution data falling between two specific values.

$$p = \frac{1}{\sqrt{2\pi}\sigma}\int_a^b e^{-\frac{(x-\mu)^2}{2\sigma^2}}dx$$

a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

[F5](DIST)
[F1](NORM)
[F2](Ncd)



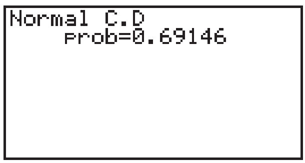
Data is specified using parameter specification. The following shows the meaning of each item.

Lower .... lower boundary
Upper .... upper boundary
σ .... population standard deviation ($\sigma > 0$)
μ .... population mean
Execute .... executes a calculation

Example **To calculate the normal distribution probability for a specific parameter value**

For this example, we will calculate the normal distribution probability when lower boundary = –∞ (–1E99), upper boundary = 36, σ = 2 and μ = 35.

[(–)][1][EXP][9][9][EXE]
[3][6][EXE]
[2][EXE]
[3][5][EXE]
[F1](CALC)



prob .... normal distribution probability

- This calculator performs the above calculation using the following:

  ∞ = 1E99, –∞ = –1E99

●Inverse cumulative normal distribution

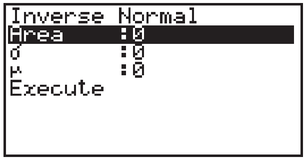
Inverse cumulative normal distribution calculates a value that represents the location within a normal distribution for a specific cumulative probability.

$$\int_{-\infty}^{\alpha} f(x)dx = p \qquad \alpha = ?$$

Specify the probability and use this formula to obtain the integration interval.

Perform the following key operation from the statistical data list.

F5 (DIST)
F1 (NORM)
F3 (InvN)



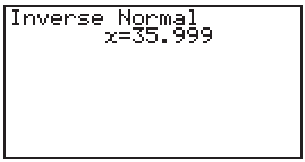
Data is specified using parameter specification. The following shows the meaning of each item.

Area .... probability value (0 ≦ Area ≦ 1)
σ .... population standard deviation (σ > 0)
μ .... population mean
Execute .... executes a calculation

Example **To calculate inverse cumulative normal distribution for a specific parameter value**

For this example, we will determine inverse cumulative normal distribution when probability value = 0.691462, σ = 2 and μ = 35.

0 • 6 9 1 4 6 2 EXE
2 EXE
3 5 EXE
F1 (CALC)



x .... inverse cumulative normal distribution (upper boundary of integration interval)

Student-*t* Distribution

You can use the following menu to select from the different types of Student-*t* distribution.

- {**tpd**}/{**tcd**} ... {Student-*t* probability density}/{Student-*t* distribution probability} calculation

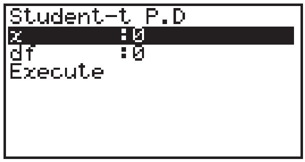
●Student-*t* probability density

Student-*t* probability density calculates whether data taken from a *t* distribution is less than a specific value.

$$f(x) = \frac{\Gamma\left(\frac{df+1}{2}\right)}{\Gamma\left(\frac{df}{2}\right)} \frac{\left(1+\frac{x^2}{df}\right)^{-\frac{df+1}{2}}}{\sqrt{\pi df}}$$

Perform the following key operation from the statistical data list.

F5 (DIST)
F2 (t)
F1 (tpd)



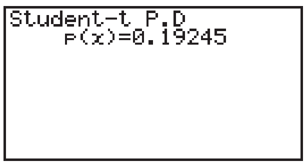
Data is specified using parameter specification. The following shows the meaning of each item.

x .... data
df .... degrees of freedom ($df \geqq 1$)
Execute .... executes a calculation or draws a graph

Example **To calculate Student-*t* probability density for a specific parameter value**

For this example, we will calculate Student-*t* probability density when x = 1 and degrees of freedom = 2.

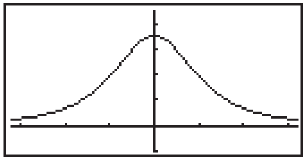
1 EXE
2 EXE
F1 (CALC)



$p(x)$ .... Student-*t* probability density

Perform the following key operation to display a graph.

[EXIT]
[▼][▼]
[F6](DRAW)



●Student-*t* distribution probability

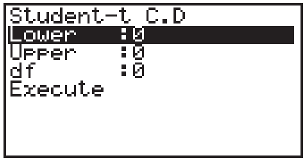
Student-*t* distribution probability calculates the probability of *t* distribution data falling between two specific values.

$$p = \frac{\Gamma\left(\frac{df+1}{2}\right)}{\Gamma\left(\frac{df}{2}\right)\sqrt{\pi df}} \int_a^b \left(1+\frac{x^2}{df}\right)^{-\frac{df+1}{2}} dx$$

a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

[F5](DIST)
[F2](*t*)
[F2](tcd)



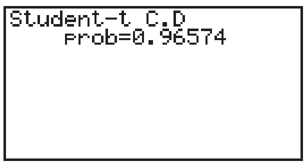
Data is specified using parameter specification. The following shows the meaning of each item.

Lower .... lower boundary
Upper .... upper boundary
df .... degrees of freedom ($df \geqq 1$)
Execute .... executes a calculation

Example **To calculate Student-*t* distribution probability for a specific parameter value**

For this example, we will calculate Student-*t* distribution probability when lower boundary = –2, upper boundary = 3, and degrees of freedom = 18.

[(–)][2][EXE]
[3][EXE]
[1][8][EXE]
[F1](CALC)



prob .... Student-*t* distribution probability

Chi-square Distribution

You can use the following menu to select from the different types of chi-square distribution.

- **{Cpd}**/**{Ccd}** ... {χ^2 probability density}/{χ^2 distribution probability} calculation

●χ^2 probability density

χ^2 probability density calculates whether data taken from a χ^2 distribution is less than a specific value.

$$f(x) = \frac{1}{\Gamma\left(\frac{df}{2}\right)}\left(\frac{1}{2}\right)^{\frac{df}{2}} x^{\frac{df}{2}-1} e^{-\frac{x}{2}} \qquad (x \geqq 0)$$

Perform the following key operation from the statistical data list.

F5 (DIST)
F3 (CHI)
F1 (Cpd)

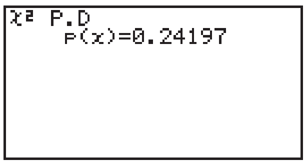
Data is specified using parameter specification. The following shows the meaning of each item.

x .... data
df .... degrees of freedom (positive integer)
Execute .... executes a calculation or draws a graph

Example **To calculate χ^2 probability density for a specific parameter value**

For this example, we will calculate χ^2 probability density when x = 1 and degrees of freedom = 3.

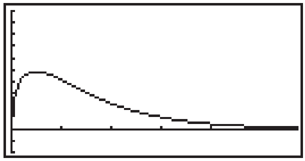
1 EXE
3 EXE
F1 (CALC)



$p(x)$ .... χ^2 probability density

Perform the following key operation to display a graph.

[EXIT]
[▼] [▼]
[F6] (DRAW)



•χ^2 distribution probability

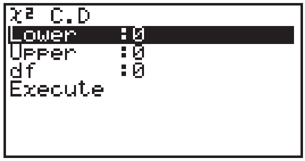
χ^2 distribution probability calculates the probability of χ^2 distribution data falling between two specific values.

$$p = \frac{1}{\Gamma\left(\frac{df}{2}\right)}\left(\frac{1}{2}\right)^{\frac{df}{2}}\int_a^b x^{\frac{df}{2}-1} e^{-\frac{x}{2}} dx$$

a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

[F5] (DIST)
[F3] (CHI)
[F2] (Ccd)



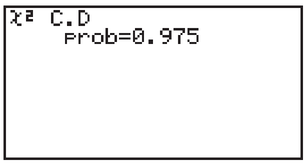
Data is specified using parameter specification. The following shows the meaning of each item.

Lower .... lower boundary
Upper .... upper boundary
df .... degrees of freedom (positive integer)
Execute .... executes a calculation

Example **To calculate χ^2 distribution probability for a specific parameter value**

For this example, we will calculate χ^2 distribution probability when lower boundary = 0, upper boundary = 19.023, and degrees of freedom = 9.

[0] [EXE]
[1] [9] [•] [0] [2] [3] [EXE]
[9] [EXE]
[F1] (CALC)



prob .... χ^2 distribution probability

■ *F* Distribution

You can use the following menu to select from the different types of *F* distribution.

- {**Fpd**}/{**Fcd**} ... {*F* probability density}/{*F* distribution probability} calculation

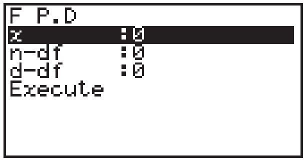
• *F* probability density

F probability density calculates whether data taken from a *F* distribution is less than a specific value.

$$f(x) = \frac{\Gamma\left(\frac{n+d}{2}\right)}{\Gamma\left(\frac{n}{2}\right)\Gamma\left(\frac{d}{2}\right)} \left(\frac{n}{d}\right)^{\frac{n}{2}} x^{\frac{n}{2}-1} \left(1 + \frac{nx}{d}\right)^{-\frac{n+d}{2}} \qquad (x \geqq 0)$$

Perform the following key operation from the statistical data list.

[F5] (DIST)
[F4] (F)
[F1] (Fpd)



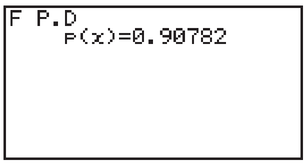
Data is specified using parameter specification. The following shows the meaning of each item.

x .... data
n-df .... numerator degrees of freedom (positive integer)
d-df .... denominator degrees of freedom (positive integer)
Execute .... executes a calculation or draws a graph

Example **To calculate *F* probability density for a specific parameter value**

For this example, we will calculate *F* probability density when *x* = 1, *n-df* = 24, and *d-df* = 19.

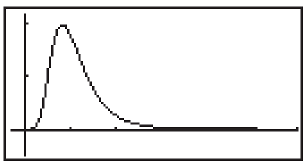
[1] [EXE]
[2] [4] [EXE]
[1] [9] [EXE]
[F1] (CALC)



p(*x*) .... *F* probability density

Perform the following key operation to display a graph.

[EXIT]
[▼] [▼] [▼]
[F6] (DRAW)



• *F* distribution probability

F distribution probability calculates the probability of *F* distribution data falling between two specific values.

$$p = \frac{\Gamma\left(\frac{n+d}{2}\right)}{\Gamma\left(\frac{n}{2}\right)\Gamma\left(\frac{d}{2}\right)}\left(\frac{n}{d}\right)^{\frac{n}{2}}\int_a^b x^{\frac{n}{2}-1}\left(1+\frac{nx}{d}\right)^{-\frac{n+d}{2}}dx$$

a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

[F5] (DIST)
[F4] (F)
[F2] (Fcd)

```
F C.D
Lower    :0
Upper    :0
n-df     :0
d-df     :0
Execute
```

Data is specified using parameter specification. The following shows the meaning of each item.

Lower .... lower boundary
Upper .... upper boundary
n-df .... numerator degrees of freedom (positive integer)
d-df .... denominator degrees of freedom (positive integer)
Execute .... executes a calculation

Example **To calculate *F* distribution probability for a specific parameter value**

For this example, we will calculate *F* distribution probability when lower boundary = 0, upper boundary = 1.9824, *n-df* = 19 and *d-df* = 16.

[0] [EXE]
[1] [•] [9] [8] [2] [4] [EXE]
[1] [9] [EXE]
[1] [6] [EXE]
[F1] (CALC)

```
F C.D
   prob=0.914
```

prob .... *F* distribution probability

■ Binomial Distribution

You can use the following menu to select from the different types of binomial distribution.

- {**Bpd**}/{**Bcd**} ... {binomial probability}/{binomial cumulative density} calculation

•Binomial probability

Binomial probability calculates whether data taken from a binomial distribution is less than a specific value.

$$f(x) = {}_nC_x p^x (1-p)^{n-x} \qquad (x = 0, 1, \cdots\cdots, n)$$

p : success probability ($0 \leqq p \leqq 1$)

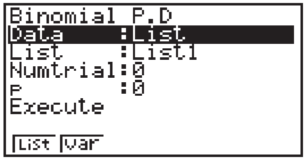
n : number of trials

Perform the following key operation from the statistical data list.

[F5] (DIST)

[F5] (BINM)

[F1] (Bpd)



The following shows the meaning of each item when data is specified using list specification.

Data .... data type

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

Numtrial .... number of trials (positive integer)

p .... success probability ($0 \leqq p \leqq 1$)

Execute .... executes a calculation

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

x .... integer from 0 to n

Example **To calculate binomial probability for one list of data**

For this example, we will calculate binomial probability for data = {10, 11, 12, 13, 14} when Numtrial = 15 and success probability = 0.6.

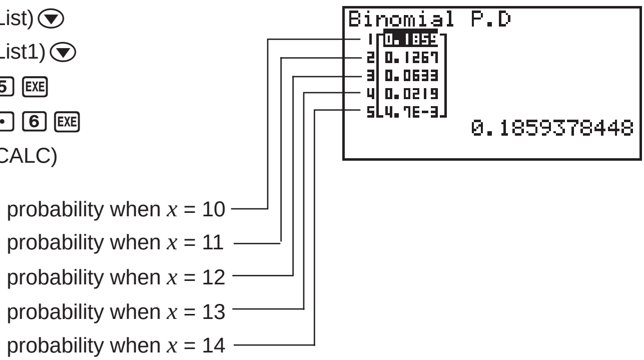
[F1] (List) [▼]

[F1] (List1) [▼]

[1] [5] [EXE]

[0] [.] [6] [EXE]

[F1] (CALC)



•Binomial cumulative density

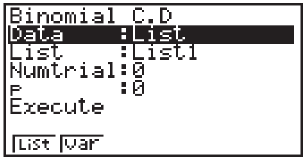
Binomial cumulative density calculates the probability of binomial distribution data falling between two specific values.

Perform the following key operation from the statistical data list.

[F5] (DIST)

[F5] (BINM)

[F2] (Bcd)



The following shows the meaning of each item when data is specified using list specification.

Data .... data type

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

Numtrial .... number of trials (positive integer)

p .... success probability (0 ≦ *p* ≦ 1)

Execute .... executes a calculation

The following shows the meaning of parameter data specification item that is different from list data specification.

x .... integer from 0 to *n*

Example **To calculate binomial cumulative density for one list of data**

For this example, we will calculate binomial cumulative density for data = {10, 11, 12, 13, 14} when Numtrial = 15 and success probability = 0.6.

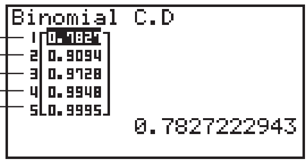
[F1] (List) [▼]

[F1] (List1) [▼]

[1] [5] [EXE]

[0] [•] [6] [EXE]

[F1] (CALC)



cumulative density when *x* = 10

cumulative density when *x* = 11

cumulative density when *x* = 12

cumulative density when *x* = 13

cumulative density when *x* = 14

Poisson Distribution

You can use the following menu to select from the different types of Poisson distribution.

- {**Ppd**}/{**Pcd**} ... {Poisson probability}/{Poisson cumulative density} calculation

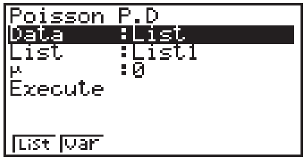
•Poisson probability

Poisson probability calculates whether data taken from a Poisson distribution is less than a specific value.

$$f(x) = \frac{e^{-\mu}\mu^{x}}{x!} \qquad (x = 0, 1, 2, \cdots) \qquad \mu : \text{population mean } (\mu > 0)$$

Perform the following key operation from the statistical data list.

F5 (DIST)
F6 (▷)
F1 (POISN)
F1 (Ppd)



The following shows the meaning of each item when data is specified using list specification.

Data .... data type
List .... list whose contents you want to use as sample data
μ .... population mean (μ > 0)
Execute .... executes a calculation

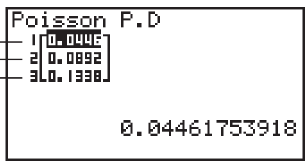
The following shows the meaning of parameter data specification item that is different from list data specification.

x .... value

Example **To calculate Poisson probability for one list of data**

For this example, we will calculate Poisson probability for data = {2, 3, 4} when μ = 6.

F1 (List) ▼
F1 (List1) ▼
6 EXE
F1 (CALC)



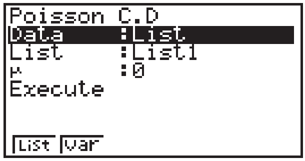
probability when x = 2
probability when x = 3
probability when x = 4

•Poisson cumulative density

Poisson cumulative density calculates the probability of Poisson distribution data falling between two specific values.

Perform the following key operation from the statistical data list.

F5 (DIST)
F6 (▷)
F1 (POISN)
F2 (Pcd)



The following shows the meaning of each item when data is specified using list specification.

Data .... data type
List .... list whose contents you want to use as sample data
μ .... population mean (μ > 0)
Execute .... executes a calculation

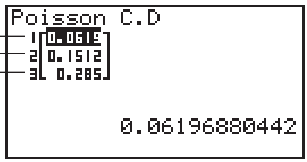
The following shows the meaning of parameter data specification item that is different from list data specification.

x .... value

Example **To calculate Poisson cumulative density for one list of data**

For this example, we will calculate Poisson cumulative density for data = {2, 3, 4} when μ = 6.

F1 (List) ▼
F1 (List1) ▼
6 EXE
F1 (CALC)



cumulative density when x = 2
cumulative density when x = 3
cumulative density when x = 4

■ Geometric Distribution

You can use the following menu to select from the different types of geometric distribution.

- {**Gpd**}/{**Gcd**} ... {geometric probability}/{geometric cumulative density} calculation

●Geometric probability

Geometric probability calculates whether data taken from a geometric distribution is less than a specific value.

$$f(x) = p(1-p)^{x-1} \qquad (x = 1, 2, 3, \cdots)$$

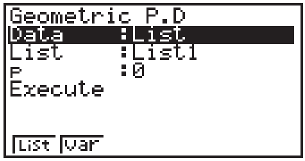
Perform the following key operation from the statistical data list.

[F5] (DIST)

[F6] (▷)

[F2] (GEO)

[F1] (Gpd)



The following shows the meaning of each item when data is specified using list specification.

Data .... data type

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

p .... success probability ($0 \leqq p \leqq 1$)

Execute .... executes a calculation

The following shows the meaning of parameter data specification item that is different from list data specification.

x .... value

- Positive integer number is calculated whether list data (Data:List) or *x* value (Data:variable) is specified.

Example **To calculate geometric probability for one list of data**

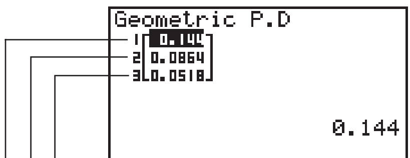
For this example, we will calculate geometric probability for data = {3, 4, 5} when *p* = 0.4.

[F1] (List) [▼]

[F1] (List1) [▼]

[0] [.] [4] [EXE]

[F1] (CALC)



probability when $x = 3$

probability when $x = 4$

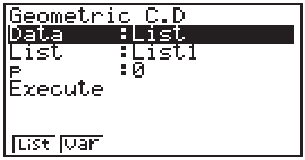
probability when $x = 5$

•Geometric cumulative density

Geometric cumulative density calculates the probability of geometric distribution data falling between two specific values.

Perform the following key operation from the statistical data list.

F5 (DIST)
F6 (▷)
F2 (GEO)
F2 (Gcd)



The following shows the meaning of each item when data is specified using list specification.

Data .... data type
List .... list whose contents you want to use as sample data
p .... success probability ($0 \leqq p \leqq 1$)
Execute .... executes a calculation

The following shows the meaning of parameter data specification item that is different from list data specification.

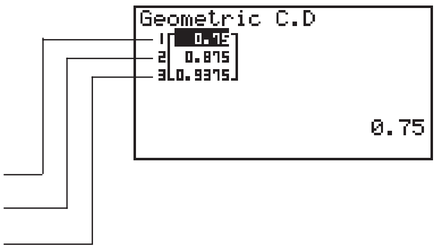
x .... value

- Positive integer number is calculated whether list data (Data:List) or x value (Data:variable) is specified.

Example **To calculate geometric cumulative density for one list of data**

For this example, we will calculate geometric cumulative density for data = {2, 3, 4} when p = 0.5.

F1 (List) ▼
F1 (List1) ▼
0 • 5 EXE
F1 (CALC)



cumulative density when x = 2
cumulative density when x = 3
cumulative density when x = 4