EN

CLASSWIZ CG

Graphics Calculator

fx-CG100 (Version 2.00)

fx-1AU GRAPH (Version 2.00)

Software User´s Guide

Be sure to read the “Safety Precautions” in the “Hardware User’s Guide”, and make sure you use this product correctly.

CASIO Worldwide Education Website

https://edu.casio.com

Manuals are available in multi languages at

https://world.casio.com/manual/calc/

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Getting Started

Read This First

About This Manual

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- The contents of this manual have been checked at each step along the production process. Feel free to contact us if you notice anything that is questionable, erroneous, etc.
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Attention fx-CG100 Users

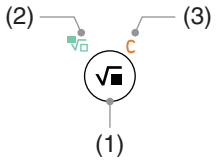
- Unless otherwise noted, this manual describes operations when “International” is selected for the Country setting (page 200). When “United States” or something else other than “International” is selected for the Country setting, screen contents and the arrangement of screen items may differ from what is shown in this manual.

Attention fx-1AU GRAPH Users

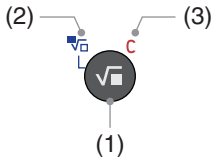
- Unless otherwise noted, this manual describes operations with fx-CG100 (Country setting (page 200): International). With the fx-1AU GRAPH, screen contents and the arrangement of screen items may differ.

Key Operations

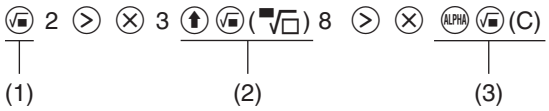
Some of the keys of your calculator have multiple functions assigned to them. This manual uses the conventions below to indicate the key operations required to access each function.

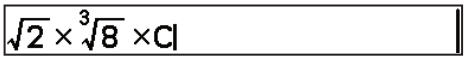


fx-CG100



fx-1AU GRAPH





(1) Press √ to enter "√".
This is the operation for using the function printed on the key top.

(2) After pressing Shift √, press the above key to enter "▪√□", which is shown in parentheses.
This operation is used to access the function printed in green (fx-CG100) / blue (fx-1AU GRAPH) above and to the left of the key.

(3) After pressing ALPHA √, press the above key to enter the "C", which is shown in parentheses.
This operation is used to access the function printed in orange (fx-CG100) / red (fx-1AU GRAPH) above and to the right of the key.

OK Key and EXE Key

The OK key and EXE key perform the same operation. In this manual, OK is used for selecting or applying a setting, while EXE is used for executing a calculation. Note, however, that it makes no difference whether you press OK or EXE for operations where either OK or EXE is shown.

▼/▲/◀/▶ Keys

Use these keys to move the cursor or highlighting. These keys are referred to as "cursor keys" throughout this manual.

General Precautions for All Applications

- **Calculations may take time.**
  A rotating icon is shown in the upper right corner of the screen while an internal calculation is in progress. To interrupt a calculation without waiting for it to complete, press AC.

  Examples of time-consuming calculations
  - Integral calculations (depending on $f(x)$ and the range of x)
  - Calculations involving matrices or vectors with a large number of elements
  - Solving simultaneous equations with three or more variables or higher linear equations, or cubic or higher order equations
  - Drawing regression graphs when there is a large amount of data (especially sinusoidal regression and logistic regression)
- **Calculation results may be subject to error.**
  For information about your calculator's calculation accuracy and error, see "Calculation Ranges, Number of Digits, and Precision" (page 254).
- **If an error message appears, check its contents.**
  For the meaning of each error message, see "Error Message Table" (page 247).
- **Most functions are called from the Catalog menu.**
  See "Catalog Menu Details" (page 221) for descriptions of functions and their syntax.

Calculator “Get Started” Screen

While the HOME screen is displayed, pressing ☰ will display the “Get Started” screen, which includes the information below.

- QR Code for accessing the “Get Started” webpage of the Worldwide Education Service (https://wes.casio.com/calc/cg/)
  The Get Started webpage gives you access to the User’s Guide and other related information to help you get started with your calculator.
- Calculator ID number (8-character string)

To adjust the display brightness of the QR Code

While the “Get Started” screen is displayed, use ◁ and ▷ to adjust the display brightness. The settings made with this adjustment are shared with the Display Settings (page 200) of the System app.

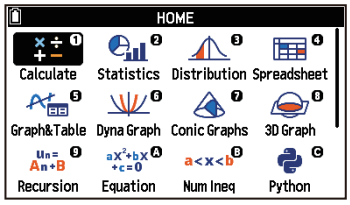
To return to the HOME screen

Press ⎋.

Basic App Operations

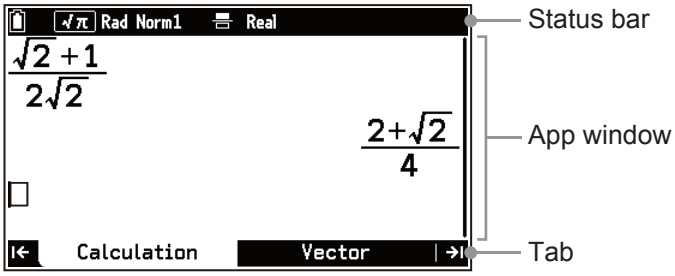
Starting Up an Application

1. Press the ⌂ key to display the HOME screen.



2. Use the cursor keys to move the highlighting to the icon of the app you want to start up, and then press OK. Alternatively, you can press a number or letter key to select an app.
   - If 1 is shown in the upper right corner of the icon you want to select, press ①. If A is shown, press (x/θ/T) A.

App Screen Configuration



Status bar

The status bar at the top of the screen shows the current battery level, current settings, various statuses, and help messages.

App window

This is the display area of the app. While the window displays a graph, you can hide the tabs to expand the display area (see “Using Tabs” (page 8)).

Tab

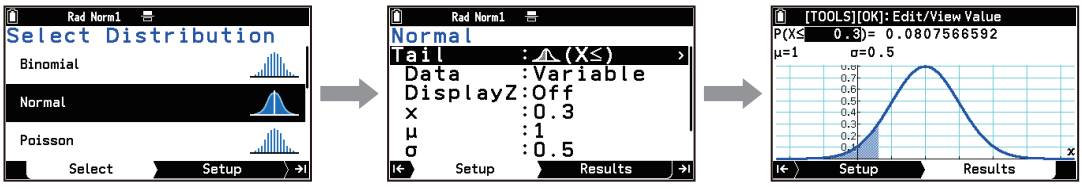
Some applications of your calculator have multiple tabs. Each tab is assigned a role or function. The currently active tab is white, while inactive tabs are black. Some apps do not have tabs.

Using Tabs

Some apps have tabs that are organized according to functions or properties.

- There are two types of apps with tabs, and the app type depends on the app organization.

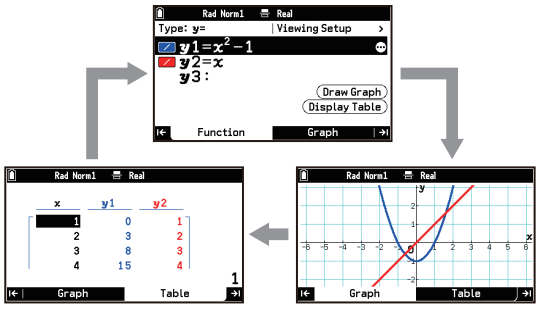
  One-way type: This type of app has a starting tab and an ending tab. App operations proceed sequentially from the start (left-most) tab to the end (right-most) tab. Each press of ⇥ moves to the next tab to the right.



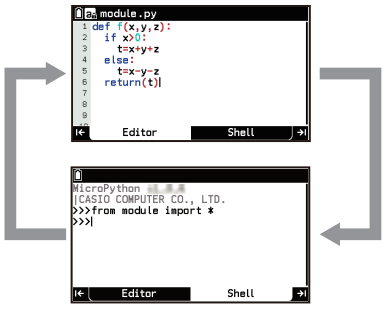
Distribution App

Pressing ⇤ moves in reverse sequence (to the left) until the start (left-most) tab is reached.

Cyclical type: With this app type, operations proceed cyclically among tabs. Pressing ⇥ while any tab is displayed moves to the next tab to the right.



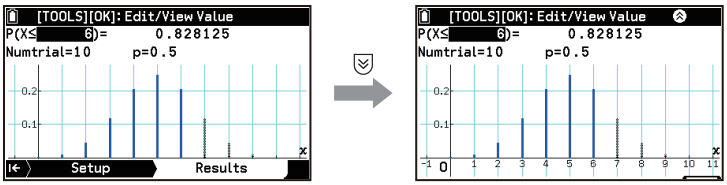
Graph&Table App



Python App

Press ⇤ to move to the next tab to the left.

- ⇤ and ⇥ on either end of the tabs means there is a tab in the direction indicated by the arrow(s).
- While the window displays a graph, you can hide the tabs by pressing ⌄⌄. This expands the display area.



In some cases, tabs may be hidden automatically. If you are able to show hidden tabs, ⌃⌃ will be shown in the status bar. In this case, press ⌃⌃ to show the tabs.

App Alpha Character and Numeric Input

Natural Input and Linear Input

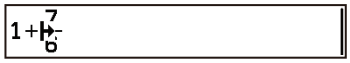
Your calculator lets you enter expressions using either of two input methods: natural input or linear input. Natural input lets you input expressions in textbook format. With linear input, you can input expressions in linear format. There are differences between natural input and linear input when entering fractions, square roots (√), some functions, vectors, and matrices. The table below shows examples of natural and linear input.

Input method \ Expression	Fractions, √	Functions (Integration example)	Matrix
Natural input	$\frac{\sqrt{2}}{3}$	$\int_1^3 2x^2-1\,dx$	$\begin{bmatrix}1 & 2\\ 3 & 4\end{bmatrix}$
Linear input	√(2)⌟3	∫(2x²−1,1,3)	[[1,2][3,4]]

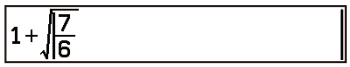
To incorporate a previously entered numeric value as an argument into a function (natural input only)

Example: To enter $1+\frac{7}{6}$ and change it to $1+\sqrt{\frac{7}{6}}$

1⊕▤7⌄6<<<<↑⌫(INS)



√■



Pressing ↑⌫(INS) makes $\frac{7}{6}$, which was input in the above example, the argument of the function (√) entered with the next key operation.

To switch between insert mode and overwrite mode (linear input only)

In overwrite mode, the character at the current cursor position is replaced by the character you enter. Each press of (INS) toggles between the insert and overwrite modes. The cursor shape is "|" in insert mode and "▮" in overwrite mode.

Alphabet Input

To enter a single alpha character, press (ALPHA) (which displays A in the status bar), followed by a key marked with an orange letter (fx-CG100) / a red letter (fx-1AU GRAPH). In addition to the alpha characters, you can also enter spaces (␣) and quotation marks (").*

* Other symbols can be entered using > [All] > [Symbol].

Alpha Lock

You can alpha lock keys to allow continuous input of alpha characters, so you don't need to press (ALPHA) for each one.

Pressing (A-LOCK) alpha locks the keys, which is indicated by A in the status bar. To unlock alpha lock, press (ALPHA).

> **Note**
> - When using the Python app's Editor, keys are automatically alpha-locked to lowercase, which is indicated by a in the status bar.

Copying, Cutting, and Pasting Expressions

You can select a range of expressions or strings that have already been entered and copy or cut them to the clipboard. You can then paste the clipboard contents into the same app or another app.

To copy or cut screen data

1. Move the input cursor (|) to the start of the range of data you want to copy or cut.
2. Press (0).
   - This displays in the status bar until you press (OK) in step 4.
3. Move the cursor to the end of the range of data you want to copy or cut.
4. Select [Copy] or [Cut] in the menu that appeared after you pressed (OK).
   - You can specify the end point first if you want.

To paste data

1. Move the input cursor (|) to the location where you want to paste the data.
2. Press (.).

Frequently Used App Menus

Settings Menu (Changing App Settings)

The Settings menu displays setting items for the app you are currently using. It includes items common to multiple apps and items specific to a particular app.

To change app settings

1. Press (⌂), select an app, and then press (OK).
2. Press to display the Settings menu and then change the app's settings.
   - If there is a switch (Off: , On:) to the right of a menu item, press (OK) to toggle between Off and On.
   - For details about setting items and options, see "Settings Menu Details" (page 214).

Variable Menu (Inputting a Variable into a Calculation or Expression)

Use the Variable menu to input a variable into a calculation or expression.

To recall this variable:	Select this menu item:	Details:
Alpha variable	> [Alpha]	Using Alpha Variables (page 18)
Function variable	> [Function]	Using Function Variables (page 18) To input a function (page 76)
Vector variable	> [Vector]	Inputting a Vector into a Calculation (page 22) Storing Vector Variables (page 21)
Matrix variable	> [Matrix]	Inputting a Matrix into a Calculation (page 25) Storing Matrix Variables (page 24)
List variable	> [List]	Inputting a List into a Calculation (page 27) Storing List Variables (page 27)

Note

- The menu item for each variable also shows the line form of the contents currently stored in the variable.

Catalog Menu (Inputting Functions and Commands)

The Catalog menu is a comprehensive list of all functions, commands, app variables,* and symbols.

* Variables that automatically store specific input or output values.

For details about the items included on the Catalog menu, see “Catalog Menu Details” (page 221).

Note

- Pressing while using the Python app or Base-N app displays the Catalog menu for the app you are using. For details, see the chapters explaining each app.

Tools Menu (Displaying Operation Options)

Press to display the Tools menu. The items that appear on the Tools menu depend on the app or tab you are currently using.

When is displayed on the right end of a highlighted menu item, the Tools menu that appears when you press will contain operation options enabled for the highlighted line.

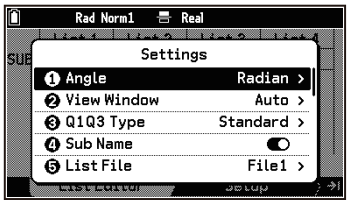
Format Menu (Changing the Display Format)

The Format menu that appears when you press * lets you change the format of the calculation result display and cell details. For details about the items included on the Format menu, see “Changing the Display Format of Calculation Results (Format Menu)” (page 17).

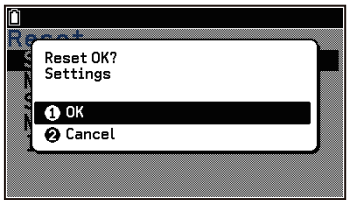
* When “ ↔ Decimal” is selected for > [FORMAT Key] (page 220) (initial default).

Menu and Dialog Operations (Using Option Numbers)

Pressing certain keys (, , etc.) or executing some operation in an app causes a menu or dialog to appear.



Menu Example



Dialog Example

There are two ways to select an item on a menu or dialog.

- **Method 1**: Use and to move the highlighting to the item you want to use and then press .

• **Method 2**: Press the number or letter key* that corresponds to the number or letter to the left of the item you want to select.
The number or letter to the left of an item is its “Option Number”.

* To enter a letter from A through L, press (x) A through) L (without pressing (ALPHA)).
To enter a letter from M through Z, press (ALPHA) + 7 M to (ALPHA) + 0 Z. Be sure to press (ALPHA) first in this case.

Note

- You can use Option Numbers to select a menu or dialog operation by pressing its corresponding number or letter key even if its menu or dialog is not currently displayed. To understand how this works, try performing the example operation below.
- Option Numbers are displayed when (≡) > [Show Option Numbers] (page 220) is turned on and not displayed when it is turned off. The default setting is On. Note that menu and dialog operations you execute by pressing number and letter keys remain in effect even when (≡) > [Show Option Numbers] is turned off.

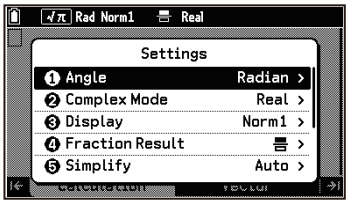
Example of Menu Operations Using Option Numbers

The operations in this example are performed with the Calculate app running and the Settings menu displayed. The following operations will be performed using Option Numbers.

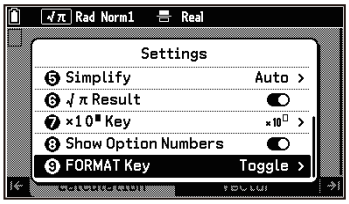
- Selecting [a+b*i*] for the [Complex Mode] setting
- Turning [Show Option Numbers] off and then back on

1. (⌂) > Calculate

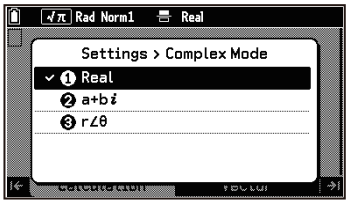
2. Press (≡).
   - This displays the Settings menu.
   - Note that ❷ is shown to the left of [Complex Mode].



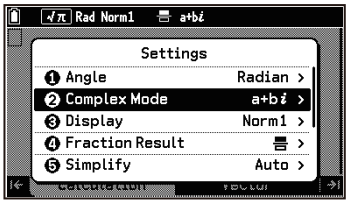
3. Press (^).
   - This jumps to the last line of the menu.
   - Note that ❽ is shown to the left of [Show Option Numbers].



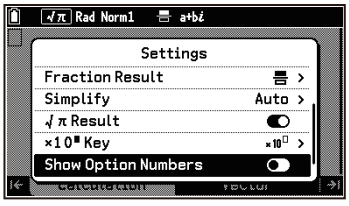
4. Press ② to select [Complex Mode].
   - This displays a list of available Complex Mode settings.



5. Press ② to select [a+b*i*].
   - This changes the Complex Mode setting to a+b*i* and returns to the Settings menu.



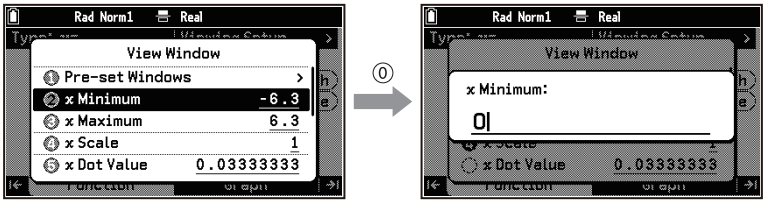
6. Press ⑧ to select [Show Option Numbers].
   - This turns off the [Show Option Numbers] setting (●), which causes the Option Numbers to the left of the menu items to disappear.



7. Press ⑧ again (or ⓄⓀ).
   • This turns on the [Show Option Numbers] setting (), which causes the Option Numbers to reappear.

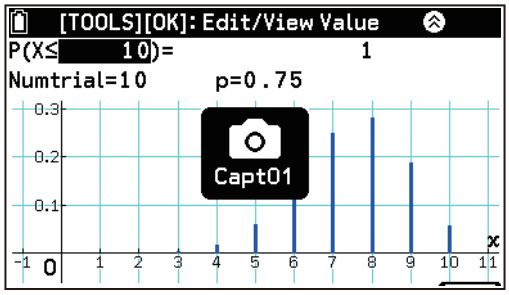
Cases when Option Number Operations Are Disabled

Option Number operations are disabled while a setting item that requires direct numeric input is highlighted because pressing a number or letter key displays an input dialog. Option Numbers are dimmed when they are disabled.



Using the Screen Capture Function

To capture what is displayed on the screen, press ⬆ ⑩ (). “Capt01” (where “01” is a number from 01 to 20) will appear in the center of the screen when the capture is successful.



The captured image file is saved in the Storage Memory “Capt” folder.

Captured Image Storage Format

Captured images can be saved as either .g4p (default) or .bmp images. For details, see “Specifying the Image Capture Format (Capture Format)” (page 201).

Viewing Captured Images

You can view the captured images in the “Capt” folder by displaying the Memory app’s Storage Memory tab. For details, see “Using the Storage Memory Tab” (page 196).

Using Captured Images

An image saved in .g4p format can be used as a graph window background (“Background (Graph)” (page 219)). Images saved in bmp format can be used by transferring them to a PC (“Connecting the Calculator to a Computer” (page 210)).

Conditions When Capture Cannot be Performed

Pressing ⬆ ⑩ () when any of the conditions below exists causes  to appear in the center of the screen, indicating that capture cannot be performed.

- When there is insufficient Storage Memory available.
- When you attempt to save a bmp image while all of the available bmp file names (Capt01.bmp to Capt20.bmp) are in use.
- When you attempt to save a g4p image while all of the available g4p file names (Capt01.g4p to Capt20.g4p) are in use.
- When there is insufficient battery power.
- When you are in an Exam Mode.

Before Assuming Malfunction

If a problem continues to occur, try performing the steps below starting from ①.

① **Reset your calculator's settings.**

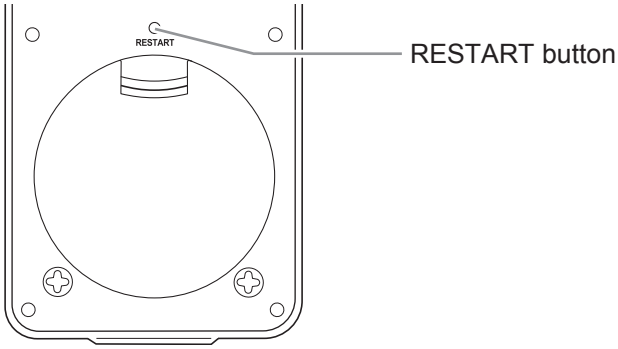
(1) ⌂ > System
(2) Select [Reset] > [Settings].
(3) On the dialog that appears, select [OK].

If this does not resolve the problem, try step ②.

② **Press the RESTART button to restart your calculator.**

Important!

- When you press the RESTART button to restart the calculator, data already stored in the memory of the calculator is normally retained. However, data that is being edited or data that is being entered but not yet finalized at the time RESTART is pressed is not retained.



After you press the RESTART button, configure all of the following settings that appear sequentially on the screen: Language, Country (fx-CG100 only), Display Settings, Power Properties, Battery Settings.

For information about each setting, see "System App" (page 199).

If this does not resolve the problem, try step ③.

③ **Reset calculator memory.**

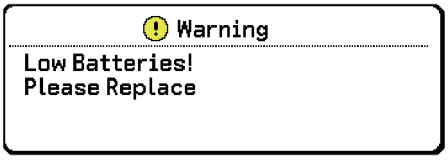
Before performing the operation below, make sure to copy any important data stored in the calculator. Step (2) deletes all the data in your calculator's Main Memory. Step (3) returns all calculator settings to their initial defaults and erases all data in Main Memory and Storage Memory.

(1) ⌂ > System
(2) Execute [Reset] > [Main Memory].
(3) If the operation does not improve, execute [Reset] > [Initialize All].

For information about the reset operation, see "Resetting the Calculator (Reset)" (page 199).

Low Battery Warning

If the Low Battery Warning below appears, immediately turn off your calculator and replace its batteries.



Important!

- If you continue to use your calculator without replacing the batteries after the low battery warning appears, it will automatically turn off to protect memory contents, and you will not be able to turn it on again.
- Leaving the unit without replacing the batteries after the low battery warning appears may cause the memory contents to be cleared.
- After the low battery warning appears, you will not be able to transfer data to a computer until you replace the batteries.

Using Apps

Calculate App

Calculate is an app that lets you use various types of functions to input and execute various functions. It supports the use of real numbers, complex numbers, vectors, matrices, and lists.

Basic Calculation Operations

Starting a Calculation

1. (MENU) > Calculate
   - The cursor appears at the far left of the input box on the Calculation tab.
2. Enter the calculation formula and press (EXE).
   - The calculation result appears on the next line, right justified.

Example Calculations

Arithmetic Calculation	$7 \times 8 - 4 \times 5 = 36$	7 (×) 8 (−) 4 (×) 5 (EXE)	7×8−4×5 36
Minus Sign	$-8 \times 7 - (-6) = -50$	(SHIFT) (−) ((−)) 8 (×) 7 (−) (SHIFT) (−) ((−)) 6 (EXE)	-8×7−-6 -50
Fractions	$\frac{2}{3} + 1\frac{1}{2} = \frac{13}{6}$	2 (▤) 3 (▷) (+) (SHIFT) (▤) (■ ▤) 1 (▷) 1 (▽) 2 (EXE)	$\frac{2}{3}+1\frac{1}{2}$ $\frac{13}{6}$

To clear the calculation you are entering

Press (AC).

To clear all Calculation tab contents

While the cursor is located at the far left of the input box in a line that has nothing input, press (AC).

Using the Latest Calculation Result (Ans)

The latest calculation result is stored in a variable named Ans. You can input the Ans variable into a new calculation by pressing (ALPHA) (FORMAT) (Ans).

Example:

4 (×) 20 (EXE)
(√■) (ALPHA) (FORMAT) (Ans) (EXE)

Pressing (×), (÷), (+), (−) operator key at the beginning of a new calculation automatically inputs the Ans variable followed by the corresponding operator.

Example:

5 (×) 30 (EXE)
(×) 4 (EXE)

Ans is automatically entered when you press (■□) or (■²), or when you enter a function that takes an argument immediately before it (such as $n!$ or $_nP_r$, etc.)

Using Calculation History

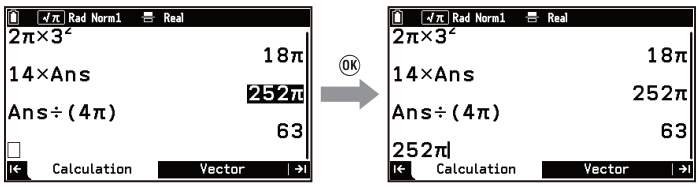
The Calculation tab stores up to 30 sets (calculation line and result) of recent calculation history.

To edit and re-execute a calculation line in calculation history

Use (▽)/(△) to highlight the calculation line you want to edit. Press (◁)/(▷) to display the cursor in the calculation line and then edit the formula. After editing, press (EXE) to recalculate all subsequent calculation lines and update the result line.

To copy the result line of a calculation history and insert it into a new formula

Highlight the calculation history result line (result line with numerical values) you want to copy and then press (OK). This will copy the line to the clipboard (see "Copying, Cutting, and Pasting Expressions" (page 10)).



This operation cannot be performed in the cases described below.

- If the result line is in vector, matrix, or list form (In this case, pressing (OK) displays the Ans window.*)
- If the result line is such that it cannot be entered in a formula (For example, the result of a calculation using "▶Simp" (page 223) "$F = 4, \frac{1}{4}$," etc.)

* For information about the Ans window, see "Vct Ans" (page 23), "Mat Ans" (page 26), and "List Ans" (page 28).

To delete a calculation history set

Highlight either the calculation line or result line of the calculation history set you want to delete and then select (⋯) > [Delete Line].

To clear calculation history

Select (⋯) > [Delete All].

> **Note**
>
> - Changing the (≡) > [$\sqrt{\pi}$ Result] setting also clears calculation history.

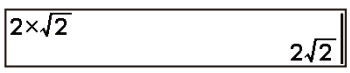
Toggling Calculation Results between Standard (Fraction, π, $\sqrt{}$ Form) and Decimal

Each press of (FORMAT) while a calculation result is displayed toggles the result between the following two forms:

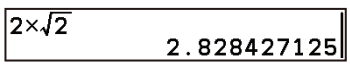
- a form that includes fraction, π, or $\sqrt{}$
- decimal form

Operation Example:

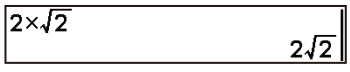
2 (×) (√■) 2 (EXE)



(FORMAT)



(FORMAT)



> **Note**
>
> - Toggling calculation result display formats by pressing only (FORMAT) is supported when "a b/c π √ ↔ Decimal" (initial default) is selected for the (≡) > [FORMAT Key] (page 220) setting. If "Format Menu" is selected for the (≡) > [FORMAT Key] setting, press (⇧) (FORMAT).

Changing the Display Format of Calculation Results (Format Menu)

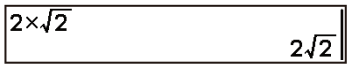
Pressing (Shift) (FORMAT)*1 displays the Format menu, which you can use to change the display format of calculation results.

Pressing (Shift) (FORMAT) and selecting this:	Does this:
$\square\frac{\square}{\square}\pi\sqrt{}$ (Standard) ↔ Decimal	Switches the displayed calculation result between standard form*2 and decimal form. Conversion to standard form is enabled when (Menu) > [$\sqrt{}\pi$ Result] > [On].*3
$\blacksquare\square\frac{\square}{\square}$ ↔ $\square\frac{\square}{\square}$	Switches the displayed calculation fraction result between mixed fraction and improper fraction form. If the displayed calculation result is in decimal form, selecting this form converts it to a fraction if conversion is possible.
Sexagesimal	Converts the displayed calculation result to degrees/minutes/seconds (sexagesimal) form.
ENG Notation Reverse ENG Notation	Converts the displayed calculation result to engineering notation form ($a \times 10^n$ form, where n is an integer multiple of 3). Each time you select [ENG Notation], the current decimal point position in the mantissa is shifted three places to the right (exponent is decreased by 3). Each time you select [Reverse ENG Notation], the current decimal point position in the mantissa is shifted three places to the left (exponent is increased by 3).

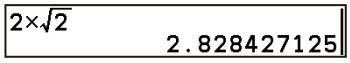
*1 When "$\square\frac{\square}{\square}\pi\sqrt{}$ ↔ Decimal" is selected for (Menu) > [FORMAT Key] (page 220) (initial default).
*2 Form that includes a fraction, π, or $\sqrt{}$
*3 Display ranges of conversions are limited. For information about the displays ranges of the fraction form and $\sqrt{}$ form of the calculator's calculation results, see "Fraction Form Calculation Results" (page 17) and "$\sqrt{}$ Form Calculation Range" (page 18).

Operation Example:

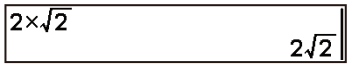
2 (×) (√) 2 (EXE)



(Shift) (FORMAT) > [$\square\frac{\square}{\square}\pi\sqrt{}$ (Standard) ↔ Decimal]



(Shift) (FORMAT) > [$\square\frac{\square}{\square}\pi\sqrt{}$ (Standard) ↔ Decimal]



Note

- Display format changes using the Format menu are also applied to the cell details.
- After entering a formula, pressing (Shift) (EXE) (≈) instead of (EXE) displays the calculation results in decimal form.

Fraction Form Calculation Results

How the calculator displays a fraction calculation result (fraction form or decimal form) depends on the number of places required to express the result in linear form. The number of places is counted as shown below.

Proper fraction: $\frac{1}{2}$ = 1⌟2

Three places. Two places digits for the numerator and denominator, one place for the separator (⌟).

Improper fraction: $\frac{3}{2} = 1\frac{1}{2}$ = 1⌟1⌟2

Five places. Three places for the integer, numerator, and denominator, and two places for the separators.

If the linear form of the calculation result has 10 digits or fewer, it is displayed in fraction form as shown in Example 1 below. If it has 11 or more digits, it is displayed in decimal form as shown in Example 2 below.

Example 1: $1\frac{1}{123456} = \frac{123457}{123456}$ (Natural form) 1⌟1⌟123456 = 123457⌟123456 (Linear form)

[SHIFT] [≡] (■/□) 1 [>] 1 [∨] 123456 [EXE]

```
1 1/123456
        123457/123456
```

Example 2: $1\frac{1}{1234567}$ = 1.00000081 (Natural form)   1⌟1⌟1234567 = 1.00000081 (Linear form)

[SHIFT] [≡] (■/□) 1 [>] 1 [∨] 1234567 [EXE]

```
1 1/1234567
        1.00000081
```

√ Form Calculation Range

The allowable display ranges of the √ form calculation result are shown below.

$\pm a\sqrt{b}, \pm d \pm a\sqrt{b}, \pm\frac{a\sqrt{b}}{c} \pm \frac{d\sqrt{e}}{f}$ $1 \leq a < 100,\ 1 < b < 1000,\ 1 \leq c < 100$
$0 \leq d < 100,\ 0 \leq e < 1000,\ 1 \leq f < 100$

Example: $10\sqrt{2} + 15 \times 3\sqrt{3} = 45\sqrt{3} + 10\sqrt{2}$ ... Displayed in √ form
$99\sqrt{999}\ (= 297\sqrt{111}) = 3129.089165$ ... Displayed as a decimal value

Using Alpha Variables

Alpha variables are used for temporary storage of numerical values. There are 28 variables, named A through Z, r, and θ.

To display the contents of an alpha variable

Select [⇐x] > [Alpha].

To assign a value to an alpha variable

Syntax: Value → Alpha Variable

Alpha variables can be entered using key or menu operations.

Example: To assign 5 to alpha variable A

Key operation: 5 [SHIFT] [x] (→) [ALPHA] [x] (A) [EXE]

```
5→A
    5
```

Menu operation: 5 [SHIFT] [x] (→) [⇐x] > [Alpha] > [A] [EXE]

```
5→A
    5
```

To batch assign the same value to several consecutive alpha variables

Example: To batch assign 10 to alpha variables A through F

10 [SHIFT] [x] (→) [ALPHA] [x] (A)
[📖] > [All] > [Symbol] > [~] [ALPHA] [e■] (F) [EXE]

```
10→A~F
    10
```

To use an alpha variable in a formula

Example: To calculate $\frac{B+A}{B-A}$ when A = 5 and B = $\sqrt{5}$

[≡] [ALPHA] [≡] (B) [+] [ALPHA] [x] (A) [∨]
[ALPHA] [≡] (B) [−] [ALPHA] [x] (A) [EXE]

```
B+A
B−A
    −(3+√5)/2
```

> **Note**
>
> - Assigning a value to an alpha variable also updates Ans with that value.
> - The x that is entered by pressing [x] is the same as alpha variable X.
> - A value is saved to a variable in accordance with the settings of [☰] > [Angle] and [☰] > [Complex Mode] in effect at the time the value is saved.

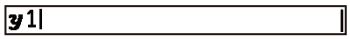
Using Function Variables

Functions saved on the Function tab of the "Graph&Table App" (page 75) can be used with the Calculate app.

Example: To recall the function assigned to function variable $y1$ ($y1 = 3x$), assign a value of 10 to variable x, and determine the value of $y1$

1. [x] > [Function]

2. Highlight [$y1$] and then press [OK].



3. Enter the value to be assigned and then press [EXE].

(10) [EXE]

Note

- Entering only "$y1$" and pressing [EXE] assigns the value currently assigned to variable x.

Scientific Function Calculations

All built-in functions can be entered from the Catalog menu, which you can display by pressing [catalog]. For details, see "Catalog Menu Details" (page 221). The table below shows example function calculations that can be entered directly using keys.

Calculation Examples ([menu] > [Angle] > [Radian]*1)

Trigonometric Functions*1	$\cos\frac{\pi}{3}=\frac{1}{2}$	[cos] [▤] [↑] 7 (π) [▽] 3 [▷]) [EXE]	$\cos\left(\frac{\pi}{3}\right)=\frac{1}{2}$
Inverse Trigonometric Functions*1	$\sin^{-1}0.5=\frac{1}{6}\pi$	[↑] [sin] ($\sin^{-1}$) 0 . 5) [EXE]	$\sin^{-1}(0.5)=\frac{1}{6}\pi$
Powers	$(5^2)^3=15625$	(5 [x^2]) [$\square^{\square}$] 3 [EXE]	$(5^2)^3=15625$
Power of 10	$\frac{4\times10^7}{3\times10^8}=\frac{2}{15}$	[▤] 4 [EXP] 7 [▽] 3 [EXP] 8 [EXE] *2	$\frac{4\times10^7}{3\times10^8}=\frac{2}{15}$
		4 [EXP] 7 [▤] 3 [EXP] 8 [EXE] *3	$\frac{4\times10^7}{3\times10^8}=\frac{2}{15}$
		4 [EXP] 7 [▷] [▤] 3 [EXP] 8 [EXE] *4	$\frac{4\times10^7}{3\times10^8}=\frac{2}{15}$
Power Roots	$\sqrt{2}\times3=3\sqrt{2}$	[$\sqrt{\square}$] 2 [▷] [×] 3 [EXE]	$\sqrt{2}\times3=3\sqrt{2}$
	$\sqrt[5]{32}=2$	[↑] [$\sqrt{\square}$] ([$\sqrt[\square]{\square}$]) 5 [▷] 32 [EXE]	$\sqrt[5]{32}=2$
Logarithms	$\log1000=3$	[↑] [x^2] (log) 1000) [EXE]	$\log(1000)=3$
	$\log_2 16=4$	[↑] [$\square^{\square}$] ([$\log_{\square}\square$]) 2 [▷] 16 [EXE]	$\log_2(16)=4$
Base of Natural Logarithms	$e^{4.5}=90.0171313$	[$e^{\square}$] 4 . 5 [EXE]	$e^{4.5}=90.0171313$

Natural Logarithms	ln (90) = 4.49980967	(Shift) (e) (ln) 90) (EXE)	ln(90) 4.49980967
Pi (π)	π = 3.141592654	(Shift) (7) (π) (Shift) (EXE) ($\approx$)*5	π 3.141592654

*1 When using trigonometric or inverse trigonometric functions, be sure to specify the angle unit ((Menu) > [Angle]).

*2 When (Menu) > [×10■Key] > [×10□ (Power)] is selected. The "× 10□" entered by pressing (×10ˣ) is the same as when you press (×) (1) (0) (□). Because of this, executing $4 \times 10^7 \div 3 \times 10^8$ causes the calculation to be performed sequentially from left to right, which produces a different calculation result than the one in the above example (using fractions). To obtain the same calculation result, each term needs to be enclosed in parentheses: $(4 \times 10^7) \div (3 \times 10^8)$.

*3 When (Menu) > [×10■Key] > [×10 (Sci Notation)] is selected. At this time, pressing (×10ˣ) and using the ×10 function that is input to execute $4\times10^7 \div 3\times10^8$ will produce the same calculation result as in the calculation example above.

*4 When (Menu) > [×10■Key] > [×10□ (Sci Notation)] is selected (default setting). At this time, pressing (×10ˣ) and using the ×10□ function that is input to execute $4\times10^7 \div 3\times10^8$ will produce the same calculation result as in the calculation example above.

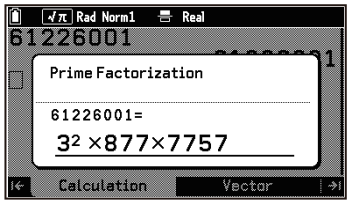
*5 Pressing (Shift) (EXE) ($\approx$) in place of (EXE) will display the calculation result in decimal form.

Prime Factorization

You can use the Calculate app to perform prime factorization on integers 2 or greater and with fewer than 10 digits.

Example: To perform prime factorization on 61226001

61226001 (EXE)
(Option) > [Prime Factorization]



- The Prime Factorization dialog is display-only. Its values cannot be edited or copied.
- To close the Prime Factorization dialog, press (Back) or (AC).

Note

- You can also prime factorize a number by highlighting the result line in calculation history (page 16) and selecting (Option) > [Prime Factorization].

Complex Number Calculations

You can use the Calculate app to perform the operations described below.

- Complex number input into calculations

To input the rectangular form $1 + i$: 1 (+) (Shift) (9) (i) → 1+i

To enter the polar form $\sqrt{2}\angle\pi$: (√■) 2 (>) (Shift) (8) (∠) (Shift) (7) (π) → √2∠π

- Imaginary solution display

An imaginary solution is displayed as shown below, depending on the (Menu) > [Complex Mode] setting.

[Real] ... Real number: $\sqrt{-1}$ = "Non-Real ERROR" (non-real number error)*1

[a+bi] ... Rectangular form: $\sqrt{-1} = i$

[r∠θ] ... Polar form: $\sqrt{-1} = 1\angle\frac{1}{2}\pi$*2

- Absolute value, argument of complex, conjugate complex number, real and imaginary part calculation, and polar and rectangular form conversion

For these calculations, see the "Complex Number" (page 229) section of "Catalog Menu Details" (page 221).

*1 When the argument is a real number and the solution is an imaginary number. If the argument is a complex number (such as $\sqrt{i}$), the calculation result is the same as if ☰ > [Complex Mode] were set to [a+b*i*].

*2 When ☰ > [Angle] > [Radian]. The display range of θ is as follows, depending on the ☰ > [Angle] setting.
Degree: $-180 < \theta \leq 180$ Radian: $-\pi < \theta \leq \pi$ Gradian: $-200 < \theta \leq 200$

Vector Calculations

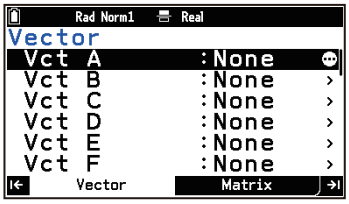
Your calculator is provided with vector variables (Vct A to Vct Z, Vct Ans) for vector calculations.

Storing Vector Variables

When using vector variables in calculations, you can store the necessary vectors for the calculation in vector variables Vct A to Vct Z as required. For example, if you want to calculate [1 2] + [3 4] and [1 2] − [3 4], store [1 2] in Vct A and [3 4] in Vct B. Next, you can execute the operations Vct A+Vct B and Vct A-Vct B.
The dimension of the vector can be specified within 999 rows by 1 column or 1 row by 999 columns.

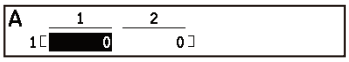
Example: To store the 1-row × 2-column vector [4 8] in Vct A

1. While the Calculation tab is active, press ⇥.
   • This displays the Vector list on the Vector tab.

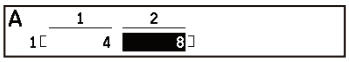


2. Highlight [Vct A] and choose ○○○ > [Dimension].

3. In the dialog that appears, perform the following operation to specify one row and two columns: 1 EXE 2 EXE OK.
   • This displays the Vct A input window.



4. Perform the following operation to enter the elements of the vector: 4 EXE 8 EXE.

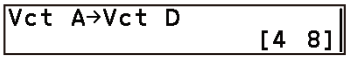


5. Press ⮌ or OK to return to the Vector list.

To assign a vector variable to another vector variable

Example: To assign Vct A to Vct D, input "Vct A → Vct D" on the Calculation tab.

⇦ > [Vector] > [Vct A]
⬆ X,θ,T (→) ⇦ > [Vector] > [Vct D] EXE



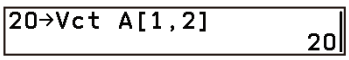
> **Note**
> • Vector variables can be assigned to matrix variables. For example, "Vct A → Mat A" assigns Vct A to Mat A.

To assign (overwrite) a value to a specific element of a vector variable

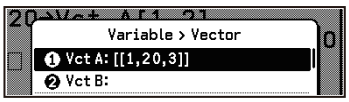
Syntax: value being assigned → vector name [row number,column number]

Example: To assign 20 to the element in row 1, column 2 of Vct A when Vct A = [1,2,3]

20 ⬆ X,θ,T (→) ⇦ > [Vector] > [Vct A]
⬆ 4 ([) 1 , 2 ⬆ 5 (]) EXE



To check the current contents of Vct A: ⇦ > [Vector]

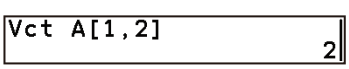


To recall the value of a specific element of a vector variable

Syntax: vector name [row number,column number]

Example: To recall the element at row 1, column 2 when Vct A = [1,2,3]

⇦ > [Vector] > [Vct A] ⬆ 4 ([) 1 , 2 ⬆ 5 (]) EXE



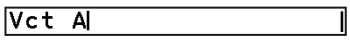
Inputting a Vector into a Calculation

To use a vector, you can use any one of the methods described below to input it into a calculation.

Method 1: Using the name of the vector variable

Example: To input "Vct A"

(⊞) > [Vector] > [Vector] (ALPHA) (x/θ/Y) (A)



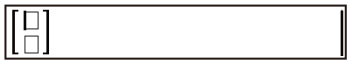
> **Note**
> • You can input either an upper-case X ((ALPHA) (+) (X)) or lower-case x ((x/θ/Y)) for vector variable "Vct X". Both "Vct X" and "Vct x" refer to the same vector variable.

Method 2: Using a template

Vectors with up to 6 rows and 1 column or up to 6 columns and 1 row can be input using a template.

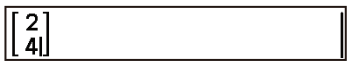
Example: To input the 2-row × 1-column vector $\begin{bmatrix}2\\4\end{bmatrix}$.

1. While the Calculation tab is active, select (⊞) > [m×n].
2. In the dialog that appears, perform the following operation to specify two rows and one column: 2 (EXE) 1 (EXE) (OK).
   • This displays a 2-row × 1-column template.



3. Use the template to enter values.

2 (▼) 4



Method 3: Using linear input form

To input this:	Use this form:
m-row × 1-column vector $\begin{bmatrix}a_{11}\\a_{21}\\\cdots\\a_{m1}\end{bmatrix}$	$[[a_{11}][a_{21}]\cdots[a_{m1}]]$
1-row × n-column vector $[a_{11}\ a_{12}\ \cdots\ a_{1n}]$	$[[a_{11}, a_{12},\ \cdots a_{1n}]]$

The maximum value of both m and n is 999.

Example: To input the 1-row × 3-column vector [1 2 3].

(▲) (4) ([]) (▲) (4) ([]) 1 (,) 2 (,) 3 (▲) (5) (]) (▲) (5) (])

Using Vectors in Calculations

Your calculator supports the types of vector calculations.

- Addition, subtraction, and multiplication of two vectors, and scalar multiplication of one vector.
  These types of calculations are performed by entering vectors and operators. Examples of how to perform these calculations are provided below.
- Dot product, cross product, norm (magnitude) of a vector, angle between two vectors, unit vector.
  For these calculations, see the "Vector" (page 227) section of "Catalog Menu Details" (page 221).

> **Note**
> • The calculation precision of displayed results for vector calculations is ±1 at the least significant digit.

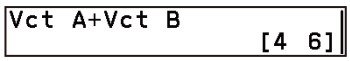
Vector Calculation Examples

The examples here show the various input methods based on the following vector addition: [1 2] + [3 4] = [4 6].

Using vector variables

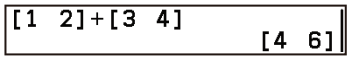
Input [1 2] in Vct A and [3 4] in Vct B and then perform the operations below.

(⏎) > [Vector] > [Vct A] (+)
(⏎) > [Vector] > [Vct B] (EXE)



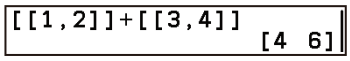
Using a template

(⋯) > [m×n]1 (EXE) 2 (EXE) (OK) 1 (>) 2 (>) (+)
(⋯) > [m×n] (∨) (∨) (OK) 3 (>) 4 (EXE)



Using linear input form

(⬆) (4) ([]) (⬆) (4) ([]) 1 (,) 2 (⬆) (5) (]) (⬆) (5) (]) (+)
(⬆) (4) ([]) (⬆) (4) ([]) 3 (,) 4 (⬆) (5) (]) (⬆) (5) (]) (EXE)



Vct Ans

Vct Ans is a variable that stores the latest vector calculation result. Whenever a calculation result is in vector form, Vct Ans contents are overwritten with that result. Note that the contents of the “Mat Ans” (page 26) variable are also overwritten with the result of each vector calculation.

Calculation results less than 256 bytes are displayed on the Calculation tab, but calculation results equal to or more than 256 bytes are displayed in the Ans window. While the Ans window is displayed, pressing (↩) returns to the Calculation tab with the result line displayed as “Mat/Vct Result”.

Note

- Assigning a vector variable to another vector variable does not affect Vct Ans contents.
- If a vector calculation result is too large to fit into Vct Ans, an error occurs.

Using the Vector Tab

With the Vector tab, you can edit vector variables Vct A through Vct Z, and Vct Ans.

Vector List Operations

To do this:	Select this menu item:
Specify the dimension of the highlighted vector variable.	(⋯) > [Dimension]
Delete the contents of the highlighted vector variable.	(⋯) > [Delete]
Clear the contents of all vector variables.	(⋯) > [Delete All]

Vector Input Window Operations

To do this:	Select this menu item:
Delete the highlighted row.	(⋯) > [Row] > [Delete]
Insert one row before the highlighted row.	(⋯) > [Row] > [Insert]
Add one row after the highlighted row.	(⋯) > [Row] > [Add]
Delete the highlighted column.	(⋯) > [Column] > [Delete]
Insert a column before the highlighted column.	(⋯) > [Column] > [Insert]
Add a column after the highlighted column.	(⋯) > [Column] > [Add]
Edit the contents of the highlighted cell.	(⋯) > [Edit]

Matrix Calculations

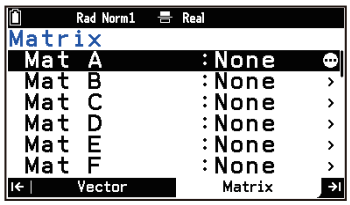
Your calculator is provided with matrix variables (Mat A to Mat Z, Mat Ans) for matrix calculations.

Storing Matrix Variables

When using matrix variables in calculations, you can store the necessary matrices for the calculation in matrix variables Mat A to Mat Z as required. For example, if you want to calculate $\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}+\begin{bmatrix}2 & 6\\4 & 8\end{bmatrix}$ and $\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}-\begin{bmatrix}2 & 6\\4 & 8\end{bmatrix}$, store $\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}$ in Mat A and $\begin{bmatrix}2 & 6\\4 & 8\end{bmatrix}$ in Mat B. Next, you can execute the operations Mat A+Mat B and Mat A−Mat B.
The number of both rows and columns of the matrix can be specified within 999.

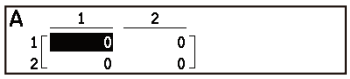
Example: To store the 2-row × 2-column matrix $\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}$ in Mat A

1. While the Calculation tab is active, press ⏎.
   • This displays the Matrix list on the Matrix tab.

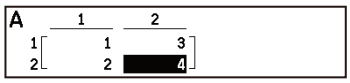


2. Highlight [Mat A], and then select ⋯ > [Dimension].

3. In the dialog that appears, perform the following operation to specify two rows and two columns: 2 EXE 2 EXE OK.
   • This displays the Mat A input window.



4. Perform the following operation to enter the elements of the matrix: 1 EXE 3 EXE 2 EXE 4 EXE.

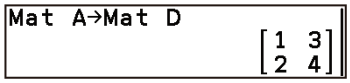


5. Press ↩ or OK to return to the Matrix list.

To assign a matrix variable to another matrix variable

Example: To assign Mat A to Mat D, input “Mat A → Mat D” on the Calculation tab.

⏎ > [Matrix] > [Mat A]
⇧ ab/c (→) ⏎ > [Matrix] > [Mat D] EXE



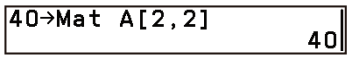
> **Note**
> • A matrix variable with 1 row and n columns or m rows and 1 column can be assigned to a vector variable. For example, “Mat A → Vct A” assigns Mat A to Vct A.

To assign (overwrite) a value to a specific element of a matrix variable

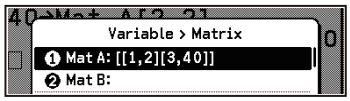
Syntax: value being assigned → matrix name [row number,column number]

Example: To assign 40 to the element in row 2, column 2 of Mat A when Mat A = $\begin{bmatrix}1 & 2\\3 & 4\end{bmatrix}$

40 ⇧ ab/c (→) ⏎ > [Matrix] > [Mat A]
⇧ 4 ([) 2 , 2 ⇧ 5 (]) EXE



To check the current contents of Mat A: ⏎ > [Matrix]

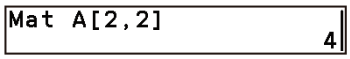


To recall the value of a specific element of a matrix variable

Syntax: matrix name [row number,column number]

Example: To recall the element at row 2, column 2 when Mat A = $\begin{bmatrix}1 & 2\\3 & 4\end{bmatrix}$

⏎ > [Matrix] > [Mat A] ⇧ 4 ([) 2 , 2 ⇧ 5 (]) EXE



Inputting a Matrix into a Calculation

To use a matrix, you can use any one of the methods described below to input it into a calculation.

Method 1: Using the name of the matrix variable

Example: To input “Mat A”

(MENU) > [Matrix] > [Matrix] (ALPHA) (x) (A)

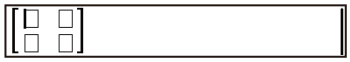
> **Note**
> • You can input either an upper-case X ((ALPHA) (+) (X)) or lower-case x ((x)) for matrix variable “Mat X”. Both “Mat X” and “Mat x” refer to the same matrix variable.

Method 2: Using a template

A matrix with up to 6 columns and 6 row can be input using a template.

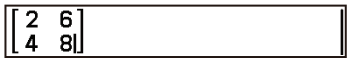
Example: To input the 2-row × 2-column matrix $\begin{bmatrix} 2 & 6 \\ 4 & 8 \end{bmatrix}$.

1. While the Calculation tab is active, select (QUICK) > [m×n].
2. In the dialog that appears, perform the following operation to specify two rows and two columns: 2 (EXE) 2 (EXE) (OK).
   • This displays a 2-row × 2-column template.



3. Use the template to enter values.

2 (>) 6 (>) 4 (>) 8



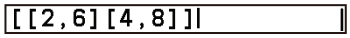
Method 3: Using linear input form

To input this:	Use this form:
m-row × n-column matrix $\begin{bmatrix} a_{11} & a_{21} & \cdots & a_{m1} \\ a_{21} & a_{22} & \cdots & a_{m2} \\ \cdots & \cdots & \cdots & \cdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$	$[[a_{11},a_{21}, \cdots ,a_{m1}][a_{12},a_{22}, \cdots ,a_{m2}] \cdots [a_{m1},a_{m2}, \cdots ,a_{mn}]]$

The maximum value of both m and n is 999.

Example: To input the 2-row × 2-column matrix $\begin{bmatrix} 2 & 6 \\ 4 & 8 \end{bmatrix}$.

(SHIFT) (4) ([]) (SHIFT) (4) ([]) 2 (,) 6 (SHIFT) (5) (])
(SHIFT) (4) ([]) 4 (,) 8 (SHIFT) (5) (]) (SHIFT) (5) (])



Using Matrices in Calculations

Your calculator supports the types of matrix calculations.

- Addition, subtraction, and multiplication of two matrices, and scalar multiplication, squaring, powers, absolute value, and complex number calculations of a single matrix.
  These types of calculations are performed by entering matrices and operators. Examples of how to perform these calculations are provided below.
- Matrix inversion, determinant, matrix transposition, identity matrix, row echelon form of a matrix, reduced row echelon form of a matrix.
  For these calculations, see the “Matrix” (page 227) section of “Catalog Menu Details” (page 221).

> **Note**
> • The calculation precision of displayed results for matrix calculations is ±1 at the least significant digit.

Matrix Calculation Examples

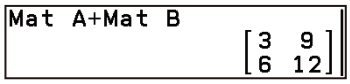
The examples here show the various input methods based on the following matrix addition:

$$\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}+\begin{bmatrix}2 & 6\\4 & 8\end{bmatrix}=\begin{bmatrix}3 & 9\\6 & 12\end{bmatrix}.$$

Using matrix variables

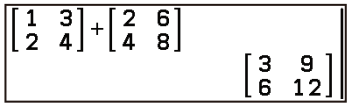
Input $\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}$ in Mat A and $\begin{bmatrix}2 & 6\\4 & 8\end{bmatrix}$ in Mat B and then perform the operations below.

(shift) > [Matrix] > [Mat A] (+)
(shift) > [Matrix] > [Mat B] (EXE)



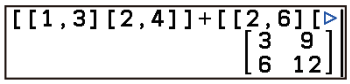
Using a template

(menu) > [m×n] 2 (EXE) 2 (EXE) (OK) 1 (>) 3 (>) 2 (>) 4 (>) (+)
(menu) > [m×n] (v) (v) (OK) 2 (>) 6 (>) 4 (>) 8 (EXE)



Using linear input form

(^) 4 ([) (^) 4 ([) 1 (,) 3 (^) 5 (]) (^) 4 ([) 2 (,) 4 (^) 5 (]) (^) 5 (]) (+)
(^) 4 ([) (^) 4 ([) 2 (,) 6 (^) 5 (]) (^) 4 ([) 4 (,) 8 (^) 5 (]) (^) 5 (]) (EXE)



Mat Ans

Mat Ans is a variable that stores the latest matrix calculation result. Any time a calculation result is in matrix form, Mat Ans contents are overwritten that result. Whenever a matrix calculation result is a 1-row × n-column or m-row × 1-column matrix, the contents of the "Vct Ans" (page 23) variable are also overwritten with the result of that matrix calculation.

Calculation results less than 256 bytes are displayed on the Calculation tab, but calculation results equal to or more than 256 bytes are displayed in the Ans window. While the Ans window is displayed, pressing (back) returns to the Calculation tab with the result line displayed as "Mat Result".

Note

- Assigning a matrix variable to another matrix variable does not affect Mat Ans contents.
- If a matrix calculation result is too large to fit into Mat Ans, an error occurs.

Using the Matrix Tab

With the Matrix tab, you can edit matrix variables Mat A through Mat Z, and Mat Ans.

Matrix List Operations

To do this:	Select this menu item:
Specify the dimension of the highlighted matrix variable.	(menu) > [Dimension]
Load a CSV format file into the highlighted matrix variable.*	(menu) > [CSV] > [Load]
Save the contents of the highlighted matrix variable to a CSV format file.*	(menu) > [CSV] > [Save As]
Delete the contents of the highlighted matrix variable.	(menu) > [Delete]
Clear the contents of all matrix variables.	(menu) > [Delete All]

* For details, see "Using CSV Files" (page 244).

Matrix Input Window Operations

To do this:	Select this menu item:
Select two rows and swap their elements.	(menu) > [Row Operation] > [Swap]*

Replace each element of a specified row with the scalar multiple of that row.	⋯ > [Row Operation] > [*Row]*
Add the scalar multiples of each element of a specified row to each element of another row.	⋯ > [Row Operation] > [*Row+]*
Add each element of a specified row to each element of another specified row.	⋯ > [Row Operation] > [Row+]*
Delete the highlighted row.	⋯ > [Row] > [Delete]
Insert one row before the highlighted row.	⋯ > [Row] > [Insert]
Add one row after the highlighted row.	⋯ > [Row] > [Add]
Delete the highlighted column.	⋯ > [Column] > [Delete]
Insert a column before the highlighted column.	⋯ > [Column] > [Insert]
Add a column after the highlighted column.	⋯ > [Column] > [Add]
Edit the contents of the highlighted cell.	⋯ > [Edit]

* Selecting this menu item displays a dialog for specifying row(s) and/or value(s).

List Calculations

Your calculator is provided with list variables (List 1 to List 26, List Ans) for list calculations.

Storing List Variables

You can use any one of the methods below to store list variables.

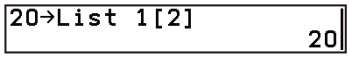
- **Method 1:** Using Statistics app's List Editor tab to create a list variable.
- **Method 2:** Using the Calculate app to assign a list to a list variable
  Example 1: {1,2,3} → List 1
  Example 2: List 1 → List 2 (Assigns the contents of List 1 to List 2.)
- **Method 3:** Using the Graph&Table app or the Table tab of the Recursion app to assign a single column of a number table to a list variable

To assign (overwrite) a value to a specific element of a list variable

Syntax: value being assigned → list name [element number]

Example: To assign 20 to Element 2 of the following list: List 1 = {1,2,3,4,5}

20 ⬆ (→) > [List] > [List 1]
⬆ 4 ([) 2 ⬆ 5 (]) EXE



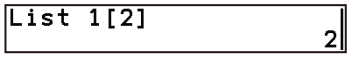
To check the current contents of List 1: > [List]

To recall the value of a specific element of a list variable

Syntax: list name [element number]

Example: To recall the element 2 when List 1 = {1,2,3}

> [List] > [List 1] ⬆ 4 ([) 2 ⬆ 5 (]) EXE



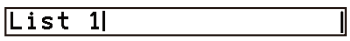
Inputting a List into a Calculation

To use a list, you can use any one of the methods described below to input it into a calculation.

Method 1: Using the name of a list variable

To input "List 1":

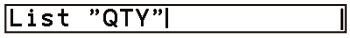
> [List] > [List 1], or > [Statistics] > [List] 1



Method 2: Inputting the sub-name of a list variable

To input a list variable with the sub-name* "QTY":

(menu) > [Statistics] > [List] "QTY"



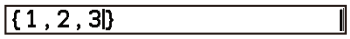
* For information about sub-names, see "Using the List Editor Tab" (page 31).

Method 3: Using linear input form ({1,2,3,…})

Select (menu) > [Statistics] > [{ }] followed by a comma-separated list of elements.

To input {1,2,3}:

(menu) > [Statistics] > [{ }] 1 (,) 2 (,) 3



Using Lists in Calculations

Your calculator supports the list calculations described below.

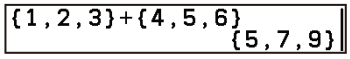
- Arithmetic operations between lists and values or between lists, and function calculations with lists as arguments

  {1,2,3}+{4,5,6}, {1,2,3}×2, $\{1,2,3\}^2$, $\sqrt{\{1,2,3\}}$, etc.

Example 1: {1,2,3}+{4,5,6}

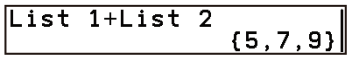
Using linear input form

(menu) > [Statistics] > [{ }] 1 (,) 2 (,) 3 (▶) (+)
(menu) > [Statistics] > [{ }] 4 (,) 5 (,) 6 (EXE)



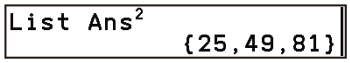
Using list variables (List 1 = {1,2,3}, List 2 = {4,5,6})

(←) > [List] > [List 1] (+)
(←) > [List] > [List 2] (EXE)



Example 2: To square the results of the above calculation

(x^2) (EXE)



- Calculations Using List Manipulation Functions

  Your calculator gives you the tools to create lists, manipulate elements, and calculate sums and means of the elements in a list. For details, see the "Statistics" (page 230) section of "Catalog Menu Details" (page 221).

List Ans

List Ans is a variable that stores the latest list calculation result. Whenever a calculation result is in list form, List Ans variable contents are overwritten with that result.

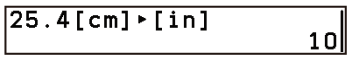
Calculation results less than 256 bytes are displayed in the result line on the Calculation tab, while results equal to or more than 256 bytes are displayed in the Ans window. While the Ans window is displayed, pressing (↩) returns to the Calculation tab with the result line displayed as "List Result".

Unit Conversions

You can convert a value from one unit to another. For details, see "Unit Conversions" (page 239).

Example: To convert 25.4 cm to inches

25 (.) 4 (menu) > [Unit Conversions] > [Length] > [[cm]]
(menu) > [Unit Conversions] > [▶]
(menu) > [Unit Conversions] > [Length] > [[in]] (EXE)

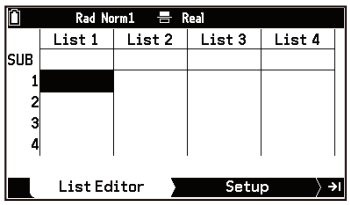


Statistics App

The Statistics app provides you with the tools you need to perform statistical calculations based on input data, to display summary statistics and regression model information, and to draw graphs. It also provides you with hypothesis testing and confidence interval capabilities.

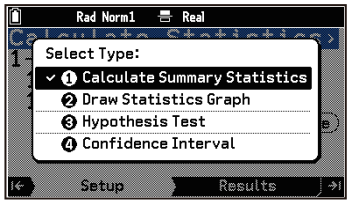
Selecting What You Want to Do with the Statistics App

1. (⌂) > Statistics
   - This enters the Statistics app with the List Editor tab active.



2. Press (⇥).
   - If this causes the Select Type menu to appear, go to step 4 of this procedure. Otherwise, go to step 3.

3. Highlight the first line of the Setup tab and then press (OK).



4. Use the menu to select what you want to do.

To do this:	Highlight this menu item:
Displaying Summary Statistics or Regression Model Information (page 32)*1	[Calculate Summary Statistics]
Drawing a Statistics Graph (page 35)*2	[Draw Statistics Graph]
Performing a Hypothesis Test (page 42)	[Hypothesis Test]
Find a Confidence Interval (page 49)	[Confidence Interval]

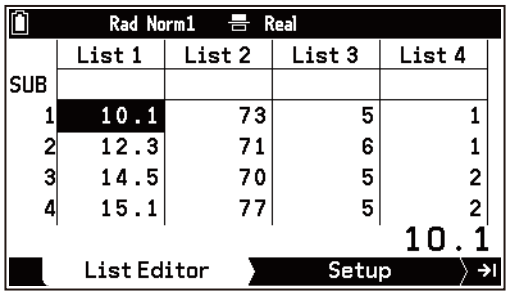
*1 Regression model information includes regression equations coefficients, coefficient of determination, etc.

*2 Scatter plots and regression graphs based on 2-Variable data, histograms and box-and-whisker diagrams based on 1-Variable data, etc.

5. Press (OK).
   - This displays on the Setup tab a menu of settings for the item you selected.

Inputting Data

The Statistics app's List Editor is an app-specific editor for inputting and editing statistical data. You can use List Editor to create up to 26 list variables (List 1 to List 26) at a time.



Create from one to three list variables, depending on the statistical data to be processed.*1

Statistical data:	Required list variable(s):
1-Variable (no frequencies)	One list variable to assign to XList*2
1-Variable (with frequencies)	Two list variables to assign to XList and Freq*2
2-Variable (no frequencies)	Two list variables to assign to XList and YList*2
2-Variable (with frequencies)	Three list variables to assign to XList, YList and Freq*2

*1 The method of statistical data creation for 1-Variable or 2-Variable statistical calculation is different from that for performing hypothesis tests (page 42) or finding confidence intervals (page 49).

*2 This calculator displays list data used for 1-Variable statistical calculations as XList, list data used for 2-Variable statistical calculations as XList and YList, and list data used for frequencies as Freq or Frequency.

Frequencies

There are two ways to input statistical data: with frequencies and without frequencies (1 is used for all data frequencies). You can specify which method you want to use on the Setup tab that appears when you press ⇥ in List Editor, as shown in the example below.

	
Uses List1 for data. Frequency of all data values: 1	Uses List1 for data. Uses List2 for frequencies.

Important!

- The values contained in a frequency list should be 0 or positive values only. Even a single negative value causes an error (Out of Domain).
- Statistical data with a frequency of 0 is not used for calculation of minimum and maximum values.

Inputting Data in List Editor

You can use either of the two methods below to input data in List Editor.

Individual cell input

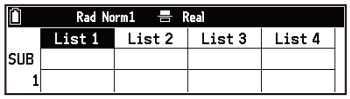
With this method, you input a value into a cell and then press EXE.

You can also input a calculation into a cell. If you do, the numeric value that is the result of the calculation is entered immediately after you press EXE.

Batch input using the form {1,2,3,...}

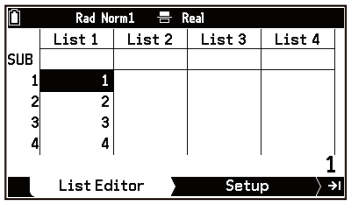
Example: To input {1,2,3,4,5}

1. Use the cursor keys to highlight the name of the list you want to use.



2. Select ⊞ > [Statistics] > [{}], input the value, and then press EXE.

1 , 2 , 3 , 4 , 5 EXE



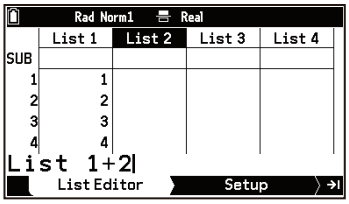
Assigning Other List Variables

You can assign List 1 data directly to List 2 or assign a list calculation (page 28) result to List 2.

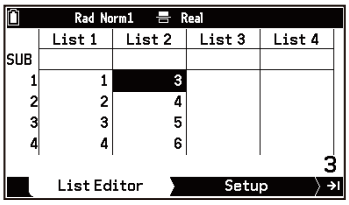
Example: To assign List 1+2 (adds 2 to each element of List 1) to List 2

1. Use the cursor keys to highlight list name List 2.
2. Input “List 1+2”.

(⊞) > [List] > [List 1]⊕2



3. Press (EXE).



Note

- You can also use the Calculate app to manipulate list variables. See "Storing List Variables" (page 27).

Using the List Editor Tab

To edit cell contents

To do this:	Perform this operation:
Replace the value of a cell	Highlight the cell and input a new value.
Edit the contents of a cell	Highlight the cell and then select (⋯) > [Edit].
Delete the contents of a cell	Highlight the cell and then select (⋯) > [Delete] > [One Value]. • This causes all the rows below the deleted cell to be shifted up one row.
Delete the contents of all cells in a particular list	Highlight any cell in the list whose cell contents you want to delete and then select (⋯) > [Delete] > [One List].
Delete all lists on the List Editor tab	Select (⋯) > [Delete] > [All Lists].
Insert a new cell	Select (⋯) > [Insert]. • This inserts a new cell that contains the value 0. All the cells below the inserted cell are shifted down one row.

To give a list a sub-name

Highlight the "SUB" row of the list to which you want to give a sub-name and then input the name you want. You can input up to eight characters but only the characters that can fit within the width of the display are shown. The "SUB" line is not displayed when the (☰) > [Sub Name] setting is turned off.

To change the display color of a value

To do this:	Perform this operation:
Change the display color of one cell	1. Highlight the cell whose value's display color you want to change and then select (⋯) > [Color]. 2. Select the color you want and then press (OK).
Change the display color of all values in a list*	1. Highlight the name of the list and then select (⋯) > [Color]. 2. Select the color you want and then press (OK).

* The color of a list's sub-name is not affected by this operation. Also, any values you input into blank cells after performing this operation are displayed in black (default setting).

Sorting List Elements

Use the procedure below to sort the elements of a list on the List Editor tab in ascending or descending order of their values. You can specify one list to use as the base list and then simultaneously sort the elements of up to six lists accordingly.

1. Select ⋯ > [Sort/Jump] > [Sort Ascending] or [Sort Descending].
   - This displays a dialog box for specifying the number of lists to sort.
2. Specify the number of lists to be sorted and then press (OK).
   - This displays a dialog for specifying the base list for the sort.
3. Input the number of the list to use as the base list and then press (OK).
   - If you specified one list in step 2, pressing (OK) sorts the data in the list whose number you input here.
   - If you specified two or more lists in step 2, pressing (OK) displays a dialog for specifying the second list to be sorted simultaneously.
4. As dialogs appear, sequentially input the numbers of the other lists to be sorted.
   - Specifying the same list more than once results in an error. An error also occurs if you try to execute sorting and all of the lists do not have the same number of elements (lines).

List Files

Your calculator provides six list files (File 1 to File 6) that hold a total of 26 list variables (List 1 to List 26) each, which means you can store up to 156 list variables in memory. However, the calculator can handle up to 26 list variables (those in the currently open list file) at one time. To switch between list files, select ☰ > [List File].

Importing and Exporting CSV Files

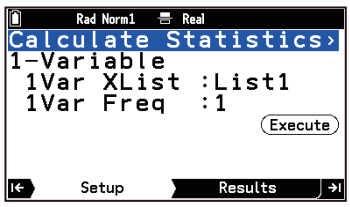
You can export the currently open list file to a CSV file. You can also import the contents of a CSV file into a list file. For details, see “Using CSV Files” (page 244).

Displaying Summary Statistics or Regression Model Information

You can use the procedure below to find and display various summary statistics from 1-Variable or 2-Variable statistical data. This procedure can also be used to display regression equation coefficients and coefficients of determination (referred to as “regression model information” in this manual) when regression models are applied to 2-Variable statistical data.

Operation Flow

1. Input the statistical data to use in the calculation.
   - Use List Editor to input the data and then create the list variables you need. For details, see “Inputting Data” (page 29).
2. Use the procedure under “Selecting What You Want to Do with the Statistics App” (page 29) to select [Calculate Summary Statistics].
   - This causes the Calculate Statistics menu to appear on the Setup tab.



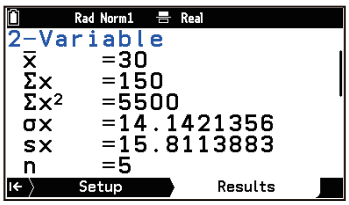
3. Highlight line 2 on the tab and then press (OK).
4. On the menu that appears, select the type of statistical calculation you want to perform.

To do this:	Select this menu item:
Display summary statistics based on 1-Variable statistical data (X)	1-Variable
Display summary statistics based on 2-Variable statistical data (X, Y)	2-Variable

Display regression model information based on 2-Variable statistical data (X, Y) (Select the desired regression model from the menu.)	Linear Regression(ax+b)
	Linear Regression(a+bx)
	Med-Med Regression
	Quadratic Regression
	Cubic Regression
	Quartic Regression
	Logarithm Regression
	Exp Regression(a·e^bx)
	Exp Regression(a·b^x)
	Power Regression
	Sinusoidal Regression
	Logistic Regression

5. If necessary, specify a list to use as statistical data.
   For 1-Variable statistical data:
   (1) Highlight [1Var XList] and then press [OK].
   (2) Use the dialog that appears to specify the number of the list variable to use as data and then press [OK].
   (3) Highlight [1Var Freq] and then press [OK].
   For 2-Variable statistical data:
   (1) Highlight [2Var XList] and then press [OK].
   (2) Use the dialog that appears to specify the number of the list variable to use as data for XList and then press [OK].
   (3) Highlight [2Var YList] and then press [OK].
   (4) Use the dialog that appears to specify the number of the list variable to use as data for YList and then press [OK].
   (5) Highlight [2Var Freq] and then press [OK].

6. Press [⇥]. Or highlight [Execute] and then press [OK].
   • This displays the summary statistics or regression model information you selected in step 4 on the Results tab. If a scroll bar appears along the right edge of the window, use [∨] and [∧] to scroll the display.



   • See “Summary Statistics” (page 33) and “Regression Model Information” (page 34) for the meanings of the values that appear on the display.

Summary Statistics

1-Variable

$\bar{x}$	mean
Σx	sum
Σx^2	sum of squares
σ_x	population standard deviation
s_x	sample standard deviation
n	number of data
minX	minimum value
Q1	first quartile*
Med	median

Q3	third quartile*
maxX	maximum value
Mod	mode
Mod:n	number of data mode items
Mod:F	data mode frequency

* The Q1 and Q3 calculation method is in accordance with the ☰ > [Q1Q3 Type] setting. For details, see "Q1Q3 Type (Statistics)" (page 216).

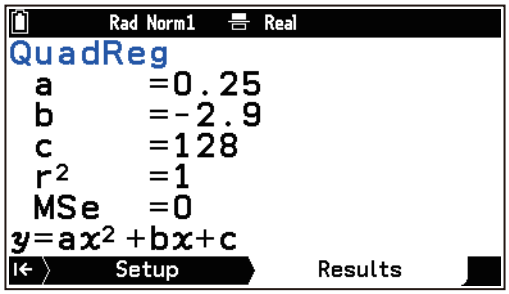
2-Variable

$\bar{x}$	mean of the XList data
Σx	sum of the XList data
Σx^2	sum of squares of the XList data
σ_x	population standard deviation of the XList data
s_x	sample standard deviation of the XList data
n	number of data
$\bar{y}$	mean of the YList data
Σy	sum of the YList data
Σy^2	sum of squares of the YList data
σ_y	population standard deviation of the YList data
s_y	sample standard deviation of the YList data
Σxy	sum of products of the XList data and YList data
minX	minimum value of the XList data
maxX	maximum value of the XList data
minY	minimum value of the YList data
maxY	maximum value of the YList data

Note

- The value of each summary statistic of 1-Variable above is stored in variables included in ⊞ > [Variable Data] > [Statistics] > [X] (page 240) and ⊞ > [Variable Data] > [Statistics] > [Graph] (page 240) (except Mod:n and Mod:F).
- The value of each summary statistic of 2-Variable above is stored in variables included in ⊞ > [Variable Data] > [Statistics] > [X] (page 240) and ⊞ > [Variable Data] > [Statistics] > [Y] (page 240).

Regression Model Information



When regression model information is displayed on the Results tab, the regression model name is displayed in the first line and the regression formula is in the bottom line. The information displayed according to the regression model is shown in the table below.

Regression Models	Displayed Information*
Linear Regression(ax+b)	a, b, r, r^2, MSe
Linear Regression(a+bx)	a, b, r, r^2, MSe
Med-Med Regression	a, b
Quadratic Regression	a, b, c, r^2, MSe
Cubic Regression	a, b, c, d, r^2, MSe
Quartic Regression	a, b, c, d, e, r^2, MSe
Logarithm Regression	a, b, r, r^2, MSe
Exp Regression(a·e^bx)	a, b, r, r^2, MSe
Exp Regression(a·b^x)	a, b, r, r^2, MSe
Power Regression	a, b, r, r^2, MSe
Sinusoidal Regression	a, b, c, d, MSe
Logistic Regression	a, b, c, MSe

* a, b, c, d, e: regression formula coefficients, r: correlation coefficient, r^2: coefficient of determination, MSe: mean square error

Note

- Each value of the above “Displayed Information” items is stored in a variable in ⊜ > [Variable Data] > [Statistics] > [Graph] (page 240).
- When a Med-Med Regression calculation is performed, each of the three sets of summary point coordinates (x_1, y_1; x_2, y_2; x_3, y_3) is stored in variables in ⊜ > [Variable Data] > [Statistics] > [Point Coordinates] (page 241).

What you can do while viewing regression model information

You can perform the operations shown below while regression model information is displayed on the Results tab.

To do this:	Perform this operation:
Save the calculation result regression equation to a function variable	1. Select ⊙⊙⊙ > [Save Function]. 2. From the menu that appears, select the destination function number*1 and then press OK.
Find the residuals ($y_n - y'_n$) of the actual data (x_n, y_n) and the values (x_n, y'_n) calculated by the regression model and save them to a list variable	1. Select ⊙⊙⊙ > [Save Residuals in List]. 2. Use the dialog that appears to input the number of a list*2 and then press OK.

*1 Select a function number where nothing is currently stored. Overwrite saving is not available.

*2 Input the number of an empty list. Overwrite saving is not available.

Drawing a Statistics Graph

You can use 2-Variable statistical data to draw scatter plots and various regression graphs. 1-Variable statistical data can be used to draw seven types of graphs, including histograms and box-and-whisker diagrams. After drawing a graph, you can display summary statistics and regression model information.

Drawing Scatter Plots and Regression Graphs Using the Default Settings

In this example, we draw a scatter plot from 2-Variable statistical data and then draw a regression graph on top of it.

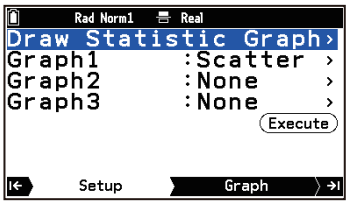
1. Use List Editor to input the data below.

List 1	List 2
11	1.5

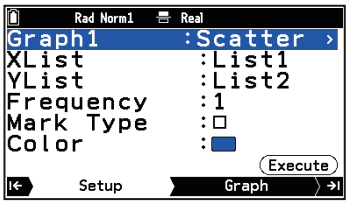
21	2.2
32	3.4
43	5.1
59	8.7

- For details, see “Inputting Data” (page 29).

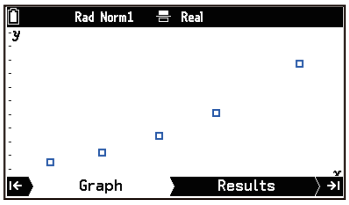
2. Use the procedure under “Selecting What You Want to Do with the Statistics App” (page 29) to select [Draw Statistics Graph].
   - This causes the Draw Statistics Graph menu to appear on the Setup tab. The default Graph1 setting is Scatter (scatter plots), and the settings of Graph2 and Graph3 are both None (Do not graph).



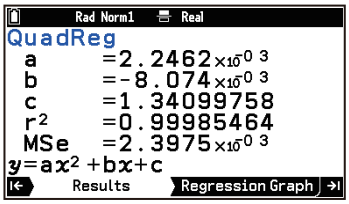
3. Highlight [Graph1] and then press (OK).
   - This causes the Setup tab display to change to the Graph1 setting menu.
   - By default, XList is assigned List1, YList is assigned List2, and Frequency is 1.



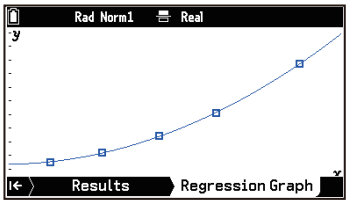
4. Press (⇥).
   - This draws a scatter plot with List1 data on the x-axis and List2 data on the y-axis.



5. Press (⇥). From the menu that appears, select [Quadratic Regression].
   - This applies a quadratic regression model to the data and displays the calculation results.



6. Press (⇥).
   - This draws a quadratic regression graph overlaid on the scatter plot.



Note

- For details about Graph1 to Graph3 on the Setup tab in step 2 above, see “Drawing Graphs Using Multiple Graph Setups” (page 42).
- For details about Graph tab operations in step 4 above and Regression Graph tab operations in step 6, see “Graph Window Operations” (page 41).
- For the meaning of the values displayed on the Results tab in step 5 above, see “Regression Model Information” (page 34).

Drawing a 1-Variable Statistics Graph (Histogram, Box-and-Whisker Diagram, etc.)

You can perform the operations below based on 1-Variable statistical data you input into List Editor.

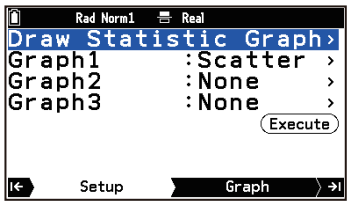
(1) Draw a Box Plot, Histogram, Broken Line Graph, Pie Chart, Bar Graph, Normal Probability Plot, or Normal Density Curve.

(2) Display summary statistics after drawing the graph (except for Pie Chart).

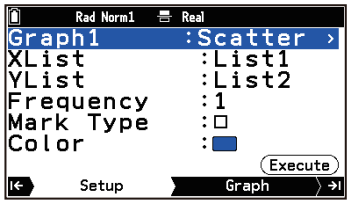
Operation Flow

1. Use List Editor to input your data.
   - For details, see “Inputting Data” (page 29).

2. Use the procedure under “Selecting What You Want to Do with the Statistics App” (page 29) to select [Draw Statistics Graph].
   - This causes the Draw Statistics Graph menu to appear on the Setup tab.



3. Select the type of graph you want to draw.
   (1) Highlight [Graph1] and then press [OK].
   - This causes the Setup tab display to change to the Graph1 setting menu.



   (2) Press [OK] again.
   - This displays a menu for selecting the graph type.

   (3) Highlight the type of graph you want to draw from the menu and then press [OK].

4. Specify a list to use as statistical data.
   For a Box Plot, Histogram, Broken Line Graph, Normal Probability Plot, or Normal Density Curve:

   (1) Highlight [XList] and then press [OK].

   (2) Use the dialog that appears to specify the number of the list variable to use as data and then press [OK].

   (3) Highlight [Frequency] and then press [OK]. (Excluding Normal Probability Plot)

   For a Pie Chart:

   (1) Highlight [Data] and then press [OK].

   (2) Use the dialog that appears to specify the number of the list variable to use as data and then press [OK].
   - When drawing a Pie Chart, you can use a maximum of 20 list variables (number of rows in a list).

   For a Bar Graph:
   You can specify up to three list variables as data for drawing bar graphs.

   (1) Highlight [Data1] and then press [OK].

   (2) Use the dialog that appears to specify the number of the list variable to use as data and then press [OK].

   (3) Repeat the steps (1) and (2) above for [Data2] and [Data3].
   - When using multiple list variables, make sure that the number of elements in all of them is the same. If all of the list variables do not have the same number of elements, an error (Dimension ERROR) results.
   - When using two list variables, assign them to [Data1] and [Data2]. Assigning list variables to [Data1] and [Data3] and specifying None for [Data2] results in an error (Condition ERROR).

5. Specify the graph color and other settings as required.
   - For details, see “Setting Items for Each 1-Variable Statistics Graph Type” (page 38).

6. To draw the graph, press [→]. Or highlight [Execute] and then press [OK].
   - The graph is displayed on the Graph tab.

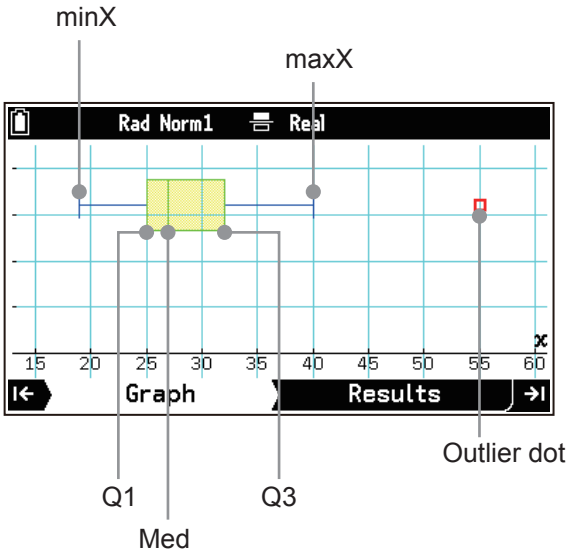
- If the graph you selected in step 3-(2) is a Histogram or Broken Line Graph, a dialog box appears where you can specify Start (x-coordinate of the graph drawing start point) and Width (graph drawing width). Input each of the values, highlight [Execute], and then press [OK].
- For information about the operations you can perform on the Graph tab, see "Graph Window Operations" (page 41).

7. To view summary statistics, press [→|]. (This operation cannot be used for a Pie Chart.)
   - This causes the summary statistics to appear on the Results tab. You can use [▽] and [△] to scroll the display contents.
   - For the meanings of the displayed summary statistics values, see "Summary Statistics" (page 33).

Setting Items for Each 1-Variable Statistics Graph Type

Box Plot

Outliers: Shows or hides outlier dots in a Box Plot.
[On]: Show
[Off]: Hide



Box: Specifies the color of the border of the box area from Q1 to Q3, and the Med line.
Whisker: Specifies the color of the lines extending from the ends of the box to minX and maxX.
OutlierColor: Specifies the color of the outlier dots.
Box Inside: Specifies the fill color of the box area from Q1 to Q3.
- Area Color: Specifies the fill color.
  Selecting [Auto] fills the area inside of the box from Q1 to Med with blue and fills the inside of the box from Med to Q3 with yellow.
- Paint Style: Specifies the density of the fill color.
  [Normal]: Normal density fill
  [Lighter]: Lighter density fill

Note

- Changing the [≡] > [Q1Q3 Type] setting may alter the position of Q1 and Q3 even if Box Plot is drawn based on the same data.

Histogram

Area: Specifies the fill color of the histogram.
- Area Color: Specifies the fill color.
  Selecting [Auto] automatically colors each data item, cycling through six colors in the following sequence: blue, red, green, magenta, cyan, yellow.
- Paint Style: Same as Box Plot.

Border: Specifies the histogram border color. A border is not drawn if [Clear] is selected.

Broken Line Graph

Color: Specifies the graph draw color.

Pie Chart

Display: Specifies the data display form.
[%]: Percentages
[Data]: Values

Pie Area: Specifies the fill color of the pie chart.

- Area Color: Same as Histogram.
- Paint Style: Same as Box Plot.

Pie Border: Specifies the border color of the pie chart. A border is not drawn if [Clear] is selected.

Bar Graph

Stick Style: Specifies the orientation of the bars.
[Length]: Vertical
[Horizontal]: Horizontal

D1 Area, D2 Area, D3 Area:
Specifies the fill color of each bar for Data1, Data2, and Data3

- Area Color: Same as Histogram.
- Paint Style: Same as Box Plot.

D1 Border, D2 Border, D3 Border:
Specifies the border color of each bar for Data1, Data2, and Data3. Borders are not drawn if [Clear] is selected.

Normal Probability Plot

Mark Type: Specifies the mark to use for the plot.
Color: Specifies the graph draw color.

Normal Density Curve

Color: Specifies the graph draw color.

Drawing a 2-Variable Statistics Graph (Scatter Plot or Regression Graph)

You can perform the operations below based on 2-Variable statistical data you input into List Editor.

(1) Draw a Scatter Plot, xy Line Graph, or regression graph
(2) After drawing a graph, display summary statistics or regression model information
(3) Draw a regression graph over a graph described in (1) above*

* Common practice in (1) is to draw a Scatter Plot and then draw a regression graph over it. You can also draw a regression graph over a xy Line Graph or another regression graph.

Operation Flow

1. Use List Editor to input your data.
   • For details, see “Inputting Data” (page 29).
2. Use the procedure under “Selecting What You Want to Do with the Statistics App” (page 29) to select [Draw Statistics Graph].
   • This causes the Draw Statistics Graph menu to appear on the Setup tab.
3. Select the type of graph you want to draw.
   (1) Highlight [Graph1] and then press (OK).
   • This causes the Setup tab display to change to the Graph1 setting menu.
   (2) Press (OK) again.
   • This displays a menu for selecting the graph type.
   • The menu includes both 1-Variable and 2-Variable graphs. Choose Scatter Plot, xy Line Graph, or regression graph.
   (3) Highlight the type of graph you want to draw from the menu and then press (OK).

4. Specify a list to use as statistical data.
   (1) Highlight [XList] and then press [OK].
   (2) Use the dialog that appears to specify the number of the list variable to use as data for XList and then press [OK].
   (3) Highlight [YList] and then press [OK].
   (4) Use the dialog that appears to specify the number of the list variable to use as data for YList and then press [OK].
   (5) Highlight [Frequency] and then press [OK]. (This operation does not work with a Sinusoidal Regression Graph or Logistic Regression Graph.)

5. Specify the graph color and other settings as required.
   • Mark Type: If you selected Scatter Plot or xy Line Graph as the graph type, specify the mark to use for the plot.
   • Color: Specifies the graph draw color.

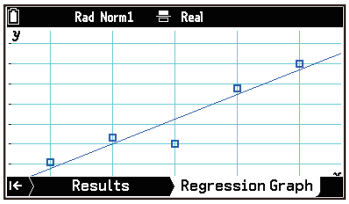
6. To draw the graph, press [⇥]. Or highlight [Execute] and then press [OK].
   • The graph is displayed on the Graph tab.
   • For information about the operations you can perform on the Graph tab, see “Graph Window Operations” (page 41).

7. Display summary statistics or regression model information.
   (1) Press [⇥].
   (2) Perform the operations described in the table below.

To display this information:	Select this menu item:
Summary statistics	2-Variable
Regression model information (You can select the one regression model you want.)	Linear Regression(ax+b)
	Linear Regression(a+bx)
	Med-Med Regression
	Quadratic Regression
	Cubic Regression
	Quartic Regression
	Logarithm Regression
	Exp Regression(a·e^bx)
	Exp Regression(a·b^x)
	Power Regression
	Sinusoidal Regression
	Logistic Regression

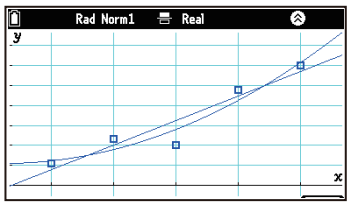
   (3) Press [OK].
      • This displays the details of the menu item you selected in step (2) above on the Results tab.
      • See “Summary Statistics” (page 33) and “Regression Model Information” (page 34) for the meanings of the displayed values.

8. Press [⇥] to go to the Regression Graph tab and draw a regression graph.
   • Choosing one of the regression models in step 7 draws a regression graph over the graph drawn in step 6. Choosing 2-Variable displays only the graph drawn in step 6.



9. Add regression graphs as needed.
   You can add multiple regression graphs on the Regression Graph tab. To do this, perform the steps below.
   (1) Select [⋯] > [Draw Regression Graph].

(2) From the menu that appears, select the regression model you want and then press (OK).
- This adds the graph of the regression model you selected.
- You can repeat steps (1) and (2) above to add more regression graphs.



- For operations that are available on the Regression Graph tab, see “Graph Window Operations” (page 41).

Graph Window Operations

This section describes operations available with the Statistics app’s graph window (Graph tab or Regression Graph tab).

Pie Chart Only Operations

The operations below are available while a Pie Chart is displayed.

To do this:	Perform this operation:
Toggle displayed values between data values and percentages	Select (⋯) > [%/Data].
Save displayed Pie Chart percentage values to a list variable	1. Select (⋯) > [Save % in List]. 2. Use the dialog that appears to input a storage destination list number and then press (OK).

To show or hide tabs

See “Showing and Hiding Tabs” (page 79).

To move the graph window up, down, left, or right

Use the cursor keys.

To zoom the graph window in or out

Press (+) to zoom in or (−) to zoom out.

Using Trace (Trace)

Trace displays a cross pointer (✜) on a graph, which you can use to read the coordinate values at a specific location. To enable trace, select (⋯) > [Trace]. The operations that can be performed while the trace function is enabled are described in the table below.

To do this:	Perform this operation:
Move the pointer along the graph	Press (<) or (>).
When there are multiple graphs, move the pointer between them	Press (∨) or (∧).
Exit trace	Press (↩).

Using Zoom (Zoom)

The menu items of (⋯) > [Zoom] can be used to change the display range of the graph window. For details, see “Changing the Graph Window Zoom Setting (Zoom)” (page 81). The Statistics app’s zoom does not support [Zoom Auto].

To specify the display range of the graph window (View Window)

See “Statistics Graph View Window Settings” (page 52).

Using Sketch (Sketch)

You can use sketch to draw dots, lines, and text within the graphing area. For details, see “Using Sketch (Sketch)” (page 85). The menu items below are available with the Statistics app.

[Clear Screen], [Plot], [Line], [Circle], [Vertical Line], [Horizontal Line], [Pen], [Text]

To graph a function input with the Graph&Table app (Draw Function)

While a 2-Variable graph is displayed, you can use the operation below to overlay graphs of functions.

1. Select ⋯ > [Draw Function].

2. On the menu that appears, highlight the function you want to graph and then press OK.

To find the y-values for x-values on a regression graph (Graph Solve)

While a regression graph is displayed, you can use the operation below to find the y-value for any x-value on the graph.

1. Select ⋯ > [Graph Solve] > [y-Cal].

2. Use the dialog that appears to input the x-value and then press OK.
   - The x- and y-coordinate values on the regression graph are displayed at the bottom of the window.
   - If both the x- and y-coordinate values are within the window's range, a pointer appears at the coordinates on the graph.
   - To redisplay the dialog and input another x-value, press OK.

3. To exit this operation, press ⎋.

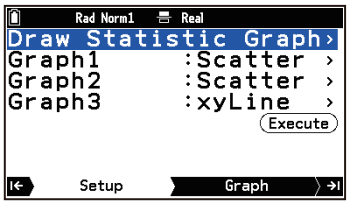
To adjust the background image (Fade I/O)

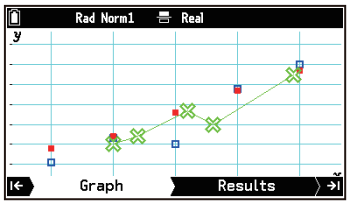
You can use this operation to adjust the opacity of the background image. See "Adjusting the Graph Window Background Image (Fade I/O)" (page 81).

Drawing Graphs Using Multiple Graph Setups

Graph1, Graph2, and Graph3 in the Draw Statistics Graph menu are independent areas for configuring graph settings. By default, None (Do not graph) is specified for Graph2 and Graph3, and only the Graph1 settings are used for graphing.

If you want, you can use two or three graph setups to simultaneously draw multiple graphs.





Note the points below when using multiple graph setups for graphing.

- Pressing ⇥ to go from the Graph tab to the Results tab displays a menu for selecting a graph setup. Choose a graph setup from the menu and press OK.
- Graph setups for a 1-Variable graph in one area and a 2-Variable graph in another area cannot be used to draw simultaneous graphs.
- When drawing a Pie Chart or Bar Graph, only the graph setup for the graph you are drawing should be assigned to an area. None should be specified for the other areas. In the case of a Pie Chart or Bar Graph, you can draw using only one graph setup at a time.

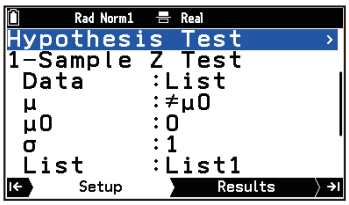
Performing a Hypothesis Test

Statistical hypotheses are tested in a variety of ways and results are presented numerically and graphically.

Operation Flow

1. Use List Editor to input the data and then create the list variables as required.
   - For details about the input operation, “Inputting Data” (page 29).
   - Create list variables only as needed for the test type. See “Test Types and List Variables” (page 44). You need to create a list variable if you want to perform a Linear Regression t-Test, χ^2 Goodness-of-Fit Test, or ANOVA.

2. Use the procedure under “Selecting What You Want to Do with the Statistics App” (page 29) to select [Hypothesis Test].
   - This displays the Hypothesis Test menu on the Setup tab.



3. Select a test type.
   (1) Highlight line two of the Hypothesis Test menu and then press [OK].
   (2) From the menu that appears, select a test type.

To select this:	Select this menu item:	Result:
1-Sample Z Test	[Z Test] > [1-Sample Z Test]	To Step 4
2-Sample Z Test	[Z Test] > [2-Sample Z Test]	
1-Proportion Z Test	[Z Test] > [1-Proportion Z Test]	To Step 5
2-Proportion Z Test	[Z Test] > [2-Proportion Z Test]	
1-Sample t Test	[t Test] > [1-Sample t Test]	To Step 4
2-Sample t Test	[t Test] > [2-Sample t Test]	
Linear Regression t Test	[t Test] > [Linear Regression t Test]	To Step 5
χ^2 Goodness-of-Fit Test	[χ^2 Test] > [χ^2 Goodness-of-Fit Test]	To Step 6
χ^2 Two-Way Test	[χ^2 Test] > [χ^2 Two-Way Test]	
2-Sample F Test	[2-Sample F Test]	To Step 4
ANOVA	[ANOVA]	To Step 6

4. Select the sample data specification method.
   (1) Highlight [Data] and then press [OK].
   (2) Perform the operations described in the table below.

To do this:	Perform this operation:
Use a list variable to specify the sample data	On the menu that appears, highlight [List] and then press [OK].
Input the sample mean, standard deviation,*1 and number of data points	On the menu that appears, highlight [Variable] and then press [OK].

   *1 No input is required for the Z test.

5. Input the parameters for the alternative hypothesis.
   - For information about sample type-specific parameters, see “Test Types and Parameters” (page 45).
   - For example, if you chose [Z Test] > [1-Sample Z Test] in step 3, perform the steps below.

   (1) Highlight [μ] and then press [OK].
   (2) On the menu that appears, highlight the direction of the test (≠, <, or >) and then press [OK].
   (3) Highlight [μ_0], input the numeric value of the hypothetical population mean, and then press [OK].

6. Input the other parameters.
   - For information about sample type-specific parameters, see “Test Types and Parameters” (page 45).

7. Specify the graph color as required.*2
   (1) Highlight [Color] and then press (OK).
   (2) On the menu that appears, highlight the color you want and then press (OK).

8. Press (⇥). Or highlight [Execute] and then press (OK).
   • This displays, on the Results tab, test calculation results and input values (or summary statistics calculated from the specified data).
   • For a description of the calculation results displayed and the operations available on the Results tab, see "Using the Test Results Tab" (page 46).

9. To display the graph, press (⇥).*2
   • For operations that can be performed on the Graph tab, see "Using the Test Graph Tab" (page 48).
   *2 This operation is not required in the following cases.
   - When the test type is Linear Regression t Test
   - When the test type is ANOVA, with [How Many] > [1] specified

Test Types and List Variables

Depending on the type of test you want to perform, input data in List Editor and create list variables as described below.

Linear Regression t Test

Required list variable(s):	Setup tab display:
Three list variables for use as XList (x data), YList (y data), and Freq (frequency data)*	XList :List1 YList :List2 Freq :1

* If you are not using frequency data, you do not need the Freq list variable.

χ^2 Goodness-of-Fit Test

Required list variable(s):	Setup tab display:
Two list variables used for Observed (observed counts)* and Expected (expected frequencies)	Observed:List1 Expected:List2

* All list elements must be positive integers.

ANOVA

You can perform either One-Way ANOVA or Two-Way ANOVA. On the Setup tab, select [How Many] > [1] for One-Way ANOVA or [2] for Two-Way ANOVA.

ANOVA Types:	Required list variable(s):	Setup tab display:
One-Way ANOVA	Two list variables used for Factor A (Factor A condition) and Dependnt (sample data)	Factor A:List1 Dependnt:List3
Two-Way ANOVA	Three list variables used for Factor A (Factor A condition), Factor B (Factor B condition) and Dependnt (sample data)	Factor A:List1 Factor B:List2 Dependnt:List3

The list variables used in ANOVA are created as described below.

• One-Way ANOVA: For example, if there are two conditions (Condition 1, Condition 2) for Factor A, each list is created as shown below.

Factor A	Dependent	
1	113	Condition 1 sample data
1	116	
2	133	Condition 2 sample data
2	131	

• Two-Way ANOVA: For example, if there are two different conditions (Condition 1, Condition 2) for Factor A and Factor B, each list is created as shown below.

Factor A	Factor B	Dependent	
1	1	113	Factor A Condition 1 × Factor B Condition 1 sample data
1	1	116	
2	1	133	Factor A Condition 2 × Factor B Condition 1 sample data
2	1	131	
1	2	139	Factor A Condition 1 × Factor B Condition 2 sample data
1	2	132	
2	2	126	Factor A Condition 2 × Factor B Condition 2 sample data
2	2	122	

1-Sample or 2-Sample Z Test, 1-Sample or 2-Sample t Test, 2-Sample F Test

If you choose [Data] > [List] in step 4 under "Operation Flow" (page 43), need to create the following list variables.

Sample data:	Required list variable(s):	Setup tab display:
One sample data (no frequencies)	List variable to assign to List	List :List1 Freq :1
One sample data (with frequencies)	Two list variables to assign to List and Freq	
Two sample data (no frequencies)	Two list variables to assign to List(1) and List(2)	List(1) :List1 List(2) :List2 Freq(1) :1 Freq(2) :1
Two sample data (with frequencies)	Four list variables to assign to List(1), List(2), Freq(1), Freq(2)	

Test Types and Parameters

Alternative Hypothesis Parameters

Test Type:	Parameter:
1-Sample Z Test 1-Sample t Test	μ: 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
2-Sample Z Test 2-Sample t Test	μ_1: 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.)
1-Proportion Z Test	Prop: test conditions ("$\neq p_0$" specifies two-tail test, "$<p_0$" specifies lower one-tail test, "$>p_0$" specifies upper one-tail test.) p_0: expected sample proportion ($0 < p_0 < 1$)
2-Proportion Z Test	p_1: test conditions ("$\neq p_2$" specifies two-tail test, "$<p_2$" specifies one-tail test where sample 1 is smaller than sample 2, "$>p_2$" specifies one-tail test where sample 1 is greater than sample 2.)
Linear Regression t Test	β&ρ: test conditions ("≠0" specifies two-tail test, "< 0" specifies lower one-tail test, "> 0" specifies upper one-tail test.)
2-Sample F Test	σ_1: test conditions ("$\neq\sigma_2$" specifies two-tail test, "$<\sigma_2$" specifies one-tail test where sample 1 is smaller than sample 2, "$>\sigma_2$" specifies one-tail test where sample 1 is greater than sample 2.)

Other Parameters

Parameters in the table below that are marked with an asterisk (*) need to be input when you select [Data] > [Variable] in step 4 of the procedure under "Operation Flow" (page 43).

Test Type:	Parameter:
1-Sample Z Test	σ: population standard deviation ($\sigma > 0$) $\bar{x}$: mean of sample*

	n: size of sample (positive integer)*
2-Sample Z Test	σ_1: population standard deviation of sample 1 ($\sigma_1 > 0$) σ_2: population standard deviation of sample 2 ($\sigma_2 > 0$) $\bar{x}_1$: mean of sample 1* n_1: size of sample 1 (positive integer)* $\bar{x}_2$: mean of sample 2* n_2: size of sample 2 (positive integer)*
1-Proportion Z Test	x: sample value ($x \geq 0$ integer) n: size of sample (positive integer)
2-Proportion Z Test	x_1: data value of sample 1 ($x_1 \geq 0$ integer) n_1: size of sample 1 (positive integer) x_2: data value of sample 2 ($x_2 \geq 0$ integer) n_2: size of sample 2 (positive integer)
1-Sample t Test	$\bar{x}$: mean of sample* s_x: sample standard deviation ($s_x > 0$)* n: size of sample (positive integer)*
2-Sample t Test	$\bar{x}_1$: mean of sample 1* s_{x1}: standard deviation of sample 1 ($s_{x1} > 0$)* n_1: size of sample 1 (positive integer)* $\bar{x}_2$: mean of sample 2* s_{x2}: standard deviation of sample 2 ($s_{x2} > 0$)* n_2: size of sample 2 (positive integer)* Pooled: pooling On (in effect) or Off (not in effect)
χ^2 Goodness-of-Fit Test	Observed: specify a list variable (List 1 to List 26) that contains observed counts (all list elements must be positive integers). Expected: specify a list variable (List 1 to List 26) as the storage location of expected frequency. df: degrees of freedom (positive integer) CNTRB: specify a list variable (List 1 to List 26) as the storage location of the contribution of each observed count obtained as calculation results.
χ^2 Two-Way Test	Observed: Specifies a matrix variable (Mat A to Mat Z) that contains observed counts. Be sure to specify a matrix that satisfies the conditions below. An error results if you specify a matrix that does not satisfy these conditions. • The matrix must have at least 2 rows and 2 columns. • All elements of the matrix must be positive integers. Expected: Specifies a matrix variable (Mat A to Mat Z) that contains expected frequencies.
2-Sample F Test	s_{x1}: standard deviation of sample 1 ($s_{x1} > 0$)* n_1: size of sample 1 (positive integer)* s_{x2}: standard deviation of sample 2 ($s_{x2} > 0$)* n_2: size of sample 2 (positive integer)*
ANOVA	How Many: 1: One-Way ANOVA 2: Two-Way ANOVA

Using the Test Results Tab

Information on the Results Tab

When a test other than ANOVA is performed

Test calculation results and summary statistics of the sample data are displayed on the Results tab. The meanings of the items that appear on the display are provided below.

Test calculation results

p:	p-value
z:	z score (Z Test)
t:	t value (t Test)
χ^2:	χ^2 value (χ^2 Test)
F:	F value (F Test)
$\hat{p}$:	estimated sample proportion (1-Proportion/2-Proportion Z Test)
$\hat{p}_1$:	estimated proportion of sample 1 (2-Proportion Z Test)
$\hat{p}_2$:	estimated proportion of sample 2 (2-Proportion Z Test)
df:	degrees of freedom (2-Sample t Test, Linear Regression t Test, χ^2 Test)
a:	constant term (Linear Regression t Test)
b:	coefficient (Linear Regression t Test)

Summary statistics of sample data

$\bar{x}$:	mean of sample
$\bar{x}_1$:	mean of sample 1
$\bar{x}_2$:	mean of sample 2
s_x:	sample standard deviation
s_{x1}:	standard deviation of sample 1
s_{x2}:	standard deviation of sample 2
s_p:	pooled sample standard deviation
n:	size of sample
n_1:	size of sample 1
n_2:	size of sample 2
s_e:	standard error
r:	correlation coefficient
r^2:	coefficient of determination

When ANOVA is performed

Calculation results are displayed using the same table form as that used in textbooks.

One-Way ANOVA

	df	ss	ms	F	P
A	1	18	18	0.1985	0.6715
ERR	6	544	90.666		

*1

Line 1: A values
Line 2: ERR values

Two-Way ANOVA

	df	ss	ms	F	P
A	1	18	18	1.8461	0.2458
B	1	84.5	84.5	8.6666	0.0422
AB	1	420.5	420.5	43.128	2.7E-3
ERR	4	39	9.75		

*1

Line 1: A values
Line 2: B values
Line 3: AB values*2
Line 4: ERR values

*1 The tables shown here would be displayed by the calculator across two screens, so you would need to scroll left and right to view all of the table contents.

*2 Line 3 does not appear when there is only one observation in each cell.

Column 1: df ... degrees of freedom
Column 2: ss ... sum of squares
Column 3: ms ... mean squares
Column 4: F ... F value
Column 5: P ... p-value

Note

- Values displayed on the Results tab are stored in variables in ⊞ > [Variable Data] > [Statistics] > [Result] > [Test] (page 241) and ⊞ > [Variable Data] > [Statistics] > [Input] (page 241). However, variables a and b are in ⊞ > [Variable Data] > [Statistics] > [Graph] (page 240).

What you can do while displaying calculation results

You can use the operation below to save all numeric values currently displayed on the Results tab[*1] to a list variable.

1. Select ⋯ > [Save Result in List].
2. Use the dialog box that appears to input the number of the list you want to use as a save destination[*2*3] and then press OK.

*1 Includes the currently displayed calculation results and input values. However, alternative hypothesis parameters (page 45) are not saved.
*2 Input the number of an empty list. Overwrite saving is not available.
*3 With ANOVA, each of the five calculation result columns is saved to five list variables, starting from the list number you input. You can specify a list number within the range from 1 to 22.

Note

- You can perform the operations described below while the calculation results of Linear Regression t Test are displayed.
  - Save the calculation result regression equation to a function variable.
  - Find the residuals between the actual data and the values calculated by the regression model and save them to list variables.

See “What you can do while viewing regression model information” (page 35).

Using the Test Graph Tab

When you perform a test other than Two-Way ANOVA

You can perform the operations below after performing one of the following tests: 1-Sample Z Test, 2-Sample Z Test, 1-Proportion Z Test, 2-Proportion Z Test, 1-Sample t Test, 2-Sample t Test, χ^2 Goodness-of-Fit Test, χ^2 Two-Way Test, 2-Sample F Test.

To do this:	Select this menu item:
Display the p-value	⋯ > [Calculate P Value]
Z Test: Display the z-value and display a cross pointer at the corresponding point on the graph	⋯ > [Calculate Z Value][*1*2]
1-Sample/2-Sample t Test: Display the t-value(s) and display a cross pointer at the corresponding point on the graph	⋯ > [Calculate T Value][*1*2]
χ^2 Test: Display the χ^2-value(s) and display a cross pointer at the corresponding point on the graph	⋯ > [Calculate CHI Value][*1*2]
2-Sample F Test: Display the F-value and display a cross pointer at the corresponding point on the graph	⋯ > [Calculate F Value][*1*2]

*1 For a two-tailed test, the cross pointer moves between the two values each time ◁ or ▷ is pressed.
*2 A relevant point outside of the display range is not displayed.

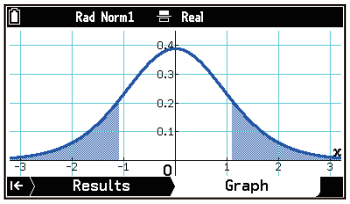
Note

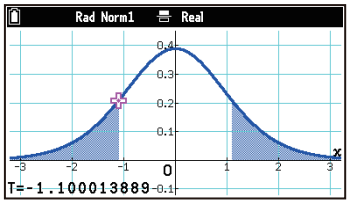
- Calculation results displayed by the above operations are stored in the alpha variables described below.

Z Test	z- and p-values are stored in variables Z and P respectively.
t Test	t- and p-values are stored in variables T and P respectively.

χ^2 Test	χ^2- and p-values are stored in variables C and P respectively.
F Test	F- and p-values are stored in variables F and P respectively.

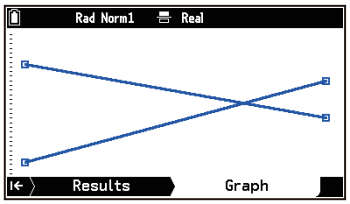
The displays below show an example of what would happen if you perform a one-sample t-test with $\mu \neq \mu_0$ (two-tailed test) and then draw a graph. The display on the right is an example when you select ⋯ > [Calculate T Value].

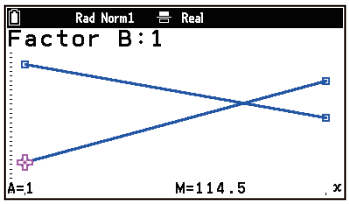




When Two-Way ANOVA is performed

With Two-Way ANOVA, you can draw Interaction Plot graphs. The number of graphs depends on Factor B, while the number of x-axis data depends on Factor A. The y-axis is the mean value of each category. Selecting ⋯ > [Trace] displays a cross pointer on the graph (Trace). Pressing ◁ or ▷ moves the pointer on the graph in the corresponding direction. When there are multiple graphs, you can use ▽ and △ to move between graphs.





Using the Trace function automatically stores the last condition number of factor A to variable A and the mean value of the last category to variable M, respectively.

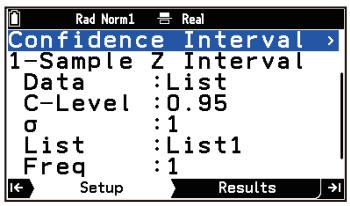
Find a Confidence Interval

You can use the procedure below to find the upper and lower limits of the confidence interval from given sample data and confidence level.

Operation Flow

1. Use List Editor to input the data and then create the list variables as required.
   - For details about the input operation, “Inputting Data” (page 29).
   - See “Confidence Interval Types and List Variables” (page 51) for the list variables that need to be created.

2. Use the procedure under “Selecting What You Want to Do with the Statistics App” (page 29) to select [Confidence Interval].
   - This displays the Confidence Interval menu on the Setup tab.



3. Select the confidence interval type.

   (1) Highlight line 2 of the Confidence Interval menu and then press OK.

   (2) From the menu that appears, select a confidence interval type.

To select this:	Select this menu item:	Result:
1-Sample Z Interval	[Z Confidence Interval] > [1-Sample Z Interval]	To Step 4
2-Sample Z Interval	[Z Confidence Interval] > [2-Sample Z Interval]	

1-Proportion Z Interval	[Z Confidence Interval] > [1-Proportion Z Interval]	To Step 5
2-Proportion Z Interval	[Z Confidence Interval] > [2-Proportion Z Interval]	
1-Sample t Interval	[t Confidence Interval] > [1-Sample t Interval]	To Step 4
2-Sample t Interval	[t Confidence Interval] > [2-Sample t Interval]	

4. Select the sample data specification method.
   (1) Highlight [Data] and then press (OK).
   (2) Perform the operations described in the table below.

To do this:	Perform this operation:
Use a list variable to specify the sample data	On the menu that appears, highlight [List] and then press (OK).
Input the sample mean, standard deviation, and number of data points	On the menu that appears, highlight [Variable] and then press (OK).

5. Input values for the parameters.
   (1) Highlight [C-Level] and then use the number keys to input the confidence level.
   • Input a value between 0 and 1. Commonly used confidence levels are 0.95 (95%) and 0.99 (99%).
   (2) Press (OK).
   (3) Input the other parameters.
   • See “Confidence Interval Types and Parameters” (page 51).

6. Press (⇥). Or highlight [Execute] and then press (OK).
   • This displays confidence interval calculation results and summary statistics of the sample data on the Results tab. The meanings of the items that appear on the display are provided below.

Confidence interval calculation results

Lower:	confidence interval lower limit
Upper:	confidence interval upper limit
df:	degrees of freedom
$\hat{p}$:	estimated sample proportion
$\hat{p}_1$:	estimated proportion of sample 1
$\hat{p}_2$:	estimated proportion of sample 2

Summary statistics of sample data

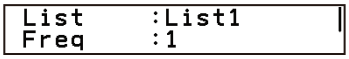
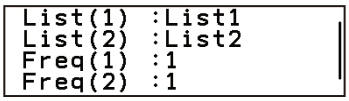
$\bar{x}$:	mean of sample
$\bar{x}_1$:	mean of sample 1
$\bar{x}_2$:	mean of sample 2
s_x:	sample standard deviation
s_{x1}:	standard deviation of sample 1
s_{x2}:	standard deviation of sample 2
s_p:	pooled sample standard deviation
n:	size of sample
n_1:	size of sample 1
n_2:	size of sample 2

Note

- You can use the operation below to save values currently displayed on the Results tab to a list.
  (1) Select (⋯) > [Save Result in List].
  (2) Use the dialog that appears to input a list number* and then press (OK).
  * Input the number of an empty list. Overwrite saving is not available.
- The values displayed on the Results tab are stored in the variables in the menu items shown below.
  Confidence interval calculation results: (▤) > [Variable Data] > [Statistics] > [Result] > [Confidence Interval] (page 241)
  Summary statistics of the sample data: (▤) > [Variable Data] > [Statistics] > [Input] (page 241)

Confidence Interval Types and List Variables

To find confidence intervals using a list of sample data, create the following list variables according to the confidence interval type.

Sample data:	Required list variable(s):	Setup tab display:
One sample data (no frequencies)	List variable to assign to List	
One sample data (with frequencies)	Two list variables to assign to List and Freq	
Two sample data (no frequencies)	Two list variables to assign to List(1) and List(2)	
Two sample data (with frequencies)	Four list variables to assign to List(1), List(2), Freq(1), Freq(2)	

Confidence Interval Types and Parameters

Parameters in the table below that are marked with an asterisk (*) need to be input when you select [Data] > [Variable] in step 4 of the procedure under “Operation Flow” (page 49).

Confidence interval type:	Parameter:
1-Sample Z Interval	σ: population standard deviation ($\sigma > 0$) $\bar{x}$: mean of sample* n: size of sample (positive integer)*
2-Sample Z Interval	σ_1: population standard deviation of sample 1 ($\sigma_1 > 0$) σ_2: population standard deviation of sample 2 ($\sigma_2 > 0$) $\bar{x}_1$: mean of sample 1* n_1: size of sample 1 (positive integer)* $\bar{x}_2$: mean of sample 2* n_2: size of sample 2 (positive integer)*
1-Proportion Z Interval	x: sample value ($x \geq 0$ integer) n: size of sample (positive integer)
2-Proportion Z Interval	x_1: data value of sample 1 ($x_1 \geq 0$ integer) n_1: size of sample 1 (positive integer) x_2: data value of sample 2 ($x_2 \geq 0$ integer) n_2: size of sample 2 (positive integer)
1-Sample t Interval	$\bar{x}$: mean of sample* s_x: sample standard deviation ($s_x > 0$)* n: size of sample (positive integer)*
2-Sample t Interval	$\bar{x}_1$: mean of sample 1* s_{x1}: standard deviation of sample 1 ($s_{x1} > 0$)* n_1: size of sample 1 (positive integer)* $\bar{x}_2$: mean of sample 2* s_{x2}: standard deviation of sample 2 ($s_{x2} > 0$)* n_2: size of sample 2 (positive integer)* Pooled: pooling On (in effect) or Off (not in effect)

Statistics Graph View Window Settings

The settings of the statistics graph View Window are automatically configured according to the graph being drawn. This is because the calculator selects ☰ > [View Window] (page 216) > [Auto] by default.
If you switch to ☰ > [View Window] > [Manual], changes to View Window settings configured with the menu that appears when you select ⋯ > [View Window] in the graph window are applied to the display range of the graph window.
For details about View Window settings, see “Specifying the Display Range of the Graph Window (View Window)” (page 80).

Note

- Note that View Window parameters are set automatically for the graph types below, regardless of whether or not ☰ > [View Window] is set to [Manual].
  Pie, 1-Sample Z Test, 2-Sample Z Test, 1-Proportion Z Test, 2-Proportion Z Test, 1-Sample t Test, 2-Sample t Test, χ^2 Goodness-of-Fit Test, χ^2 Two-Way Test, 2-Sample F Test (x-axis only disregarded).

Distribution App

The Distribution app can handle binomial distribution, normal distribution, Poisson distribution, and a variety of other types of probability distribution.

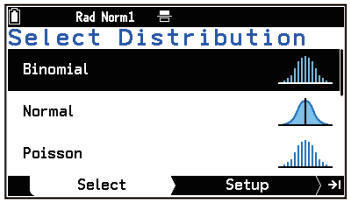
Note

- Distribution calculation can also be performed with the Calculate app using the functions in ⊞ > [Distribution]. For information about available functions, see “Distribution: Distribution Calculations” (page 233).

Operation Flow

Step 1: Select a distribution (Select tab).

1. ⌂ > Distribution
   - This displays the distribution selection menu.



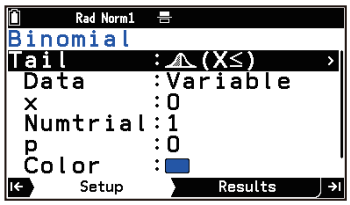
2. Highlight the distribution you want to use for calculation and then press ⇥ (or OK).
   - You can choose from among the distributions below.

   Discrete distribution
   - Binomial distribution
   - Poisson distribution
   - Geometric distribution
   - Hypergeometric distribution

   Continuous Distribution
   - Normal distribution
   - Student-t distribution
   - χ^2 distribution
   - F distribution

Step 2: Input parameters (Setup tab).

3. Select a tail setting for probability calculation.
   (1) Highlight [Tail] and then press OK.
   (2) From the menu that appears, select one of the options described below.



   [(X≤)]: Calculates the cumulative probability for specified data value x or lower.
   [(≤X≤)]: Calculates the cumulative probability for the lower (Lower) and upper (Upper) boundaries of the data values.
   [(X≥)]: Calculates the cumulative probability for specified data value x or higher.
   [(X=)]: Calculates the probability for given data value x (discrete distribution only).

4. Specify whether to use a single data value or multiple data values for the calculation.
   (1) Highlight [Data] and then press OK.
   (2) Select [Variable] to use a single data value for calculation or [List] for multiple data values.

5. Input the other parameters.

   Parameters common to all distributions
   Input the parameters below according to what you specified for [Tail] (step 3) and [Data] (step 4).

Data \ Tail	(X≤), (X≥), (X=)	(≤X≤)
Variable	x: Data value	Lower: Data value lower limit Upper: Data value upper limit
List	List*1: List to use as data values	L.List*1: List to use as the lower boundary of data values U.List*1: List to use as the upper boundary of data values

*1 For the operation to specify a list variable to use as data values, see "To specify a list variable to use as data values" (page 55).

Distribution Type Specific Parameters

Binomial distribution
- Numtrial: Number of trials
- p: Probability of success (0 ≤ p ≤ 1)

Normal distribution
- DisplayZ: Displays Z-Scores*2
- μ: Population mean
- σ: Population standard deviation (σ > 0)

Poisson distribution
- λ: Mean (λ > 0)

Geometric distribution
- p: Probability of success (0 < p ≤ 1)

Hypergeometric distribution
- n: Number of trials from population (0 ≤ n integer)
- M: Number of successes in population (0 ≤ M integer)
- N: Population size (n ≤ N, M ≤ N integer)

Student-t distribution
- df: Degrees of freedom (df > 0)

χ^2 distribution
- df: Degrees of freedom (Positive integer)

F distribution
- n:df: Degrees of freedom of numerator (Positive integer)
- d:df: Degrees of freedom of denominator (Positive integer)

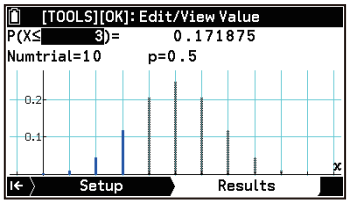
*2 Select [On] to show Z-scores (standardized values) or [Off] to hide them. If you choose [On], calculation is performed as μ = 0 and σ = 1.

Note

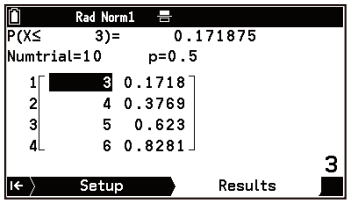
- You can specify the color of the graph by highlighting [Color] and then pressing (OK) (only if you chose [Data] > [Variable] in step 4).
- Selecting (⋯) > [Input Descriptions] displays explanations of the parameters.

Step 3: Display the calculation results (Results tab).

6. On the Setup tab, press (⇥), or highlight Execute and then press (OK).
   - Calculation results are displayed on the Results tab.



Single Data Value Calculation
(When [Data] > [Variable] selected.)



Multiple Data Value Calculation
(When [Data] > [List] selected.)

To specify a list variable to use as data values

When [Data] > [List] is selected on the Setup tab, use the following operation to specify the list variable to use as data values. The operations in steps 2 through 5 below are not necessary if you use a list variable that has already been saved.

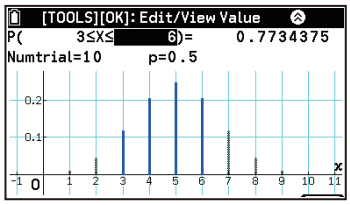
1. On the Setup tab, highlight [List], [L.List], or [U.List] and then press (OK).
2. On the menu that appears, highlight [List Editor] and then press (OK).
   - This displays List Editor.
3. Input data values in any one of the lists (List 1 through List 26).
   - For information about the input operation, see "Inputting Data in List Editor" (page 30).
4. After you finish inputting the data, press (⮌).
5. Press (OK).
6. On the menu that appears, highlight [Select List] and then press (OK).
7. Use the dialog that appears to input a list number and then press (OK).

Using the Results Tab

To change data values and recalculate probability values (Only when [Data] > [Variable] is selected.)

Highlight the value of x, Lower, or Upper and then use the number keys or select (⋯) > [Edit/View Value] to change the value.

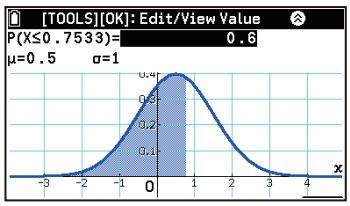
P (X ≤ x) = p
P (Lower ≤ X ≤ Upper) = p
P (X ≥ x) = p
P (X = x) = p*
* Discrete distribution only



To change the probability value and calculate inverse data values (Only when [Data] > [Variable] is selected.)

Highlight the p-value and then use the number keys or select (⋯) > [Edit/View Value] to change the value.

P (X ≤ x) = p
P (Lower ≤ X ≤ Upper) = p*
P (X ≥ x) = p
* Normal distribution only



Note

- The inverse operation cannot be performed with [Tail] > [(X=)] for discrete distribution.

To change the Tail setting

From the menu that appears when you select (⋯) > [Tail], select the option you want. For information about available options, see step 3 under "Operation Flow" (page 53).

Other Operations

To do this:	Select this menu item:
Check the value set for the display range of the graph window (Data: Only when Variable is selected.)	(⋯) > [View Window]*1
Adjust the background image (Data: Only when Variable is selected.)	(⋯) > [Fade I/O]*2

Save all p-values of the calculation result to the specified list variable (Only when Data: List is selected.)	⋯ > [Save Probabilities in List]

*1 You can use the menu that appears when you select ⋯ > [View Window] to check setting values only. If you change the values, the changes are not reflected in the graph window.

*2 For details, see “Adjusting the Graph Window Background Image (Fade I/O)” (page 81).

Precision and Input Ranges

- Note that in the below conditions, calculations are performed as $\infty = 9.99 \times 10^{99}$, $-\infty = -9.99 \times 10^{99}$.
  - Discrete distributions, when $P(X \geq)$ is selected
  - Continuous distributions, when $P(X \leq)$ or $Q(X \geq)$ is selected
- The result of an inverse calculation of a discrete distribution is an integer. Precision is reduced if the cumulative probability p you input has 10 or more digits.
- The following conditions cause an error (Out of Domain).
  - Binomial distribution, when you input a value of 100,000 or greater for Numtrial
  - Binomial distribution, when you input a value for p within the range of $0 < p \leq 0.00001$ or $0.99999 \leq p < 1$
  - Normal distribution, when you input a value of 1×10^{10} or greater or 1×10^{-10} or less for μ
  - Normal distribution, when you input a value of 1×10^{10} or greater for σ
  - Poisson distribution, when you input a value of 1,000 or greater for λ
  - Geometric distribution, when you input a value of 0.00001 or less for p, or when p is within the range of $0.99999 \leq p < 1$
  - Hypergeometric distribution, when you input a value of 201 or greater for n
  - Hypergeometric distribution, when you input a value of 100,000 or greater for M or N
  - χ^2 distribution, when you input a value of 1×10^{16} or greater for df
  - F distribution, when you input a value of 2,000,001 or greater for $n{:}df$ or $d{:}df$

Spreadsheet App

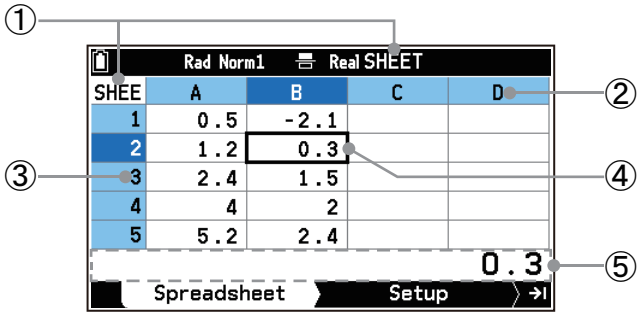
You can use the Spreadsheet app to input values and formulas into cells, and perform spreadsheet calculations. You can also enter statistical data into cells, perform statistical calculations, and draw statistical graphs.

Note

- The maximum file size supported by the Spreadsheet app is about 30KB. The spreadsheet in this app has 999 rows and 26 columns, but due to file size restrictions, it may not be possible to input data into all of the cells. The maximum file size also depends on the type of data being input into the spreadsheet and its formatting, and on the amount of space available in main memory.
- The Spreadsheet app does not support input of complex numbers.

Using the Spreadsheet Tab

Selecting ⌂ > Spreadsheet to start up the app causes the Spreadsheet tab to appear first. The table below describes the name and function of each part of this tab.



① File name	This is the file name of the currently opened file. “SHEET” is the initial default file of the Spreadsheet app, a “SHEET” file is automatically created when you start up the Spreadsheet app for the first time.
② Column letter (A to Z) ③ Row number (1 to 999)	These letters and numbers indicate the current cursor position. For example, “B2” indicates the second row of column B. The row number and column letter of the currently selected cell are displayed in white with a blue background.
④ Cursor	The currently selected cell is indicated by a thick frame. When multiple cells are selected, all of the selected cells are enclosed in a thick frame.
⑤ Edit box	When a single cell is selected, the edit box shows the content of the selected cell. When multiple cells are selected, the edit box shows the range of cells that are selected.

Selecting Cells

Before performing any operation on a cell, you must first select it. You can select a single cell, a range of cells, all the cells in a row or column, or all of the cells in the spreadsheet.

To select this:	Do this:
A single cell	Use the cursor keys to move the cursor to the cell you want, or use the Jump command (page 58) to jump directly to the cell.
A range of cells	1. Move the cursor to the start point of the range of cells you want to select. • You could select an entire row or column of cells as the start point, if you want. 2. Press ⇧ 0 (⬚).* • This changes the cursor to a double frame boundary instead of the normal thick frame.

	3. Use the cursor keys to move the cursor to the end point of the range of cells you want to select. • The edit box shows the range of the selected cells. • To cancel cell selection, press ⑤.
An entire row of cells	Move the cursor to column A of the row whose cells you want to select and then press ◁. This causes the cursor to move to the row header and selects that entire row.
An entire column of cells	Move the cursor to row 1 of the column whose cells you want to select and then press △. This causes the cursor to move to the column header and selects that entire column.
All of the cells in the spreadsheet	Press ◁ while the entire column A is selected or press △ while the entire row 1 is selected.

* Pressing ⇧ 0 (⬚) while you are editing the contents of a cell with the edit box will execute a range specification operation for copying or cutting the characters in the edit box. For more information, see "Copying, Cutting, and Pasting Expressions" (page 10).

To use the Jump command to move the cursor

To move the cursor to this cell	Do this:
A specific cell	1. Select ⋯ > [Edit] > [Jump] > [Go]. 2. On the dialog box that appears, enter the name of the cell (A1 to Z999) to which you want to jump. 3. Press OK.
Top row of current column	Select ⋯ > [Edit] > [Jump] > [Move to the Top Row].
Column A of current row	Select ⋯ > [Edit] > [Jump] > [Move to the First Column].
Bottom row of current column	Select ⋯ > [Edit] > [Jump] > [Move to the Bottom Row].
Column Z of current row	Select ⋯ > [Edit] > [Jump] > [Move to the Last Column].

Inputting Data into a Cell

You can input the types of data described below into a cell.

Constants: A constant is something whose value is fixed as soon as you finalize its input. A constant can be either a numeric value or a calculation formula (such as 7+3, sin(30), A1 × 2, etc.) that does not have an equal sign (=) in front of it. A constant you input is aligned to the right of the cell.

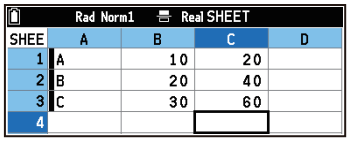
Formula: A formula that starts with an equal sign (=), such as =A1 × 2, is executed as it is written. The result of a formula you input is aligned to the right of the cell.

Text: A character string that starts with a quote mark (") is treated as text. Text you input is aligned to the left of the cell. In addition, a thick vertical line is displayed on the left side of a cell when it contains text. If a cell contains the text "B, for example, its content is displayed as "B.

Example: Input the text A, B, C into cells A1, A2, A3, the constants 10, 10+10, 10 × 3 into cells B1, B2, B3, and formulas that specify doubling of the value in the cell to the left into cells C1, C2, C3

	A	B	C
1	"A	10	=B1 × 2
2	"B	10+10	=B2 × 2
3	"C	10 × 3	=B3 × 2

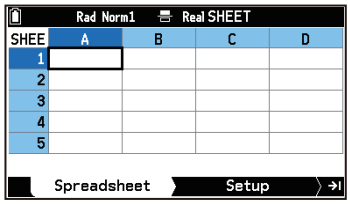
Cell contents



Display screen after input

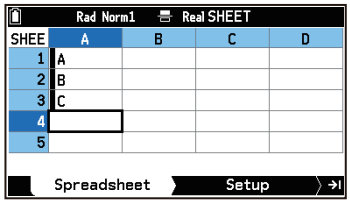
1. ⌂ > Spreadsheet

• This displays the Spreadsheet tab.



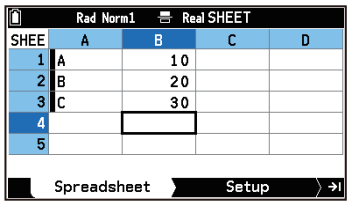
2. Enter the text into cells A1, A2, A3.

[ALPHA] [×10^x] (") [ALPHA] [x,θ,T] (A) [EXE]
[ALPHA] [×10^x] (") [ALPHA] [▤] (B) [EXE]
[ALPHA] [×10^x] (") [ALPHA] [√■] (C) [EXE]



3. Enter the constants into cells B1, B2, B3.

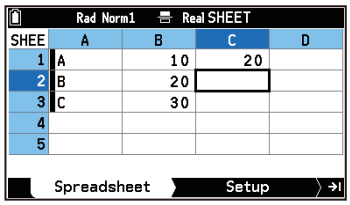
[▲▲] [▶] (Moves to cell B1.)
10 [EXE]
10 [+] 10 [EXE]
10 [×] 3 [EXE]



• This causes the calculation results to appear in cells B2 and B3.

4. Input the formula into cell C1.

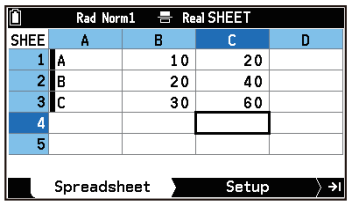
[▲▲] [▶] (Moves to cell C1.)
[▲] [(] (=) [ALPHA] [▤] (B) 1 [×] 2 [EXE]



• Input the formula as-is into cell C1. This causes the numeric result of the calculation to appear in the cell.

5. Copy the formula in cell C1 and then paste it into cells C2 and C3.

[▲▲] (Moves to cell C1.)
[∞] > [Copy & Paste] (Copies the formula in cell C1.)
[▼] [OK] (Pastes into cell C2.)
[OK] (Pastes into cell C3.)
[↩] (Cancels the copy operation.)



• For details about copy and paste operations, see “Copying or Cutting Cell Contents and Pasting Them in Another Location” (page 61).

Note

- Pressing [EXE] in steps 2 through 4 or [OK] in step 5 above causes the cursor to move down to the next cell. You configure a setting to have the cursor move to the next cell to the right, if you want. For details, see [≡] > [Cursor Moves] under “Spreadsheet App Settings Menu Items” (page 74).
- If you input a letter from A to Z, or the characters r or θ as a constant or as part of a formula instead of text, it will be treated as an alpha variable. For example, if you enter [ALPHA] [x,θ,T] (A) [EXE] into a cell, the letter A is treated as a constant and the value stored in variable A appears in the cell.

To fill a range of cells with the same formula (Fill)

Use the Fill command when you want to input the same formula into a specified range of cells. The rules governing relative and absolute cell name references are the same as those for copy and paste. When you need to input the same formula into cells B1, B2, and B3, for example, the Fill command lets you do so by inputting the formula once, into cell B1.

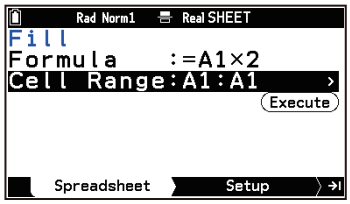
Example: To input into the range of cells B1:B3 a formula that doubles the value in the cell to the left

1. Select the range of cells where you want to input the same formula.
   • You could skip this step and start with step 2, below.

2. Select ⋯ > [Fill].
   • This displays the Fill screen.

3. Highlight the Formula row and then input the formula you want (“=A1×2” here) into the cell at the top of the selected range (B1 here).

(=)(A)1×2



4. If you did not choose a cell range in step 1, specify the cell range here.
   (1) Highlight Cell Range.
   (2) (B)1(:)(B)3

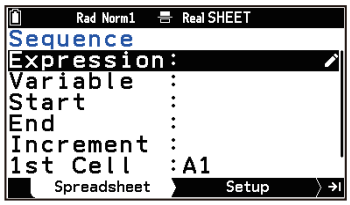
5. Select Execute and then press OK.
   • This inputs the formula into the range of cells you specified.

To fill a column of cells with a numeric sequence (Sequence)

Example: To input the sequence of numbers produced when variable X in function expression “$X^2 + 1$” is assigned a value of 2 to 10 in increments of 2 into column B, starting from cell B1

1. Select the cell from which you want input of the numeric sequence to start.
   • You could skip this step and start with step 2, below.

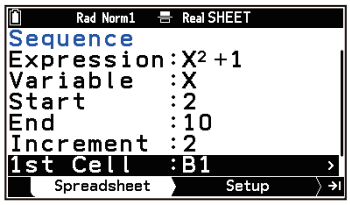
2. Select ⋯ > [Sequence].
   • This displays the Sequence screen.



3. Configure the Sequence operation as described below.

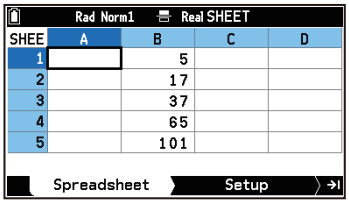
Parameter	Description
Expression	Input the function expression for generating the number sequence.
Variable	Specify the variable name used in the function expression input for Expression.
Start/End	Specify the starting/ending value being assigned to the variable specified by Variable.
Increment	Specify the value that should be added to the variable value with each step.
1st Cell	Specify the starting cell from which the results of the function expression should be inserted.

X ■² +1
X (2) 10 2
(B)1



- Performing the next step inputs the number sequence automatically starting from the specified cell. If any cell that is within the range of cells where the number sequence values will be input already contains data, the existing data is replaced with the number sequence values.

4. After everything is the way you want, select [Execute] and then press [OK].
   - This performs all the required calculations according to your settings and inserts the results into the spreadsheet.



Copying or Cutting Cell Contents and Pasting Them in Another Location

Use the procedures below to copy or cut the contents of one cell or multiple cells, and then paste them into another cell or cells.
For information about what happens when you copy or cut cell contents that include cell references and paste them into another location, see “Relative Cell Reference” (page 62) and “Absolute Cell Reference” (page 62).

To copy the contents of a single cell and paste them into another cell

1. Select the cell whose contents you want to copy.
2. Select [⋯] > [Copy & Paste].
   - This causes “[OK]: Paste” to appear in the status bar. You can continue to paste while this message is displayed.
3. Move the cursor to the cell where you want to paste the contents.
4. Press [OK].
   - The contents of the cell you copied are pasted and the cursor moves down* to the next cell.
5. If you want to paste the same contents to another cell, repeat steps 3 and 4.
   - If you want to continue pasting to the cell to which the cursor has been moved, just repeat the operation in step 4.
6. To end the paste operation, press [⮌].

* Default setting. The direction of cell movement is in accordance with the [☰] > [Cursor Moves] (page 74) setting.

To copy the contents of a range of cells and paste them into another location in the spreadsheet

1. Select the range of cells whose contents you want to copy.
2. Select [⋯] > [Copy & Paste].
   - This causes “[OK]: Paste” to appear in the status bar. You can continue to paste while this message is displayed.
3. Move the cursor to the cell that is the upper left corner of the range of paste destination cells.
4. Press [OK].
   - This pastes the contents of the range of cells you copied.
5. If you want to paste the same contents to another location, repeat steps 3 and 4.
6. To end the paste operation, press [⮌].

To cut the contents of a single cell and paste them into another cell

1. Select the cell whose contents you want to cut.
2. Select [⋯] > [Cut & Paste].
   - This causes “[OK]: Paste” to appear in the status bar.
3. Move the cursor to the cell where you want to paste, and then press [OK].

- This pastes the contents you cut. At the same time, the contents are deleted from the cell where you performed the cut operation.

To cut the contents of a range of cells and paste them into another location in the spreadsheet

1. Select the range of cells whose contents you want to cut.
2. Select ⋯ > [Cut & Paste].
   - This causes “[OK]: Paste” to appear in the status bar.
3. Move the cursor to the cell that is the upper left corner of the range of paste destination cells.
4. Press OK.
   - This pastes the contents of the range of cells that you cut. At the same time, the contents are deleted from the cell where you performed the cut operation.

Note

- Even if ☰ > [Auto Recalculation] (page 68) is turned off, cutting and pasting cell contents results in only the formulas in the pasted cell(s) being recalculated.

Inputting a Cell Reference

A cell reference is a symbol that references the value of one cell for use by another cell. If you input “= A1 + B1” into cell C2, for example, the spreadsheet adds the current value of cell A1 to the current value of cell B1, and displays the result in cell C2.
There are two types of cell references: relative and absolute.

Relative Cell Reference

A relative cell reference changes according to its location on the spreadsheet. The cell reference “= A1” in cell C2, for example, is a reference to the cell located “two columns to the left and one cell up” from the current cell (C2, in this case). Because of this, if we copy the contents of cell C2 and paste them into cell D12, for example, the cell reference changes automatically to “= B11”, because B11 is two columns to the left and one cell up from cell D12. Be sure to remember that relative cell references always change dynamically in this way whenever you move them using copy and paste.

Absolute Cell Reference

An absolute cell reference does not change, regardless of where it is located or where it is copied to or moved to. You can make both the row and column of a cell reference absolute, or you can make only the row or only the column of a cell reference absolute, as described below.

This cell reference:	Does this:
A1	Always refers to column A, row 1.
$A1	Always refers to column A, but the row changes dynamically when moved, as with a relative cell reference.
A$1	Always refers to row 1, but the column changes dynamically when moved, as with a relative cell reference.

Let’s say, for example, that a reference to cell A1 is in cell C1. The following shows what each of the above cell references would become if the contents of cell C1 were copied to cell D12.

A1 → A1	$A1 → $A12	A$1 → B$1

Note

- If the result of a copy-and-paste operation causes a relative cell reference name to change to something that is outside the range of the spreadsheet cells, the applicable column letter and/or row number is replaced by a question mark (?), and “ERROR” is displayed as the cell’s data.

To input a cell reference name using direct input

For example, to input “= A1+5” into cell B1, move the cursor to cell B1 and perform the operation below.

⬆ ((=) ALPHA X,θ,T (A)1 + 5 EXE

To input the absolute cell reference name symbol ($)

Select ⊡ > [Spreadsheet] > [$].

To input a cell reference name using the GRAB command

For example, to input "= A1+5" into cell B1, move the cursor to cell B1 and perform the operation below.

⬆ ((=) ⋯ > [Grab] < (Selects cell A1.) OK + 5 EXE

Note

- Selecting ⋯ > [Grab] causes "[OK]: Enter this cell's ref" to appear in the status bar. While this message is displayed, you can use the Jump command in addition to the cursor keys to navigate between cells. To use the Jump command, press ⋯ while "[OK]: Enter this cell's ref" is displayed. For details, see "To use the Jump command to move the cursor" (page 58).

Using Special Spreadsheet App Commands

The Spreadsheet app has several special commands like CellSum(), which returns the sum of a range of cells, and CellIf(,,), which specifies branching conditions. These special commands can be used inside of formulas. To input these commands, use ⊡ > [Spreadsheet]. The commands described below are included in this menu.

CellIf(,,)

Returns Expression 1 when the equality or inequality provided as the branch condition is true, and Expression 2 when it is false.

Syntax: CellIf(equality,expression 1,expression 2) or
CellIf(inequality,expression 1,expression 2)

Example: =CellIf(A1>B1,A1,B1)
Returns the value of A1 when {Cell A1 value} > {Cell B1 value}. Otherwise, returns the value of B1.

CellMin()

Returns the minimum value in a specified range of cells.

Syntax: CellMin(start cell:end cell)

Example: =CellMin(A3:C5)
Returns the minimum value of the data in cell range A3:C5.

CellMax()

Returns the maximum value in a specified range of cells.

Syntax: CellMax(start cell:end cell)

Example: =CellMax(A3:C5)
Returns the maximum value of the data in cell range A3:C5.

CellMean()

Returns the mean value in a specified range of cells.

Syntax: CellMean(start cell:end cell)

Example: =CellMean(A3:C5)
Returns the mean value of the data in cell range A3:C5.

CellMedian()

Returns the median value in a specified range of cells.

Syntax: CellMedian(start cell:end cell)

Example: =CellMedian(A3:C5)
Returns the median value of the data in cell range A3:C5.

CellSum()

Returns the sum of the data in a specified range of cells.

Syntax: CellSum(start cell:end cell)

Example: =CellSum(A3:C5)
Returns the sum of the data in cell range A3:C5.

CellProd()

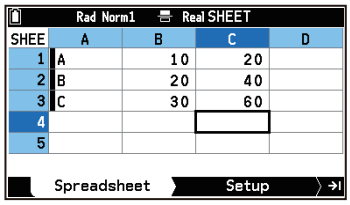
Returns the product of the data in a specified range of cells.

Syntax: CellProd(start cell:end cell)

Example: =CellProd(A3:C5)

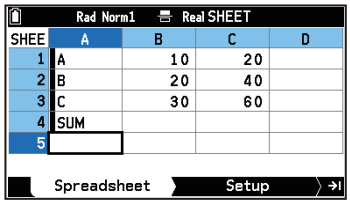
Returns the product of the data in cell range A3:C5.

Example: To input the formula for calculating the sum the values in cells B1:B3 and C1:C3 during the example under “Inputting Data into a Cell” (page 58) into cells B4 and C4, respectively



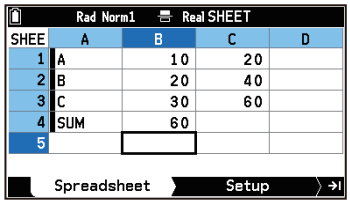
1. Move the cursor to cell A4 and input “SUM” as text.

(ALPHA) (×10^) (”) (ALPHA) (×) (S) (ALPHA) (1) (U) (ALPHA) (7) (M) (EXE)



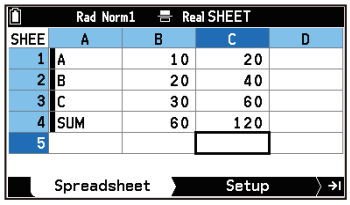
2. Move the cursor to cell B4 and enter the formula to calculate the sum of B1:B3.
   - We want to calculate the sum of B1:B3, so we use the CellSum() command and input: =CellSum(B1:B3).

(Shift) (() (=)
(Menu) > [Spreadsheet] > [CellSum()]
(ALPHA) (Cell) (B)1 (Shift) (,) (:) (ALPHA) (Cell) (B)3
(EXE)



3. Move the cursor to cell C4 and input the formula to calculate the sum of C1:C3.

(Shift) (() (=)
(Menu) > [Spreadsheet] > [CellSum()]
(ALPHA) (√) (C)1 (Shift) (,) (:) (ALPHA) (√) (C)3
(EXE)



Editing Cell Contents

You can perform the editing operations described in the table below on the contents of individual cells, as well as on rows, columns, and the entire spreadsheet.

To do this:	Perform this operation:
Edit the contents of a single cell	1. Select the cell whose contents you want to edit and then select (Edit) > [Edit] > [Cell]. • This causes the cell contents and cursor to appear left-aligned in the edit box. 2. Use (<)/(>) to move the cursor to the location you want and edit the contents as required. 3. After you are finished editing, press (OK).
Sort data in a range of a single row or single column in ascending or descending order	1. Select the range of cells whose data you want to sort. 2. Select one of the menu items below. To sort in ascending order: (Edit) > [Edit] > [Sort Ascending] To sort in descending order: (Edit) > [Edit] > [Sort Descending]
Delete a row or column*1	1. Move the cursor to a cell inside the row or column you want to delete.

<table>
<tr><td></td><td>• You can select multiple rows or multiple columns, if you want. The row(s) or column(s) you select will be deleted.
2. Select one of the menu items below.
To delete row(s):
⋯ > [Delete] > [Row]
To delete column(s):
⋯ > [Delete] > [Column]</td></tr>
<tr><td>Insert a row or column*2</td><td>1. Move the cursor to a cell in the row where you want to insert a row or in the column where you want to insert a column.
• You can select multiple rows or multiple columns, if you want. The row or column will be inserted at the location you selected.
2. Select one of the menu items below.
To insert row(s):
⋯ > [Insert] > [Row]
To insert column(s):
⋯ > [Insert] > [Column]</td></tr>
<tr><td>Delete the contents of all the cells in a spreadsheet</td><td>1. Press AC or select ⋯ > [Delete] > [All].
2. In response to the confirmation dialog that appears, select [OK].</td></tr>
<tr><td>Clearing the contents of selected cells</td><td>1. Select the range of cells whose contents you want to clear.
2. Select one of the menu items below.<table><tr><th>To do this:</th><th>Select this menu item:</th></tr><tr><td>Clear contents only</td><td>⋯ > [Clear] > [Content]</td></tr><tr><td>Clear formatting only</td><td>⋯ > [Clear] > [Format]</td></tr><tr><td>Clear all contents and formatting</td><td>⋯ > [Clear] > [All]</td></tr></table></td></tr>
</table>

*1 This operation can also be performed using the steps below.

(1) Move the cursor to the header of the row or column being deleted.

(2) Select ⋯ > [Delete].

*2 This operation can also be performed using the steps below.

(1) Move the cursor to the header of the line or the column where you want to insert a line or column.

(2) Select ⋯ > [Insert].

Note

- A Range ERROR occurs if an insert operation causes existing cells that contain data to move outside the range of A1:Z999.

Spreadsheet File Operations

With the Spreadsheet app, you can use the file operations described in the table below.

To do this:	Select this menu item:
Close the currently open file and create a new file	⋯ > [File] > [New]*1
Close the currently open file and open another file	⋯ > [File] > [Open]
Save the currently open file under a different name	⋯ > [File] > [Save As]
Delete a file	⋯ > [File] > [Delete]*2

*1 Inputting the name of an existing file in the dialog that appears opens the existing file without creating a new one.

*2 Deleting the currently open file other than “SHEET” opens the file named “SHEET”. Deleting the currently open “SHEET” file automatically creates a new “SHEET” file.

Transferring Data between a Spreadsheet and CSV Files

You can import into a spreadsheet the contents of a CSV file that is stored in calculator memory or transferred from a computer. You also can save the contents of a spreadsheet as a CSV file. For information about the procedure for transferring data between a spreadsheet and CSV files, see “Using CSV Files” (page 244).

Specifying the Text Color and Fill Color of Each Cell

For each cell, you can specify the text color, fill color, and fill color intensity (Normal or Lighter).

To specify the text color and fill color of each cell

1. Select the range of cells whose text color and fill color you want to specify.
2. Select ⋯ > [Color].
3. Configure the above dialog box with the following settings.

To specify this:	Perform this operation:
Specify the text color	Select [Char Color]. On the menu that appears, select the desired color.
Specify the cell color	Select [Area Color]. On the menu that appears, select the desired color.
Specify the intensity of the cell color	Select [Paint Style]. On the menu that appears, select [Normal] or [Lighter].

4. To apply the settings you configure, press ⏎.

Saving Data to/Recalling Data from Variables

Spreadsheet data can be saved to variables, and data stored in variables can be recalled into a spreadsheet. Variables that can be saved to or recalled from are described below.

- Save only: alpha variables
- Save and recall: vector variables, matrix variables, list variables, list files*

  * A list file is equivalent to 26 list variables. For details, see “List Files” (page 32).

To save spreadsheet data to a variable

1. Select a single cell or a range of cells containing the data you want to save to a variable.
   - Select the cell range in the table below that corresponds to the type of variable you are saving to.

To save to this type of variable:	Select this range:
Alpha variable	Single cell
List variable or vector variable	A range of cells in a single row or a single column
List file or matrix variable	A range of cells that spans multiple rows and columns

   - You could skip this step and start with step 2, below.
2. Select ⋯ > [Memory] > [Store].
3. On the menu that appears, select the type of variable to which you want to save the data.

To save to this type of variable:	Select this menu item:	Destination:
Alpha variable	[Alpha]	A to Z, r, or θ
List variable	[List]	List 1 to List 26
List file	[File]	File 1 to File 6
Matrix variable	[Matrix]	Mat A to Mat Z
Vector variable	[Vector]	Vct A to Vct Z

4. Use the screen that appears to specify the cell range and the destination variable.
   - If you specified a cell range in step 1 of this procedure, you do not need to specify it again here.
   - Refer to “Destination” in the table in step 3 for the destinations that you can specify.

5. Select Execute and then press OK.

Note

- Text color and other formatting settings are disregarded when cells are saved to a variable.
- The following describes what happens if you try to store data in a variable when a cell does not contain any data, when a cell contains text, or when ERROR is displayed for a cell.
  - If you are assigning data to an alpha variable, an error occurs.
  - If you are storing data in a list variable, a list file, a matrix variable, or a vector variable, 0 is written into the applicable cell(s).

To recall data stored in a variable into a spreadsheet

1. Specify the cell to which you want to recall the variable data.
   - Select a cell for recall in accordance with the type of variable as shown in the table below.

To recall from this type of variable:	Select a cell like this:
List variable	When "Down" is selected for ☰ > [Cursor Moves] (page 74): Select the cell at the top of the range to which you want to recall data. The data is recalled from top to bottom starting from the selected cell. When "Right" is selected for ☰ > [Cursor Moves]: Select the leftmost cell of the range to which you want to recall data. The data is recalled from left to right starting from the selected cell.
List file or matrix variable	Select the cell at the top-left corner of the range to which you want to recall data.
Vector variable	Select the leftmost cell (for a vector with 1 row and n columns) or the topmost cell (for a vector with n rows and 1 column) of the range to which you want to recall data.

   - You could skip this step and start with step 2, below.

2. Select ○○○ > [Memory] > [Recall].

3. On the menu that appears, choose the type of variable whose data you want to recall.

To recall from this type of variable:	Select this menu item:	Recall source:
List variable	[List]	List 1 to List 26
List file	[File]	File 1 to File 6
Matrix variable	[Matrix]	Mat A to Mat Z
Vector variable	[Vector]	Vct A to Vct Z

4. Use the screen that appears to specify the variable being recalled and the destination cell.
   - See the "Recall source" column in the table in step 3 for information about the types of variables that can be specified.
   - If you selected a cell in step 1 of this procedure, you do not need to specify a cell here.

5. Select Execute and then press OK.

Note

- If you specify a cell that results in the recalled data not being able to fit within the range of the spreadsheet (A1:Z999), pressing Execute in step 5 results in an error and does not execute the recall.
- The recalled data is formatted according to the default formatting of the cell to which it is recalled.

Auto Recalculation and Recalculate

“Auto Recalculation” is a setting item on the Settings menu. With the Spreadsheet app’s initial default setting (Auto Recalculation: On), all formulas in a spreadsheet are automatically re-calculated whenever you open a file or perform an editing operation in the Spreadsheet app. Depending on the content of the spreadsheet, auto re-calculation can take a long time to complete. When Auto Recalculation is disabled (Off), you need to execute re-calculation manually as required.

To execute re-calculation manually

Select ⋯ > [Recalculate].

Note

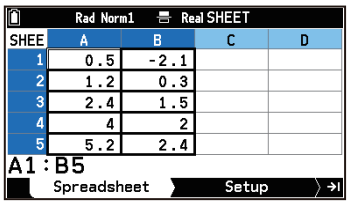
- Even if the Auto Recalculation setting is On, you should execute ⋯ > [Recalculate] in the cases below.
  - When the Settings menu is used to change the Angle setting
  - When a cell contains a formula using an alpha variable or a function variable and the corresponding variable is updated

Statistical Calculations and Graph Drawing

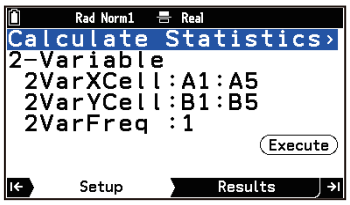
You can perform statistical calculations and draw statistical graphs using data input into a spreadsheet.

Inputting Data

Depending on the statistical data being processed, input the data using columns 1, 2, and 3 of the Spreadsheet tab.



Input of 2-Variable data without frequencies



Example setup (Setup tab)

For this statistical data:	Input like this:
1-Variable (no frequencies)	Input variable-X data (1VarXCell*1) into a single column.
1-Variable (with frequencies)	Input variable-X data (1VarXCell*1) into the first column and frequency data (1VarFreq*2) into the second column.
2-Variable (no frequencies)	Input variable-X data (2VarXCell*1) into the first column and variable-Y data (2VarYCell*1) into the second column.
2-Variable (with frequencies)	Input variable-X data (2VarXCell*1) in the first column, variable-Y data (2VarYCell*1) into the second column, and frequency data (2VarFreq*2) into the third column.

*1 In the Spreadsheet app Setup tab, specify the cell range for data being used for 1-Variable statistical calculation to 1VarXCell (or XCellRange), the cell range for data being used for 2-Variable statistical calculation to 2VarXCell, 2VarYCell (or XCellRange, YCellRange).

*2 In the Spreadsheet app Setup tab, the cell range of frequency data used for 1-Variable statistical calculation is displayed as 1VarFreq (or Frequency), while the cell range of frequency data used for 2-Variable statistical calculation is displayed as 2VarFreq (or Frequency).

Frequencies

There are two ways to input statistical data: with frequencies and without frequencies (1 is used for all data frequencies). You can specify which method you want to use on the Setup tab that appears when you press ⇥ on the Spreadsheet tab, as shown in the example below.

	
Using cell range A1:A5 as data Frequency of all data values: 1	Using cell range A1:A5 as data Using cell range B1:B5 as frequencies

Important!

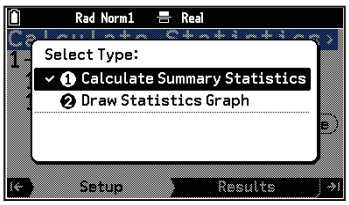
- The values contained in the cell range used as the frequency data should be 0 or positive values only. Even a single negative value causes an error (Out of Domain).
- Statistical data with a frequency of 0 is not used for calculation of minimum and maximum values.

Displaying Summary Statistics or Regression Model Information

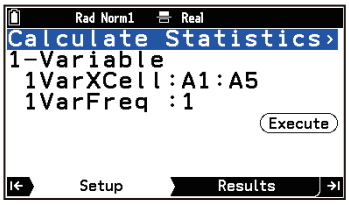
You can use the procedure below to find and display various summary statistics from 1-Variable or 2-Variable statistical data. This procedure can also be used to display regression equation coefficients and coefficients of determination (referred to as “regression model information” in this manual) when regression models are applied to 2-Variable statistical data.

To display summary statistics or regression model information

1. Input the statistical data to use in the calculation.
   - For details, see “Inputting Data” (page 68).
2. Select the range of cells into which you input statistical calculation data.
   - You could skip this step and go to step 3, below.
3. Press ⇥.
   - If this causes the Select Type menu to appear, go to step 5 of this procedure. Otherwise, go to step 4.
4. Highlight the first line of the Setup tab and then press [OK].



5. Select [Calculate Summary Statistics].
   - This causes the Calculate Statistics menu to appear on the Setup tab.



6. Highlight line 2 on the tab and then press [OK].
7. On the menu that appears, select the type of statistical calculation you want to perform.

To do this:	Select this menu item:
Display summary statistics based on 1-Variable statistical data (X)	1-Variable
Display summary statistics based on 2-Variable statistical data (X, Y)	2-Variable
Display regression model information based on 2-Variable statistical data (X, Y) (Select the desired regression model from the menu.)	Linear Regression(ax+b)
	Linear Regression(a+bx)
	Med-Med Regression
	Quadratic Regression
	Cubic Regression

	Quartic Regression
	Logarithm Regression
	Exp Regression(a·e^bx)
	Exp Regression(a·b^x)
	Power Regression
	Sinusoidal Regression
	Logistic Regression

8. Specify the cell range containing the statistical data being used in the calculation as required.

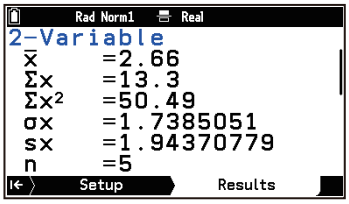
   For 1-Variable statistical data:

   (1) Highlight [1VarXCell] and then press [OK].
   (2) Use the dialog box that appears to input the range of X-data cells and then press [OK].
   (3) Highlight [1VarFreq] and then press [OK].
   (4) If you do not want to use frequency data, select [1] on the menu.
   If you want to use frequency data, select [Cell Range] and then advance to step (5).
   (5) Use the dialog box that appears to input the range of frequency data cells and then press [OK].

   For 2-Variable statistical data:

   (1) Highlight [2VarXCell] and then press [OK].
   (2) Use the dialog box that appears to input the range of X-data cells and then press [OK].
   (3) Highlight [2VarYCell] and then press [OK].
   (4) Use the dialog box that appears to input the Y-data cell range and then press [OK].
   (5) Highlight [2VarFreq] and then press [OK].
   (6) If you do not want to use frequency data, select [1] on the menu.
   If you want to use frequency data, select [Cell Range] and then advance to step (7).
   (7) Use the dialog box that appears to input the range of frequency data cells and then press [OK].

9. Press [→]. Or highlight [Execute] and then press [OK].
   - This displays the summary statistics or regression model information you selected in step 6 on the Results tab. If a scroll bar appears along the right edge of the window, use [▼] and [▲] to scroll the display.



   - See “Summary Statistics” (page 33) and “Regression Model Information” (page 34) for the meanings of the values that appear on the display.

Drawing a Statistics Graph

You can use 2-Variable statistical data to draw scatter plots and various regression graphs. 1-Variable statistical data can be used to draw seven types of graphs, including histograms and box-and-whisker diagrams. After drawing a graph, you can display summary statistics and regression model information.

Drawing a 1-Variable Statistics Graph (Histogram, Box-and-Whisker Diagram, etc.)

You can perform the operations below based on 1-Variable statistical data you input into a spreadsheet.

(1) Draw a Box Plot, Histogram, Broken Line Graph, Pie Chart, Bar Graph, Normal Probability Plot, or Normal Density Curve.
(2) Display summary statistics after drawing the graph (except for Pie Chart).

To draw a 1-Variable statistics graph

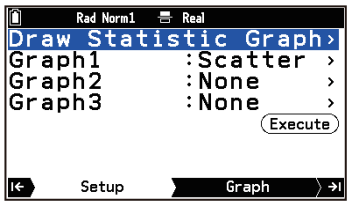
1. Input the statistical data to use in the calculation.
   - For details, see “Inputting Data” (page 68).

2. Select the range of cells into which you input statistical calculation data.
   • You could skip this step and go to step 3, below.

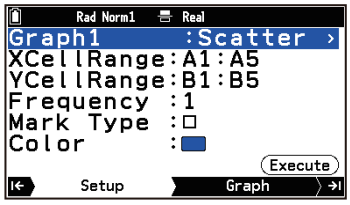
3. Press ⇥.
   • If this causes the Select Type menu to appear, go to step 5 of this procedure. Otherwise, go to step 4.

4. Highlight the first line of the Setup tab and then press [OK].

5. On the Select Type menu, select [Draw Statistics Graph].
   • This causes the Draw Statistics Graph menu to appear on the Setup tab.



6. Select the type of graph you want to draw.
   (1) Highlight [Graph1] and then press [OK].
      • This causes the Setup tab display to change to the Graph1 setting menu.



   (2) Press [OK] again.
      • This displays a menu for selecting the graph type.
   (3) Highlight the type of graph you want to draw from the menu and then press [OK].

7. Specify statistical data cell range on the spreadsheet.

   <u>For a Box Plot, Histogram, Broken Line Graph, Normal Probability Plot, or Normal Density Curve:</u>
   (1) Highlight [XCellRange] and then press [OK].
   (2) Use the dialog box that appears to input the range of data cells and then press [OK].
   (3) Highlight [Frequency] and then press [OK]. (Excluding Normal Probability Plot)

   <u>For a Pie Chart:</u>
   (1) Highlight [Category] and then press [OK].
   (2) Use the dialog box that appears to input the range of data category name cells and then press [OK].
   (3) Highlight [Data] and then press [OK].
   (4) Use the dialog box that appears to input the range of data cells and then press [OK].

   <u>For a Bar Graph:</u>
   You can specify up to three sets of data to draw a bar graph.
   (1) Highlight [Category] and then press [OK].
   (2) Use the dialog box that appears to input the range of data category name cells and then press [OK].
   (3) Highlight [Data1] and then press [OK].
   (4) Use the dialog box that appears to input enter the range of data cells and then press [OK].
   (5) Repeat the steps (3) and (4) above for [Data2] and [Data3].
      • When specifying [Data2] and [Data3], be sure to specify the same number of rows as [Data1] data. If the number of rows is different, an error (Dimension ERROR) occurs.
      • When specifying two sets of data, be sure to specify the cell range for [Data1] and [Data2]. If a cell range is specified for [Data1] and [Data3] while [Data2] is set to “None”, an error (Condition ERROR) occurs.

8. Specify the graph color and other settings as required.

- For details, see “Setting Items for Each 1-Variable Statistics Graph Type” (page 38).

9. To draw the graph, press ⇥. Or highlight [Execute] and then press [OK].
   - The graph is displayed on the Graph tab.
   - If the graph you selected in step 6-(3) is a Histogram or Broken Line Graph, a dialog box appears where you can specify Start (x-coordinate of the graph drawing start point) and Width (graph drawing width). Input each of the values, highlight [Execute], and then press [OK].
   - For information about the operations you can perform on the Graph tab, see “Graph Window Operations” (page 41).

10. To view summary statistics, press ⇥. (This operation cannot be used for a Pie Chart.)
    - This causes the summary statistics to appear on the Results tab. You can use ▽ and △ to scroll the display contents.
    - See “Summary Statistics” (page 33) for the meanings of the displayed values.

Drawing a 2-Variable Statistics Graph (scatter plot or regression graph)

You can perform the operations below based on 2-Variable statistical data.

(1) Draw a Scatter Plot, xy Line Graph, or regression graph

(2) After drawing a graph, display summary statistics or regression model information

(3) Draw a regression graph over a graph described in (1) above*

* Common practice in (1) is to draw a Scatter Plot and then draw a regression graph over it. You can also draw a regression graph over a xy Line Graph or another regression graph.

To draw a 2-Variable statistics graph

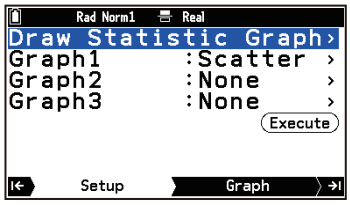
1. Input the statistical data to use in the calculation.
   - For details, see “Inputting Data” (page 68).

2. Select the range of cells into which you input statistical calculation data.
   - You could skip this step and go to step 3, below.

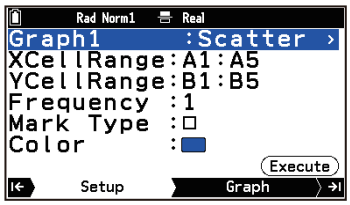
3. Press ⇥.
   - If this causes the Select Type menu to appear, go to step 5 of this procedure. Otherwise, go to step 4.

4. Highlight the first line of the Setup tab and then press [OK].

5. On the Select Type menu, select [Draw Statistics Graph].
   - This causes the Draw Statistics Graph menu to appear on the Setup tab.



6. Select the type of graph you want to draw.
   (1) Highlight [Graph1] and then press [OK].
      - This causes the Setup tab display to change to the Graph1 setting menu.



   (2) Press [OK] again.
      - This displays a menu for selecting the graph type.
   (3) Highlight the type of graph you want to draw from the menu and then press [OK].

7. Specify statistical data cell range on the spreadsheet.
   (1) Highlight [XCellRange] and then press [OK].

(2) Use the dialog that appears to input the data cell range and then press [OK].

(3) Highlight [YCellRange] and then press [OK].

(4) Use the dialog that appears to input the data cell range and then press [OK].

(5) Highlight [Frequency] and then press [OK]. (This operation does not work with a Sinusoidal Regression Graph or Logistic Regression Graph.)

8. Specify the graph color and other settings as required.
   - Mark Type: If you selected Scatter Plot or xy Line Graph as the graph type, specify the mark to use for the plot.
   - Color: Specifies the graph draw color.

9. To draw the graph, press [⇥]. Or highlight [Execute] and then press [OK].
   - The graph is displayed on the Graph tab.
   - For information about the operations you can perform on the Graph tab, see “Graph Window Operations” (page 41).

10. Display summary statistics or regression model information.

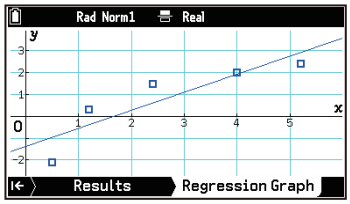
(1) Press [⇥].

(2) Perform the operations shown in the table below.

To display this information:	Select this menu item:
Summary statistics	2-Variable
Regression model information (You can select the one regression model you want.)	Linear Regression(ax+b)
	Linear Regression(a+bx)
	Med-Med Regression
	Quadratic Regression
	Cubic Regression
	Quartic Regression
	Logarithm Regression
	Exp Regression(a·e^bx)
	Exp Regression(a·b^x)
	Power Regression
	Sinusoidal Regression
	Logistic Regression

(3) Press [OK].
   - This displays the details of the menu item you selected in step (2) above on the Results tab.
   - See “Summary Statistics” (page 33) and “Regression Model Information” (page 34) for the meanings of the displayed values.

11. Press [⇥] to go to the Regression Graph tab and draw a regression graph.
   - Choosing one of the regression models in step 10 draws a regression graph over the graph drawn in step 9. Choosing 2-Variable displays only the graph drawn in step 9.

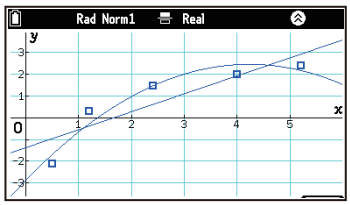


12. Add regression graphs as needed.
   You can add multiple regression graphs on the Regression Graph tab. To do this, perform the steps below.

(1) Select [⋯] > [Draw Regression Graph].

(2) From the menu that appears, select the regression model you want and then press [OK].
   - This adds the graph of the regression model you selected.

- You can repeat steps (1) and (2) above to add more regression graphs.



- For operations that are available on the Regression Graph tab, see “Graph Window Operations” (page 41).

Note

- For details about Graph1 to Graph3 on the Setup tab in step 5 above, see “Drawing Graphs Using Multiple Graph Setups” (page 42).
- The settings of the statistics graph View Window are automatically configured according to the graph being drawn. For more information, see “Statistics Graph View Window Settings” (page 52).

Spreadsheet App Settings Menu Items

The Settings menu items (page 214) described below are specific to the Spreadsheet app.

☰ > [Auto Recalculation] …	Toggles between automatic recalculation and no recalculation for each data input.
☰ > [Edit Box Shows] …	Specifies whether the contents of a formula already entered in a cell are displayed as a formula or as a value. Even if value is specified by this setting, the formula is displayed when editing cell contents.
☰ > [Cursor Moves] …	Selects the cursor movement direction (down or right) after data is input or pasted into a cell.

Graph&Table App

You can use the Graph&Table app to draw various types of graphs and to create numeric tables.

Operation Flow

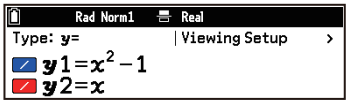
Example: To input the functions $y = x^2 - 1$ and $y = x$, draw a graph, and create a numeric table

1. (Menu) > Graph&Table

2. On the Function tab (page 75), input the function.

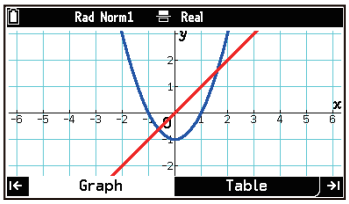
   (1) In the $y1$ line, input $x^2 - 1$.
   (2) In the $y2$ line, input x.

   (X,θ,T) (x²) (−) 1 (EXE)
   (X,θ,T) (EXE)

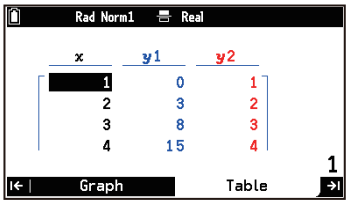


3. To draw a graph of the function you entered, press (F6).
   - This displays the View Window menu. Change the range specification as required. For more information, see "Specifying the Display Range of the Graph Window (View Window)" (page 80).

4. Highlight Draw and then press (OK).
   - This draws the graph on the Graph tab (page 79).



5. To display the numeric table for the function you entered, press (F6).
   - This displays the numeric table on the Table tab (page 86).



6. To return to the Function tab, press (F6) or (EXIT).

> **Note**
> - Functions input on the Function tab of the Graph&Table app also appear on the Function tab of the Dyna Graph app (page 89). Similarly, functions input on the Function tab of the Dyna Graph app also appear on the Function tab of the Graph&Table app.

Out of Drawing Range Graph Warning Message

The Out of Drawing Range warning message appears when there is nothing to draw in the window when you try to draw a graph. If this happens, choose the desired operation from the menu that appears.

To do this:	Select this menu item:
Display the View Window menu	[View Window]
Automatically adjust View Window settings and draw a graph	[Auto Zoom]
Display the graph window (without drawing a graph) without adjusting View Window settings	[Cancel]

Using the Function Tab

Within the Function tab, you can enter up to 20 functions of various types.

Using the Setup Menu

Use the Setup menu to select a function type. You can also use this menu to specify the range of the graph window and numeric table.

To display the Setup menu

1. On the Function tab, highlight the first line.
   - Pressing ⏫ always highlights the first line.
2. Press [OK].

To select a function type

1. From the Setup menu, select [Type].
   - This displays the Type menu.
2. Perform the operations described in the table below.

To select this function type:	Select this menu item:
Cartesian coordinate type ($y=f(x)$ form)	[y=]
Polar coordinate type ($r=f(\theta)$ form)	[r=]
Parametric type ($\begin{cases}\mathrm{Xt}=f(\mathrm{T})\\ \mathrm{Yt}=f(\mathrm{T})\end{cases}$ form)	[Param]
Cartesian coordinate type ($\mathrm{X}=f(\mathrm{Y})$ form)	[X=]
Inequality type ($y>f(x)$, $y<f(x)$, $y\geq f(x)$, $y\leq f(x)$ form)	[y>], [y<], [y≥], [y≤]
Inequality type ($\mathrm{X}>f(\mathrm{Y})$, $\mathrm{X}<f(\mathrm{Y})$, $\mathrm{X}\geq f(\mathrm{Y})$, $\mathrm{X}\leq f(\mathrm{Y})$ form)	[X>], [X<], [X≥], [X≤]

   - The type you choose is applied to the function you are about to input. It does not affect any function that has already been entered.

To specify the display range of the graph window

From the Setup menu, select [View Window]. See “Specifying the Display Range of the Graph Window (View Window)” (page 80) for details.

To specify the numeric table domain

From the Setup menu, select [Set Table Domain]. See “Specifying a Table Domain” (page 86) for details.

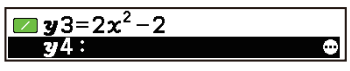
Inputting and Editing Functions

To input a function

1. Use the operation under “To select a function type” (page 76) to select the type of function you want to input.
2. On the Function tab, highlight the line where you want to input, and then input a function.
   - Press [X,θ,T] to input the variables (x, θ, T, Y) according to the function type you chose.

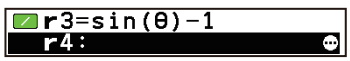
Example 1: To input the y form of Cartesian coordinate type $y = 2x^2 - 2$

[X,θ,T] [x²] [(−)] 2 [EXE]



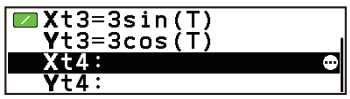
Example 2: To input the polar coordinate type $r = \sin(\theta) - 1$

[sin] [X,θ,T] [)] [(−)] 1 [EXE]



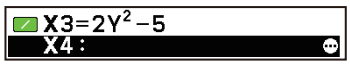
Example 3: To input parametric type $\begin{cases}\mathrm{Xt} = 3\sin(\mathrm{T})\\ \mathrm{Yt} = 3\cos(\mathrm{T})\end{cases}$

3 [sin] [X,θ,T] [)] [EXE]
3 [cos] [X,θ,T] [)] [EXE]



Example 4: To input the X form of Cartesian coordinate type $\mathrm{X} = 2\mathrm{Y}^2 - 5$

2 [X,θ,T] [x²] [(−)] 5 [EXE]



In addition to the above, you can also use the special format input methods described below.

To do this:	Perform this operation:
Input a composite function **Example:** To input the composite function "$y1(y2)$" into $y3$ after $y = x^2 - 1$ and $y = x$ have already been input[*1]	Input "$y1(y2)$" into the $y3$ line. [x] > [Function] > [$y1$] ( ) [x] > [Function] > [$y2$]) [EXE]
Input a function containing one or more alpha variable[*2] while simultaneously specifying the value to be assigned to one of the alpha variables in the function[*3*4] **Example:** Assign 1, 2, 3 to variable A of $y = Ax^2 - 1$ [*5]	Input "$Ax^2 - 1$, [A=1,2,3]" into a y line.[*6*7] [ALPHA] [X] (A) [x²] [−] 1 , [↑] 4 ([]) [ALPHA] [X] (A) [↑] ((=) 1 , 2 , 3 [↑] 5 (]) [EXE]
Input a function that includes a list[*3*4] **Example:** Input $y = \{1,2,3\}x^2$ [*8]	Input "$\{1,2,3\}x^2$" into a y line. [▭] > [Statistics] > [{ }] 1 , 2 , 3 [>] [X] [x²] [EXE]
Input a function with a range of variable values **Example:** Specify the x value of $y = x^2$ within the range $0 \le x \le 2$	Input "x^2, [0,2]" into a y line. [X] [x²] , [↑] 4 ([]) 0 , 2 [↑] 5 (]) [EXE]

*1 Composite functions can be nested up to five levels.
*2 Alpha variables except x, θ, T and Y.
*3 If there are multiple variables or multiple elements in the list, multiple graphs will be drawn at the same time based on a single input function.
*4 The color and line type of the graph drawn by this operation cannot be changed.
*5 If there is only one value to be assigned, it can also be entered using the syntax $Ax^2 - 1$ (A=1).
*6 Be sure to input numeric values within the square brackets ([ ]). You cannot input alpha variables here.
*7 Even if there are multiple variables in a function, values can be assigned to only one of the variables.
*8 When multiple lists are used in a function, all of the lists must have the same number of elements. For example, $y = \{1,2,3\}x^2 - \{1,1,1\}$. If a list does not have the same number of elements as the other lists, a Dimension ERROR will occur.

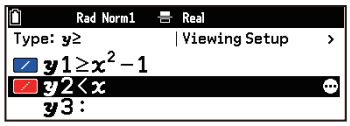
Inputting Inequalities and Configuring Fill Settings

Example: To input the inequalities $y \ge x^2 - 1$ and $y < x$

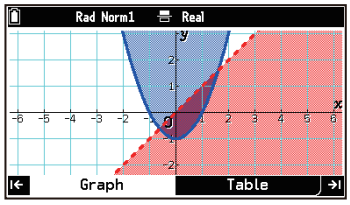
1. Use the procedure under "To select a function type" (page 76) to select [Type] > [$y\ge$].

2. Input $x^2 - 1$ into the $y1$ line and x into the $y2$ line.

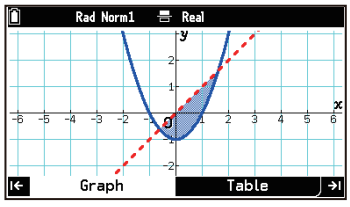
3. Highlight the $y2$ line and then select [⋯] > [Change Symbol] > [<].



4. Press [⇥] to draw the graph.
   - By default ([☰] > [Ineq Region Type] > [Union]), all ranges satisfying the conditions of each inequality are filled.



   - If you choose [☰] > [Ineq Region Type] > [Intersection] to draw the graph, only the range that satisfies the conditions of all inequalities is filled.



To edit a function

On the Function tab, highlight the line you want to edit and then perform the operation below.

To do this:	Perform this operation:
Edit what you have already entered	Press ◁, ▷, or EXE. This causes the input cursor to appear so you can edit the entry.*
Overwrite input	Press the key of the number or letter you want to re-input.*
Change the symbol of a Cartesian coordinate type or inequality type	⋯ > [Change Symbol] and select a sign from the list displayed.

* Edits are not finalized until you press EXE after editing. To cancel editing without changing anything, press ↩ before pressing EXE.

To delete a function

To do this:	Perform this operation:
Delete the function in the highlighted row	Highlight the line that contains the content you want to delete,* and then press DEL. Or you could select ⋯ > [Delete] > [Delete Formula].
Delete all functions on the Function tab	Press AC. Or you could select ⋯ > [Delete] > [Delete All].

* For parametric type functions, highlight either the Xt or Yt line.

Graph Drawing Settings (Line Type, Line Color)

On the Function tab, highlight the row that contains the graph drawing settings you want to change and then perform the operations described in the table below.

To do this:	Perform this operation:
Change the line type for graph drawing	Select ⋯ > [Line Style]. Use the list that appears to select a line style.
Change the line color for graph drawing	Select ⋯ > [Line Color]. Use the list that appears to select a color.

The line type and color you specify are shown by the icons to the left of each line of the Function tab.

Drawing Graphs and Creating Tables

To select a function to draw a graph and create a numeric table

1. On the Function tab, highlight a line that contains an input function.
2. Press ⋯.
   - This displays a Tools menu with [Select] highlighted.
3. Change [Select] to (On) to enable or to (Off) to disable graphing and numeric table generation for the selected function.
4. Press ↩ to close the Tools menu.
   - The on/off setting of step 3 is indicated by the icons to the left of each line of the Function tab.

… On … Off

Note

- All functions that you enable (turn on) in step 3 can be graphed, regardless of their type.
- A numeric table can be created for a function that you enable (turn on) in step 3 if its function type selected for [Type] on the Setup menu (page 76) is [y=], [r=], or [Param].

To go from the Function tab to the Graph tab (to draw a graph)

Press ⇥ or highlight [Draw Graph] and then press [OK]. This causes the View Window menu to appear so you can specify the range of the graph window. Change the range specification as required. For more information, see “Specifying the Display Range of the Graph Window (View Window)” (page 80).

To return to the Function tab, press ⇤ or ↩.

> **Note**
>
> • To prevent the View Window menu from appearing when you go to the Graph tab, turn off ☰ > [Show V-Win Settings] (page 215).

To go from the Function tab to the Table tab (to create a numeric table)

Press ⇤ or highlight [Display Table] and then press [OK].

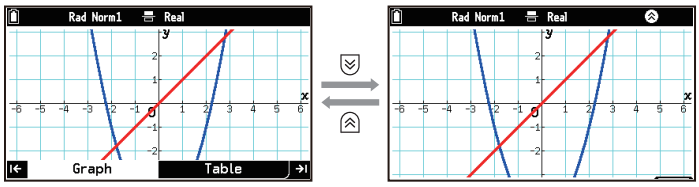
To return to the Function tab, press ⇥ or ↩.

> **Note**
>
> • If you want to add a column of derivative coefficients to the numeric table on the Table tab, turn on ☰ > [Derivative] (page 219). In addition to the x and y columns, a y'-column for the derivative coefficient will be included in the numeric table.

Using the Graph Tab

Showing and Hiding Tabs

While the Graph tab is active, press ⌄* to hide the tab and expand the graph window. Press ⌃ to show the tab again.



——— in the lower-right corner of the window and ⌃ in the status bar indicate that a hidden tab can be shown again.

* You can hide the tab by pressing [OK], [AC], or almost any other key. Tabs also may be hidden automatically when certain functions (such as graph analysis) are executed. ⌃ is not displayed, the tab cannot be redisplayed until execution of the current function is stopped.

Adjusting the Graph Window

To move the graph window up, down, left, or right

Use the cursor keys.

To zoom the graph window in or out

Press ⊕ to zoom in or ⊖ to zoom out.

To fine-tune the graph window (Tools menu)

To do this:	Select this menu item:	Details:
Specify the display range	⋯ > [View Window]	“Specifying the Display Range of the Graph Window (View Window)” (page 80)
Zoom the graph window in or out	⋯ > [Zoom]	“Changing the Graph Window Zoom Setting (Zoom)” (page 81)

Grab a point on a window and drag it around the display	⋯ > [Pan]	“Grabbing a Point on a Window and Drag It Around the Display (Pan)” (page 81)
Adjust the background image	⋯ > [Fade I/O]	“Adjusting the Graph Window Background Image (Fade I/O)” (page 81)

Specifying the Display Range of the Graph Window (View Window)

Use the View Window menu* to specify the display range (x- and y-axis range) of the graph window. You can also use this menu to specify the range of values for drawing polar and parametric type graphs.

* This menu appears on the Graph tab when you select ⋯ > [View Window]. It can also be displayed from other tabs in the Graph&Table app, Dyna Graph app and the Recursion app. The menu contents are the same regardless of where it is displayed.

Using the Preset View Window Settings

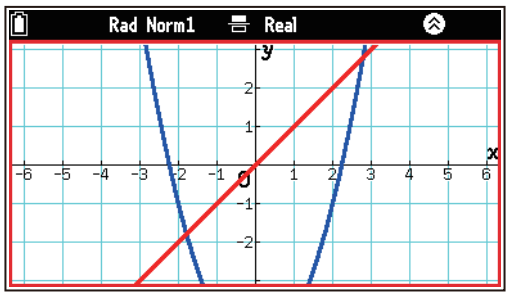
To use this setting:	Select ⋯ > [View Window] > [Pre-set Windows] and then select this:
Initial calculator setup	[Initialize]
Presets according to the current angle unit setting (⚙ > [Angle])	[Trigonometric]
Calculator standard setup	[Standard]
Fix the current y-axis setting and change the x-axis setting so the on-screen y-axis and x-axis scale widths are one-to-one	[Square] > [Y Base]
Fix the current x-axis setting and change the y-axis setting so the on-screen y-axis and x-axis scale widths are one-to-one	[Square] > [X Base]

To specify the display range manually

Use the View Window to input values for the items below.

- x Minimum, x Maximum, x Scale (x-axis minimum value, maximum value, scale)
- y Minimum*, y Maximum, y Scale (y-axis minimum value, maximum value, scale)
- x Dot Value is the value per dot in the x-axis direction. It is determined according to the values of x Minimum and x Maximum. Changing the x Dot Value value automatically updates the x Maximum value.

* When the tab is hidden, the value set by y Minimum is the bottom edge of the graph window (red frame below).



To specify the range of T and θ values and the pitch

These settings are applied when drawing parametric and polar graphs. Use the View Window to input values for the items below.

- T,θ Minimum, T,θ Maximum (maximum and minimum values assigned to T in the parametric type function, and maximum and minimum values to be assigned to θ in the polar coordinate type function)
- T,θ Pitch is the pitch of the T and θ values when drawing the graph. The smaller the pitch values, the finer the graph that is drawn. Larger values result in coarser graphs.

Changing the Graph Window Zoom Setting (Zoom)

Your calculator provides various convenient zoom settings that you can use to change the display range of the graph window.

To do this within the graph window:	Select ⋯ > [Zoom] and then select this:
Adjust the display so the graph is drawn along the entire y-axis	[Zoom Auto]
Enclose a portion of the window and then zoom in on it	[Zoom Box]*1
Zoom in or out on the center of the window*2	[Zoom In] [Zoom Out]
Correct the x-axis so the x- and y-axis scales are in a 1:1 ratio	[Zoom Square]
Make the displayed x-coordinate value an integer when using trace (page 84)	[Zoom Integer]*3
Round the displayed x-coordinate value to the appropriate number of significant digits when using trace (page 84)	[Zoom Round]
Restore previous View Window settings for all subsequent zoom operations	[Zoom Original]
Reset to View Window settings in effect immediately before the last zoom operation	[Zoom Previous]

*1 Selecting ⋯ > [Zoom] > [Zoom Box] displays a cross pointer (✛) in the window. Move the pointer to one of the box's vertices and then press OK. Next, move the pointer to the opposite vertex and then press OK.

*2 The zoom in/out ratio is the one specified in the dialog that appears when you select ⋯ > [Zoom] > [Zoom In/Out Factors].

*3 Selecting ⋯ > [Zoom] > [Zoom Integer] displays a pointer in the window. Move the pointer to the coordinate you want to center in the window and press OK.

Grabbing a Point on a Window and Drag It Around the Display (Pan)

You can use the hand icon that appears to drag the graph window around the display.

1. While the graph window is displayed, select ⋯ > [Pan].
   - This displays an arrow pointer (↖).
2. Use the cursor keys to move the arrow pointer to the point in the window that you want to grab and then press OK.
   - This causes the pointer to change from an arrow (↖) to a hand (✋).
3. Use the cursor keys to move the hand and drag the window around the display.
   - The contents of the window move along with the hand.
4. Press OK.
   - This returns the pointer to an arrow. You can repeat steps 2 and 3 as required.
   - When you are finished dragging window contents, press ↩.

Adjusting the Graph Window Background Image (Fade I/O)

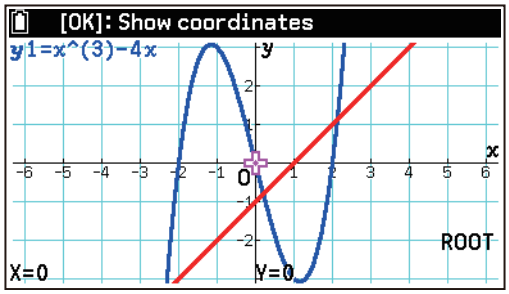
You can use this operation to adjust the opacity of the background image. This operation can be performed only when a 16-bit color image is being used as the graph window background image. For information about displaying a background image, see "Background (Graph)" (page 219).

1. While the graph window is displayed, select ⋯ > [Fade I/O].
2. Use ◁ and ▷ to adjust the opacity of the background image.
3. When the setting is the way you want, press ↩.

Using Graph Solve (Graph Solve)

You can use Graph Solve to obtain the coordinates of roots, and other values for the integrals, y-axis intercept, or other key feature points on a graph. For example, perform the operation below to find the root of a function on a graph.

1. Enter the function in the Function tab and press ⇥ to draw a graph.
2. Select ⋯ > [Graph Solve] > [Root].
   - If there are multiple graphs in the graph window, one of them will flash.
3. Use ▽ and △ to move the flashing to the graph whose root you want to obtain and then press OK.
   - This causes a cross pointer (✛) to appear at the coordinates of the root and the coordinate values to appear at the bottom of the window. If there are multiple roots, you can use ▷ and ◁ to move the pointer to another root.



4. To exit graph analysis, press ↩.

The values that can be obtained using graph analysis are shown in the table below.

To obtain this value:	Select ⋯ > [Graph Solve] and then select this:
Roots on a graph	[Root]
Maximum value on a graph	[Maximum Value]
Minimum value on a graph	[Minimum Value]
Coordinates of intersection of two graphs*1	[Intersection]
Integral value of the specified range on the graph*2	[$\int dx$] > [$\int dx$]
Integral value and area*2*3 of a range delimited by multiple roots on the graph	[$\int dx$] > [Root]
Integral and area*2*4 of a range bounded by multiple intersections of two graphs	[$\int dx$] > [Intersection]
Integral and area*2*5 of a range bounded by the intersection of two graphs and a root on either of them	[$\int dx$] > [Mixed]
y-axis intercept	[y-Intercept]
x-coordinate value on a graph for a given y-value*6	[x-Cal]
y-coordinate value on a graph for a given x-value	[y-Cal]

*1 Can be calculated for Cartesian coordinate type ($y=f(x)$ form) and inequality type ($y>f(x)$, $y<f(x)$, $y\geq f(x)$, $y\leq f(x)$ form) graphs.
*2 Can be calculated for Cartesian coordinate type ($y=f(x)$ form) graphs.
*3 An error occurs if there are more than 21 roots between the two specified roots.
*4 An error occurs if there are more than 21 intersections between the two specified intersections.
*5 You can also use the number keys to specify any x-coordinate value instead of the intersections or roots of the graph.
*6 Cannot be calculated for parametric type graphs.

Important!

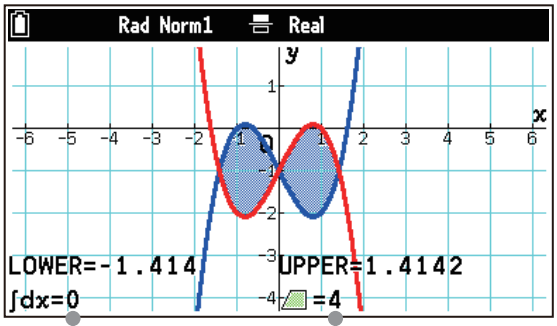
- In the cases described below, solution accuracy may be reduced or solution may be impossible.

- When the solution is at the point of tangency between graphs or at the point of tangency between a graph and the x-axis.
- When the solution is at or near the inflection point of a graph.

Operation Example:

Example 1: To graph $y = x^3 - 2x - 1$ and $y = -x^3 + 2x - 1$, specify two intersections, and then calculate the integral and area between them

1. Graph the two functions.
2. Select ⋯ > [Graph Solve] > [$\int dx$] > [Intersection].
   • This causes a pointer to appear at the coordinate of the leftmost intersection.
3. Press OK to make the current pointer location the lower limit of integration.
4. Press ▷ twice to move the pointer two intersections to the right.
5. Press OK to make the current pointer location the upper limit of integration.
   • This defines the integral range and displays the calculation result.



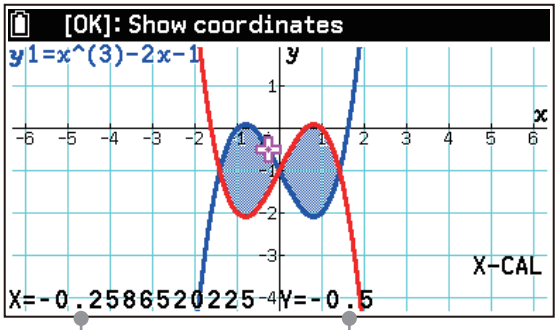
Area

Integral value

6. To exit graph analysis, press ↩.

Example 2: To calculate the x-value of the $y = x^3 - 2x - 1$ graph you drew in Example 1 above when $y = -0.5$

1. Select ⋯ > [Graph Solve] > [x-Cal].
2. Use ▽ and △ to move the flashing to the graph of $y = x^3 - 2x - 1$ and then press OK.
   • This displays a dialog for inputting the y-value.
3. Input -0.5 and then press OK.
   • This will cause a pointer to appear at one of the coordinates where $y = -0.5$ and the coordinate value will appear at the bottom of the window. You can use ▷ and ◁ to move the pointer to another coordinate where $y = -0.5$.



y-coordinate value

x-coordinate value

4. To exit graph analysis, press ⑤.

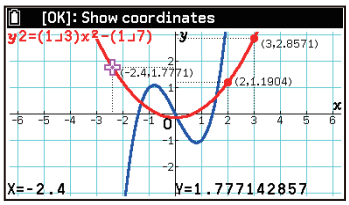
Using Trace (Trace)

Trace displays a crosshair pointer (✛) on a graph that you can use to read the coordinate values at a specific location. When ☰ > [Derivative] (page 219) is turned on, derivative coefficients are displayed along with the coordinate values.

To enable trace

Select ⋯ > [Trace].

The operations that can be performed while the trace function is enabled are described in the table below.

To do this:	Perform this operation:
Move the pointer along the graph	Press ◁ or ▷.
Move to pointer to a specific x-coordinate on the graph	Use the number keys to input an x-coordinate value and then press OK.
When there are multiple graphs, the pointer will move between them	Press ▽ or △.
Plot a dot with coordinate values on a graph* 	Move the pointer to the location where you want to plot a dot with coordinate values and then press OK.
Exit trace	Press ⑤.

* If the dot location is within the coordinates of a graph, it is displayed as a solid red dot (●). If the dot location is not within the coordinates of the graph, it is displayed as a red circle (○).

Modifying a Graph by Changing the Coefficient Values of Its Function (Modify)

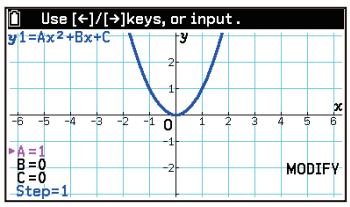
You can input a functional expression with five alpha variables included in the coefficients (such as $y = Ax + B$) and then change the values of the variables (coefficient values) while the graph is displayed. This lets you see how changes in the coefficient values affect the appearance of the graph.

Important!

- When multiple functions are selected for graphing, modify cannot be used if there are more than two functions that contain variables.

Example: Input $y = Ax^2 + Bx + C$ and observe how the shape of the graph is affected when the coefficient values are changed. The initial values of A, B, and C are $A = 1$, $B = 0$, and $C = 0$.*1

1. On the Function tab, input $y = Ax^2 + Bx + C$.
   - Select ⋯ > [Built-In Function] > [y=Ax^2+Bx+C] and then input the function.*2
2. Turn off all other function expression graphing settings.
   - See "To select a function to draw a graph and create a numeric table" (page 78).
3. Press ⇥ to draw the graph.
4. Select ⋯ > [Modify] to enable modify.
   - The current values of A, B, and C and the step value are displayed in the lower-left corner of the graph window. You can change the value where the pointer (▶) is currently located.
   - Use ▽ and △ to move the pointer (▶) up and down.



5. Use ◁ and ▷ to change the value of A.

- Each press of ◁ or ▷ changes the value of A by the step value. You can also use the number keys to enter values.

6. Press ▽ to move the pointer (▶) to B. Use ◁ and ▷ to change the value of B.
7. Press ▽ to move the pointer (▶) to C. Use ◁ and ▷ to change the value of C.
8. To exit modify, press ↩.

*1 Assign $A = 1$, $B = 0$, and $C = 0$ before beginning. See "To assign a value to an alpha variable" (page 18).

*2 You can use ⋯ > [Built-In Function] to input the functions below.

$y = Ax + B$
$y = A(x - B)^2 + C$
$y = Ax^2 + Bx + C$
$y = Ax^3 + Bx^2 + Cx + D$
$y = A\sin(Bx + C)$
$y = A\cos(Bx + C)$
$y = A\tan(Bx + C)$

Note

- While modify is enabled, you can copy the function of the currently displayed graph to any function area on the Function tab (except an area of a function currently being used for drawing). To copy the function, select ⋯ > [Copy] and choose the destination area on the menu that appears.

Using Sketch (Sketch)

You can use sketch to draw dots, lines, and text within the graphing area. For example, to draw a tangent line on the graph of $y = x^2 + 1$, perform the steps below.

1. On the Function tab, input the function $y = x^2 + 1$ and then press ⇥ to graph it.
   - This example graphs $y = x^2 + 1$ only.
2. Select ⋯ > [Sketch] > [Tangent Line].
   - This draws a line that is tangent to $x = 0$ of the $y = x^2 + 1$ graph. You can use ◁ or ▷ to change the coordinates of the point of tangency.
3. To view the coordinates of the point of tangency, press OK.
   - This executed the tangent line drawing and displays a dot (●) with coordinate values at the point of tangency.
   - Now you can use ◁ and ▷ to change the coordinates of the point of tangency and add a tangent line by pressing OK.
4. To exit sketch, press ↩.

The following table shows what you can do with sketch.

To do this:	Select ⋯ > [Sketch] and then select this:
Clear all points, lines, and text drawn using sketch	[Clear Screen]
Draw a line tangent to a graph	[Tangent Line]
Draw a graph normal line	[Normal Line]
Draw the inverse graph of a graph*1	[Inverse]
Toggle a point between draw and delete	[Plot]
Specify two points and draw a line segment between them	[Line]
Draw a circle by specifying its center point and one point on the circumference	[Circle]
Draw a vertical line	[Vertical Line]
Draw a horizontal line	[Horizontal Line]
Draw a freehand line*2	[Pen]

Write text*3	[Text]

*1 Sketch is automatically exited after a graph is drawn.
*2 You can use the cursor keys to move the pointer and draw a line.
*3 Input is possible starting from the current pointer location and ending with the right edge of the graph window. ⌫ key operations while input is in progress are ignored.

Note

- Sketch points, lines, and text are drawn according to the settings of ☰ > [Plot/Line Color] (page 218) and ☰ > [Sketch Line] (page 218).

Graphing a Function Copied to the Clipboard

You can copy a function* from another app, paste it onto the Graph tab and then graph it.
* An $f(x)$ form expression (such as x^2-2) or a $y=f(x)$ form equation (such as $y=x^2-2$).
Example: To copy $(x+\sqrt{2})(x-\sqrt{2})$, paste it onto the Graph tab, and then graph it

1. Use the Calculate app to input $(x+\sqrt{2})(x-\sqrt{2})$ and then copy the expression.
   - For details about the copy operation, see "Copying, Cutting, and Pasting Expressions" (page 10).
2. Start up the Graph&Table app and then press ⇥ to graph the expression.
3. Press ⇧ . (📋).
   - This graphs $y=(x+\sqrt{2})(x-\sqrt{2})$.

Graph Drawing Setting Items

You can use the Settings menu to configure settings for the graph drawing operation and the graph drawing display area. For details, see "Settings Menu Details" (page 214).

Using the Table Tab

With the Table tab, you can edit the numbers in the x-column of a numeric table and also perform the operations below from the menu that appears when you press ⋯.

To do this:	Select this menu item:	Details:
Specify the domain of the table being created	⋯ > [Set Table Domain]	"Specifying a Table Domain" (page 86)
Draw a graph that shows dots at the coordinates of a numeric table	⋯ > [Graph Points]	"Graphing a Numeric Table" (page 87)
Draw a graph that connects the coordinates of a numeric table with straight line segments	⋯ > [Graph Points (Joined)]	
Specify the display range of the graph window	⋯ > [View Window]	"Specifying the Display Range of the Graph Window (View Window)" (page 80)
Insert or add a row	⋯ > [Row]	"Editing a Numeric Table" (page 87)
Edit input data	⋯ > [Edit]	
Save one column of a numeric table to a list variable	⋯ > [Store List]	"Saving a Numeric Table to a List Variable" (page 87)
Delete one row of a numeric table or the entire table	⋯ > [Delete]	"Editing a Numeric Table" (page 87)

Specifying a Table Domain

The numeric table domain is specified by the value of the x-variable (or θ, T) that is assigned to the function used to create the numeric table. The following two methods are available to specify a table domain.

To specify a table domain using this method:	Perform this operation:
Inputting the x-variable starting value, ending value, and step value	1. Select ⋯ > [Set Table Domain] > [Range]. 2. Input the starting value into the [Start] line, the ending value into the [End] line, and the step values into the [Step] line. 3. Highlight [Display Table] and then press [OK].
Using list variable elements as the x-variable	1. Use List Editor to input the values to be used as the x-variable into one of the lists (List 1 to List 26). For details, see "Inputting Data in List Editor" (page 30). 2. Select ⋯ > [Set Table Domain] > [List]. 3. Highlight the list variable in step 1 and then press [OK]. 4. To close the dialog, press ↩.

Graphing a Numeric Table

1. While the numeric table is displayed, select one of the options below.
   To draw a graph of coordinate dots only: ⋯ > [Graph Points]
   To draw a graph by linking coordinate dots with straight line segments: ⋯ > [Graph Points (Joined)]
2. Use the View Window menu that appears to change display range settings as required.
   • For details, see "Specifying the Display Range of the Graph Window (View Window)" (page 80).
3. Highlight [Draw] and then press [OK].
   • This draws the graph on the Table tab.

Note

- To prevent the View Window menu from appearing when drawing a graph, turn off ☰ > [Show V-Win Settings] (page 215).
- The operations that can be performed while viewing a graph are the same as those on the Graph tab (except for [Graph Solve] and [Modify]).

Editing a Numeric Table

To do this:	Perform this operation:
Overwrite a numeric table x-value* with a different value	Move the cursor to the x-column* line whose value you want to change and then input the new value.
Edit a numeric table x-value*	Move the cursor to the x-column* line you want to edit and then select ⋯ > [Edit].
Add one row below the row where the cursor is currently located	Select ⋯ > [Row] > [Add].
Insert a row above the row where the cursor is currently located	Select ⋯ > [Row] > [Insert].
Delete the row where the cursor is located	Select ⋯ > [Delete] > [Row].
Delete the entire numeric table and return to the Function tab	Select ⋯ > [Delete] > [Table].

* x, θ, or T

Saving a Numeric Table to a List Variable

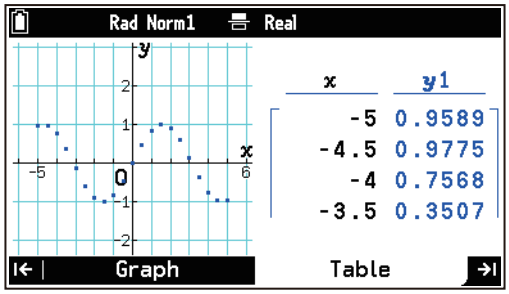
One column of numeric table data can be saved to a list variable, which is specified by its number.

1. Move the cursor to the numeric table column you want to save to a list variable.
2. Select ⋯ > [Store List].
3. Use the dialog that appears to input a list variable number and then press [OK].

Displaying a Numeric Table and Graph at the Same Time

When ☰ > [Table with Graph] is turned on, the numeric table window is displayed on the right of the Table tab, and the graph window is displayed on the left.

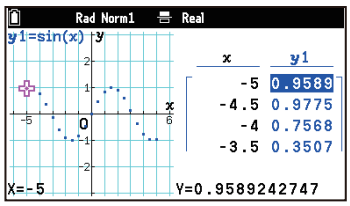
- Nothing is drawn in the graph window immediately after you go from the Function tab or the Graph tab to the Table tab. Use the following operations to draw the graph.
  - Select ⋯ > [Switch Active Window].
  - From ⋯, select [Graph Points] or [Graph Points (Joined)].



- Each time you select ⋯ > [Switch Active Window], the active window (the window that is affected by the operations you perform) toggles between the numeric table window and the graph window. The numeric table window is active when the cursor is displayed on the numeric table.
- The operations below can be used while the numeric table window is active.
  "To display a pointer on a graph at the current numeric table cursor location (Graph-Link)" (page 88)
  "Specifying a Table Domain" (page 86)
  "Editing a Numeric Table" (page 87)
  "Saving a Numeric Table to a List Variable" (page 87)
- You can perform the operations below while the graph window is active.
  "Showing and Hiding Tabs" (page 79)
  "Adjusting the Graph Window" (page 79) (Excluding Pan and Fade I/O)
  "Specifying the Display Range of the Graph Window (View Window)" (page 80)
  "Changing the Graph Window Zoom Setting (Zoom)" (page 81)
  "Using Trace (Trace)" (page 84)
  "Using Sketch (Sketch)" (page 85)

To display a pointer on a graph at the current numeric table cursor location (Graph-Link)

1. Turn on ☰ > [Table with Graph].
2. On the Function tab, input the function and then press ⇤ to go to the Table tab.
3. Select ⋯ > [Switch Active Window].
   - This makes the graph window active and draws the graph.
4. Select ⋯ > [Graph-Link].
   - This causes a crosshair pointer to appear on the graph at the coordinates that correspond to the numeric table cursor position.
   - Using ∨ and ∧ to move the numeric table cursor also causes the graph pointer to move accordingly.



5. To exit this operation, press ↩.

Note

- If no graph is drawn in the graph window, the ⋯ > [Graph-Link] cannot be performed while the numeric table window is active. ⋯ > [Graph-Link] becomes enabled after a graph is drawn in the graph window.

Dyna Graph App

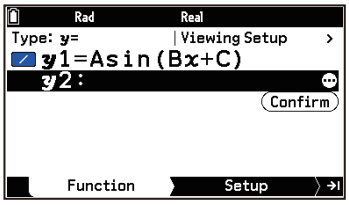
You can use the Dyna Graph app to input a function like $y = Ax + B$, which includes alpha variables as coefficients. A displayed graph is continuously re-drawn as the value of a specific coefficient of its function is varied within a specific range. A Dynamic Graph makes it possible to observe the effect of coefficient values on the form and position of a graph.

Operation Flow

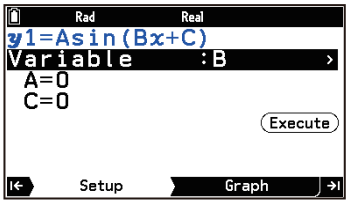
Example: To select the Dyna Graph app's $y = \text{Asin}(Bx + C)$ built-in function and input it. Observe the change in the graph as the value of the coefficient B of the function is varied. Specify a value of 1 for A and C.

> **Note**
> - If there are already functions on the Function tab of the Graph&Table app (page 75), they will also appear on the Function tab of the Dyna Graph app of step 1 in the procedure below. Note that the Function tab shown in the example below starts out with no functions.

1. ⌂ > Dyna Graph
   - This displays the Function tab.
2. Select ⋯ > [Built-In Function] > [y=Asin(Bx+C)].
   - This inputs the function you select.

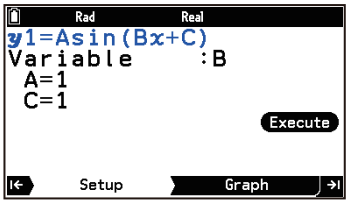


3. Press ⇥, or highlight [Confirm] and then press OK.
4. In the Setup tab that appears, specify the variable name of the coefficient whose value is to be varied.
   (1) Highlight [Variable] and then press OK.
   (2) On the menu that appears, highlight [B] and then press OK.



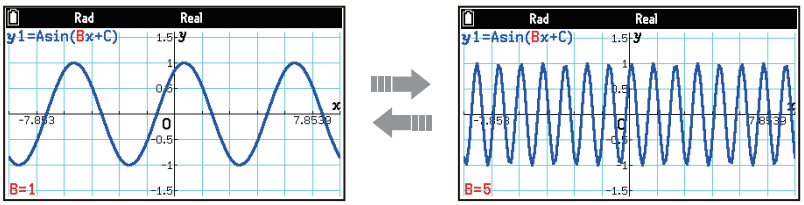
5. Assign values to the variables for each of the other coefficients.

   ▽ 1 EXE 1 EXE



6. Press ⇥ (or highlight [Execute] and then press OK.)
   - This displays the View Window menu. See "Specifying the Display Range of the Graph Window (View Window)" (page 80) for details.
7. Configure View Window settings and draw the graph.
   (1) Select [Pre-set Windows] > [Trigonometric].
   (2) Highlight [Draw] and then press OK.
   - The graph is continually re-drawn as the value of coefficient B is increased or decreased within the range of 1 and 5, in increments of 1 (default setting[*1]).

- The Setup tab reappears after 10 iterations of coefficient value increase and decrease (default setting*2).



- To interrupt re-drawing of the graph and return to the Setup tab, press [AC].

*1 You can specify the start value, end value, and step value of the increase/decrease. See "Using the Setup Tab" (page 91) for details.

*2 You can specify the speed at which the coefficient values are automatically varied during the graph drawing operation. See "Using the Setup Tab" (page 91) for details.

Using the Function Tab

You can enter up to 20 functions on the Function tab.

Note

- Functions input on the Function tab of the Dyna Graph app also appear on the Function tab of the Graph&Table app (page 75).

Inputting and Editing Functions

To select the function type and input a function manually

1. On the Function tab, highlight the first line and then press [OK].
2. On the Setup menu that appears, select [Type].
   - This displays the Type menu.
3. Perform the operations shown in the table below.

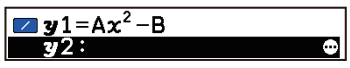
To select this function type:	Select this menu item:
Cartesian coordinate type (y=$f(x)$ form)	[y=]
Polar coordinate type (r=$f(\theta)$ form)	[r=]
Parametric type ($\begin{cases}\mathrm{Xt}=f(\mathrm{T})\\ \mathrm{Yt}=f(\mathrm{T})\end{cases}$ form)	[Param]

   - The function type you choose is applied to the function you are about to input. It does not affect any function that has already been entered.

4. Highlight the line where you want to input a function, and then input it.
   - Press [X,θ,T] to input the variables (x, θ, T) in accordance with the function type you chose.

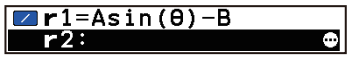
Example 1: To input the Cartesian coordinate type $y = \mathrm{A}x^2 - \mathrm{B}$

[ALPHA] [X,θ,T] (A) [X,θ,T] [x²] [−] [ALPHA] [▤] (B) [EXE]



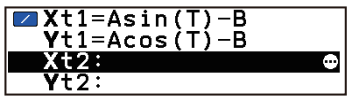
Example 2: To input the polar coordinate type $r = \mathrm{A}\sin(\theta) - \mathrm{B}$

[ALPHA] [X,θ,T] (A) [sin] [X,θ,T] [)] [−] [ALPHA] [▤] (B) [EXE]



Example 3: To input the parametric type $\begin{cases}\mathrm{Xt} = \mathrm{A}\sin(\mathrm{T}) - \mathrm{B}\\ \mathrm{Yt} = \mathrm{A}\cos(\mathrm{T}) - \mathrm{B}\end{cases}$

[ALPHA] [X,θ,T] (A) [sin] [X,θ,T] [)] [−] [ALPHA] [▤] (B) [EXE]
[ALPHA] [X,θ,T] (A) [cos] [X,θ,T] [)] [−] [ALPHA] [▤] (B) [EXE]



To select and input a built-in function

1. On the Function tab, highlight the line where you want to input.
2. Select ⋯ > [Built-In Function].
3. On the menu that appears, highlight the function you want to input and then press OK.
   - You can input the functions listed below.

$y = Ax + B$
$y = A(x - B)^2 + C$
$y = Ax^2 + Bx + C$
$y = Ax^3 + Bx^2 + Cx + D$
$y = A\sin(Bx + C)$
$y = A\cos(Bx + C)$
$y = A\tan(Bx + C)$

To edit or delete a function

To edit or delete an existing function, use the same operation as one in the Graph&Table app. See “To edit a function” (page 78) and “To delete a function” (page 78) for more information.

To change the line color for graph drawing

1. On the Function tab, highlight the function you want to change the line color of the graph.
2. Select ⋯ > [Line Color].
3. Use the list that appears to select a color.

To select a function to draw a graph

1. On the Function tab, highlight a line that contains an input function.
2. Press ⋯.
   - This displays a Tools menu with [Select] highlighted.
3. Change [Select] to ● (On) to enable or to ○ (Off) to disable graphing for the selected function.
4. Press ↩ to close the Tools menu.
   - The on/off setting of step 3 is indicated by the icons to the left of each line of the Function tab.

▰… On ▱… Off

Note

- If multiple functions are selected on the Function tab for graphing, the message “Too Many Functions” will appear on the Setup tab.

Using the Setup Tab

You can use the Setup tab to configure the settings described below, which appear when you press ⋯.

To do this:	Perform this operation:
Specify the range of variation of the coefficient value	1. Select ⋯ > [Range]. 2. Input the starting value into the [Start] line, the ending value into the [End] line, and the step value into the [Step] line. 3. To close the menu, press ↩ twice.
Specify the speed that the coefficient value changes automatically during graph drawing	1. Select ⋯ > [Speed]. 2. On the menu that appears, highlight the setting you want and then press OK. • You can select one of the speeds described below. [Stop&Go]: Coefficient value changes with each press of ◁ or ▷ instead of automatically.* [Slow]: Coefficient value changes at half of normal speed. [Normal]: Coefficient value changes at normal speed.

	[Fast]: Coefficient value changes at double normal speed. 3. To close the menu, press ⮌ twice.
Specify the display range	Select ⋯ > [View Window]. For details, see “Specifying the Display Range of the Graph Window (View Window)” (page 80).

* If [Stop&Go] is selected for graph drawing, press ⮌ to return from the Graph tab to the Setup tab.

Dyna Graph App Settings Menu Items

The Settings menu items (page 214) described below are specific to the Dyna Graph app.

☰ > [Looping]: Specifies whether graphing should end automatically or continue once started.

☰ > [Locus]: Specify whether or not to display the graph locus.

☰ > [Processing Speed]: Speeds up drawing by thinning out the graph dots.

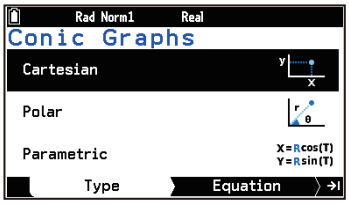
Conic Graphs App

You can use the Conic Graphs app to graph various types of conic curves (parabola, circle, ellipse, and hyperbola) using built-in Cartesian, polar, or parametric function equations.

Operation Flow

Example: To graph the parabola $x = 2y^2 + y - 1$ using the built-in Cartesian coordinate function equation X=AY²+BY+C. Next, use the built-in polar coordinate equation R=2Acos(θ) to graph the circle r=4cosθ.

1. ⌂ > Conic Graphs
   - This displays a menu of equation types (Cartesian, Polar, Parametric).

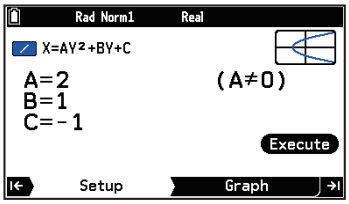


2. Highlight Cartesian and then press ⇥ (or OK).
   - This displays the Equation tab with a menu of Cartesian coordinate function equations.

3. Highlight [X=AY²+BY+C] and then press ⇥ (or OK).
   - This displays the Setup tab (page 94) for input of coefficient values.

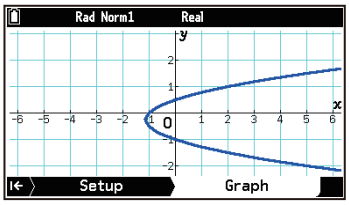
4. Input the values of the coefficients of $x = 2y^2 + y - 1$.

2 EXE
1 EXE
▲ ⊖ (−) 1 EXE



5. To draw the graph, press ⇥ (or OK).
   - This displays the View Window menu. Change the range specification as required. For more information, see "Specifying the Display Range of the Graph Window (View Window)" (page 80).

6. Highlight Draw and then press OK.
   - This draws the graph on the Graph tab (page 94).



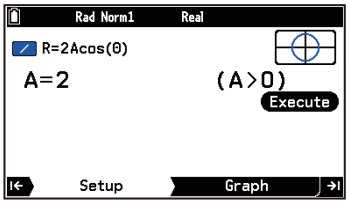
7. Press ⇤ (or ↩) three times to return to the equation type menu.

8. Highlight Polar and then press ⇥ (or OK).
   - This displays the Equation tab with a menu of polar coordinate function equations.

9. Highlight [R=2Acos(θ)] and then press ⇥ (or OK).
   - This displays the Setup tab (page 94) for input of coefficient values.

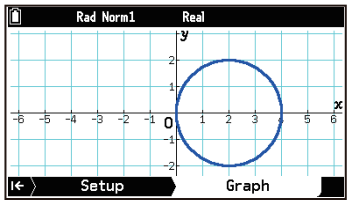
10. Input the values of the coefficients of r=4cosθ (r=2 · 2cosθ).

2 EXE



11. To draw the graph, press ⇥ (or OK).

12. Next, on the View Window menu that appears, highlight Draw and then press OK.
    - This draws the graph on the Graph tab (page 94).



Using the Setup Tab

In addition to inputting the values of coefficients of function equations, you can also use the Tools menu while on the Setup tab to perform the operations described below.

To do this:	Perform this operation:
Specify the display range	Select ⋯ > [View Window]. See "Specifying the Display Range of the Graph Window (View Window)" (page 80) for details.
Change the line color for graph drawing	Select ⋯ > [Line Color]. Use the list that appears to select a color.

Using the Graph Tab

You can use the Tools menu while on the Graph tab to perform the operations described below.

To do this:	Select this menu item:	Details:
Specify the display range	⋯ > [View Window]	"Specifying the Display Range of the Graph Window (View Window)" (page 80)
Obtain the coordinates of the x-axis or y-axis intercept or other key feature points of a graph	⋯ > [Graph Solve]	"Using Graph Solve (Graph Solve)" (page 94)
Display a pointer on a graph and read the coordinate values	⋯ > [Trace]	"Using Trace (Trace)" (page 84)
Modify a graph by changing the coefficient values of its function	⋯ > [Modify]	"Modifying a Graph (Modify)" (page 96)
Zoom in and out of the display	⋯ > [Zoom]	"Changing the Graph Window Zoom Setting (Zoom)" (page 81)
Draw dots, lines, characters, etc.	⋯ > [Sketch]	"Using Sketch (Sketch)" (page 85)*
Grab a point on a window and drag it around the display	⋯ > [Pan]	"Grabbing a Point on a Window and Drag It Around the Display (Pan)" (page 81)
Adjust the background image	⋯ > [Fade I/O]	"Adjusting the Graph Window Background Image (Fade I/O)" (page 81)

* The Sketch menu of the Conic Graphs app does not include the following items. Tangent Line, Normal Line, Inverse

Using Graph Solve (Graph Solve)

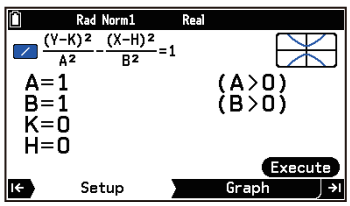
Depending on the type of graph currently on the display, you can use Graph Solve to calculate specific coordinate values (such as the coordinates of the center point of a circle) or to draw specific lines (such as a parabolic directrix). The table below shows what you can do with Graph Solve.

To do this:	Select ⋯ > [Graph Solve] and then select this:	Parabola	Circle	Ellipse	Hyperbola
Calculate the focus	[Focus]	Yes	-	Yes	Yes
Draw the directrix	[Directrix]	Yes	-	-	-
Calculate the vertex	[Vertex]	Yes	-	Yes	Yes
Draw the axis of symmetry	[Axis of Symmetry]	Yes	-	-	-
Calculate the length of the latus rectum	[Latus Rectum]	Yes	-	-	-
Calculate the center	[Center]	-	Yes	Yes	Yes
Calculate the radius	[Radius]	-	Yes	-	-
Draw the asymptotes	[Asymptotes]	-	-	-	Yes
Calculate the eccentricity	[Eccentricity]	Yes	-	Yes	Yes
Calculate the x-axis intercept	[x-Intercept]	Yes	Yes	Yes	Yes
Calculate the y-axis intercept	[y-Intercept]	Yes	Yes	Yes	Yes

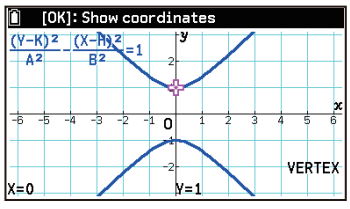
Example: To graph the hyperbola $y^2 - x^2 = 1$ $\left(\frac{(Y-0)^2}{1^2} - \frac{(X-0)^2}{1^2} = 1\right)$ and then determine their vertices

1. On the Type tab, highlight [Cartesian] and then press OK.
2. Highlight [$\frac{(Y-K)^2}{A^2} - \frac{(X-H)^2}{B^2} = 1$] and then press OK.
3. On the Setup tab, input the coefficients of the function.

   1 EXE
   1 EXE
   0 EXE
   0 EXE



4. Press ⇥ to draw the graph.
5. Select ⋯ > [Graph Solve] > [Vertex].
   - This causes a cross pointer (✛) to appear at the coordinates of the first vertex and the coordinate values to appear at the bottom of the window.
   - Press ◁ or ▷ to calculate the second vertex. Pressing ◁ or ▷ returns to the first vertex.



6. To exit Graph Solve, press ↩.

Note

- When calculating two foci for an ellipse or hyperbolic graph, press ◁ or ▷ to calculate the second focus. Pressing ◁ or ▷ returns to the first focus.
- Pressing ▷ when calculating the vertices of an ellipse will calculate the next value. Pressing ◁ will scroll back through previous values. An ellipse has four vertices.

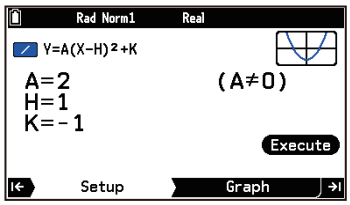
Modifying a Graph (Modify)

With the Conic Graphs app, you can select a built-in function equation, input coefficient values, and then draw a graph. By changing coefficient values while the graph is displayed, you can observe how each affects the graph.

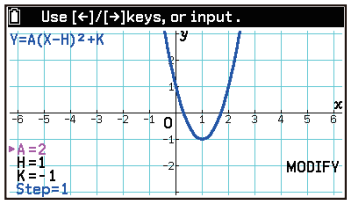
Example: To graph the parabola $y = 2(x-1)^2 - 1$ using the built-in Cartesian coordinate function equation Y=A(X−H)²+K. Next, observe how the graph changes as you vary the values of equation coefficients A, H, and K.

1. On the Type tab, highlight [Cartesian] and then press (OK).
2. Highlight [Y=A(X−H)²+K] and then press (OK).
3. On the Setup tab, input the coefficients of the function.

2 (EXE)
1 (EXE)
(↑) (−) ((−)) 1 (EXE)



4. Press (⇥) to draw the graph.
5. Select (○○○) > [Modify] to enable modification.
   - The current values of A, H, and K and the step value are displayed in the lower-left corner of the graph window. You can change the value where the pointer (▶) is currently located.
   - Use (▽) and (△) to move the pointer (▶) up and down.



6. Use (◁) and (▷) to change the value of A.
   - Each press of (◁) or (▷) changes the value of A by the step value. You can also use the number keys to enter values.
7. Press (▽) to move the pointer (▶) to H. Use (◁) and (▷) to change the value of H.
8. Press (▽) to move the pointer (▶) to K. Use (◁) and (▷) to change the value of K.
9. To exit modify, press (↩).

3D Graph App

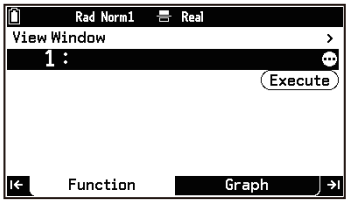
You can use the 3D Graph app to draw 3D graphs in three-dimensional space using x-, y-, and z-coordinates. You can graph lines, planes, spheres, cylinders, and cones using built-in templates, or you can manually enter functions to draw lines, curved surfaces, solids of revolution, and other forms.

Operation Flow

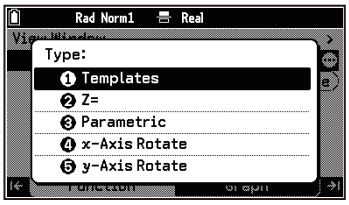
Using a Built-in Template to Draw a Graph

Example 1: To select the [Sphere] > [(X-a)²+(Y-b)²+(Z-c)²=r²] built-in template and draw a 3D graph of the sphere $x^2 + y^2 + z^2 = 2^2$.

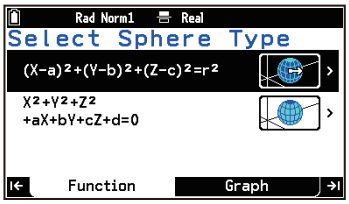
1. (⌂) > 3D Graph
   - This displays the Function tab.



2. Press (OK) (or select (⋯) > [Enter Equation]) to display the Type menu.*

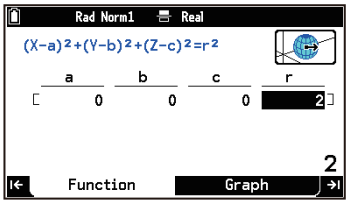


3. On the Type menu, select [Templates] > [Sphere].
   - This displays a list of sphere templates.

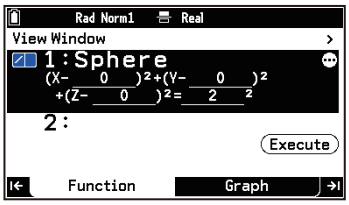


4. Select [(X-a)²+(Y-b)²+(Z-c)²=r²].
   - This displays the template's numeric value input window.
   - Since we want to graph "$x^2 + y^2 + z^2 = 2^2$", input a=0, b=0, c=0, and r=2.

0 (EXE) 0 (EXE) 0 (EXE) 2 (EXE)

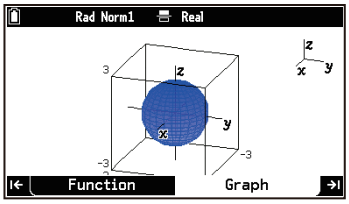


5. Press (OK).
   - This displays the template name (Sphere) along with the values you input.



6. To draw a 3D graph using a built-in template you stored, press (⇥).
   - This displays the View Window menu. Change the range specification as required. For more information, see "Specifying the Spatial Range and Drawing Accuracy for 3D Graphing (View Window)" (page 102).
7. Highlight [Draw] and then press (OK).

• This draws the graph on the Graph tab.



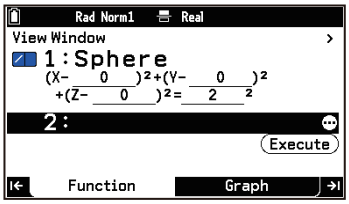
8. To return to the Function tab, press ⇥ or ⮌.

* If the highlighted line is blank, simply press [OK] to display the Type menu. If the highlighted line contains an equation, you need to select ⋯ > [Enter Equation].

Using a Manually Input Function to Draw a Graph

Example 2: Continuing from Example 1, above, to manually input $Z = X^2 + Y^2 - 3$ and simultaneously draw two 3D graphs

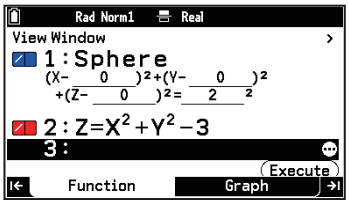
1. Use ▽ to highlight "2:" on the Function tab.



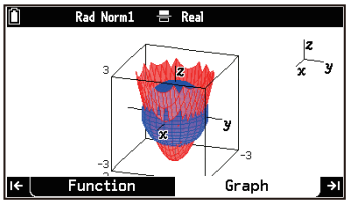
2. Press [OK]. On the menu that appears, select [Z=].
   • Alternatively, you could also perform the operation ⋯ > [Enter Equation] > [Z=].

3. Input $Z = X^2 + Y^2 - 3$.

[X,θ,T] [x²] [+] [ALPHA] [−] (Y) [x²] [−] 3 [EXE]



4. To draw the 3D graph, press ⇥. Next, on the View Window menu that appears, highlight [Draw] and then press [OK].
   • This draws the graphs on the Graph tab.



5. To return to the Function tab, press ⇥ or ⮌.

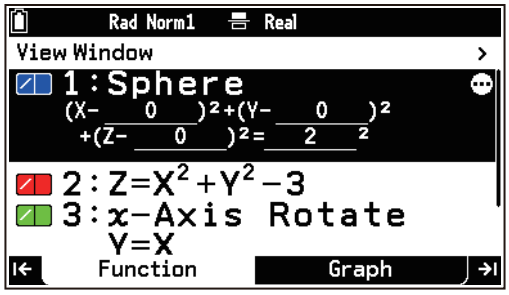
Out of Drawing Range Graph Warning Message

The Out of Drawing Range warning message appears when there is nothing to draw in the window when you try to draw a graph. If this happens, choose the desired operation from the menu that appears.

To do this:	Select this menu item:
Display the View Window menu	[View Window]
Display the graph window (without drawing a graph) without adjusting View Window settings	[Cancel]

Using the Function Tab

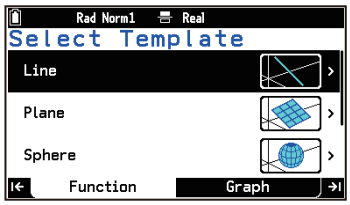
You can use the Function tab to store templates and functions you want to use for 3D graph drawing. You can store up to a total of three templates and/or functions. The example screen below shows the Function tab when one template and two functions are stored.



Storing and Editing 3D Graphing Templates

To store a template

1. On the Function tab, highlight the line where you want to store a template.
2. Select ⋯ > [Enter Equation] > [Templates].
   - This displays the Select Template menu.



3. Select the template you want to use.
   - Use the template menu to select what you want to graph and the graphing method you want to use.

To graph this:	Select this menu item:
Straight line with the equation $\frac{X-X_0}{a}=\frac{Y-Y_0}{b}=\frac{Z-Z_0}{c}$	[Line] > $\left[\frac{X-Xo}{a}=\frac{Y-Yo}{b}=\frac{Z-Zo}{c}\right]$
Straight line by using a vector equation $\vec{r}=\vec{r_0}+t\vec{v}$ (two vectors)	[Line] > $[\vec{r}=\vec{ro}+t\vec{v}]$
Straight line by specifying the coordinates of two points	[Line] > [Line through 2 points]
Straight line by specifying the coordinates of one point and a direction vector	[Line] > [Through point (X_0,Y_0,Z_0) Direction vector [a,b,c]]
Plane by using the equation $aX+bY+cZ+d=0$	[Plane] > [aX+bY+cZ+d=0]
Plane by using a vector equation $\vec{r}=\vec{r_0}+s\vec{u}+t\vec{v}$ (three vectors)	[Plane] > $[\vec{r}=\vec{ro}+s\vec{u}+t\vec{v}]$
Plane by specifying the coordinates of three points	[Plane] > [Plane through 3 points]
Sphere by using the equation: $(X-a)^2+(Y-b)^2+(Z-c)^2=r^2$	[Sphere] > $[(X-a)^2+(Y-b)^2+(Z-c)^2=r^2]$
Sphere by using the equation: $X^2+Y^2+Z^2+aX+bY+cZ+d=0$	[Sphere] > $[X^2+Y^2+Z^2+aX+bY+cZ+d=0]$
Cylinder	[Cylinder]
Cone	[Cone]

   - Selecting any one of the above options displays a window for inputting the selected template's values.
4. Depending on the template you chose, input the required value in each cell (or row) in the window.
5. After inputting all of the values, press OK.
   (If you chose [Cylinder] or [Cone] in step 3, highlight Execute and then press OK here.)
   - This returns to the Function tab.

Note

- Note that the following input in step 4 results in an error.

For this template:	This type of input results in an error:
[Line] > [$\frac{X-X_0}{a}=\frac{Y-Y_0}{b}=\frac{Z-Z_0}{c}$]	a=0 or b=0 or c=0
[Line] > [$\vec{r}=\vec{r_0}+t\vec{v}$]	X, Y, Z elements = 0 for $\vec{v}$
[Line] > [Line through 2 points]	Both points = Identical coordinate values
[Line] > [Through point (X_0,Y_0,Z_0) Direction vector [a,b,c]]	All direction vector elements = 0
[Plane] > [$aX+bY+cZ+d=0$]	a=0 and b=0 and c=0
[Plane] > [$\vec{r}=\vec{r_0}+s\vec{u}+t\vec{v}$]	• X, Y, Z elements of either or both $\vec{u}$ and $\vec{v}$ = 0 • $\vec{u}$ and $\vec{v}$ = Identical orientation
[Plane] > [Plane through 3 points]	• Two of three points = Identical coordinate values • Three points are on a straight line
[Sphere] > [$(X-a)^2+(Y-b)^2+(Z-c)^2=r^2$]	r = 0 or less
[Sphere] > [$X^2+Y^2+Z^2+aX+bY+cZ+d=0$]	Input values do not satisfy $a^2+b^2+c^2>4d$.
[Cylinder]	Radius: 0 or less Same value for Zmin and Zmax
[Cone]	

To edit a template

1. Highlight the line where the template you want to edit is located, and then press (OK).
   - This displays the template's numeric input window.
2. Make changes to the existing values as required.
3. After everything is the way you want, press (OK).
   (If you are editing a [Cylinder] or [Cone] template, highlight Execute and then press (OK) here.)

To delete a template

To delete a stored template, use the same operation as that for deleting a Graph&Table app's stored function. See "To delete a function" (page 78) for details.

Storing and Editing Functions for 3D Graphing

To store a function

1. On the Function tab, highlight the line where you want to store a function.
2. Select (menu) > [Enter Equation].
3. Perform the operations shown in the table below.

To select this function type:	Select this menu item:
Cartesian coordinate type (Z=f(X, Y) form)	[Z=]
Parametric type $\begin{pmatrix}Xst=f(S,T)\\Yst=f(S,T)\\Zst=f(S,T)\end{pmatrix}$ form	[Parametric]
Solid of rotation on the X-axis (Y=f(X) form)*1	[x-Axis Rotate]
Solid of rotation on the Y-axis (Y=f(X) form)*2	[y-Axis Rotate]

*1 This draws a three-dimensional graph on the XY plane input using the Y=f(X) format and rotates it 360 degrees around the X axis.

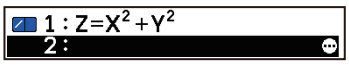
*2 This draws a three-dimensional graph on the XY plane input using the Y=f(X) format and rotates it 360 degrees around the Y axis.

4. Input the function in accordance with the selected type.
   - Press (x,θ,T) to input the variables (X or T) in accordance with the function type you chose.
   - To input "Y" for a Z= form function, press (ALPHA) (−)(Y) or press (▭) and then input using the menu that appears.
   - To input "S" for a parametric type function, press (ALPHA) (×)(S) or press (▭) and then input using the menu that appears.

Example 1: To input the Cartesian coordinate type $Z = X^2 + Y^2$

(⋯) > [Enter Equation] > [Z=]

(x,θ,T) (■²) (+) (ALPHA) (−)(Y) (■²) (EXE)



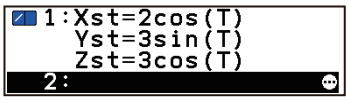
Example 2: To input the parametric type $\begin{cases} Xst = 2\cos(T) \\ Yst = 3\sin(T) \\ Zst = 3\cos(T) \end{cases}$

(⋯) > [Enter Equation] > [Parametric]

2 (cos) (x,θ,T)) (EXE)

3 (sin) (x,θ,T)) (EXE)

3 (cos) (x,θ,T)) (EXE)



Example 3: To input the solid of rotation on the X-axis type $Y = X^2 - 2$

(⋯) > [Enter Equation] > [x-Axis Rotate]

(x,θ,T) (■²) (−) 2 (EXE)

Note

- You can input only Absolute Value (page 226) and Hyperbolic Calc (page 237) category functions using the menu that appears when you press (▭) in step 4.

To edit or delete a function

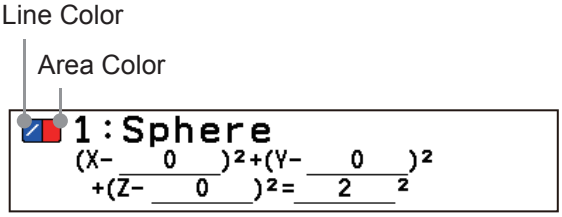
To edit or delete a stored function, use the same operation as one in the Graph&Table app. See "To edit a function" (page 78) and "To delete a function" (page 78) for more information.

Graph Drawing Settings (Line Color, Area Color)

On the Function tab, highlight the row that contains the graph drawing settings you want to change and then perform the operations described in the table below.

To do this:	Perform this operation:
Change the line color for graph drawing	Select (⋯) > [Line Color]. Use the list that appears to select a color.
Change the area color for graph drawing	Select (⋯) > [Area Color]. Use the list that appears to select a color.

The line color and area color you specify are shown by the icons to the left of each line of the Function tab as shown below.



Drawing Graphs

To select a function to draw a graph

1. On the Function tab, highlight a line where a template or function is stored.
2. Press ⋯.
   • This displays a Tools menu with [Select] highlighted.
3. Change [Select] to (On) to enable or to (Off) to disable graphing for the selected template or function.
4. Press ↩ to close the Tools menu.
   • The on/off setting of step 3 is indicated by the icons to the left of each line of the Function tab.

… On … Off

To go from the Function tab to the Graph tab (to draw a graph)

Press → or highlight Execute and then press OK. This causes the View Window menu*1*2 to appear so you can specify the range of the graph window. Change the range specification as required. For more information, see “Specifying the Spatial Range and Drawing Accuracy for 3D Graphing (View Window)” (page 102).

To return to the Function tab, press ← or ↩.

*1 You can also display the View Window menu by pressing ▲ OK on the Function tab.

*2 To prevent the View Window menu from appearing when you go to the Graph tab, turn off ≡ > [Show V-Win Settings].

Using the Graph Tab

Adjusting the Graph Window

To zoom the graph window in or out

Press ⊕ to zoom in or ⊖ to zoom out.

To rotate a 3D Graph manually

Use the cursor keys to rotate a 3D graph up, down, left, and right.

> **Note**
> • You can also rotate a 3D graph automatically. See “Auto Rotating a 3D Graph (Rotate)” (page 106).

To fine-tune the graph window (Tools menu)

To do this:	Select this menu item:	Details:
Specify the display range	⋯ > [View Window]	“Specifying the Spatial Range and Drawing Accuracy for 3D Graphing (View Window)” (page 102)
Zoom the graph window in or out	⋯ > [Zoom]	“Changing the Graph Window Zoom Setting (Zoom)” (page 106)

Specifying the Spatial Range and Drawing Accuracy for 3D Graphing (View Window)

You can use the View Window menu to specify the spatial range (x-, y-, and z-axis ranges) and the precision for drawing a 3D graph. This View Window also lets you specify the range of values for drawing a parametric type graphs, and the viewpoint of a 3D graph.

To display the View Window menu

On the Graph tab, select ⋯ > [View Window].

To specify the coordinate range and drawing precision for drawing a 3D graph

Use the View Window to input values for the items below.

- x Minimum, x Maximum, x Grid (x-axis minimum value[*1], maximum value[*1], grid value[*2*3])
- y Minimum, y Maximum, y Grid (y-axis minimum value[*1], maximum value[*1], grid value[*2*3])
- z Minimum, z Maximum (z-axis minimum value[*1], maximum value[*1])

To specify the range and drawing precision for each of the parameters (S and T) of a parametric type graph

These settings are applied when drawing parametric graphs. Use the View Window to input values for the items below.

- S Minimum, S Maximum, S Grid (parameter S minimum value[*1], maximum value[*1], grid value[*2*3])
- T Minimum, T Maximum, T Grid (parameter T minimum value[*1], maximum value[*1], grid value[*2*3])

To adjust the viewpoint of the graph window

Use the settings below to adjust the viewpoint of the graph display with respect to the x-axis and z-axis. Always specify a value in degrees, regardless of the current ☰ > [Angle] (page 215) angle unit setting.

Angle θ: Specifies the angle of clockwise rotation of the x-axis ($-180° < \theta < 180°$) viewed from the positive end of the x-axis (0°).

Angle φ: Specifies the angle rotation of the z-axis towards the back ($0° < \varphi < 360°$) viewed from the positive end of the z-axis forward (0°).

To initialize the View Window settings

On the View Window menu, select [Pre-set Windows] > [Initialize].

*1 Input minimum/maximum values in the range where the absolute value is smaller than 1×10^{98}.

*2 Input a grid value in the range $2 \leq$ grid ≤ 50.

*3 The grid value specifies the number of calculation points (number of divisions) for drawing a graph within the specified drawing range (from the minimum value to the maximum value). However, in the case of a sphere and certain other graph forms, the grid value is the number of divisions of the graph itself rather than the number of divisions of the drawing range.

Note

- The greater the x Grid and y Grid values, the more detailed the graph. Also note, however, that larger values require more calculation, which means that the graphing operation takes more time.
- Graphing may be impossible if the x Grid and y Grid values are too small.

Displaying the Cross Section of a 3D Graph

You can display the cross section of a 3D graph sliced with any vertical plane relative to the x-, y-, or z-axis. This operation is available for lines, planes, spheres, cylinders, or cones drawn using a template.

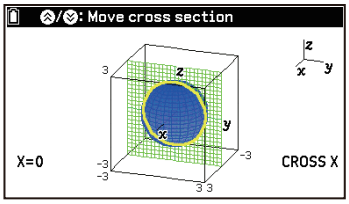
To display the cross section of a 3D graph

On the Graph tab that already shows a 3D graph, perform the operations in the table below.

To do this:	Select ⋯ > [Graph Solve] > [Draw Cross Section] and then select this:
Display a cross section of a 3D graph sliced with a plane perpendicular to the x-axis.	[Cross X]
Display a cross section of a 3D graph sliced with a plane perpendicular to the y-axis.	[Cross Y]
Display a cross section of a 3D graph sliced with a plane perpendicular to the z-axis.	[Cross Z]

Example: To display a cross section sliced on a plane perpendicular to the x-axis of the sphere graphed for Example 1 of “Operation Flow” (page 97).

(OPTN) > [Graph Solve] > [Draw Cross Section] > [Cross X]



Note

- The outline of the cross section of a 3D graph sliced with a plane is highlighted using the opposite color of the color specified by Area Color (page 101). Also, the outline of the cross section is displayed in the forefront plane.
- When a planar graph is sliced, the outer border of the planar graph is highlighted if the planar graph overlaps the plane being used for slicing.

To view a cross section from a particular direction

While a cross section is displayed, perform one of the operations below.

To do this:	Select this menu item:
Display the view along the positive x-axis	(OPTN) > [View From pos x Direction]
Display the view along the positive y-axis	(OPTN) > [View From pos y Direction]
Display the view along the positive z-axis	(OPTN) > [View From pos z Direction]
Return the view direction to its original view	(OPTN) > [Zoom Original]

To move the cross section of a 3D graph

Press (▲) or (▼) to move a cross section on the applicable axis. You can also specify a location on a cross section by directly inputting a coordinate value on the applicable axis.

Determining the Intersect of Straight Lines or Planes (fx-CG100 only)

You can use the operations below to determine the intersect of two lines, the intersect of a line and a plane, or the intersect of two planes. This operation can be performed on lines and/or planes drawn using a template.

Example 1: To graph the lines $\frac{X-1}{1}=\frac{Y-1}{1}=\frac{Z-1}{-1}$ and $\frac{X-1}{2}=\frac{Y-1}{2}=\frac{Z-1}{2}$, and determine where they intersect

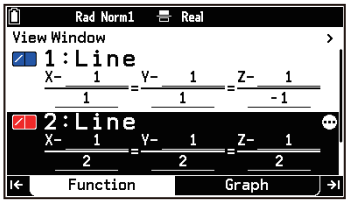
1. Use Function tab templates to store the equations of the two lines.

   (OPTN) > [Enter Equation] > [Templates] > [Line] > $[\frac{X-Xo}{a}=\frac{Y-Yo}{b}=\frac{Z-Zo}{c}]$

   1 (EXE) 1 (EXE) 1 (EXE) 1 (EXE) 1 (EXE) (▲) (−) ((−)) 1 (EXE) (EXE)

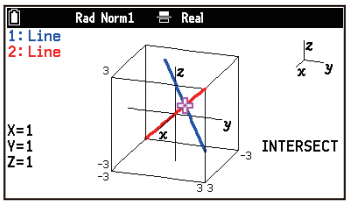
   (▼) (OPTN) > [Enter Equation] > [Templates] > [Line] > $[\frac{X-Xo}{a}=\frac{Y-Yo}{b}=\frac{Z-Zo}{c}]$

   1 (EXE) 1 (EXE) 1 (EXE) 2 (EXE) 2 (EXE) 2 (EXE) (EXE)



2. Press (⇥) to draw the graph.

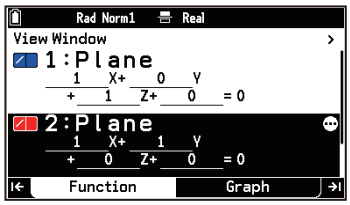
3. Select (OPTN) > [Graph Solve] > [Intersection].
   - This displays the intersect of the two lines. The coordinates of the intersect are shown in the lower left corner of the display.



Example 2: To graph the two planes X+Z=0 and X+Y=0 and determine their intersect

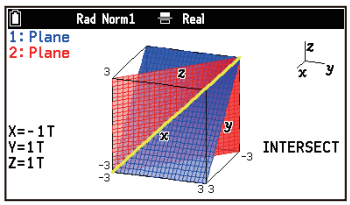
1. Use Function tab templates to store the equations of the two planes.

(⋯) > [Enter Equation] > [Templates] > [Plane] > [aX+bY+cZ+d=0]
1 (EXE) 0 (EXE) 1 (EXE) 0 (EXE) (EXE)
(▼) (⋯) > [Enter Equation] > [Templates] > [Plane] > [aX+bY+cZ+d=0]
1 (EXE) 1 (EXE) 0 (EXE) 0 (EXE) (EXE)



2. Press (→) to draw the graph.

3. Select (⋯) > [Graph Solve] > [Intersection].
   - This displays the intersect of the two planar graphs. The parametric equation of the intersect is shown in the lower left corner of the display.



Note

- The message “NOT FOUND” appears if the two 3D graphs do not intersect.
- The message “COINCIDENT” appears in the cases described below.
  - Two straight lines that are being considered align perfectly
  - Two planes that are being considered overlap completely
  - A line and plane are being considered, and the line is on the plane
- When there are three straight lines or planes, you can change how they are combined by pressing (▲) or (▼).

Determining the Relationship Between Straight Lines or Planes (fx-CG100 only)

You can determine the relationship between two 3D graphs using the combinations below.

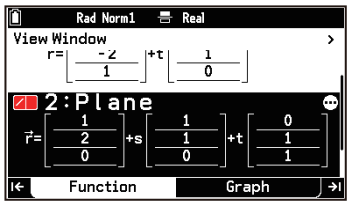
For this combination:	You can determine these types of relationships:
Line-line	Intersect, orthogonal, parallel, skew lines, or same line
Line-plane	Intersect, orthogonal, parallel, or line on the plane
Plane-plane	Intersect, orthogonal, parallel, or same plane

This operation can be performed on lines and/or planes drawn using a template.

Example: To graph line $\vec{r} = \begin{bmatrix}-1\\-2\\1\end{bmatrix} + t\begin{bmatrix}1\\1\\0\end{bmatrix}$ and plane $\vec{r} = \begin{bmatrix}1\\2\\0\end{bmatrix} + s\begin{bmatrix}1\\1\\0\end{bmatrix} + t\begin{bmatrix}0\\1\\1\end{bmatrix}$, and determine the relationship between them

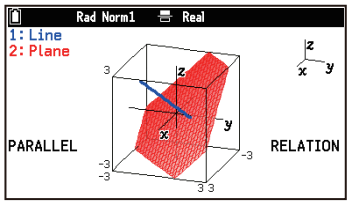
1. On the Function tab, use the templates to store the equations of the line and plane.

(⋯) > [Enter Equation] > [Templates] > [Line] > [$\vec{r}=\vec{r_0}+t\vec{v}$]
(▲) (−) ((−)) 1 (EXE) (▲) (−) ((−)) 2 (EXE) 1 (EXE) 1 (EXE) 1 (EXE) 0 (EXE) (EXE)
(▼) (⋯) > [Enter Equation] > [Templates] > [Plane] > [$\vec{r}=\vec{r_0}+s\vec{u}+t\vec{v}$]
1 (EXE) 2 (EXE) 0 (EXE) 1 (EXE) 1 (EXE) 0 (EXE) 0 (EXE) 1 (EXE) 1 (EXE) (EXE)



2. Press (→) to draw the graph.

3. Select (⋯) > [Graph Solve] > [Relationship].
   - A message indicating the relationship between the line and the plane is displayed in the lower left corner of the display. In this example, the relationship is “PARALLEL”.



   - The meanings of the relationship messages that appear in the lower left corner of the display are shown in the table below.

Message	Meaning
INTERSECT	Intersecting point or lines
ORTHOGONAL	Perpendicular intersection
PARALLEL	Parallel
SKEW LINES	Skewed relationship
COINCIDENT	Same line
ON THE PLANE	Line on the plane
COINCIDENT	Same plane

Note

- When there are three straight lines or planes, you can change how they are combined by pressing ⏫ or ⏬.

Using Trace (Trace)

Trace displays a crosshair pointer (✜) on a graph that you can use to read the coordinate values at a specific location. To enable trace, select ⋯ > [Trace].
The operations that can be performed while the trace function is enabled are described in the table below.

To do this:	Perform this operation:
Move the pointer along the graph	Press ⏷, ⏶, ⏴, or ⏵.
Move the pointer to a specific x- and y- coordinates on the graph	Use the number keys to input x-coordinate and y-coordinate values and then press OK. (Z= graphs and parametric type graphs only)
Move the pointer between graphs when multiple graphs are displayed	Press ⏬ or ⏫.*
Exit trace	Press ⏎.

* If there is only one graph on the display and the crosshair pointer (✜) is shown (because you selected ⋯ > [Trace]), pressing ⏬ or ⏫ returns the pointer to its initial position.

Changing the Graph Window Zoom Setting (Zoom)

To do this within the graph window:	Select ⋯ > [Zoom] and then select this:
Zoom in or out on the center of the window	[Zoom In][Zoom Out]
Display the view along the positive x-axis	[View From pos x Direction]
Display the view along the positive y-axis	[View From pos y Direction]
Display the view along the positive z-axis	[View From pos z Direction]
Return the 3D graph to its original (unrotated, unzoomed) state	[Zoom Original]

Auto Rotating a 3D Graph (Rotate)

You can rotate a 3D graph automatically using Auto Rotate. Auto rotation stops automatically after two rotations.

1. On the Graph tab, select ⋯ > [Rotate].
2. On the menu that appears, select a rotation direction.
   - To stop the auto rotation part way through, press AC.

Using Sketch (Sketch)

You can use sketch to draw dots and text within the graphing area. The following table shows what you can do with sketch.

To do this:	Select ⋯ > [Sketch] and then select this:
Clear all points and text drawn using sketch	[Clear Screen]
Toggle a point*1 between draw and delete	[Plot]
Write text*1*2	[Text]

*1 Sketch points and text are drawn according to the settings of ☰ > [Plot/Line Color] (page 218).

*2 Input is possible starting from the current pointer location and ending with the right edge of the graph window. ⌫ key operations while input is in progress are ignored.

3D Graph App Settings Menu Items

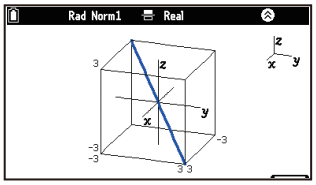
The Settings menu items (page 214) described below are specific to the 3D Graph app.

☰ > [3D Axes] ... Shows/hides Cartesian coordinate axes in the graph window.

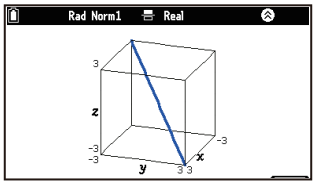
☰ > [Box] ... Shows/hides boxed axes in the graph window.

☰ > [3D Label] ... Shows/hides axis labels in the graph window.

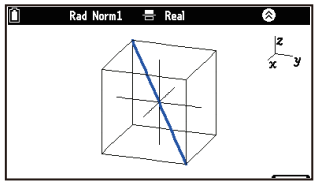
Setting Examples



3D Axes: On
Box: On
3D Label: On



3D Axes: Off
Box: On
3D Label: On



3D Axes: On
Box: On
3D Label: Off

Recursion App

You can use the Recursion app to work with general terms or two-term or three-term recursion formulas of numeric sequences. It creates a numeric table from a recursion formula and draws a graph. You can also draw a Phase Graph based on two recursion formulas of the same type, or a Web Graph to check the convergence or divergence of two-term recursion formulas.

Operation Flow

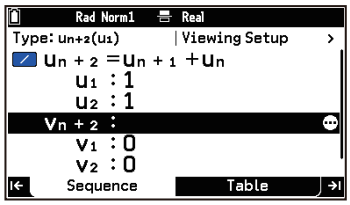
Example: To create a numeric table for the three-term recursion formula (Fibonacci sequence) $u_{n+2} = u_{n+1} + u_n$ where the first term is $u_1 = 1$ and the second term is $u_2 = 1$, and the value of the n-variable changes from 1 to 6, and then draw a graph of the numeric table

1. ⌂ > Recursion

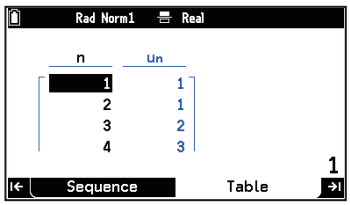
2. Specify the formula type, first term type and the numeric table domain.
   (1) On the Sequence tab, press ▲ to highlight the first line.
   (2) Press OK, and then use the Setup menu that appears to configure the settings shown below.
   - [Type] > [u_{n+2}]
   - [First Term] > [u_1]
   - [Set Table Domain] > [Start] : 1 ; [End] : 6

3. On the Sequence tab, input $u_{n+2} = u_{n+1} + u_n$, $u_1 = 1$, $u_2 = 1$.

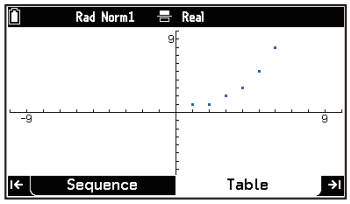
   ▼ (Highlights line 2 (u_{n+2}).)
   ⊞ > [Recursion] > [u_{n+1}] +
   ⊞ > [Recursion] > [u_n] EXE
   1 EXE
   1 EXE



4. To display the numeric table, press ⇥.
   - The numeric table is displayed on the Table tab.



5. To draw a graph, select ⋯ > [Graph Points].
   (1) Use the View Window menu that appears to select [Pre-set Windows] > [Standard].
   (2) Next, highlight Draw and then press OK.
   - This causes the graph of the numeric table to appear on the Table tab.



6. To return to the numeric table display, press ⮌.
   - Pressing ⇤ returns to the Sequence tab.

Using the Sequence Tab

On the Sequence tab, select one of the formula types shown below and input the formula.

For this formula type:	Enter this formula:
u_n	General term (Up to three of u_n, v_n, w_n)
u_{n+1}	Two-term recursion formula (Up to three of u_{n+1}, v_{n+1}, w_{n+1})

u_{n+2}	Three-term recursion formula (Up to three of u_{n+2}, v_{n+2}, w_{n+2})
u_n,v_n	Two general terms u_n and v_n
u_n,v_{n+1}	General term u_n and two-term recursion formula v_{n+1}
u_{n+1},v_n	Two-term recursion formula u_{n+1} and general term v_n
u_{n+1},v_{n+1}	Two two-term recursion formulas u_{n+1} and v_{n+1}

Using the Setup Menu

To display the Setup menu

1. On the Sequence tab, use ⊙ to highlight the first line.
   - Pressing ⊙ always highlights the first line.
2. Press [OK].

To choose the formula type and first term type

To select this:	Select this from the Setup menu:
General term (u_n)	[Type] > [u_n]
Two-term recursion formula (u_{n+1})	[Type] > [u_{n+1}]
Three-term recursion formula (u_{n+2})	[Type] > [u_{n+2}]
Two general terms u_n and v_n	[Type] > [u_n,v_n]
General term u_n and two-term recursion formula v_{n+1}	[Type] > [u_n,v_{n+1}]
Two-term recursion formula u_{n+1} and general term v_n	[Type] > [u_{n+1},v_n]
Two two-term recursion formulas u_{n+1} and v_{n+1}	[Type] > [u_{n+1},v_{n+1}]
First term type u_0*	[First Term] > [u_0]
First term type u_1*	[First Term] > [u_1]

* The first term type must be specified when the formula type is [u_{n+1}], [u_{n+2}], [u_n,v_{n+1}], [u_{n+1},v_n] or [u_{n+1},v_{n+1}].

To specify the numeric table domain

1. From the Setup menu (page 109), select [Set Table Domain].
2. Highlight [Start], input a starting value (0 or some positive integer) and then press [EXE].
3. Highlight [End], input the ending value* (a positive integer that is greater than the starting value) and then press [EXE].
4. To close the menu, press [⤺].

* Do not specify an ending value that exceeds the starting value plus 998. The ending value must be equal to or less than 1×10^6.

To specify the starting coordinates for drawing a web graph (Formula type: u_{n+1})

Before drawing a web graph on the Table tab, specify the starting coordinates (x-coordinates) for drawing in advance. To specify the starting coordinates, select [Set Web Graph Start] from the Setup menu (page 109). For information about web graph drawing, see "Using Web Graph to Check the Convergence or Divergence of a Numeric Sequence" (page 112).

Inputting and Editing Recursion Formulas

To input or edit a recursion formula

- On the Sequence tab, highlight the line where you want to input something and then start inputting. To edit part of something you have already entered, press [OK], ⊙, or ⊙.
- Use [▭] > [Recursion] to input n, u_n, u_{n+1} (and v_n, v_{n+1}, w_n, w_{n+1}).

• If the formula type is [u_{n+1}], [u_n,v_{n+1}], [u_{n+1},v_n] or [u_{n+1},v_{n+1}], input the first term. If the formula type is [u_{n+2}], input the first and second terms.

Note

• The restrictions described below apply when [u_n,v_n], [u_n,v_{n+1}], [u_{n+1},v_n] or [u_{n+1},v_{n+1}] is selected as the formula type.

With this formula type:	This type of input is not supported:
u_n,v_n	• Input of v_n in the left-side u_n expression and input of u_n in the left-side v_n expression at the same time*1 • Input of an expression that includes w*2
u_n,v_{n+1}	• Input of v_n in the left-side u_n expression and input of u_{n+1} in the left-side v_{n+1} expression at the same time*1 • Input of an expression that includes w*2
u_{n+1},v_n	• Input of v_{n+1} in the left-side u_{n+1} expression and input of u_n in the left-side v_n expression at the same time*1 • Input of an expression that includes w*2
u_{n+1},v_{n+1}	• Input of v_{n+1} in the left-side u_{n+1} expression and input of u_{n+1} in the left-side v_{n+1} expression at the same time*1 • Input of an expression that includes w*2

*1 Input on the Sequence tab itself is possible, but doing so causes an error (Circular ERROR) when you try to create a table.

*2 Input in the Sequence tab itself is possible, but doing so causes an error (Syntax ERROR) when you try to create a table.

Example of Inputting a Two-term Recursion Formula and General Term at the Same Time

Example: To enter the equation below, which consists of two-term recursion formula u_{n+1} and a general term v_n. Next, create a numeric table and then graph the table.

$$u_{n+1} = \frac{6u_n + 2}{u_n + 5} \text{ (However } u_0 = 8)$$

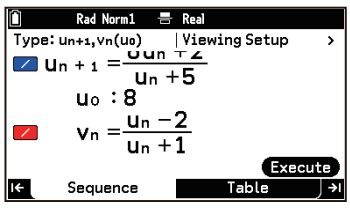
$$v_n = \frac{u_n - 2}{u_n + 1}$$

1. On the Sequence tab, press (^) to highlight the first line.

2. Press [OK]. Next, use the Setup menu that appears to configure the settings shown below.
   • [Type] > [u_{n+1},v_n]
   • [First Term] > [u_0]
   • [Set Table Domain] > [Start] : 1 ; [End] : 6

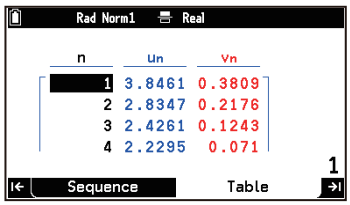
3. Input: $u_{n+1} = \frac{6u_n + 2}{u_n + 5}$, $u_0 = 8$, $v_n = \frac{u_n - 2}{u_n + 1}$

   (v) (Highlights line 2 (u_{n+1}).)
   [Menu] [6] [Recursion] > [u_n] [+] [2] (v)
   [Recursion] > [u_n] [+] [5] [EXE]
   [8] [EXE]
   [Menu] [Recursion] > [u_n] [−] [2] (v)
   [Recursion] > [u_n] [+] [1] [EXE]

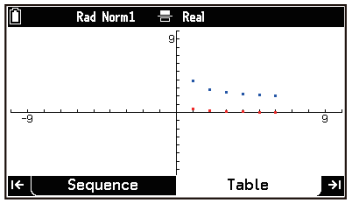


4. To display the number table, press [→].

• This displays the numeric table on the Table tab.



5. To draw a graph, select ⋯ > [Graph Points].
   (1) Use the View Window menu that appears to select [Pre-set Windows] > [Standard].
   (2) Next, highlight Draw and then press OK.
   • This causes the graph of the numeric table to appear on the Table tab.



To delete a recursion formula

See "To delete a function" (page 78).

To specify the line type and line color of a graph drawn from a recursion formula

See "Graph Drawing Settings (Line Type, Line Color)" (page 78).

Creating a Numeric Table

- Of the recursion formulas on the Sequence tab, those with ⋯ > [Select] turned on can be used for numeric table creation. You can determine the current on/off setting by checking the icon to the left of a recursion formula.

  ✓ … On ✓ … Off

- To create a numeric table, press ⇥ or ⇤, or highlight Execute and then press OK.
- Turning on ☰ > [ΣDisplay] adds a cumulative sum column to the numeric table for each term (Σu_n, Σv_n, Σw_n).

Using the Table Tab

The Table tab displays a numeric table or a graph. When you move from the Sequence tab to the Table tab, the numeric table is initially displayed. You can switch from numeric table display to graph display by using the ⋯ menu.

Operations While a Numeric Table is Displayed

You can use the cursor keys, as well as the ⇑ and ⇓ keys to move the cell highlighting between cells. You can also perform the operations below from the ⋯ menu.

To do this:	Select this menu item:
Specify the domain of the table being created*1	⋯ > [Set Table Domain]
Draw a graph that shows dots at the coordinates*2 of a numeric table	⋯ > [Graph Points]
Draw a graph that connects the coordinates*2 of a numeric table with straight line segments	⋯ > [Graph Points (Joined)]
Use Web Graph to check the convergence or divergence of a numeric sequence*3	⋯ > [Web Graph]
Draw a Phase Graph based on two recursion formulas*4	⋯ > [Phase Graph]
Specify the display range of a graph*5	⋯ > [View Window]
Save one column of a numeric table to a list variable	⋯ > [Store List]
Delete an entire numeric table and return to the Sequence tab	⋯ > [Delete]

*1 See "To specify the numeric table domain" (page 109).

*2 Each coordinate consists of the numeric table n-column as the x-axis and the $u_n/v_n/w_n$-column as the y-axis.

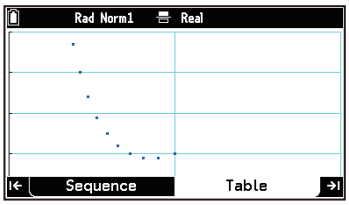
*3 Drawing is possible when u_{n+1} is selected as the formula type. See "Using Web Graph to Check the Convergence or Divergence of a Numeric Sequence" (page 112).
*4 Drawing is possible when u_n, u_{n+1}, or u_{n+2} is selected as the formula type. See "Drawing a Phase Graph From Two Sequences" (page 112).
*5 See "Specifying the Display Range of the Graph Window (View Window)" (page 80).

Drawing a Phase Graph From Two Sequences

You can create numeric tables (sequences) from two recursion formulas and then draw a Phase Graph using the values of one formula as the horizontal axis and the values of the other formula as the vertical axis.

Example: To input the two two-term recursion formulas $u_{n+1} = 0.9u_n$ and $v_{n+1} = v_n + 0.1n - 0.2$, where the first terms are $u_1 = 1$ and $v_1 = 1$ respectively. Next, create sequences that change the value of variable n from 1 to 10, and then use the sequences to draw a Phase Graph.

1. On the Sequence tab, press (^) to highlight the first line.
2. Press [OK], and then use the Setup menu that appears to configure the settings shown below.
   - [Type] > [u_{n+1}]
   - [First Term] > [u_1]
   - [Set Table Domain] > [Start] : 1 ; [End] : 10
3. On the Sequence tab, input $u_{n+1} = 0.9u_n$, $u_1 = 1$, $v_{n+1} = v_n + 0.1n - 0.2$, $v_1 = 1$.
4. Press [→|] to go to the Table tab.
5. Select [ooo] > [Phase Graph].
6. On the View Window menu that appears, input the values shown below.
   x Minimum = 0, x Maximum = 2, x Scale = 1
   y Minimum = 0, y Maximum = 4, y Scale = 1
7. Highlight [Draw] and then press [OK].
   - Phase Graph appears on the Table tab.



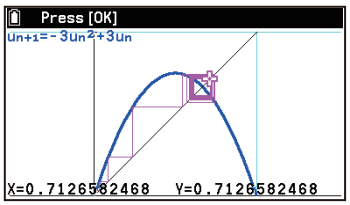
Note

- A Phase Graph can be drawn when u_n, u_{n+1}, or u_{n+2} is selected as the formula type.
- The x-axis values are those of the formula that is higher in the Sequence tab list, while the y-axis values are those of the lower formula.
- The color used to draw the graph is the color assigned to the formula that is higher in the Sequence tab list.
- If three regression formulas (u_n, v_n, w_n) have been entered and all three are selected for numeric table creation, a menu will appear in step 5 above asking you to select two of the three (u_n-v_n, v_n-w_n, u_n-w_n).
- If [≡] > [ΣDisplay] is turned on, a menu will appear to select whether to graph using u_n (sequence) or Σu_n (cumulative sum of sequences) in step 5 above.

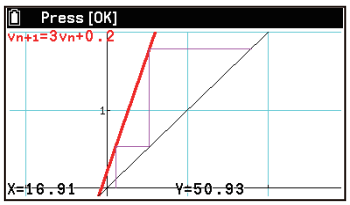
Using Web Graph to Check the Convergence or Divergence of a Numeric Sequence

For example, graph $y = f(x)$ where $u_{n+1} = y$ and $u_n = x$ in a two-term recursion formula that can be expressed in terms of u_{n+1} and u_n. Overlap this with a straight line with a slope of 45 degrees (graph of $y = x$). You can use these two graphs to draw a web graph automatically.

Selecting [Web Graph] in the example procedure below automatically graphs $y = f(x)$ and draws a straight line with a 45-degree slope. Then you can simply press [OK] multiple times to draw the web graph. By observing the behavior of the web graph, you can intuitively grasp whether the sequence is convergent or divergent.



Convergent

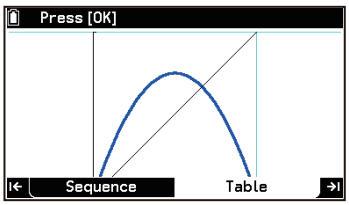


Divergent

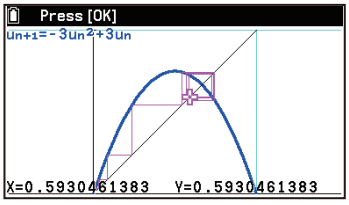
Example: To enter the two-term recursion formula equation $u_{n+1} = -3u_n^2 + 3u_n$ (first term $u_0 = 0.01$), draw a web graph, and determine if the graph is convergent or divergent

1. On the Sequence tab, press ⌃ to highlight the first line.
2. Press OK, and then use the Setup menu that appears to configure the settings shown below.
   - [Type] > [u_{n+1}]
   - [First Term] > [u_0]
   - [Set Table Domain] > [Start] : 0 ; [End] : 6
   - [Set Web Graph Start] > [u_nStart] : 0.01*

     * Make the x-coordinate of the starting point for drawing the web graph the same value as u_0.
3. On the Sequence tab, input $u_{n+1} = -3u_n^2 + 3u_n$, $u_0 = 0.01$.
4. Press ⇥ to go to the Table tab.
5. Select ⋯ > [Web Graph].
6. On the View Window menu that appears, input the values shown below.
   x Minimum = -0.52, x Maximum = 1.52, x Scale = 1
   y Minimum = 0, y Maximum = 1, y Scale = 1
7. Highlight Draw and then press OK.
   - This graphs $u_{n+1} = -3u_n^2 + 3u_n$ and draws a straight line with a slope of 45 degrees.



8. Press OK.
   - This causes a cross pointer (✜) to flash at the starting point of the web graph.
9. Press OK 20 times.
   - Each press of OK draws the straight lines of the web graph. The graph indicates that the numeric series is convergent.
   - To exit web graph drawing, press ⮌.



Note

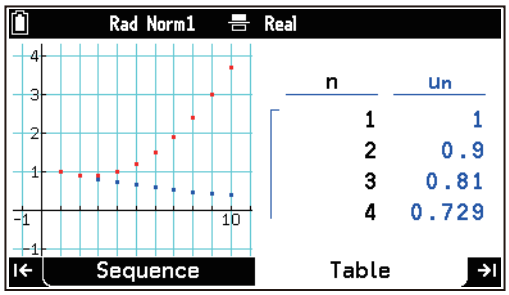
- A web graph can be drawn when u_{n+1} is selected as the formula type.
- You can specify the line type and line color of the $y=f(x)$ graph drawn above. For details, see "Graph Drawing Settings (Line Type, Line Color)" (page 78).

Operations While a Graph is Displayed

To do this:	Select this menu item:	Details:
Specify the display range	⋯ > [View Window]	“Specifying the Display Range of the Graph Window (View Window)” (page 80)
Display a pointer on a graph and read the coordinate values	⋯ > [Trace]	“Using Trace (Trace)” (page 84)
Zoom in and out of the display	⋯ > [Zoom]	“Changing the Graph Window Zoom Setting (Zoom)” (page 81)
Draw dots, lines, characters, etc.	⋯ > [Sketch]	“Using Sketch (Sketch)” (page 85)
Grab a point on a window and drag it around the display	⋯ > [Pan]	“Grabbing a Point on a Window and Drag It Around the Display (Pan)” (page 81)
Adjust the background image	⋯ > [Fade I/O]	“Adjusting the Graph Window Background Image (Fade I/O)” (page 81)

Displaying a Numeric Table and Graph at the Same Time

When ☰ > [Table with Graph] is turned on, the numeric table window is displayed on the right of the Table tab and the graph window is displayed on the left.



- Nothing is drawn in the graph window immediately after you move to the Table tab from the Sequence tab. Use the following operations to draw the graph.
  - Select ⋯ > [Switch Active Window].
  - From ⋯, select the menu item for drawing a graph.
- Each time you select ⋯ > [Switch Active Window], the active window (the window that is affected by the operations you perform) toggles between the numeric table window and the graph window. The numeric table window is active when the cursor is displayed on the numeric table.
- While the numeric table window is active, you can perform the operations described under “Operations While a Numeric Table is Displayed” (page 111). While the graph window is displayed, you can perform the operations under “Operations While a Graph is Displayed” (page 114), except for Pan and Fade I/O.

Equation App

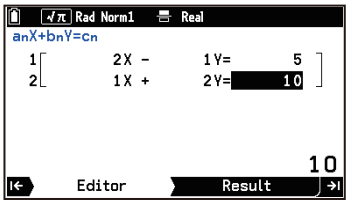
You can use the Equation app to solve simultaneous linear equations (two to six unknowns) and higher-order equations (2 to 6 degrees). It also has a Solver function that solves an equation for any variable.

Solving Simultaneous Linear Equations

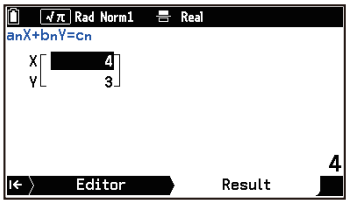
Example: To solve the following equations for x and y $\begin{cases} 2x - y = 5 \\ x + 2y = 10 \end{cases}$

1. ⌂ > Equation
2. On the Type tab, select [Simultaneous] and then press ⇥ or OK.
3. On the Unknowns tab, select the number of unknowns and then press ⇥ or OK.
   • Here we have two unknowns, (x and y), so we choose [2 Unknowns].
4. On the Editor tab, input the coefficients of the equation.

2 EXE ↑ (−) (−) 1 EXE 5 EXE
1 EXE 2 EXE 10 EXE



5. To solve the equations, press ⇥ or OK.
   • This displays the solutions for x and y on the Result tab. Details about the values in the cell at the current cursor location are shown in the lower-right corner of the window.*



* When ☰ > [$\sqrt{\pi}$ Result] is turned on, display is in $\sqrt{}$ and π form when possible (decimal form when not possible).
When ☰ > [$\sqrt{\pi}$ Result] is turned off, display is in decimal form only.

Note

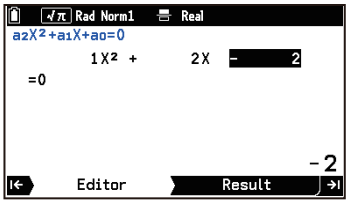
- The message “Infinitely Many Solutions” is displayed when there are infinite solutions.
- The calculator uses inverse matrix M^{-1} of coefficient matrix M to solve a linear system of equations. Because of this, accuracy may suffer as determinant Det(M) of coefficient matrix M approaches 0.

Solving Higher-Order Equations

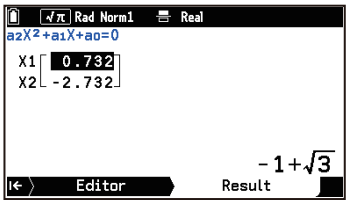
Example: To solve $x^2 + 2x - 2 = 0$

1. ⌂ > Equation
2. On the Type tab, select [Polynomial] and then press ⇥ or OK.
3. On the Degree tab, select the degree of the equation and then press ⇥ or OK.
   • Since we are solving a quadratic equation, we select [$a_2X^2+a_1X+a_0=0$] here.
4. On the Editor tab, input the coefficients of the equation.

1 EXE 2 EXE ↑ − (−) 2 EXE



5. To solve the equation, press → or OK.
   - This displays the solution for x on the Result tab. Details about the values in the cell at the current cursor location are shown in the lower-right corner of the window.*



* When ☰ > [$\sqrt{\pi}$ Result] is turned on, display is in $\sqrt{}$ and π form when possible (decimal form when not possible). When ☰ > [$\sqrt{\pi}$ Result] is turned off, display is in decimal form.

Note

- If the equation has multiple solutions, the number of solutions is displayed to the right of the solution.

  Example: Solution of $x^3 + 3x^2 + 3x + 1 = 0$

  X1 -1 ×3

  Higher-order equation calculations may not produce accurate results or cause an error when the equation has multiple solutions.
- If the equation has an imaginary solution, the solution is displayed in the form specified by the ☰ > [Complex Mode] setting.
- ☰ key operation is ignored on the Result tab. Operate the ☰ key on the Editor tab.

Using Solver

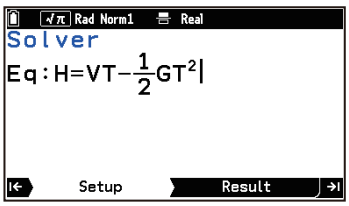
You can find the value of any variable in the equation without having to solve the equation by transforming or organizing the equation.

Example: Suppose an object is thrown into the air with initial velocity V and reaches height H after T time. Use the equation below to determine initial velocity V when H = 14 (m) and T = 2 (seconds), and gravitational acceleration G = 9.8 (m/s^2).

$$H = VT - \frac{1}{2}GT^2$$

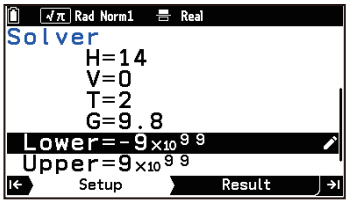
1. ⌂ > Equation
2. On the Type tab, select [Solver] and then press → or OK.
3. On the Setup tab, enter the equation into the Eq line.

H = VT − 1 ▽ 2 ▷ GT x²



4. Press OK.
   - This displays a list of variables included in the equation.
5. Specify for which of the variables you want to solve.
   (1) Press OK to display the Solve for dialog.
   (2) To obtain initial speed V, select [V] and then press OK.
6. Sequentially input H=14, T=2, and then G=9.8.

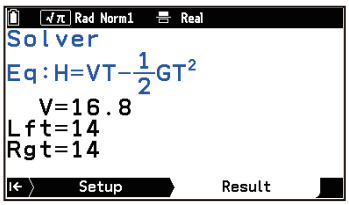
14 (EXE) 0 (EXE) *2 (EXE) 9 (.) 8 (EXE)



* The value to be solved for is the initial estimate value. Here, the initial estimated value is 0.

- In the “Upper=” and “Lower=” lines, input the upper and lower limits of the desired solution, if necessary.

7. Press (⇥). Or select [Execute] and then press (OK).
   - This displays the calculation results on the Result tab.
   - “Lft=” and “Rgt=” are the calculated results of the left side and right side with the obtained result.



Note

- x and X are treated as the same variable.
- If you input an expression without “=” in the “Eq” line in step 3, “expression = 0” is assumed.
- Functions registered with the Graph&Table app can be input into the “Eq” line. Select (○○○) > [Recall], highlight the function you want to enter, and then press (OK).
- Solver uses Newton’s method of approximation to find solutions. “Lft=” and “Rgt=” values are displayed because calculation using Newton’s method may produce an error with respect to the true solution. The closer the difference between the values of “Lft=” and “Rgt=” gets to 0, the smaller the error in the calculation results.
- The [Continue] button appears on the display when the calculator judges that convergence is not sufficient for the displayed results.
- Solver obtains only one solution. For information about obtaining multiple solutions of a higher-order equation (such as $ax^2+bx+c=0$), see “Solving Higher-Order Equations” (page 115).

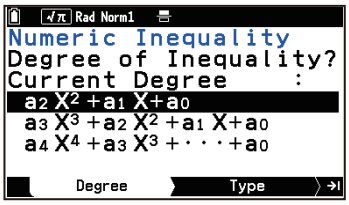
Num Ineq App (fx-CG100 only)

You can use the Num Ineq (Numeric Inequality) app to solve a 2nd, 3rd, or 4th degree inequality.

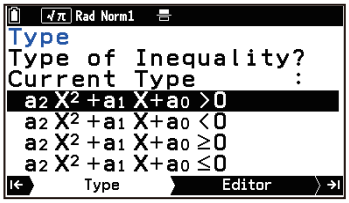
Operation Flow

Example: To solve $x^2 + 2x - \frac{3}{4} \geq 0$

1. (⌂) > Num Ineq
   - This displays the Degree tab.



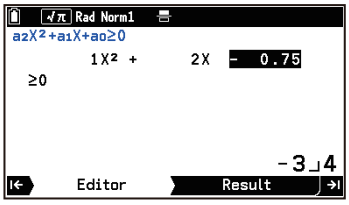
2. On the the Degree tab, select [$a_2X^2+a_1X+a_0$], and then press (OK).
   - This displays the Type tab.



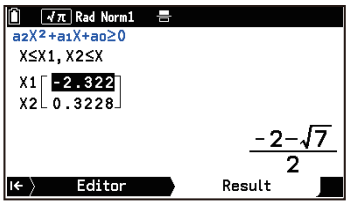
3. On the Type tab, select the inequality symbol type and orientation (>, <, ≥, ≤).
   - Here we want to solve $x^2 + 2x - \frac{3}{4} \geq 0$, select [$a_2X^2+a_1X+a_0 \geq 0$] and then press (OK).

4. On the Editor tab that appears, input coefficient values.

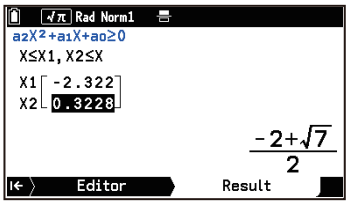
   1 (EXE) 2 (EXE) (↑) (−) ((−)) 3 (▤) 4 (EXE)



5. Press (⇥) or (EXE).
   - This will display the solution on the Result tab. Details about the values in the cell at the current cursor location are shown in the lower-right corner of the window.*



(▽)



* When (☰) > [√π Result] is turned on, display is in √ and π form when possible (decimal form when not possible). When (☰) > [√π Result] is turned off, display is in decimal form only.

Note

- "No Solution" appears on the Result tab when no solution exists for an inequality (such as $x^2 < 0$).
- "All Real Values of X " appears on the Result tab when the solution of an inequality is all numbers (such as $x^2 \geq 0$).
- (☰) key operation is ignored on the Result tab. Operate the (☰) key on the Editor tab.

Python App

The Python app supports a version of MicroPython Version 1.9.4, which has been adapted to run on this calculator.

Important!

- Note that generally, MicroPython is different from the Python that runs on a computer. Also, the Python app does not support all of the functions, commands, modules, and libraries of MicroPython.
- The Python app performs executions using the MicroPython processing system. Because of this, calculation results and other data produced by this app may differ from execution results of other function apps.

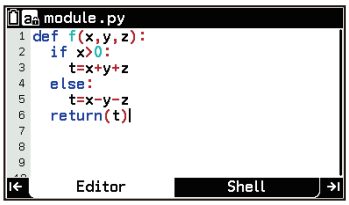
Operation Flow

Example: To create the script shown below and then execute it

Input	Meaning
def f(x,y,z):	Defines a user-defined function with function name f, and arguments x, y, and z.
if x>0:	If variable x is greater than 0,
t=x+y+z	Defines variable t as the execution result of x+y+z.
else:	Otherwise (if variable x is 0 or less),
t=x-y-z	Defines variable t as the execution result of x-y-z.
return(t)	Makes t the return value.

1. ⌂ > Python
   - This displays Editor and opens a py file named “module.py”.

2. Input the script.
   - For information about input operations, see “App Alpha Character and Numeric Input” (page 9) and “Input Operations (Same for Editor and Shell)” (page 121).



3. To execute the resulting script, press ⇥.
   - The imports module.py into Shell.

4. Call user-defined function f and then input 1, 2, 3 for arguments x, y, and z, respectively.
   (1) Press ⇦ to display the Variable menu.
   (2) Select f(,,) and then press OK.
   (3) Input 1, 2, and 3 as f arguments.

5. Press EXE to execute f(1,2,3).
   - Since x>0, t=x+y+z (=1+2+3) is executed and a value of t=6 is returned.

6. To return to Editor, press ⇦.

Using Editor

The first thing you will see when you enter the Python app from the HOME screen is Editor. A py file named “module.py” will always open automatically immediately after you enter the Python app.

Creating and Editing Scripts

You can input your scripts directly into “module.py” or edit another py file by performing the operations below.

To do this:	Select this menu item:
Close the currently open file and create a new file	⋯ > [File] > [New]
Close the currently open file and open another file	⋯ > [File] > [Open]
Save the currently open file under a different name	⋯ > [File] > [Save As]

The Python app lets you input up to 255 characters × 300 lines (text, functions, commands) for each file. For information about inputting text, functions, and commands into the Editor, see “Input Operations (Same for Editor and Shell)” (page 121).

To toggle alpha lock on and off

Whenever you enter the Python app, the Editor alpha lock setting is lowercase characters, which is indicated by a in the status bar. Press ALPHA to change the alpha lock setting to uppercase character input. This causes A to appear in the status bar. Press ALPHA again to unlock alpha lock.

To copy or cut scripts within Editor

1. Move the cursor to the start of the range that you want to copy or cut.
2. Press ⬆ 0 (⬚).
   - This displays ⬚ in the status bar until you press OK in step 4.
3. Move the cursor to the end of the range of data you want to copy or cut.
4. Select [Copy] or [Cut] in the menu that appears when you press OK.
   - You can specify the end point first if you want.

To paste a copied or cut script within Editor

1. Move the input cursor to the location where you want to paste the script.
2. Press ⬆ . (📋).

To move the cursor to a specified line

Select ⋯ > [Jump]. Use the dialog that appears to input a line number that specifies the move destination.

To save the currently open py file and overwrite its previous version

Select ⋯ > [File] > [Save].

To delete all scripts in Editor

Press AC or select ⋯ > [Delete All].

To delete a py file

1. Select ⋯ > [File] > [Delete].
2. Use the file list that appears to select the file you want to delete and then press OK.
3. In response to the confirmation dialog that appears, select [OK].
   - You cannot use this operation to delete a currently open file.
   - If you delete “module.py,” a new “module.py” file will be created automatically and opened the next time you start up the Python app.

Executing a Script

Use the operation below to execute the script that is currently displayed in Editor.

1. Press ⇥ (or ⇤), or select ⋯ > [Run].
   • If the script (py file) has already been saved, this will go to Shell and execute the script.

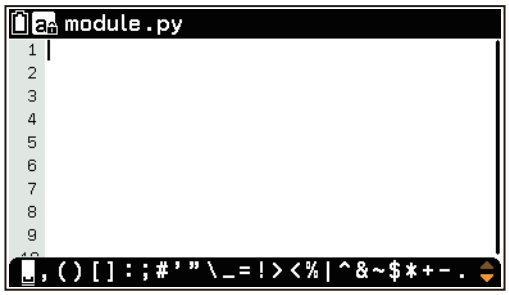
2. If the script (py file) has not been saved, use the dialog that appears to select an operation.

To do this:	Select this:
Save a py file, go to Shell and execute a script	[Yes]
Go to Shell without saving the py file and execute a script	[No]
Return to Editor without executing the script	[Cancel]

Input Operations (Same for Editor and Shell)

To use the Character Select menu to input characters

Select ⋯ > [Character Select] to display a character list along the bottom of Editor.



You can use this list to input alpha characters, symbols, and operators. To input a character, use the cursor keys to move the highlight to the character you want to input and then press OK. To hide the character list, press ↩ or AC.

To use keys to input characters and functions

The table below shows the characters and functions that you can input using keys.

Key	Input Character	Key	Input Character	Key	Input Character
0 to 9	0 to 9	,	,	⇧ , (:)	:
x^2	**2	×	*	⇧ sin ($\sin^{-1}$)	asin()
$x^{\square}$	**	÷	/	⇧ cos ($\cos^{-1}$)	acos()
x θ T,Y	x	+	+	⇧ tan ($\tan^{-1}$)	atan()
sin	sin()	−	−	⇧ ((=)	=
cos	cos()	$\times 10^{\square}$	*10**	⇧ 4 ([)	[
tan	tan()	$\sqrt{\square}$	sqrt()	⇧ 5 (])	]
(	(	$e^{\square}$	exp()	⇧ 7 (π)	pi
)	)	⇧ $e^{\square}$ (ln)	log()	⇧ 9 (i)	1j
.	.	⇧ x^2 (log)	log10()		

Autocomplete during input into Editor

Autocomplete is enabled while you are inputting into Editor. Inputting alpha-characters causes the corresponding candidate commands to appear on the display.

You can perform the following operations while input candidates are displayed.

To do this:	Do this:
Scroll through candidates (when multiple candidates are available)	Use ▽/△.
Input the currently displayed candidate	Press ▷ or OK.
Stop display of input candidates	Press ◁. (This causes the cursor to move one character back.)

Note

- The autocomplete function only displays the commands in the menu that appears when you press ☰.
- Autocomplete cannot be disabled.

To input commands and functions from the Catalog menu

1. Select the menu for the item you want to input.

When you want to input this:	Select this menu item:
Built-in Python commands and functions	☰ > [Built-in]
math module commands and functions	☰ > [math]
random module commands and functions	☰ > [random]
matplotlib.pyplot module commands and functions	☰ > [matplotlib.pyplot]
turtle module commands and functions	☰ > [turtle]
casioplot module (page 137) commands and functions	☰ > [casioplot]
Symbols and operators	☰ > [Symbol]
Commands and functions from an alphabetic list	☰ > [All] > [a] to [z]

   - This displays a list of items.

2. Highlight the item you want to input and then press OK.
   - You can jump to an item in the list by using the (x/θ/T) A to 0 Z keys to input the first characters of the item name.

Auto Indent Upon Newline

Pressing EXE while editing a script in Editor inputs a newline.

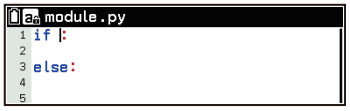
- Pressing EXE after the colon (:) at the end of a line, adds two more spaces at the beginning of the new line (Auto Indent).
- Pressing EXE while in an indented line will add the same indent (space) to the new line.

Statement Block Input

When inputting to Editor, selecting a command that has a multi-line syntax such as “if:else” or “for:range()” from the Catalog menu inputs a statement block that includes line breaks and spaces.

Example: To select “if:else” and add the multi-line context shown below, where “□” indicates a space

if□:
□□
else:
□□



When inputting into Shell, only the first line of the block is input.

To input user-defined variables and functions

1. Press (-) to display the Variable menu.

2. Highlight the variable or function you want to input and then press OK.
   - The Variable menu displays variables and functions as described below.

When (-) is pressed while Editor is displayed	Displays global variables and user-defined functions that are defined in the displayed py file.
When (-) is pressed while Shell is displayed	Displays global variables and user-defined functions that were defined in the last py file executed before Shell initialization.*

   * See “Initializing Shell” (page 123).

Note

- The items below are not shown on the Variable menu.

- Local variables, functions within functions, function arguments, user-defined classes
- Variables and functions contained in a py file imported from the currently open py file
- Variables defined with Shell
- Variables and functions contained in py files imported from Shell

• Variables displayed when you press ⏎ in other apps are not displayed in the Python app.

Using Shell

Shell is an interactive command line. From the Shell >>> prompt, you can input commands*1 and press EXE to obtain the result*2 immediately. Shell history stores up to 200 of the latest prompt and result lines.*3

*1 Up to 255 characters. For information about inputting text, functions, and commands into the Shell, see “Input Operations (Same for Editor and Shell)” (page 121).

*2 Result output has up to 509 characters per line.

*3 Until you select ⋯ > [Delete All] or start up another app.

To display Shell

While Editor is displayed, execute a script (page 120) or select ⋯ > [Shell].* Shell is initialized at this time.

* Selecting ⋯ > [Shell] does not execute the script currently displayed by Editor.

Initializing Shell

Shell stores variables and functions defined in the most recently executed script in the Shell heap area (temporary memory area for storage). Whenever you go from Shell to Editor, the Shell heap area contents up to that point are cleared. This clearing of Shell heap area contents is called “SHELL initialization.” When Shell is initialized, the message “∗ SHELL Initialized ∗” is inserted on the line that corresponds to when it was initialized.

To clear all Shell history contents

Press AC or select ⋯ > [Delete All].

matplotlib.pyplot Module

The matplotlib.pyplot module provides functions for drawing graphs with the Python app.

Important!

- The matplotlib.pyplot module of the Python app is a proprietary module created to run on this calculator. It is different from the matplotlib.pyplot module that runs on PC-based Python.
- The functions included in the matplotlib.pyplot module in the Python app of this calculator may differ from those of the matplotlib.pyplot module of PC-based Python in terms of behavior, supported arguments, and other specifications. Each function supports only the format and arguments specified here.

Note

- To use functions in the matplotlib.pyplot module, you must import the matplotlib.pyplot module.

  To import the matplotlib.pyplot module

  1. Select ⊞ > [matplotlib.pyplot].
  2. On the menu that appears, select the commands below.
     - from matplotlib.pyplot import *
     - import matplotlib.pyplot

- In the syntax of each function shown in this section, anything included in square brackets ([ ]) can be omitted.

The functions included in the matplotlib.pyplot module of the Python app are described below.

Displaying the Drawing Screen

show()

Shows graphs, grids, and axes that have been specified for drawing on the drawing screen.

Syntax: show() (no argument)

To return to Shell after displaying the drawing screen, press ⮌.

> **Note**
> - Execution of *show* clears all of the following items that were specified prior to execution.
> - Graphs that were specified for drawing
> - Axis settings (Returned to initial default settings.)
> - Grid settings (Returned to initial default settings.)
> - If a script contains multiple *show* calls, the graphs, grids, and axes that were described or configured between the second-to-last *show* and the final *show* will be displayed on the drawing screen.

Axis and Grid Settings

axis()

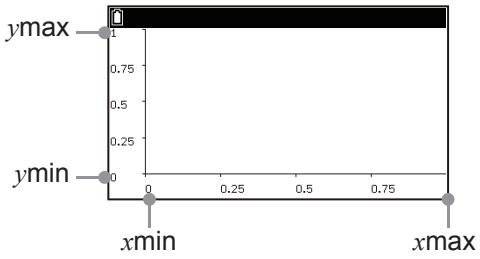
This function can be used to specify the display range of an axis and to change axis settings.

Syntax 1: axis(listxy)

Input the axis display range in the form [$x$min,$x$max,$y$min,$y$max] for the argument listxy. The coordinates of the lower left corner of the screen are determined by $x$min and $y$min.

$x$min	x-axis minimum value
$x$max	x-axis maximum value
$y$min	y-axis minimum value
$y$max	y-axis maximum value

- listxy type: list or tuple
- listxy element type: int or float
- Initial defaults: [0,1,0,1]



Syntax 2: axis(option)

Specifies the axis setting by inputting one of the keywords (type: str) into the option argument.

"on": Show axis

"off": Hide axis

"auto": Automatically set the axis range to match the graph[*1]

Syntax 3: axis() (no argument)

Returns to the display range of the currently specified axis.[*2]

*1 axis("auto") is valid only when it comes after the graph drawing function.

*2 When executed with Shell. To write to a py file and output the setting values, you need to write “print(axis())”.

> **Note**
> - The axis display color is always black.

grid()

Use this function to show or hide the grid and to specify the grid color.

Syntax 1: grid(option[,color])
Specifies show/hide grid. You can also specify the grid color at the same time.
• option argument: Specifies show/hide grid.
  - To specify using str type, use the keywords below.
    "on", "True", or "true": Show grid
    "off", "False", or "false": Hide grid
  - To specify using bool type, use the terms below.
    True: Show grid
    False: Hide grid
• color argument: Specifies the grid color.
  - Type: str
  - How to specify: Use the syntax grid(option,color="keyword") to specify the grid color. For information about text strings that can be specified as keywords, see “Color Keywords” (page 129).
  - Operation when omitted: The grid is drawn with solid gray lines. (The grid is not shown if the "Hide grid" argument option is specified.)

Syntax 2: grid(color)
Specifies the grid color. Also switches to "Show grid." (This is the same as when grid("on") is specified in Syntax 1.)
• color argument: Specifies the grid color. The type and method for specifying the color are the same as that for Syntax 1.

Syntax 3: grid() (no argument)
Toggles the grid setting between show and hide.
• For example, calling grid() after grid("on") toggles the grid from show to hide.
• Calling grid() after grid("off") toggles the grid from hide to show. In this case, the grid is drawn as solid gray.

> **Note**
> • If *axis* was used to hide the axis, the grid will also be hidden.

Drawing Graphs and Text Strings

plot()
Plots a point or draws a line segment.

Syntax 1: plot(x,y[,color])
Plots a point at the specified coordinates. You can also specify the color of the point.
• x, y arguments: Specifies coordinates (x, y).
  - Type: int or float
• color argument: Specifies the color.
  - Type: str
  - How to specify: Use the syntax plot(x,y,"keyword") to specify the color. For information about text strings that can be specified as keywords, see “Color Keywords” (page 129).
  - Operation when omitted: The color is specified automatically. For details, see “Auto Color Specification” (page 129).

Syntax 2: plot([list$x$,]list$y$[,color])
Draws a line segment connecting multiple specified coordinates. You can also specify the color of the line segment.
• list$x$, list$y$ arguments: Specifies multiple coordinates (x_1, y_1 ; x_2, y_2 ; x_3, y_3 ; …).
  - list$x$, list$y$ type: list or tuple
  - list$x$, list$y$ element type: int or float
  - Omitting list$x$ automatically assigns list$x$ = [0,1,2,3,…].
  - When both list$x$ and list$y$ are specified, both lists must contain the same number of elements.
• The color argument is the same as that for Syntax 1.

Note

- The form of a point drawn at the coordinates specified by *plot* is always a cross (+).
- Executing *plot* without specifying anything for *axis* causes the axis to be adjusted automatically.
- If you input a "shape keyword" that is supported by PC-based Python for the color argument, the keyword will be ignored without causing an error. If you input only a shape keyword for the color argument, the color argument will be treated as if no argument was input. The behavior is the same as when it is omitted.

bar(,)

Draws a bar chart.

Syntax 1: bar(x,y[,width])

Draws a single bar chart.

- x argument: Specifies the bar chart x-coordinate.
  y argument: Specifies the bar chart height.
  - x, y type: int or float
- width argument: Specifies the bar chart width (scale width along the x-axis). Specifying 0 draws using a width of one dot.
  - Type: int or float
  - Initial default: 0.8 (0.8 when omitted)

Syntax 2: bar(list$x$,list$y$[,width])

Draws a bar chart with one or multiple bars.

- list$x$ argument: Each list element specifies the x-coordinate each bar.
  list$y$ argument: Each list element specifies the height of each bar.
  - list$x$, list$y$ type: list or tuple
  - list$x$, list$y$ element type: int or float
  - The number of elements in list$x$ and list$y$ must match.
- The width argument is the same as that for Syntax 1.

Note

- Executing *bar* without specifying anything for *axis* causes the axis to be adjusted automatically.
- The color of a bar chart drawn using *bar* is specified automatically. For details, see "Auto Color Specification" (page 129).

scatter(,)

Draws a scatter plot.

Syntax 1: scatter(x,y)

Plots a point at the specified coordinates.

- x, y arguments: Specifies coordinates (x, y).
  - x, y type: int or float

Syntax 2: scatter(list$x$,list$y$)

Draws a scatter plot by plotting points at all of the specified coordinates.

- list$x$, list$y$ arguments: Specifies multiple coordinates (x_1, y_1 ; x_2, y_2 ; x_3, y_3 ; …).
  - list$x$, list$y$ type: list or tuple
  - list$x$, list$y$ element type: int or float
  - The number of elements in list$x$ and list$y$ must match.

Note

- The form of a point drawn at the coordinates specified by *scatter* is always a cross (+).

- Executing *scatter* without specifying anything for *axis* causes the axis to be adjusted automatically.
- The color of the points drawn using *scatter* is automatically specified. For details, see "Auto Color Specification" (page 129).

hist()

This function draws a histogram (a frequency distribution chart in which the horizontal axis represents classes and the vertical axis represents frequencies).

Syntax 1: hist(x[,bins]) or hist(x,listbins)

Draws a histogram where the number of data points is 1 (frequency=1).

- x argument: Inputs a data value.
  - x type: int or float
- bins argument: Specifies the number of bins in the histogram as an integer greater than or equal to 1.
  - bins type: int
  - Initial default: 10 (10 when this argument is omitted)
  - How to specify: To specify four bins, for example, use hist(x,bins=4), or hist(x,4).
- listbins argument: Specifies multiple values for the histogram class division points.
  - listbins type: list or tuple
  - listbins element type: int or float
  - For example, hist(1,[0,2,4]) would result in two intervals of 0-to-2 and 2-to-4.

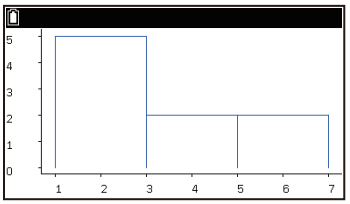
Syntax 2: hist(list$x$[,bins]) or hist(list$x$,listbins)

Draws a histogram with multiple data points.

- list$x$ argument: Input a data value for each element.
  - list$x$ type: list or tuple
  - list$x$ element type: int or float
- The bins and listbins arguments are the same as that for Syntax 1.

Note

- Executing *hist* without specifying anything for *axis* causes the axis to be adjusted automatically.
- The color of the histogram drawn by *hist* is specified automatically. For details, see "Auto Color Specification" (page 129).
- Values input for the listbins argument are automatically sorted into ascending order. For example, inputting [4,0,2] is treated as [0,2,4].
- Data values at the division point of a class are included in the class above the division point, except in the case of the maximum value. For example, executing hist([1,1,2,2,2,3,4,5,7],3) specifies 3 for the bins argument, so the classes are 1-to-3, 3-to-5, and 5-to-7. Data value 3 at the division point would be included in the 3-to-5 class, and data value 5 in the 5-to-7 class. However, the maximum value of 7 will be included in the 5-to-7 class.



arrow(,,,)

Draws an arrow.

Syntax: arrow(x,y,dx,dy[,edgecolor[,facecolor[,head_width[,head_length]]]])

- x, y arguments: Specify the coordinates (x, y) of the draw start point of the arrow.
- dx, dy arguments: Specify the end point* of the arrow, which will be at the coordinates (x+dx, y+dy).
  - x, y, dx, dy type: int or float

  * End point of the line segment that does not include the arrowhead.

- edgecolor argument: Specifies the arrow edge color.
- facecolor argument: Specifies arrowhead face color.

- edgecolor, facecolor type: str
- edgecolor initial value: black; facecolor initial color: blue (These colors are used when these arguments are omitted.)

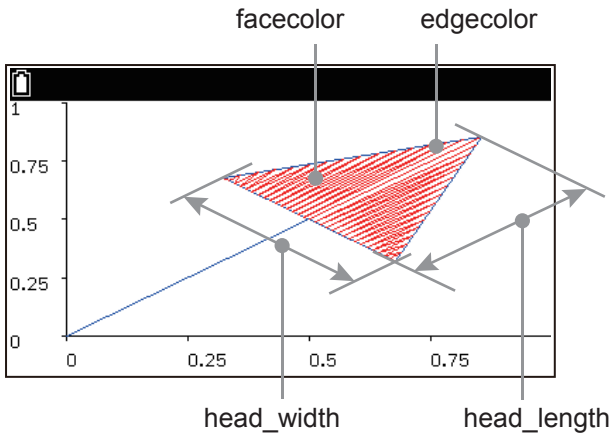
• head_width argument: Specifies the arrowhead width.
- head_width, head_length type: int or float
- head_width initial value: 0.003; head_length initial value: head_width × 1.5
- If a negative value is specified for head_width or head_length, the absolute value of the value is applied.

• head_length argument: Specifies the arrowhead length.

Example: To draw an arrow with coordinates (0, 0) as its start point and coordinates (0.5, 0.5) as its end point. Specify blue for the arrow edge color, red for the arrowhead face color, and 0.5 for the head width and length.

```
from matplotlib.pyplot import *
arrow(0,0,0.5,0.5,edgecolor="blue",facecolor="red",head_width=0.5,head_length=0.5)
show()
```

Operation results are shown below.



Note

- When specifying the edgecolor, facecolor, head_width, and head_length arguments, you should always write a string that specifies an argument (edgecolor= part) as shown in the Example above. The text string specifying each argument can be entered using ⓜ > [matplotlib.pyplot].
- See “Color Keywords” (page 129) for keywords like blue, red, etc. that can be used to specify colors.
- The axis is not adjusted automatically if you execute *arrow* without specifying anything for *axis*. If the arrow extends beyond the drawing screen, specify the axis manually.

text(,,)

Draws a text string at the specified coordinates.

Syntax: text(x,y,text)

• x, y arguments: Specify the coordinates (x, y) of the left end of the string.
- x, y type: int or float

• text argument: Specifies a text string.
- There are no restrictions on the text argument’s type. Any text string can be entered by enclosing it within double quotes (" ").

Note

- The axis is not adjusted automatically if you execute *text* without specifying anything for *axis*. If the text string extends beyond the drawing screen, specify the axis manually.
- The color of text strings drawn with *text* is always black.

Color Keywords

The keywords shown in the tables below can be used as *grid*, *plot*, and *arrow* arguments to specify colors.

To specify this color:	Use this keyword:
Blue	"b" or "blue"
Red	"r" or "red"
Green	"g" or "green"
Magenta	"m" or "magenta"
Black	"k" or "black"
Cyan	"c" or "cyan"
Yellow	"y" or "yellow"

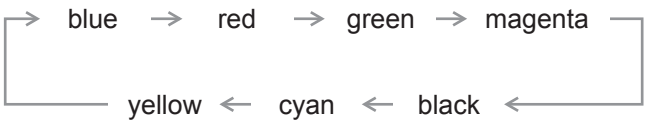
To specify this color:	Use this keyword:
White	"w" or "white"
Grey	"grey"
Orange	"orange"
Purple	"purple"
Brown	"brown"
Pink	"pink"

Note

- Color keywords can be input using ⓜ > [matplotlib.pyplot].

Auto Color Specification

When a graph is drawn using a single execution of *plot**, *bar*, *scatter*, or *hist*, blue is automatically specified as the color. When these functions are executed in succession to draw graphs, the graph colors are automatically specified in the following sequence:



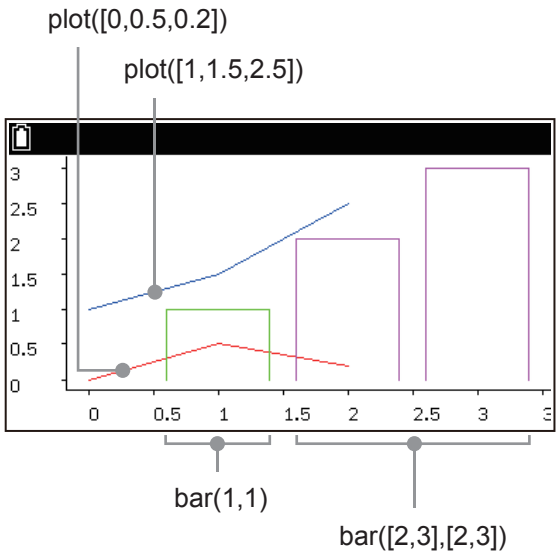
Each execution of *show* causes the auto graph color sequence to return to blue.

* For the *plot* function, the color is automatically assigned only when the color argument is omitted.

Example: To use *plot* and *bar* to draw two graphs in succession. Omit the *plot* color argument.

```
from matplotlib.pyplot import *
plot([1,1.5,2.5])
plot([0,0.5,0.2])
bar(1,1)
bar([2,3],[2,3])
show()
```

Operation results are shown below.



turtle Module

The turtle module provides functions to manipulate a virtual "turtle" ( ) with the pen. You can make the turtle draw shapes and patterns.

Important!

- The turtle module of the Python app is a proprietary module created to run on this calculator. It is different from the turtle module that runs on PC-based Python.
- The functions included in the turtle module in the Python app of this calculator may differ from those of the turtle module of PC-based Python in terms of behavior, supported arguments, and other specifications. Each function supports only the format and arguments specified here.

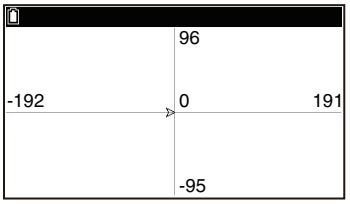
Note

- To use functions in the turtle module, you must import the turtle module.

  To import the turtle module

  1. Select ⓜ > [turtle].
  2. On the menu that appears, select the commands below.
     - from turtle import *
     - import turtle

- When using the turtle module with the Python app, the coordinates are fixed as shown below.
  Origin: 0, 0
  x-axis minimum value: -192, maximum value: 191
  y-axis minimum value: -95, maximum value: 96



- The functions below can be written as is only when executed with Shell. To write them to a py file and output the setting values, you need to write them inside print(), such as print(pencolor()).
  pencolor(), pensize(), width(), shape(), speed(), isvisible(), isdown(), xcor(), ycor(), position(), distance(,), towards(,), heading()

- In the syntax of each function shown in this section, anything included in square brackets ([ ]) can be omitted.

The functions included in the turtle module of the Python app are described below.

Specifying a Pen

pendown()
Lowers the pen, enabling drawing.

Syntax: pendown() (no argument)
- When you move the turtle with the pen down, a line is drawn from the current location of the turtle to its destination. To move the turtle, use the functions under "Specifying Direction and Forward/Back Movement" (page 132) and "Moving to Specified Coordinates" (page 132).

penup()
Raises the pen, disabling drawing.

Syntax: penup() (no argument)
- When the pen is up, nothing is drawn if the turtle is moved.

pencolor()
- Specifies the line drawing color or returns the value of the line drawing color.

Syntax 1: pencolor(colorstring)
- colorstring argument: Uses a keyword to specify the line drawing color.
  - Type: str
  - How to specify: Use the syntax pencolor("keyword") to specify the color. The text strings below can be specified as keywords
    black, blue, green, red, cyan, yellow, magenta, white, orange, purple, brown, pink, grey

Syntax 2: pencolor(list)
- list argument: Uses RGB values to specify the line drawing color.
  - Type: list or tuple
  - Element type: int or float
  - How to specify: Use the syntax [r,g,b] ($0 \le r \le 1$, $0 \le g \le 1$, $0 \le b \le 1$) to specify RGB values. Each RGB value corresponds to a Syntax 1 keyword as shown in the table below.

Keyword	RGB Values
black	[0,0,0]
blue	[0,0,1]
green	[0,1,0]
red	[1,0,0]
cyan	[0,1,1]

Keyword	RGB Values
yellow	[1,1,0]
magenta	[1,0,1]
white	[1,1,1]
orange	[1,0.65,0]
purple	[0.66,0,0.66]

Keyword	RGB Values
brown	[0.75,0.25,0.25]
pink	[1,0.75,0.8]
grey	[0.66,0.66,0.66]

Syntax 3: pencolor() (no argument)
- Returns the RGB values (or the keyword if applicable) of the current line drawing color.

pensize(), width()
Specifies the line width or returns the value of the current line width.

Syntax 1: pensize(n)
width(n)
- n argument: Specifies the line width as a real number from 0 to 5. The greater the number, the wider the line.
  - Type: int or float

Syntax 2: pensize() (no argument)

width() (no argument)

- Returns the value of the current line drawing width.

Specifying Direction and Forward/Back Movement

right()

Rotates the turtle to the right by a specified angle so its head is pointed in a desired orientation.

Syntax: right(a)

- a argument: Specifies in degrees the angle (0° ≤ a < 360°) which the turtle should be rotated.
  - Type: int or float

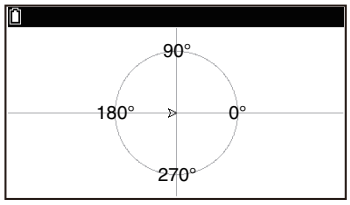
left()

Rotates the turtle to the left by a specified angle so its head is pointed in a desired orientation.

Syntax: left(a)

- argument a is the same as that for *right*.

setheading()



Specifies the absolute orientation of the turtle's head, with east being 0° (right), 90° north (top), 180° west (left), and 270° south (bottom).

Syntax: setheading(a)

- a argument: Specifies the orientation of the head of the turtle in degrees (0° ≤ a < 360°).
  - Type: int or float

forward()

Moves the turtle forward in the direction of the current turtle head orientation. The head orientation does not change.

Syntax: forward(n)

- n argument: Specifies the distance of turtle movement.
  - Type: int or float

backward()

Moves the turtle back, in the direction opposite that of the current turtle head orientation. The head orientation does not change.

Syntax: backward(n)

- The argument n is the same as that for *forward*.

Moving to Specified Coordinates

goto(,)

Moves the turtle to the specified coordinates. The head orientation does not change.

Syntax: goto(x,y)

- x, y arguments: Specify the coordinates (x, y) of the turtle's destination.
  - x, y type: int or float

setposition(,)

Moves the turtle to the specified coordinates. The head orientation does not change.

Syntax: setposition(x,y)
- The x, y arguments are the same as those for $goto$.

setx()
Moves the turtle to the specified x-coordinate without changing its current y-coordinate. The head orientation does not change.

Syntax: setx(x)
- x argument: Specifies x-coordinate of the turtle's destination.
  - x type: int or float

sety()
Moves the turtle to the specified y-coordinate without changing its current x-coordinate. The head orientation does not change.

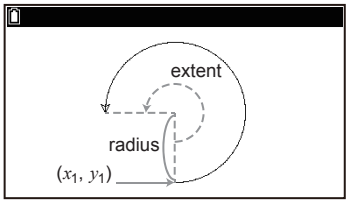
Syntax: sety(y)
- y argument: Specifies y-coordinate of the turtle's destination.
  - y type: int or float

home()
Moves the turtle to the origin (0,0) and returns the head to its initial orientation (rightward).

Syntax: home() (no argument)

Drawing Circles and Text

circle()
Draws a circle or an arc from the current turtle location. The circle or arc is drawn counterclockwise starting from the current turtle location. The figure on the right shows the relationship between the arguments in the following syntax and the arc being drawn, assuming that the current position of the turtle is (x_1, y_1).



Syntax: circle(radius[,extent=360])
- radius argument: Specifies a circle radius.
  - Type: int or float
- extent argument: Specifies an arc angle in degrees.
  - Type: int or float
  - How to specify: For example, to set the extent to 180, use circle(radius,extent=180) or circle(radius,180).
  - Initial default: 360 (360 when omitted)

write()
Draws a text string from the current turtle location.

Syntax: write(text)
- text argument: Specifies a text string.
  - There are no restrictions on the text argument's type. Any text string can be entered by enclosing it within double quotes (" ").

Specifying the Turtle Status

shape()
Use this function to specify the turtle shape or to return the current turtle shape. There are two available turtle shapes.

"classic"	"turtle"
	

Syntax 1: shape(name)
Use this syntax to specify the shape of the turtle.
- name argument: Uses keywords (classic, turtle) to specify the turtle shape.
  - Type: str
  - How to specify: For example, if you want a "classic" (arrow) shaped turtle, specify shape(name="classic") or shape("classic").
  - Initial default: "classic"

Syntax 2: shape() (no argument)
Returns the currently specified turtle shape.

speed()
Specifies the drawing speed of the turtle (the speed the turtle moves when the pen is down) or returns the currently specified turtle drawing speed.

Syntax 1: speed(speed)
Specifies the speed of turtle drawing. The speed argument can be a real number or a keyword.
- Specifying by real number: Input a value from 0 to 10. 0 is the fastest speed. For non-zero values, a greater number corresponds to a faster speed. The setting defaults to 0 if a value outside of the allowable range is specified.
  - Type: int or float
  - Initial default: 5
- Specifying by keyword: Use the keyword strings shown in the table below.

Keyword	Corresponding Real Number
fastest	0
fast	10
normal	6
slow	3
slowest	1

  - Type: str
  - How to specify: To specify slow, for example, use speed(speed="slow"), or speed("slow")
  - Initial default: speed=None

Syntax 2: speed() (no argument)
Returns the real number that corresponds to the turtle's currently specified drawing speed.

showturtle()
Displays the turtle on the drawing screen.

Syntax: showturtle() (no argument)

hideturtle()
Hides the drawing screen turtle.

Syntax: hideturtle() (no argument)

Get Status

isvisible()
Returns the current turtle show/hide status (Show: True, Hide: False).

Syntax: isvisible() (no argument)

isdown()
Returns the current pen state (Pen down: True, Pen up: False).

Syntax: isdown() (no argument)

xcor()
Returns the x-coordinate of the turtle's current location.

Syntax: xcor() (no argument)

ycor()
Returns the y-coordinate of the turtle's current location.

Syntax: ycor() (no argument)

position()
Returns the turtle's current location (x, y coordinates).

Syntax: position() (no argument)

distance(,)
Returns the linear distance from the turtle's current location to the specified coordinate.

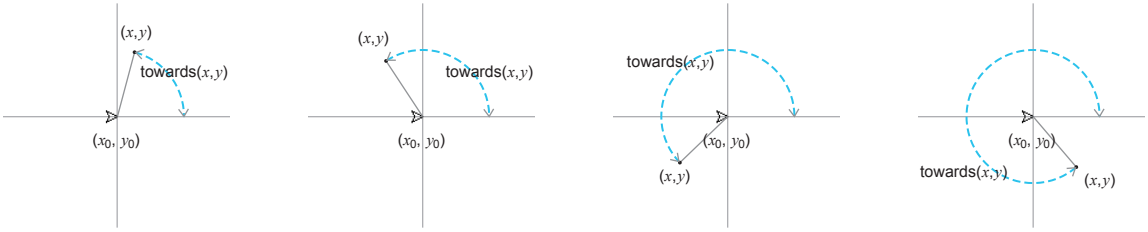
Syntax: distance(x,y)
- x, y arguments: Specify the coordinates (x, y) of the point to which you want to check the linear distance from the turtle's current location.
  - x, y type: int or float

towards(,)
Returns the angle of the arc created by the current turtle location and the specified coordinates (See Note below).

Syntax: towards(x,y)
- x, y arguments: Specify the coordinates (x, y) at which you want to check the angle with the current turtle location.
  - x, y type: int or float

Note

- If the current turtle location is (x_0, y_0) and the specified coordinates are (x, y), then the angle of the arc shown by the dashed line in the figure below will be returned by the towards(x,y) function.



$x_0 < x,\ y_0 < y$ $\quad$ $x < x_0,\ y_0 < y$ $\quad$ $x < x_0,\ y < y_0$ $\quad$ $x_0 < x,\ y < y_0$

- When $x = x_0$, $y = y_0$, towards(x,y) returns 0.

heading()

Returns the current turtle orientation. See “setheading()” (page 132) for information about turtle orientation.

Syntax: heading() (no argument)

Turtle Reset and Drawing Screen Clear

reset()

Clears the contents of the drawing screen and initializes the turtle.

Syntax: reset() (no argument)

The initial status of the turtle is shown in the table below.

Status Type	Initial Default
Location	(0,0)
Orientation	0° (east, right)
Color	(0,0,0) (black)
Pen up/down	Down
Pen drawing width	1
Turtle drawing speed	5
Turtle show/hide	Show
Turtle shape	"classic"

clear()

Clears the contents of the drawing screen while preserving the current turtle state.

Syntax: clear() (no argument)

casioplot Module

The casioplot module is a CASIO-original module that includes draw functions for drawing pixels and character in the Python app. To input these functions, use ⓜ > [casioplot]. The functions described below are included in the casioplot module. Arguments enclosed in square brackets ([ ]) in a function syntax can be omitted.

show_screen() (No argument)

Displays the drawing screen. For details about displaying the drawing screen, drawing screen refresh and clear timing, and other information, see "Drawing Screen" (page 139).

Example: To display the drawing screen

```
from casioplot import *
show_screen()
```

clear_screen() (No argument)

Clears all draw contents from the drawing screen. This function is executed regardless of whether or not there are any draw contents on the drawing screen.

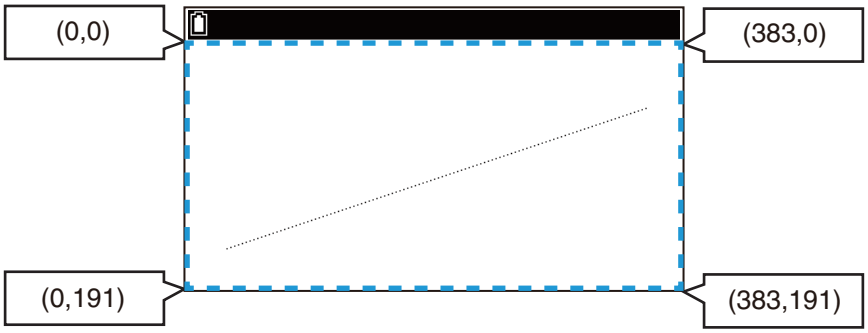
set_pixel(*x*,*y*[,color])

Draws a pixel of the specified color at the specified coordinates.

x argument, *y* argument:

Specifies the *x*- and *y*-coordinates of the pixel to be drawn. Only int type values within the following ranges can be specified: $0 \leq x \leq 383$, $0 \leq y \leq 191$

The figure below shows the relationship between coordinate values and locations on the drawing screen.

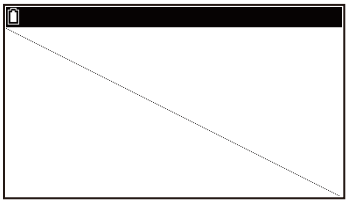


color argument:

Specifies the color of the pixel to be drawn. For details about this argument, see "Draw Function color Argument" (page 139).

Example: To draw a straight line that runs from the upper left corner to the lower right corner of the display and display the drawing screen

```
from casioplot import *
for i in range(192):
    set_pixel(i*2,i)
show_screen()
```



Note

- If either the *x*- or *y*-coordinate value is outside of the allowable range, function execution will be ignored (nothing drawn, no error).

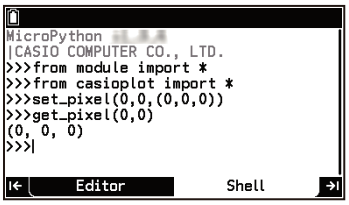
get_pixel(*x*,*y*)

Gets color information at the specified coordinates on the drawing screen.

x argument, *y* argument:
Specifies the *x*- and *y*-coordinates of the pixel whose color information is to be retrieved. The range and type of value that can be specified are the same as the *x*-argument and *y*-argument of *set_pixel*. The retrieved color information is returned as a 256-gradation RGB value.

Example: To get color information (0,0,0) of coordinates (0,0)

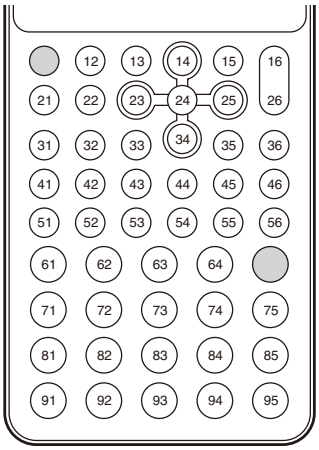
```
from casioplot import *
set_pixel(0,0,(0,0,0))
get_pixel(0,0)
```



Note

- If either the *x*- or *y*-coordinate value is outside of the allowable range, nothing is returned.

getkey()　(No argument)
Returns the key code of the calculator key pressed at the time this function is executed.
The key codes of the keys are shown below.



Example: To display the key code of the pressed key in the upper left corner of the drawing screen. For this example, the ⑤ key is held down.

```
from casioplot import *
while (True):
    key=getkey()
    clear_screen()
    draw_string(0,0,str(key))
    show_screen()
```

Note

- To stop script execution, press [AC].

draw_string(*x*,*y*,*s*[,color[,size]])
Draws a character string of the specified color at the specified coordinates.

x argument, *y* argument:
Specify the *x*-coordinate and *y*-coordinate of the upper left corner of the first character of the string to be drawn. The range and type of value that can be specified are the same as the *x*-argument and *y*-argument of *set_pixel*.
s argument:
Specifies the character string to be drawn as a str type. Only ASCII characters* can be displayed.

color argument:
Specifies the color of the character string to be drawn. For details about this argument, see “Draw Function color Argument” (page 139).
size argument:
Specifies one of the following as the character size of the character string to be drawn: “large”, “medium”, “small”. “medium” is applied when this argument is omitted.
* A-Z a-z 0-9 ! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~ space

Example: To draw large size “abc” in black at coordinates (0,0) and display the drawing screen

```
from casioplot import *
draw_string(0,0,”abc”,(0,0,0),”large”)
show_screen()
```

Note

- If both the x- and y-coordinate values are within the allowable range, the drawn character string will be displayed within the drawing screen range, even if it partially runs off of the drawing screen. If either the x- or y-coordinate value is outside of the allowable range, function execution will be ignored (nothing drawn, no error).

Draw Function color Argument

The color argument specifies the drawing color in 256 shades of RGB. For example, to specify black, input (0,0,0) or [0,0,0]. To specify white, input (255,255,255) or [255,255,255]. If color argument input is omitted, (0,0,0) is applied. Note that due to the performance of the display, the displayed color may be an approximation of the specified value.

Drawing Screen

Executing *show_screen* displays the drawing screen with the contents drawn by *set_pixel* and *draw_string* are displayed.

Updating and Clearing the Drawing Screen

The drawing screen is updated each time *show_screen* is executed and cleared when *clear_screen* is executed or when Shell is initialized. The currently displayed drawing screen is also updated when the py script finishes executing.

To return to Shell from the drawing screen, press ⎋.

File Compatibility

py files can be shared between your calculator and a computer. A py file created with the calculator can be transferred to a computer for editing with a text editor or other software. A py file created on a computer can be transferred to and run on the calculator.
py files you create in the Python app are stored in the calculator’s storage memory (with file name extension py). For information about the procedure for transferring files between the calculator and a computer, see “Connecting the Calculator to a Computer” (page 210).

py Files Created and Saved with This Calculator

The formats of py files created and saved with this calculator are shown below.

Character Code:	ASCII code
Characters used:	ASCII*
Newline code:	CR+LF
Indent:	Spaces (two spaces for auto indent)

* A-Z a-z 0-9 ! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~ space

Precautions When Using an Externally Created py File on this Calculator

The restrictions below apply whenever you are trying to use the calculator's Python app to display (file name or file content), edit, or run a py file that was transferred to the calculator from a computer.

File Names

- Your calculator recognizes only file names made up of ASCII characters.* A file name that includes any non-ASCII characters is not recognized.
  * The ASCII characters below are not supported.
    \ / : * ? " < > | .
- If the name of a py file transferred to storage memory from a computer or other source has a file name that is more than eight characters long, its name will abbreviated to eight characters when displayed on the storage memory information screen. (Example: AAAABBBBCC.py will become AAAABB~1.py.)

File Content Display and Editing

Opening a py file that satisfies conditions (A) and (B) below in the Python app will produce a normal display of all of the file contents. A py file that shows contents can be displayed normally and edited in the Python app.

(A) py file written in ASCII characters only and saved using UTF-8 or other ASCII-compatible codes

- If a file is saved with character codes that are not compatible with ASCII, none of its contents will be displayed if you open it in the Python app. All of the characters will be replaced by spaces, or appear garbled.

(B) py file with up to 300 lines, each line containing up to 255 characters

- The contents of a py file that exceeds the number of characters and/or number of lines specified above cannot be displayed in the Python app. If a file cannot be opened, use the command below to import it.
  from (filename) import *
- All tab codes in a py file will be replaced by two spaces when the file is opened in the Python app.
- No type of newline codes (LF, CR, CR+LF) affect Python app display contents. All newline codes in a py file will be replaced by CR+LF (Windows standard newline code) when the file is opened in the Python app. Before transferring a py file that was edited and saved in the Python app to a computer for use on the computer, replace its newline codes with the type that is appropriate for the environment where the file will be used.

Running a py File

A py file in the file list that appears when you select ⋯ > [File] > [Open] may be executable with the Python app. Note the information below.

- Running a py file that includes commands not supported by the calculator's Python app will result in an error.
- Using the Python app to open a py file created on a computer will cause characters and newline codes to be replaced. Because of this, opening a py file in the Python app, saving it, and running it, will change the content from the original py file, which may affect the running results. For details, see "File Content Display and Editing" (page 140).

Base-N App

The Base-N application batch returns the results of a calculation in hexadecimal, decimal, octal, and binary form. The calculation can be input using hexadecimal, decimal, octal, or binary numbers.
In this chapter, subscripts are appended to values to indicate the radix of the value. For example, 1_{16} means hexadecimal 1.

Basic Calculation Operations

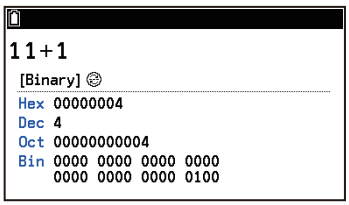
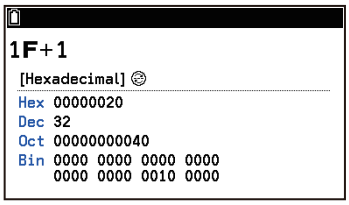
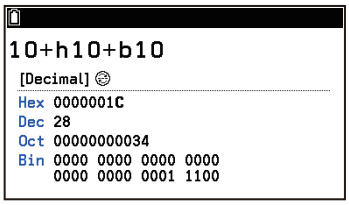
To start a calculation

1. (⌂) > Base-N
   - This causes the input cursor to appear in the upper left corner of the app window.
2. Use (FORMAT) to select a number system (base).
   - Each press of (FORMAT) cycles the number system setting in the sequence: [Decimal] → [Hexadecimal] → [Binary] → [Octal]. The currently selected number system is shown in line two of the app window.
3. Input the calculation and then press (EXE).
   - The calculation result is displayed in Hex (hexadecimal), Dec (decimal), Oct (octal), and Bin (binary) form.

Inputting Values

- The letters A through F for hexadecimal values can be entered using key input or menu input.
  (x) A, (log) B, (√) C, (x²) D, (□²) E, (eˣ) F or (Menu) > [Hex Value] > [A], [B], [C], [D], [E], [F]
- You can specify the number system for any value in a calculation by including d, h, b, or o before the value.
  (Menu) > [Base Prefix] > [d], [h], [b], [o] (d: Decimal, h: Hexadecimal, b: Binary, o: Octal)
  Example: d10 is treated as 10_{10}. b111 is treated as 111_2.
- Input of decimal fractions and exponents is not supported. If a calculation result produces a decimal fraction or exponent, the decimal fraction or exponent will be cut off.

Example Calculation

$11_2 + 1_2$	(FORMAT) > [Binary] 11+1(EXE)	
$1F_{16} + 1_{16}$	(FORMAT) > [Hexadecimal] 1(eˣ)F(+)1(EXE)	
$10_{10} + 10_{16} + 10_2$	(FORMAT) > [Decimal] 10(+) (Menu) > [Base Prefix] > [h]10(+) (Menu) > [Base Prefix] > [b]10(EXE)	

Latest Calculation Result (Ans)

- The result of the latest calculation is stored in a variable named Ans, which is independent of the Calculate app's Ans. To input Ans into a new calculation, press (ALPHA) (FORMAT) (Ans).
- Pressing (FORMAT) clears the calculation and all results, but Ans retains the latest calculation result.
- The Base-N app's Ans is reset to 0 each time you exit the Base-N app.

Logical Operations and Negative Number Calculations

The following functions and commands can perform logical (bitwise operations) and negative number calculations.

(OPTN) > [Logic Operation] > [Neg()], [Not()], [and], [or], [xor], [xnor]

Syntax

Neg(n)	Obtains the negative value*1 of n.
Not(n)	Negates*2 n.
n and m	Obtains the logical conjunction*3 of n and m.
n or m	Obtains the logical disjunction*3 of n and m.
n xor m	Obtains the exclusive OR*3 of n and m.
n xnor m	Negates*3 the exclusive OR of n and m.

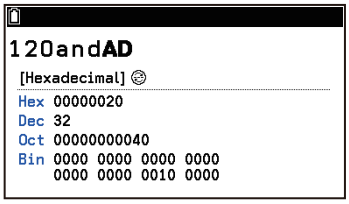
*1 Two's complement. Negative binary, octal, and hexadecimal values are produced by taking the two's complement of a 32-bit binary number and then returning the result to the original number base. With the decimal number base, negative values are displayed with a minus sign.

*2 One's complement (bitwise complement)

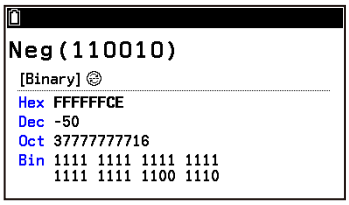
*3 Bitwise AND, bitwise OR, bitwise XOR, bitwise XNOR

Example Calculation

Logical Operators

To obtain the result of 120_{16} and AD_{16}	(FORMAT) > [Hexadecimal] 120 (OPTN) > [Logic Operation] > [and] (x-VAR) A (▪) D (EXE)	

Negative Value Calculations

To obtain the negative value of 110010_2	(FORMAT) > [Binary] (OPTN) > [Logic Operation] > [Neg()] 110010 (EXE)	

Input/Output Ranges

• Input and output ranges for each number system are shown below (32 bits).

Base	Input/Output Range
Binary	Positive: 00000000000000000000000000000000 ≤ x ≤ 01111111111111111111111111111111 Negative: 10000000000000000000000000000000 ≤ x ≤ 11111111111111111111111111111111
Octal	Positive: 00000000000 ≤ x ≤ 17777777777 Negative: 20000000000 ≤ x ≤ 37777777777
Decimal	-2147483648 ≤ x ≤ 2147483647
Hexadecimal	Positive: 00000000 ≤ x ≤ 7FFFFFFF Negative: 80000000 ≤ x ≤ FFFFFFFF

Financial App

You can use the Financial app to perform a variety of financial calculations.

Important!

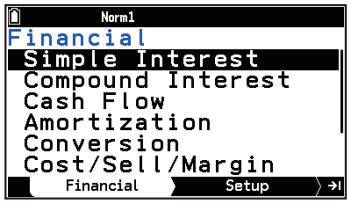
- Calculation results and graphs produced in this app should be regarded as reference values only.
- Whenever performing an actual financial transaction, be sure to check any calculation results obtained using this calculator against the figures calculated by your financial institution.
- Whether you should use a positive or a negative value for the present value (PV) or the purchase price (PRC) depends on the type of calculation you are trying to perform.

Operation Flow

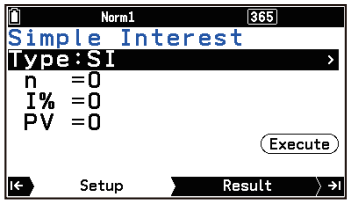
Example: To calculate the total principal and interest after two years (730 days*) when $3,000 is invested at a simple interest rate of 5.0%, and then to display a graph and check the calculation results against the graph

* ☰ > [Number of Days/Year] (page 152): 365

1. ⌂ > Financial
   - This displays the Financial tab.



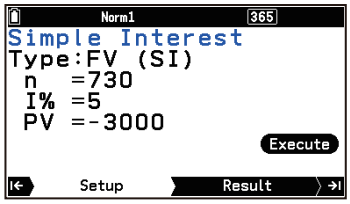
2. Highlight [Simple Interest] and then press (OK).
   - This displays the Simple Interest Setup tab.



3. Since we want to determine the sum of principal and interest, select the [Type] menu's [Future Value (SI)] item.
   (1) Highlight [Type] and then press (OK).
   (2) On the menu that appears, select [Future Value (SI)] and then press (OK).

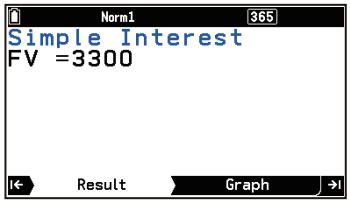
4. Input the following information: n (days) = 730; I% (annual interest rate) = 5; PV (present value) = -3000.

(▼)730(EXE)5(EXE)(▲)(−)((−))3000(EXE)



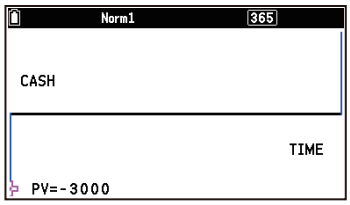
5. Specify the color that you want to use for the graph in step 7 of this procedure.
   (1) Select ⁘ > [Graph Color].
   (2) Select the color you want and then press (OK).

6. To execute the calculation, press ⇥ (or highlight Execute and press (OK)).
   - This displays the calculation result for future value (FV = principal + interest) on the Result tab.
   - An error occurs if parameters are not configured correctly.



7. To display the graph, press ⇥.

8. To check the calculation results on the graph, select ⋯ > [Trace].
   - This enables trace and causes a crosshair pointer (✛) to appear on the graph.
   - Each press of ▷ while trace is enabled cycles the displayed value in the sequence: present value (PV) → simple interest (SI) → future value (FV). Pressing ◁ cycles in the reverse direction.
   - To exit trace, press ↩.



9. To return from the Graph tab to the Result tab, press ↩ or ⇤.

Performing Financial Calculations

The calculations in the table below can be performed with the Financial app.

To perform this type of calculation:	Select this on the Financial tab:
Interest without compounding based on the number of days money is invested	Simple Interest*1
Interest based on compounding parameters specified by you	Compound Interest*2
Value of money paid out or received in varying amounts over time	Cash Flow
Interest and principal portions of a payment or payments	Amortization*2
Effective or nominal interest rate for interest compounded multiple times during a year	Conversion
Cost, selling price, or margin of profit on an item given the other two values	Cost/Sell/Margin
Number of days between two dates, or the date that is a specified number of days from another date	Days Calculation*1
Amount that a business expense can be offset by income (depreciated) over a given year	Depreciation
Purchase price or annual yield of a bond	Bond Calculation*1*3

*1 Before performing a calculation, specify ☰ > [Number of Days/Year] (page 152).
*2 Before performing a calculation, specify ☰ > [Payment Point] (page 152).
*3 Before performing a calculation, specify ☰ > [Interest Paid] (page 152).

Calculation Examples

Example 1 (Conversion):

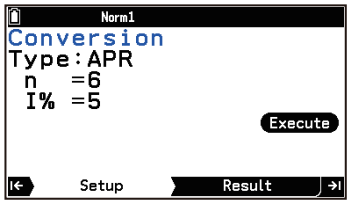
To determine the annual percentage rate (APR) on a bi-monthly compounded (n = 6) bond with an effective interest rate (I%) of 5%

1. On the Financial tab, highlight [Conversion] and then press OK.
   - This displays the Conversion Setup tab.

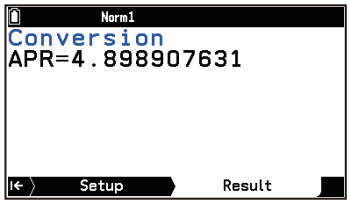
2. Since we want to find the annual percentage rate, select [Annual Percent Rate] from the [Type] menu.
   (1) Highlight [Type] and then press OK.
   (2) On the menu that appears, select [Annual Percent Rate] and then press OK.

3. Input the following information: n (number of compoundings) = 6; I% (interest rate) = 5.

▽ 6 EXE 5 EXE



4. To execute the calculation, press ⇥.
   • This displays the calculation result on the Result tab.



Example 2 (Depreciation):

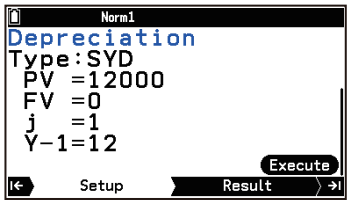
To use the sum-of-years'-digits method to calculate the first-year depreciation for a personal computer with a useful life (n) of 5 years and original cost (PV) of $12,000. Assume 12 months as the number of months of depreciation in the first year (Y-1). Also, display a list of the depreciation for each year.

1. On the Financial tab, highlight [Depreciation] and then press OK.
   • This displays the Depreciation Setup tab.

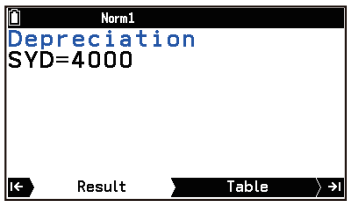
2. Since we are using the sum-of-years'-digits method, select [Sum-of-the-Years'-Digits] from the [Type] menu.

3. Input the following information: n (useful life) = 5; PV (original cost) = 12000; FV (residual book value) = 0; j (year for calculation of depreciation cost) = 1; Y-1 (number of months in the first year of depreciation) = 12.

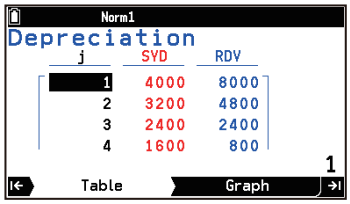
   ▽ 5 EXE 12000 EXE 0 EXE 1 EXE 12 EXE



4. To execute the calculation, press ⇥.
   • This displays the calculation result on the Result tab.



5. To display a list of the depreciation for each year, press ⇥.
   • The Table tab shows the depreciation (SYD) for each year (j) and the remaining depreciated value (RDV) at the end of each year.
   • While viewing the Table tab, you can display the graph by pressing ⇥.



Example 3 (Bond Calculation):

You want to purchase a semiannual bond*1 that matures on December 15, 2028 (d2) and has a settlement date of June 1, 2024 (d1). The bond is calculated based on 365 days per year.*2 The bond is redeemed at 100% of its face value (RDV) and the coupon rate (CPN) is 3%. If the yield to maturity (YLD) is 4%, determine the price of the bond (PRC), the accrued interest (INT), and the purchase price including accrued interest (CST).

*1 ☰ > [Interest Paid] (page 152): Semi-annually

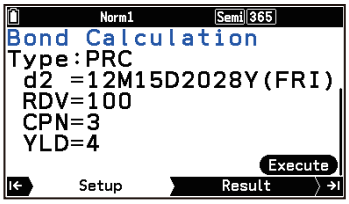
*2 ☰ > [Number of Days/Year] (page 152): 365

1. On the Financial tab, highlight [Bond Calculation] and then press OK.
   • This displays the Bond Calculation Setup tab.

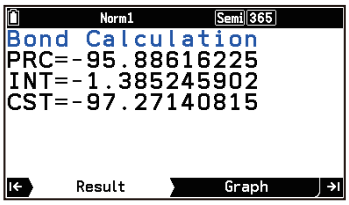
2. Since we want to determine the bond price, select [Bond's Price] from the [Type] menu.

3. Input the following information: d1 = 6/1/2024 (month/day/year); d2 = 12/15/2028 (month/day/year); RDV = 100; CPN = 3; YLD = 4.

(▽) (EXE) 6 (EXE) 1 (EXE) 2024 (EXE) (EXE)
(EXE) 12 (EXE) 15 (EXE) 2028 (EXE) (EXE)
100 (EXE) 3 (EXE) 4 (EXE)

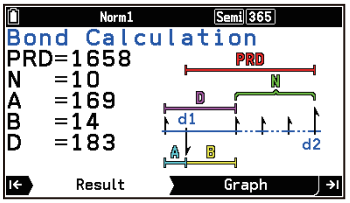


4. To execute the calculation, press (⇥).
   - This displays the calculation result on the Result tab.



Note: Bond Calculation Memorandum Screen

- Selecting (⋯) > [Display Memorandum] on the Result tab of Bond Calculation displays the number-of-day values used in the calculation as shown below.
  - PRD: number of days from d1 to d2
  - N: number of coupon payments between settlement date and maturity date
  - A: accrued days
  - B: number of days from settlement date until next coupon payment date (D − A)
  - D: number of days in coupon period where settlement occurs



- Selecting (⋯) > [Show Coupon Payment Day] while the Memorandum screen is displayed changes to a screen showing the interest payment date (only when (☰) > [Number of Days/Year] is “365”). If there are multiple interest payment dates from the redemption year to the year of purchase, each press of (OK) while this screen is displayed each interest payment date scrolls back sequentially until the first payment is reached.

Input/Output Terms and Calculation Formulas

Simple Interest

SI: interest
n: number of interest periods
PV: principal
$I\%$: annual interest rate
FV: principal plus interest

365-day Mode: $SI' = \frac{n}{365} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

360-day Mode: $SI' = \frac{n}{360} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

$SI = -SI'$
$FV = -(PV + SI')$

Compound Interest

n: number of compound periods
$I\%$: annual interest rate
PV: present value
PMT: payment
FV: future value
P/Y: installment periods per year
C/Y: compounding periods per year

When calculating PV, PMT, FV, n

$I\% \neq 0$

$PV = -(\alpha \times PMT + \beta \times FV)$

$PMT = -\frac{PV + \beta \times FV}{\alpha}$

$FV = -\frac{PV + \alpha \times PMT}{\beta}$

$$n = \frac{\log\left\{\frac{(1+iS)\times PMT - FV\times i}{(1+iS)\times PMT + PV\times i}\right\}}{\log(1+i)}$$

$I\% = 0$

$$PV = -(PMT \times n + FV) \quad (n > 0)$$
$$PMT = -\frac{PV + FV}{n} \quad (n > 0)$$
$$FV = -(PMT \times n + PV) \quad (n > 0)$$
$$n = -\frac{PV + FV}{PMT}$$

$$\alpha = (1 + i \times S) \times \frac{1-\beta}{i} \qquad \beta = (1+i)^{-n}$$

	When ☰ > [Payment Point] is "End"	When ☰ > [Payment Point] is "Beginning"
$S =$	0	1

	When $P/Y = C/Y = 1$	When $P/Y \neq 1$ and/or $C/Y \neq 1$
$i =$	$\frac{I\%}{100}$	$\left(1 + \frac{I\%}{100 \times [C/Y]}\right)^{\frac{C/Y}{P/Y}} - 1$

When calculating I%

i (effective interest rate) is calculated using Newton's Method.

$PV + \alpha \times PMT + \beta \times FV = 0$

$I\%$ = is calculated from i using the formulas below:

	When $P/Y = C/Y = 1$	When $P/Y \neq 1$ and/or $C/Y \neq 1$
$I\% =$	$i \times 100$	$\left((1+i)^{\frac{P/Y}{C/Y}} - 1\right) \times C/Y \times 100$

Important!

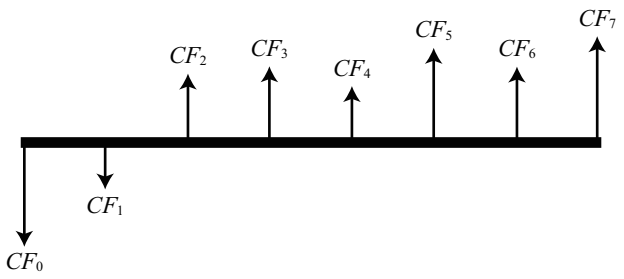
- When inputting both the present value (PV) and future value (FV) for a calculation, either PV or FV must be positive, while the other (PV or FV) is negative.
- Annual interest rate (I%) calculations are performed using Newton's Method, which produces approximate values whose precision can be affected by various calculation conditions. Interest calculation results produced by this application should be used keeping the above in mind, or results should be confirmed separately.

Cash Flow

This calculator uses the discounted cash flow (DCF) method to perform investment appraisal by totalling cash flow for a fixed period. This calculator can perform the following four types of investment appraisal.

NPV: Net present value	NFV: Net future value
IRR: Internal rate of return	PBP: Payback period

A cash flow diagram like the one shown below helps to visualize the movement of funds.



With this graph, the initial investment amount is represented by CF_0. The cash flow one year later is shown by CF_1, two years later by CF_2, and so on.

$$NPV = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \cdots + \frac{CF_n}{(1+i)^n} \quad \left(i = \frac{I\%}{100},\ I\%\text{: Interest rate},\ n\text{: natural number up to 254}\right)$$

$$NFV = NPV \times (1+i)^n$$

IRR is calculated using the formula below:

$$0 = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \cdots + \frac{CF_n}{(1+i)^n}$$

In this formula, NPV = 0, and the value of IRR is equivalent to i × 100. It should be noted, however, that minute fractional values tend to accumulate during the subsequent calculations performed automatically by the calculator, so NPV never actually reaches exactly zero. IRR becomes more accurate the closer that NPV approaches to zero.

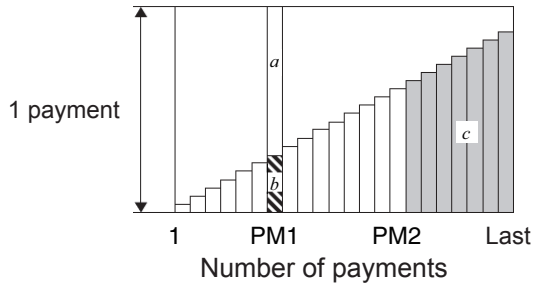
$$PBP = \begin{cases} 0 \cdots\cdots\cdots\cdots\cdots\cdots\cdots (CF_0 \geq 0) \\ n - \dfrac{NPV_n}{NPV_{n+1} - NPV_n} \cdots \text{(Other than those above)} \end{cases}$$

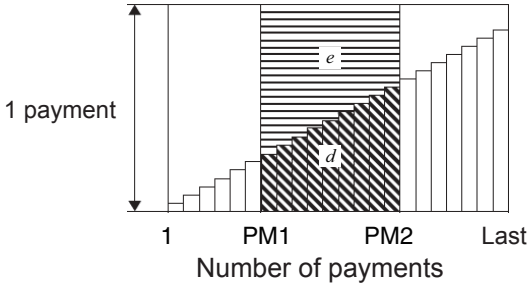
$$NPV_n = \sum_{k=0}^{n} \frac{CF_k}{(1+i)^k}$$

n: smallest positive integer that satisfies the conditions $NPV_n \leq 0$, $0 \leq NPV_{n+1}$, or 0

Amortization

$PM1$: first installment of installments 1 through n	PMT: payment for each installment
$PM2$: second installment of installments 1 through n	FV: balance following final installment
n: installments	P/Y: installments per year
$I\%$: interest rate	C/Y: compoundings per year
PV: principal	





a: interest portion of installment PM1 (INT)	$INT_{\text{PM1}} = \lvert BAL_{\text{PM1-1}} \times i \rvert \times (PMT \text{ sign})$
b: principal portion of installment PM1 (PRN)	$PRN_{\text{PM1}} = PMT + BAL_{\text{PM1-1}} \times i$

a + b = one repayment (PMT)

c: balance of principal after installment PM2 (BAL)	$BAL_{\text{PM2}} = BAL_{\text{PM2-1}} + PRN_{\text{PM2}}$
d: total principal from installment PM1 to payment of installment PM2 (ΣPRN)	$\sum_{\text{PM1}}^{\text{PM2}} PRN = PRN_{\text{PM1}} + PRN_{\text{PM1+1}} + \cdots + PRN_{\text{PM2}}$
e: total interest from installment PM1 to payment of installment PM2 (ΣINT)	$\sum_{\text{PM1}}^{\text{PM2}} INT = INT_{\text{PM1}} + INT_{\text{PM1+1}} + \cdots + INT_{\text{PM2}}$

When ☰ > [Payment Point] is “End”, $BAL_0 = PV$.

When ☰ > [Payment Point] is “Beginning”, $INT_1 = 0$ and $PRN_1 = PMT$.

Converting between the nominal interest rate and effective interest rate

The nominal interest rate (I% value input by user) is converted to an effective interest rate (I%') for installment loans where the number of installments per year is different from the number of compound interest calculation periods.

$$I\%' = \left\{\left(1 + \frac{I\%}{100 \times [C/Y]}\right)^{\frac{[C/Y]}{[P/Y]}} - 1\right\} \times 100$$

The following calculation is performed after conversion from the nominal interest rate to the effective interest rate, and the result is used for all subsequent calculations.

$\boldsymbol{i} = I\%' \div 100$

Conversion

EFF: Effective interest rate (%)	n: number of compoundings
APR: Annual percent rate (%)	$I\%$: Interest rate

$$EFF = \left[\left(1 + \frac{APR/100}{n}\right)^{n} - 1\right] \times 100$$

$$APR = \left[\left(1 + \frac{EFF}{100}\right)^{\frac{1}{n}} - 1\right] \times n \times 100$$

Cost/Sell/Margin

Cst: Cost price	Sel: Selling price	Mrg: Margin (%)

$$Cst = Sel\left(1 - \frac{Mrg}{100}\right)$$

$$Sel = \frac{Cst}{1 - \frac{Mrg}{100}}$$

$$Mrg(\%) = \left(1 - \frac{Cst}{Sel}\right) \times 100$$

Days Calculation

Number of Days	= d2-d1	(d1: date 1, d2: date 2)
Days After	= d1+D	(d1: date, D: number of days)
Days Before	= d1-D	(d1: date, D: number of days)

Depreciation

Straight-Line Method (SL)

SL_j: depreciation charge for the jth year
n: useful life
PV: original cost (basis)
FV: residual book value
j: year for calculation of depreciation cost
$Y - 1$: number of months in the first year of depreciation

$$SL_1 = \frac{(PV - FV)}{n} \times \frac{\{Y - 1\}}{12} \quad SL_j = \frac{(PV - FV)}{n} \quad SL_k = \frac{(PV - FV)}{n} \times \frac{12 - \{Y - 1\}}{12} \quad (k = n + 1,\ \{Y - 1\} \neq 12)$$

Fixed-Percent Method (FP)

FP_j: depreciation charge for the jth year
RDV_j: remaining depreciable value at the end of jth year
$I\%$: depreciation ratio

$$FP_1 = PV \times \frac{I\%}{100} \times \frac{\{Y-1\}}{12} \qquad FP_j = \left(RDV_{j-1} + FV\right) \times \frac{I\%}{100} \qquad FP_{n+1} = RDV_n \ (\{Y-1\} \neq 12)$$

$$RDV_1 = PV - FV - FP_1 \qquad RDV_j = RDV_{j-1} - FP_j \qquad RDV_{n+1} = 0 \ (\{Y-1\} \neq 12)$$

Sum-of-the-Years'-Digits Method (SYD)

SYD_j: depreciation charge for the jth year
RDV_j: remaining depreciable value at the end of jth year

$$Z = \frac{n(n+1)}{2} \qquad n' = n - \frac{\{Y-1\}}{12} \qquad Z' = \frac{(\mathrm{Intg}(n')+1)(\mathrm{Intg}(n')+2\times\mathrm{Frac}(n'))}{2}$$

$$SYD_1 = \frac{n}{Z} \times \frac{\{Y-1\}}{12}(PV - FV) \qquad SYD_j = \left(\frac{n'-j+2}{Z'}\right)(PV - FV - SYD_1) \qquad (j \neq 1)$$

$$SYD_{n+1} = \left(\frac{n'-(n+1)+2}{Z'}\right)(PV - FV - SYD_1) \times \frac{12 - \{Y-1\}}{12} \ (\{Y-1\} \neq 12)$$

$$RDV_1 = PV - FV - SYD_1 \qquad RDV_j = RDV_{j-1} - SYD_1$$

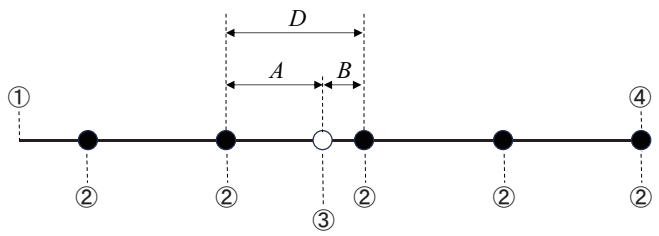
Declining-Balance Method (DB)

DB_j: depreciation charge for the jth year
RDV_j: remaining depreciable value at the end of jth year
$I\%$: depreciation factor

$$DB_1 = PV \times \frac{I\%}{100n} \times \frac{\{Y-1\}}{12} \qquad RDV_1 = PV - FV - DB_1 \qquad DB_j = \left(RDV_{j-1} + FV\right) \times \frac{I\%}{100n}$$

$$RDV_j = RDV_{j-1} - DB_j \qquad DB_{n+1} = RDV_n \ (\{Y-1\} \neq 12) \qquad RDV_{n+1} = 0 \ (\{Y-1\} \neq 12)$$

Bond Calculation



① Issue date
② Coupon payment dates
③ Purchase date (d1)
④ Redemption date (d2)

PRC: price per $100 of face value
CPN: coupon rate (%)
YLD: annual yield (%)
M: number of coupon payments per year (1=annual, 2=semi annual)
N: number of coupon payments between settlement date and maturity date
RDV: redemption price or call price per $100 of face value
INT: accrued interest
CST: price including interest
D: number of days in coupon period where settlement occurs
A: accrued days
B: number of days from settlement date until next coupon payment date = $D - A$

For one or fewer coupon period to redemption

$$PRC = - \frac{RDV + \frac{CPN}{M}}{1 + \left(\frac{B}{D} \times \frac{YLD/100}{M}\right)} + \frac{A}{D} \times \frac{CPN}{M}$$

For more than one coupon period to redemption

$$PRC = - \frac{RDV}{\left(1 + \frac{YLD/100}{M}\right)^{\left(N - 1 + \frac{B}{D}\right)}} - \sum_{k=1}^{N} \frac{\frac{CPN}{M}}{\left(1 + \frac{YLD/100}{M}\right)^{\left(k - 1 + \frac{B}{D}\right)}} + \frac{A}{D} \times \frac{CPN}{M}$$

$$INT = - \frac{A}{D} \times \frac{CPN}{M} \qquad CST = PRC + INT$$

Important!

- The Financial app performs annual yield (YLD) calculations using Newton's Method, which produces approximate values whose precision can be affected by various calculation conditions. Because of this, annual yield calculation results produced by this app should be used keeping the above in mind, or results should be confirmed separately.

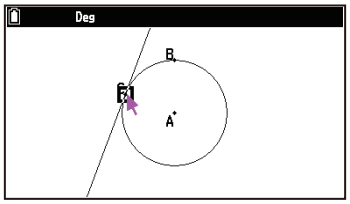
Financial App Settings Menu Items

The Settings menu items (page 214) described below are specific to the Financial app.

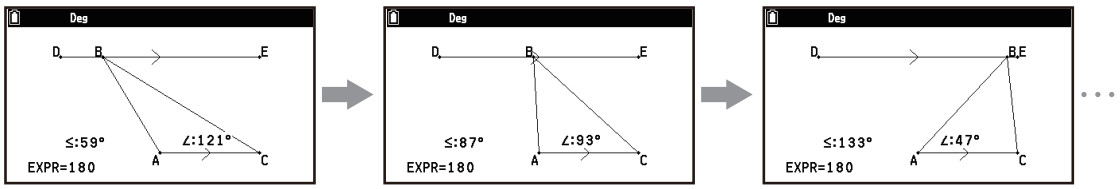
☰ > [Payment Point] ...	Specifies the beginning of the period (Beginning) or the end of the period (End) as the payment date. This setting affects Compound Interest and Amortization calculations.
☰ > [Number of Days/Year] ...	Specifies the number of days in a year as 365 or 360. This setting affects Simple Interest, Days Calculation and Bond Calculation.
☰ > [Interest Paid] ...	Specifies the interval between interest payments in a Bond Calculation as either once a year or once every six months.

Geometry App

Select ⌂ > Geometry to start up the Geometry app. This app allows you to draw and analyze geometric objects. For example, you can draw a circle and then draw a line that is tangent to a particular point on the circle.



The Geometry app also includes an animation feature that lets you watch how a figure changes in accordance with conditions you define.



Note

- Changes to the Angle, Grid, or Axes settings of the Settings menu in the Geometry app, affect only the Geometry app. They do not affect other apps. Conversely, changes made to these settings in other apps do not affect the Geometry app.
- The initial default setting of the Geometry app's Angle setting is Degree.
- The examples in this chapter assume Geometry app initial default settings are in use (which are configured when a new file is created as described under "Using the File Menu" (page 161)), unless otherwise noted.

Drawing and Editing Objects

This section explains how to perform the following operations.

- Plot points, draw line segments, polygons, etc. (Draw menu, Draw Special menu)
- Insert text into screen images
- Undo an operation
- Select and deselect objects, move an object, delete an object and other editing operations

Using the Pointer

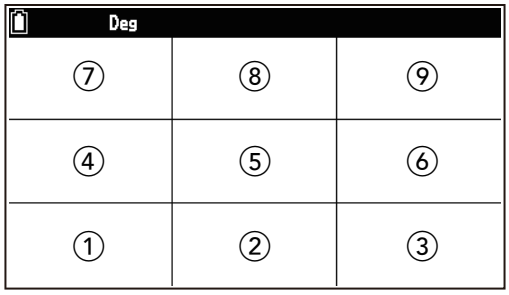
You can use the following operations to move the on-screen pointer (↖) around the display when drawing objects, editing objects, etc.

To move the pointer

Use the cursor keys (⌄/⌃/⌄/⌄) to move the pointer around the display. Holding down a cursor key moves the pointer at high speed.

To make the pointer jump to a particular location

Pressing a number key (① to ⑨) causes the pointer to jump to the corresponding location of the screen as shown below.



Using the Draw Menu

The Draw menu contains menu items for drawing basic geometric elements such as points, line segments, circles, etc.

To do this:	Select this menu item:	And then specify these points:*1
Plot a point	⋯ > [Draw] > [Point]	One point*2
Draw a line segment	⋯ > [Draw] > [Line Segment]	Two points in different locations (line segment start and end points)
Draw a straight line	⋯ > [Draw] > [Line]	Two points in different locations (two points through which a straight line passes)
Draw a ray	⋯ > [Draw] > [Ray]	Two points in different locations (ray start point and a point through which the ray passes)
Draw a vector	⋯ > [Draw] > [Vector]	Two points in different locations (vector start and end points)
Draw a circle	⋯ > [Draw] > [Circle]	Two points in different locations (circle center point and one point on the circumference)
Draw an arc	⋯ > [Draw] > [Arc]	Three points in different locations*3
Draw a semicircle	⋯ > [Draw] > [Semicircle, by Diameter]	Two points in different locations (either end of a circle diameter)

*1 To specify a single point, move the pointer to the desired location and then press OK.
*2 See the Example 1 (page 154) below.
*3 See the Example 2 (page 155) below.

Example 1: To plot a point

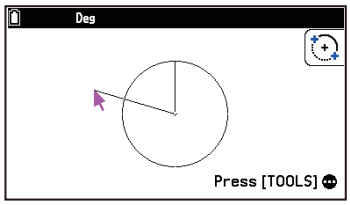
1. Select ⋯ > [Draw] > [Point].
2. Move the pointer to the location where you want to plot a point and then press OK.
   - This plots a point at the pointer location.
   - The  icon remains on the screen, which means you repeat step 2 to plot more points if you want.
3. After you are finished plotting all the points you want, press ↩ to deselect the Point tool.

Note

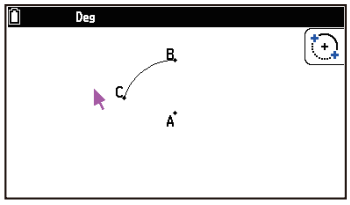
- Some drawing tools remain after you draw something, like the Point tool. To deselect such a tool, press ↩ or AC.
- You can use the following procedure to add a labeled point to an existing line, to a side of a polygon, to the periphery of a circle, etc.
  (1) Select ⋯ > [Draw] > [Point].
  (2) Move the pointer on the screen towards the line where you want to add the labeled point, and then press OK.

Example 2: To draw an arc

1. Select ⋯ > [Draw] > [Arc].
2. Move the pointer to the location where you want the center point of the arc to be and then press (OK).
3. Move the pointer to the location where you want the start point of the arc to be and then press (OK).
4. Move the pointer and the line segment to the location where you want the end point of the arc to be.



5. Press (OK).
   - This draws an arc from the start point to the end point, in a counterclockwise direction.



6. Press ↩ to deselect the Arc tool.

Using the Draw Special Menu

The Draw Special menu contains menu items for drawing triangles, rectangles, and polygons, as well as menu items for drawing graphs based on the input functions.

To do this:	Select this menu item:	And then specify these points:*1
Draw a triangle	⋯ > [Draw Special] > [Triangle]	Two points in different locations*2
Draw an isosceles triangle	⋯ > [Draw Special] > [Isosceles Triangle]	
Draw a rectangle	⋯ > [Draw Special] > [Rectangle]	
Draw a square	⋯ > [Draw Special] > [Square]	
Draw a polygon	⋯ > [Draw Special] > [Polygon]	At least three points in different locations*3

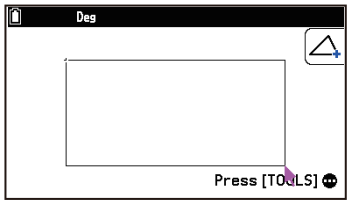
To do this:	Select this menu item:	And then perform this operation:
Draw a regular n-gon	⋯ > [Draw Special] > [Regular n-gon]	In the dialog that appears, input an integer from 3 to 12 and then press (OK).
Draw a function graph	⋯ > [Draw Special] > [Function f(x)]	In the dialog that appears, enter a function in the form $y = f(x)$ and then press (OK).*4

*1 To specify a single point, move the pointer to the desired location and then press (OK).
*2 See the Example 1 (page 155) below.
*3 See the Example 2 (page 156) below.
*4 The angle unit of the graph that is drawn is always Radian, regardless of the Angle setting on the Settings menu.

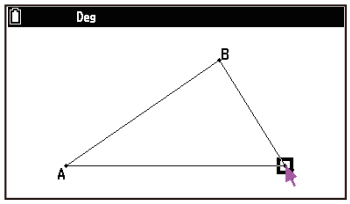
Example 1: To draw a triangle

1. Select ⋯ > [Draw Special] > [Triangle].
2. Move the pointer to any location on the screen and then press (OK).
3. Move the pointer to another location.

• This causes a selection boundary to appear, indicating the size of the triangle to be drawn.



4. Press (OK).
   • This draws a triangle.

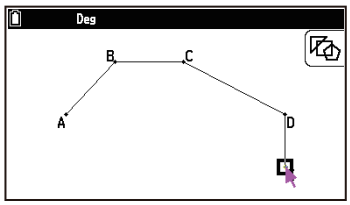


Note

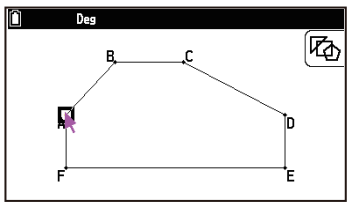
• The same type of two-point selection boundary in the above procedure is also used when drawing an isosceles triangle, rectangle, square, or regular n-gon.
In each case, the resulting object is the maximum size that fits in the screen if the second point specified is too close to or at the same location as the first point.

Example 2: To draw a polygon

1. Select (⋯) > [Draw Special] > [Polygon].
2. Move the pointer to the location where you want a vertex of the polygon to be and then press (OK).
   • Repeat this step as many times as required to specify the other vertices of the polygon.



3. To complete the polygon, move the pointer to the location of the first vertex and then press (OK).

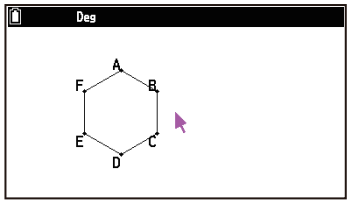


4. Press (↩) to deselect the Polygon tool.
   • If you press (↩) without performing the operation in step 3 above, the figure is finalized as-is, resulting in an unclosed non-polygon.

Inserting Text into Screen Images

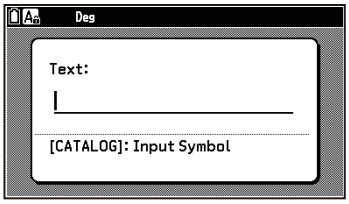
To insert text into a screen image

1. Move the pointer to the location where you want to insert the text.

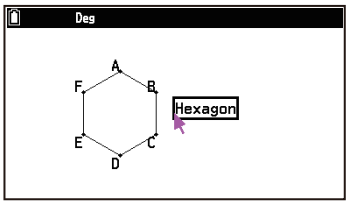


2. Select (⋯) > [Option] > [Text].

• This displays a text input dialog box and automatically switches the calculator's keys to alpha lock.

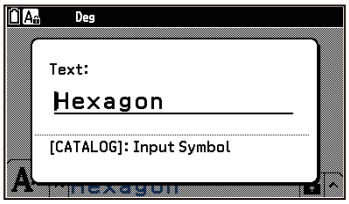


3. Input up to 31 characters of text and then press [OK].
   • The text you input is inserted into the screen image at the location of the pointer.

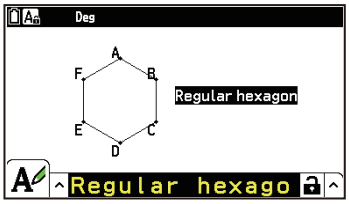


To edit screen text

1. Select the text you want to edit.
2. Press [DEL].
   • This displays the measurement box at the bottom of the screen.
3. Press [OK].
   • This displays a text input dialog box.



4. Edit the text and then press [OK].
   • This causes the newly edited text to appear on the screen.



5. To close the measurement box, press [EXIT] twice.

Note

• For details about the measurement box, see "Using the Measurement Box" (page 168).

Undoing and Redoing an Operation

To undo the last operation you performed

Immediately after performing the operation, you want to undo, press [×] or select [⋯] > [Edit] > [Undo/Redo].

Note

• [⋯] > [Edit] > [Clear All] operations cannot be undone. Also, you cannot undo an object select or deselect operation, a [⋯] > [View] menu item operation (View Window settings, pan, scroll, zoom operations), or a setting change.

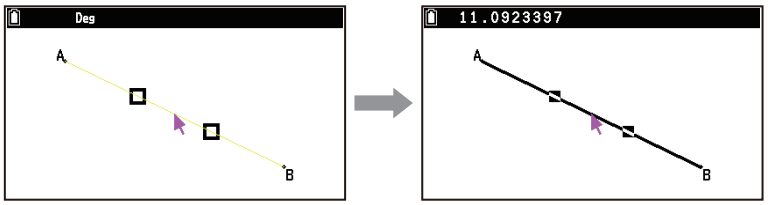
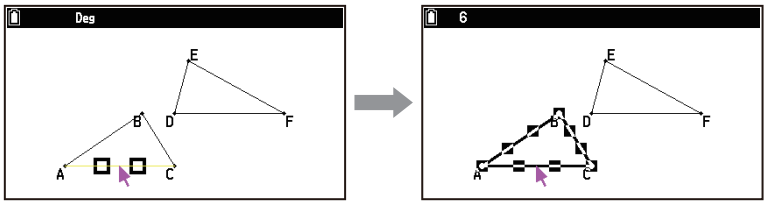
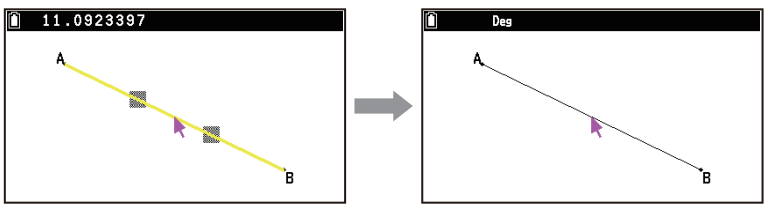
To redo an operation

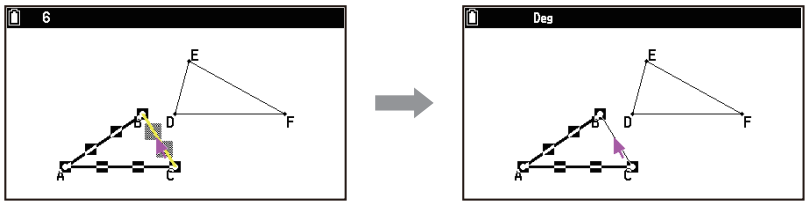
Immediately after undoing the operation, press [×] or select [⋯] > [Edit] > [Undo/Redo].

Selecting and Deselecting Objects

To edit an object (move, delete, change color, etc.) or to create a drawing using an object (such as constructing a midpoint of a line segment), you first need to select part of or all of the object. This section explains how to select and deselect objects.

Before starting the operations shown in the table below, make sure that no tool icons are displayed in the upper right corner of the screen. If a tool icon is displayed, press ⤺ or AC to deselect the tool.

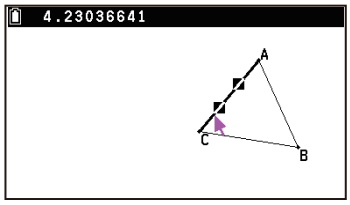
To do this:	Perform this operation:
Select a particular object	1. Move the pointer close to the object you want to select. • This causes one or more ◻ marks to appear on the object. At this time the object begins to flash. 2. Press OK. • This causes ◻ to change to ■ and changes the outline of the object to become a thick line, which indicates that the object is selected.  • Now you can repeat steps 2 and 3 to select other objects if you want.
Select an entire polygon	1. Move the pointer close to the polygon you want to select. • This causes ◻ marks to appear on some part (vertex or side) of the polygon. 2. Press ALPHA or select ○○○ > [Edit] > [Select Figure]. • This selects the entire polygon. 
Select an entire semicircle	You can use the same operation as that under “Select an entire polygon” above to select the semicircle.
Select an entire circle	1. Move the cursor near the circumference of the circle you wish to select. • This causes four ◻ marks to appear on the circumference. At this time the circumference begins to flash. 2. Press OK. • This selects the entire circle.
Deselect a particular object	1. Move the pointer close to the object you want to deselect. • This causes the ■ marks to become highlighted. At this time the object begins to flash. 2. Press OK.  **Note** • You can use the same operation as the one described above to deselect only a portion (vertex or side) of a polygon that is entirely selected.

	
Select all objects on the screen	Select ⋯ > [Edit] > [Select All].
Deselect all objects on the screen	Press AC or select ⋯ > [Edit] > [Deselect All].

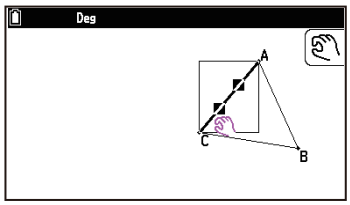
Moving and Deleting an Object

To move an object

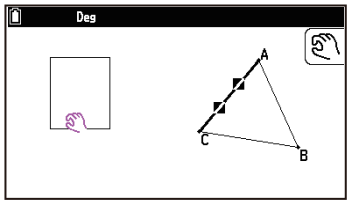
1. Select the object you want to move.
   - If you want to move only one of the vertices of a triangle for example, select the vertex. To move only one side of the triangle, select the side.
   - In each of the steps below, an example screenshot is shown when one side of a triangle is selected and moved.



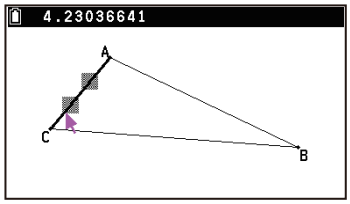
2. Press X.
   - This causes the ✋ icon to appear in the upper right corner of the screen and the pointer to change from ↖ to ✋. Also, a rectangle encloses the object that you selected in step 1.



3. Use the cursor keys to move the object in the direction you want.



4. To move the object to the current location of the rectangle, press OK.



Note

- If you press X when nothing is selected on the screen, the pointer changes to ✋, which you can use to pan (shift) the entire screen.
- Sometimes you may find that an object does not move the way you want it to. If this happens, press ⊗ to cancel the move and then do the following to try the move again.
  - Lock the part(s) of the object that you do not want to move (see “Locking or Unlocking a Measurement of an Object” (page 171))
  - Temporarily unlock all objects by selecting ⋯ > [Option] > [Clear Constraint] (page 172)

To delete an object

1. Select the object you want to delete.

- If you want to delete only one of the vertices of a triangle for example, select the vertex. To delete only one side of the triangle, select the side.

2. Press ⌫ or select ⋯ > [Edit] > [Delete].
   - This deletes the selected object.

To delete all objects on the screen

Important!
- Performing the operation below deletes all the objects currently on the screen. This operation cannot be undone.

1. Select ⋯ > [Edit] > [Clear All].
2. In response to the confirmation dialog that appears, select [OK].

Note
- You can also delete all objects by pressing AC twice while nothing is selected on the screen.

Hiding and Showing Objects

To hide an object

1. Select the object you want to hide.
2. Select ⋯ > [Option] > [Hide].
   - This hides the selected objects.

To show all hidden objects

Select ⋯ > [Option] > [Show All]. This shows all currently hidden objects.

Changing the Display Priority of Objects

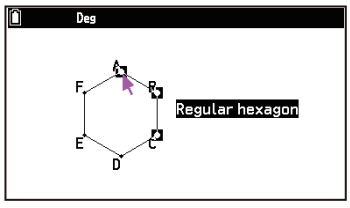
Objects you draw in the Geometry app are stacked in the order they are drawn (newest drawing on top). You can use the operations below to move a drawn object to the top or the bottom of the stack. You also can move all text to the front, if you want.

- To move a particular object to the front, select ⋯ > [Properties] > [to the front].
- To move a particular object to the back, select ⋯ > [Properties] > [to the back].
- To move all text to the front, select ⋯ > [Properties] > [All Text].

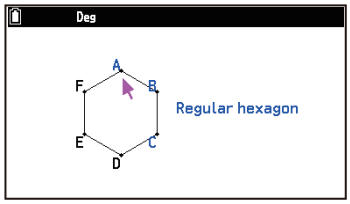
Specifying an Object's Color and Line Thickness

To specify text color

1. Select the text whose color you want to specify.
   - To specify the text color of a label appended to a point (for example, the center point of a circle or the vertex of a polygon), select the point where the label is appended.

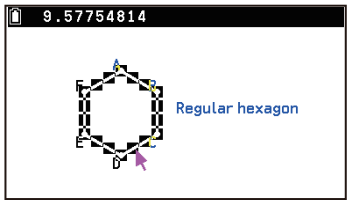


2. Select ⋯ > [Color Select] > [Char Color]. On the menu that appears, select the desired color.
3. To apply the settings you configure, press ↩.
   - Press AC to deselect all objects.

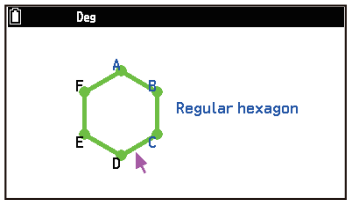


To specify the color and thickness of a line

1. Select the line whose color and thickness you want to specify.
   - If you want to specify the color and thickness for all sides of a polygon simultaneously, press [ALPHA] to select the entire polygon (see “Select an entire polygon” under “Selecting and Deselecting Objects” (page 158)).

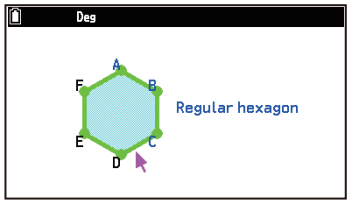


2. Select [⋯] > [Color Select] > [Line Style]. On the menu that appears, select the desired line style.
3. Select [⋯] > [Color Select] > [Line Color]. On the menu that appears, select the desired color.
4. To apply the settings you configure, press [EXIT].
   - Press [AC] to deselect all objects.



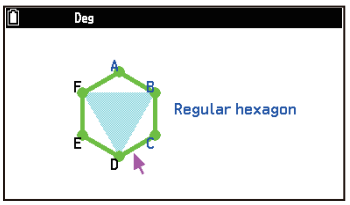
To specify fill color and intensity of a closed figure (polygon, circle, etc.)

1. Select the closed figure whose fill color and intensity you want to specify.
   - To fill a polygon or semicircle, press [ALPHA] to select the entire figure. To fill a circle, select its circumference.
2. Select [⋯] > [Color Select] > [Area Color]. On the menu that appears, select the desired color.
3. Select [⋯] > [Color Select] > [Paint Style]. On the menu that appears, select “Normal” or “Lighter”.
4. To apply the settings you configure, press [EXIT].



Note

- You can also select three arbitrary points (the vertices of a polygon, the center of a circle, the edge of a line segment, etc.) and specify the fill color and intensity of the area enclosed within the three points. Select the three points in step 1 above.
  Note that this operation is possible only when three points are selected. This operation is not performed if four or more points are selected.



Using the File Menu

The table below shows the file operations that you can perform with the Geometry app.

To do this:	Select this menu item:
Clear the current drawing and create a new file	[⋯] > [File] > [New]
Clear the current drawing and open the Geometry app file stored in Main Memory	[⋯] > [File] > [Open] > [Main Memory]
Clear the current drawing and open an image file (.g4p or .g3p)[*1] or Geometry app file (.g4p)[*2] with the background image stored in Storage Memory	[⋯] > [File] > [Open] > [Storage Memory]
Name and save the current drawing	[⋯] > [File] > [Save As]
Delete the Geometry app file stored in Main Memory	[⋯] > [File] > [Delete] > [Main Memory]

Delete an image file (.g4p or .g3p)*1 or Geometry app file*2 (.g4p) with background image stored in Storage Memory	⋯ > [File] > [Delete] > [Storage Memory]

*1 You can open a g4p or g3p file and use it as a background image for a Geometry app drawing. Attempting to open a g4p or g3p file may cause the following message to appear: “View window value is not suitable. Set initial value? ”. To open the file using the Geometry app View Window initial default value, select [OK]. For information about g4p and g3p files, see “Files Displayed on the Storage Memory Tab” (page 196).

*2 For details, see “Displaying a Geometry App Screen Background Image” (page 162).

Note

- Each time a new file is created in the Geometry app, View Window settings (page 162) are initialized. In addition, the Settings menu settings below are returned to their initial default settings (noted in parentheses).

Angle (Degree)	Angle Unit (On)	Length Unit (Off)
Grid (Off)	Grid Space (1)	Axes (Off)

Displaying a Geometry App Screen Background Image

In the Geometry app, you can open an image file (.g4p or .g3p) and use it as a background image for a Geometry app drawing. If you open a g4p or g3p file, draw something, and then save the result to a file, the file is saved in g4p format, along with the Geometry app data.

Note

- You can edit the Geometry app data (objects drawn with the app) on the saved g4p file later. However, once you save the result to a g4p file, you cannot change the background image of the file or remove it.

To adjust the opacity of the background image (Fade I/O)

This operation can be performed only when a 16-bit color image is being used as the background image.

1. Select ⋯ > [Properties] > [Fade I/O].
2. Use ◁ and ▷ to adjust the opacity of the background image.
3. When the setting is the way you want, press OK.

Using the View Menu

You can use the View menu to perform the operations below and adjust the viewing area of the drawing screen.

- Specify the display range numerically or restore default settings (View Window)
- Shift the display range up, down, left, right (Pan, Scroll)
- Zoom the display range (Zoom Box, Zoom In, Zoom Out, Zoom to Fit)

Configuring View Window Settings

You can configure View Window settings to specify the coordinates of the screen’s left edge (X Minimum) and right edges (X Maximum). The length of the y-axis is configured automatically using a ratio of 1:2 (y-axis:x-axis), but you can specify what part of the y-axis is in the middle of the screen (Y Middle).

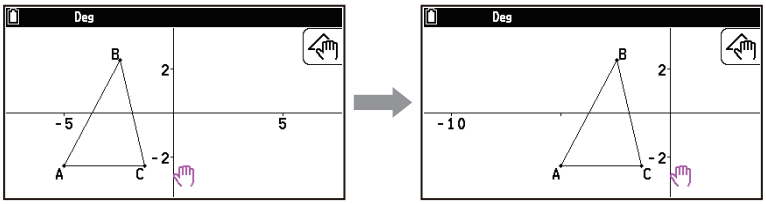
To configure View Window settings

1. Select ⋯ > [View] > [View Window].
   - To display the View Window menu.
2. Input values for X Minimum, X Maximum, Y Middle.
   - If you want to return these settings to their initial defaults, select [Pre-set Windows] > [Initialize].
3. After all the settings are the way you want, select Confirm and then press OK.
   - To close the View Window menu without applying any of the settings you changed, press ↩ instead of performing step 3.

Using Pan and Scroll to Shift the Display Image

To pan the screen

1. Select ⋯ > [View] > [Pan].
   - This enters the pan mode, which is indicated by the icon in the upper right corner of the screen.
2. Move the pointer to the location on the screen you want to grab and then press OK.
   - This causes the pointer to change from to .
3. While the pointer is displayed, use the cursor keys to shift the screen in the direction you want.



   - In the pan mode, each press of OK toggles the shape of the pointer between and . While the pointer is displayed, you can use the cursor keys to move it to another location on the screen. Pressing the cursor keys while the pointer is displayed shifts (pan) the screen contents.
4. To exit the pan mode, press ↩.

To scroll the screen

1. Press . or select ⋯ > [View] > [Scroll].
   - This enters the scroll mode, which is indicated by the icon in the upper right corner of the screen. The pointer disappears from the screen at this time.
2. Use the cursor keys to scroll the screen in the direction you want.
3. To exit the scroll mode, press ↩.

Zooming

To zoom using the zoom box

1. Select ⋯ > [View] > [Zoom Box].
   - This causes the icon to appear in the upper right corner of the screen.
2. Move the pointer to the location on the screen on one edge of the area you want to select as the zoom box area and then press OK.
3. Move the pointer in the direction of the opposite edges of the zoom box area.
   - As you do, the calculator displays a selection boundary that expands as you move the pointer.
4. After selecting the zoom box area you want, press OK.
   - The area within the zoom box area expands to fill the entire screen.

To zoom in and out

To double the size of the displayed image, press + or select ⋯ > [View] > [Zoom In].
To halve the size of the displayed image, press − or select ⋯ > [View] > [Zoom Out].

To zoom the screen image to fit the window area

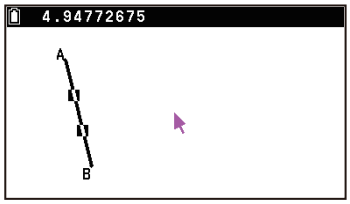
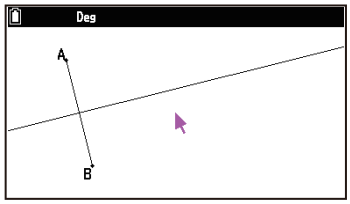
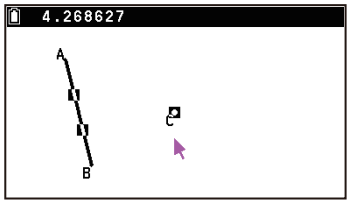
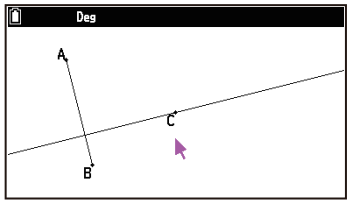
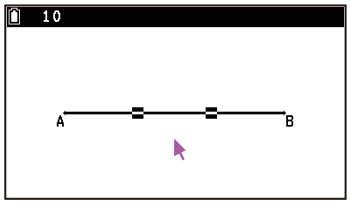
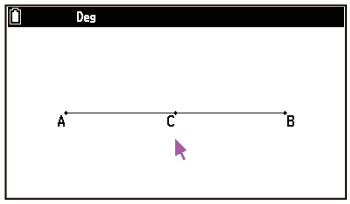
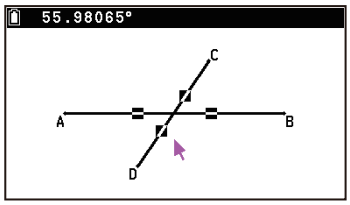
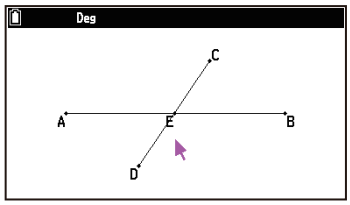
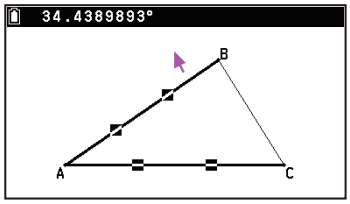
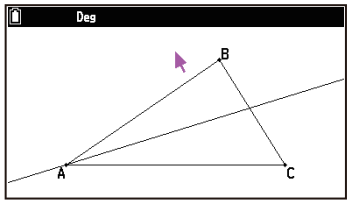
Press FORMAT or select ⋯ > [View] > [Zoom to Fit].
- This enlarges or reduces the currently display image so it fills the screen.

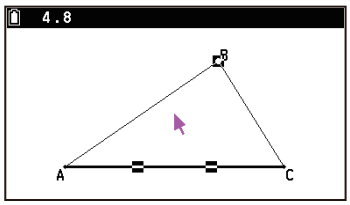
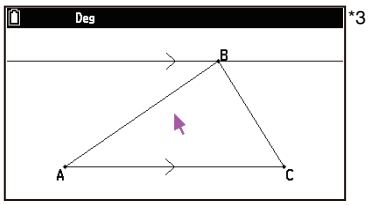
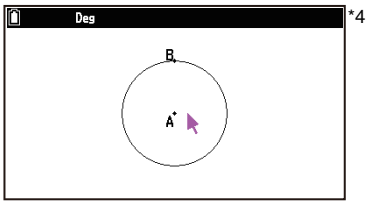
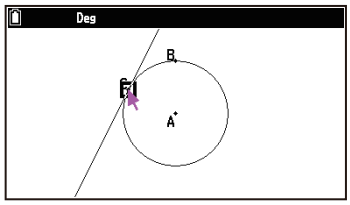
Note

- The above operation does not apply in the case of a graph drawn using ⋯ > [Draw Special] > [Function f(x)].

Using the Construct Menu

You can use the Construct menu to create a drawing based on a previously drawn figure, as described in the table below.

To construct this:	Select one or two of the following geometric elements:	Select ⋯ > [Construct] and then select this:
A perpendicular bisector	A line segment, a side of a polygon, or two points[*1] 	[Perpendicular Bisector] 
A perpendicular line	One point[*1] plus one of the following geometric elements: A line segment, a straight line, a side of a polygon 	[Perpendicular Line] 
A midpoint	A line segment, a side of a polygon, or two points[*1] 	[Midpoint] 
An intersection point	Any two of the following (or two of the same) geometric elements: line segment,[*2] straight line, ray, vector, side of a polygon, circle, arc 	[Intersection Point] 
An angle bisector	Any two of the following (or two of the same) geometric elements: line segment, straight line, ray, vector, side of a polygon 	[Angle Bisector] 

A parallel line	A single point*1 plus one of the following geometric elements: line segment, straight line, ray, vector, side of a polygon 	[Parallel Line] 
A tangent	A single circle, semi circle, arc, or function graph*4 	[Tangent] 

*1 The vertices of a polygon, the center point of a circle, or any other point that constitutes a figure.

*2 If two line segments with no points of intersection are selected, an intersection point is created at the location where the two line segments eventually intersect when extended.

*3 A symbol (>) indicating parallelism appears or both one ends of the selected line segment, line, ray, or polygon and the drawn parallel line.

*4 In the case of drawing a tangent, you don't need to select a figure first. After selecting ⋯ > [Construct] > [Tangent], move the pointer to a point on the figure to which you want to draw a tangent line, and then press (OK).

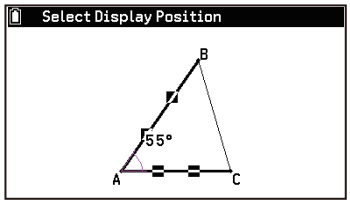
Attaching an Angle Measurement to a Figure

You can select two line segments or two sides of a polygon and attach an angle value to them.

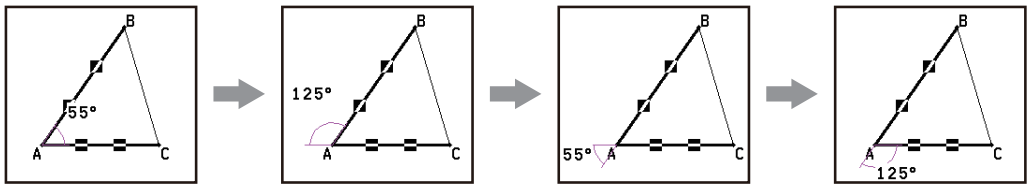
Example: To select two sides of a polygon and append an angle value

1. Draw a triangle and select two of its sides.

2. Select ⋯ > [Construct] > [Attached Angle].
   - This attaches the angle measurement to the figure.



   - While the "Select Display Position" message is displayed, you can use the cursor keys to specify which angle measurement is displayed for the two selected sides.



3. To determine the display location of an angle measurement, press (OK).

Using the Transformations Menu

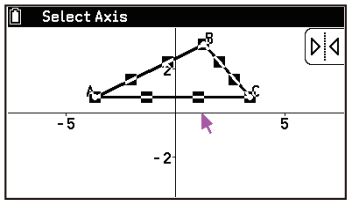
You can use the Transformations menu to perform various transform operations, such as object reflection, object rotation, etc.

Reflecting an Object

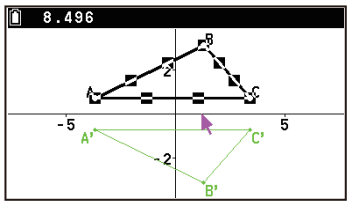
You can specify a line segment, line, ray, one side of a polygon, or the x-axis or y-axis as the axis of reflection.

Example: To draw a triangle shifted symmetrically along the x-axis

1. Select ☰ > [Axes] > [Scale].
   - This displays the x-axis and y-axis with a scale.
2. Draw a triangle and then use the ALPHA key to select the entire triangle.
   - For more information about how to select the triangle, see "Select an entire polygon" (page 158).
3. Select ⋯ > [Transformations] > [Reflection].
   - This causes the message "Select Axis" to appear.
4. Move the pointer to a location where the tip is touching the x-axis.
   - Move the pointer to a location on the x-axis away from the origin.



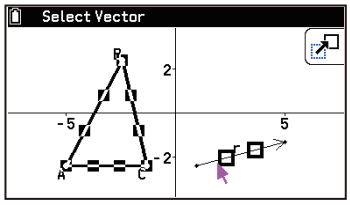
5. Press OK.
   - This draws the triangle by shifting it symmetrically on the x-axis.



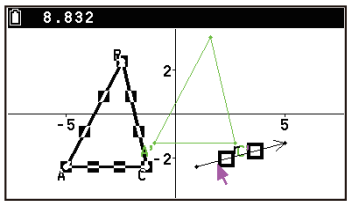
Translating an Object Using an Existing Vector

Example: To translate a triangle according to a vector direction and magnitude

1. Daw a triangle, and then draw a vector for translation.
2. Use ALPHA to select the entire triangle. For more information about how to select the triangle, see "Select an entire polygon" (page 158).
3. Select ⋯ > [Transformations] > [Translation (Select Vector)].
   - This causes the message "Select Vector" to appear.
4. Move the pointer close to the vector until ■ marks appear on it.



5. Press OK.
   - The triangle is translated according to the selected vector.



Note

- If you select only part of an object before performing step 3 of the above procedure, only the selected part is translated.

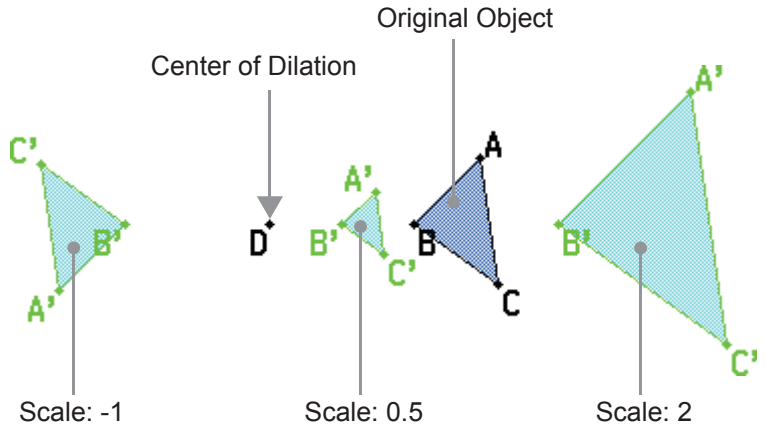
Other Transformation Operations

Before starting any of the operations shown in the table below, draw the figure you want to transform and then select the entire figure. If you select only part of an object, only the selected part is transformed.

To do this:	Select this menu item:	And then perform this operation:
Translate an object by specified values	⋯ > [Transformations] > [Translation (Enter Vector)]	1. On the Translation screen that appears, input the values for the translation distance along the x-axis and the translation distance along the y-axis. 2. Select Execute and then press OK.
Rotate an object	⋯ > [Transformations] > [Rotation]	1. While the message “Select Center of Rotation” is displayed, move the pointer to the location you want to specify as the center of rotation, and then press OK. 2. On the dialog box that appears, input the angle of rotation (counterclockwise) in degrees and then press OK.
Dilate an object	⋯ > [Transformations] > [Dilation]	1. While the message “Select Center of Dilation” is displayed, move the pointer to the location you want to specify as the center of dilation, and then press OK. 2. On the dialog box that appears, input a scale value in the range of $0.1 \leq \lvert x \rvert \leq 10$ and then press OK. • See the figure in the Note below for details about the meanings of the terms used during the dilation operation.
Rotate an object 180 degrees on a specified point	⋯ > [Transformations] > [Point Reflection]	While the message “Select Center Point” is displayed, move the pointer to the location you want to specify as the center of rotation, and then press OK. • This draws the figure rotated 180 degrees on the selected point. In addition, a point is plotted at the center point.

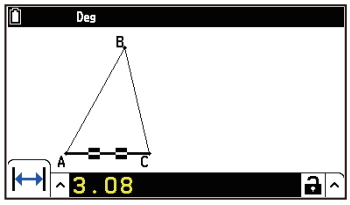
Note

- The following figure illustrates the meanings of the terms used in the dilation procedure above.



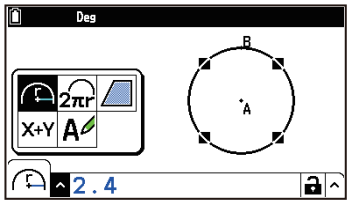
Using the Measurement Box

Pressing ⌨ displays a measurement box at the bottom of the screen. Press ↩ twice to hide the measurement box.
You can use the measurement box to view the measurements of an object, to specify a measurement of an object, to lock a measurement of an object, or to name an object.



Viewing the Measurements of an Object

The type of information that can be displayed in the measurement box depends on the object currently selected on the screen. The nearby screen shows an example when a circle is selected.
You can change the display information type by highlighting the up arrow button to the left of the measurement box, pressing OK, and then using the cursor keys to highlight the appropriate icon on the icon palette that appears.



The table below describes the information that appears in the measurement box when you select each icon and explains when each icon is available for selection.

Measurement Icon Table

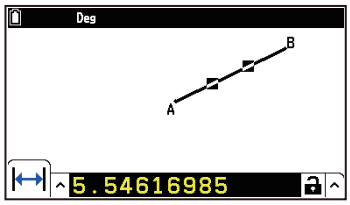
Icon[*1]	This icon is available for selection when:	Selecting this icon displays:
X,Y (🔒) Coordinates	A single point is selected.	Coordinates of the point
(🔒) Distance/Length	Two points are selected, or a single line segment or vector is selected.	Distance between two points, length of a line segment or vector
(🔒) Slope	A single line, ray, line segment, or vector is selected.	Slope of the line, ray, line segment, or vector
(🔒) Angle	Two of the following line elements in any combination are selected: lines, line segments, rays, or vectors.[*2]	Angle and its supplement formed by the two objects
(🔒) Supplementary Angle		
(🔒) Radius	A single circle, semicircle, or arc is selected.	Radius of circle, semicircle, or arc
2πr (🔒)[*3] Circumference	A single circle, semicircle, or arc is selected.	Length of the circumference
Perimeter	A single polygon is selected.	Sum of the lengths of the sides
(🔒)[*3] Area	A single circle, semicircle, arc, or polygon is selected, or any three points are selected.	Area[*4]
X+Y Equation	A single line or line segment, ray, circle, semicircle, arc, or function graph is selected.	Function of the object (using rectangular coordinates)
X+Y (🔒) Vector	A single vector is selected.	Vector components
(🔒) Tangency	Two circles, two arcs, a line and circle, or a line and arc are selected.	Whether the two items are tangent

Congruence (🔒)	Two line segments are selected.	Whether the line segments are the same length
Incidence (🔒)	A point and line, a point and arc, a point and circle, or a point and vector are selected.	Whether the point is on the line/curve
Rotation angle	Two points created by the Rotation (page 167) command are selected.	Angle of rotation
Scale of dilation	Two points created by the Dilation (page 167) command are selected.	Scale of dilation
Label/Text	A point or pasted measurement*5 that has a label or an object that can be named is selected.	Label text
Expression	A single expression is selected (“EXPR=” object).	Calculation expression

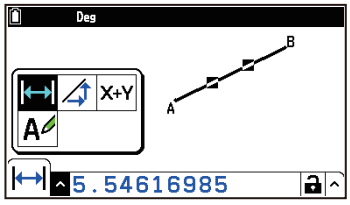
*1 “🔒” to the right of the icon indicates that the measurement is lockable. See “Locking or Unlocking a Measurement of an Object” (page 171) for information about lock operations.
*2 When two vectors are selected, the angle that is displayed in the measurement box does not mean the angle formed mathematically by the two vectors. It merely indicates the simple angle that would be formed if the vectors were two lines.
*3 Circumference and area measurements are lockable only when a circle is selected.
*4 A value that shows the area of an object whose lines intersect is indicated by double asterisks (✳✳) to the left of the value. This indicates that the value may not indicate the correct area.
*5 See “Pasting Measurements into a Screen Image” (page 172).

To view the measurements of a line segment

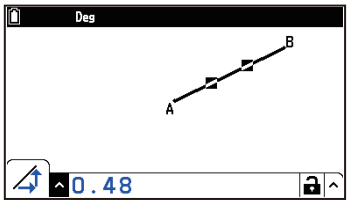
1. Draw a line segment and select it.
2. Press [EXE] to display the measurement box.
   • This displays the length of the line segment.



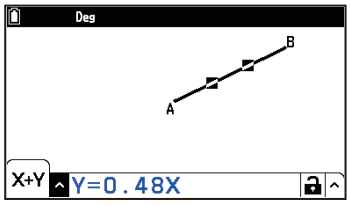
3. Press [<] to highlight the up arrow button to the left of the measurement box and then press [OK].
   • This displays an icon palette.



4. Select the icons on the icon palette to display other measurements.
   • In the case of the line segment, for example, you can view its length, slope, and equation.



Slope



Equation

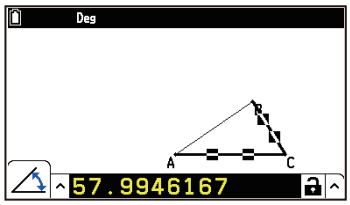
5. To close the measurement box, press [↩] twice.

Specifying and Locking a Measurement of an Object

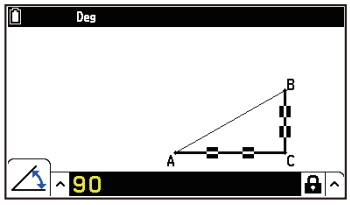
The following example shows how to specify and lock an angle of a triangle. For example, locking ∠ACB of △ABC at 90 degrees causes ∠ACB to remain at 90 degrees regardless of where the vertex is moved. In the example below, the ☰ > [Angle] setting is set to “Degree”.

To specify and lock the measure of an angle of a triangle

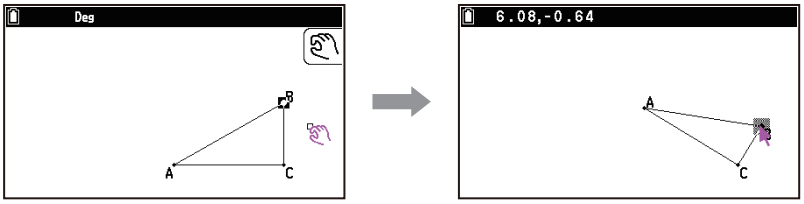
1. Draw a triangle, and then select its side AC and side BC.
2. Press ⇦ to display the measurement box.
   - This displays the measure of ∠ACB in the measurement box.
   - At this time, the icon to the right of the measurement box is 🔓 (unlocked).



3. Input 90 into the measurement box and press EXE.
   - This specifies and locks the measure of ∠ACB at 90 degrees.
   - This causes the icon to the right of the measurement box to change to 🔒 (locked), indicating that the angle is locked.



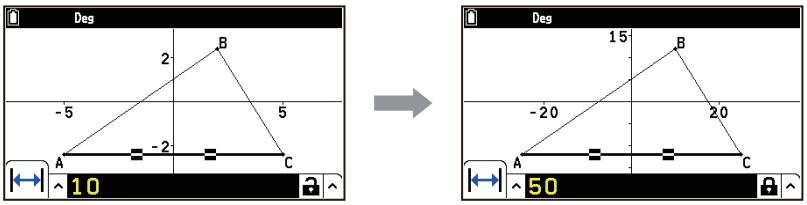
4. Try moving vertex B (make sure ∠ACB is locked at 90 degrees).
   (1) Press ↩ twice to hide the measurement box.
   (2) Press AC to deselect all objects.
   (3) Move the pointer to vertex B and then press X. See “To move an object” (page 159) for more information.
   (4) Use the cursor keys to move vertex B to the location you want and press OK.
   - Vertex A moves so ∠ACB maintains 90 degrees.



Note

- Specifying any one of the following measurements for the first time in the file you are editing (or immediately after an all-clear operation (⚙ > [Edit] > [Clear All]) causes the resulting object to be resized so it fits within the display area.
  - Length of one side of a triangle
  - Length of a line segment or vector
  - Length of one side of a rectangle, square, polygon, or regular n-gon
  - Circumference of a circle or length of an arc

  View Window settings are reconfigured automatically so the size of the object on the display may not appear to change very much. The following example shows what happens when the length of the base of a triangle drawn with the initial default View Window settings (with a screen width of 10) is changed to 50.



View Window settings are reconfigured in order to ensure that specifying a measurement of an object does not make it too big to fit on the screen or too small to see.
Note that all other objects currently on the screen also are resized by the same amount as the object whose measurement you are specifying.

- Once you specify one measurement of an object, it is not resized further if you specify another of its measurements.

Locking or Unlocking a Measurement of an Object

As described in “Specifying and Locking a Measurement of an Object” (page 170), a measurement is automatically locked as soon as it is specified numerically. This section describes how to lock or unlock a measurement without specifying a numeric value.

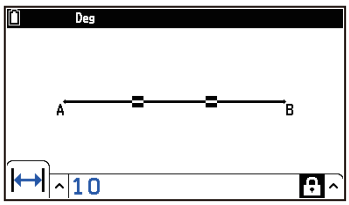
Note

- Only some measurements of an object can be locked. For information about which measurements can be locked, see the “Measurement Icon Table” (page 168).

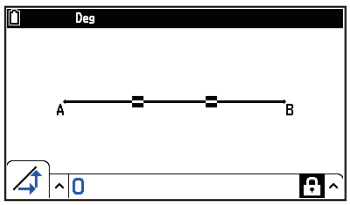
To lock a particular measurement

Example 1: To lock the length or slope of a line segment

1. Draw a line segment and select it.
2. Press [F1] to display the measurement box.
3. Press ◁ to highlight the up arrow button to the left of the measurement box and then press [OK].
4. On the icon palette that appears, highlight the icon (or) of the measurement you want to lock and then press [OK].
5. Use ▷ to highlight the icon and press [OK].*
   - The icon changes to , indicating that the measurement is locked.



Length locked



Slope locked

* You can also perform the steps below in place of step 5.

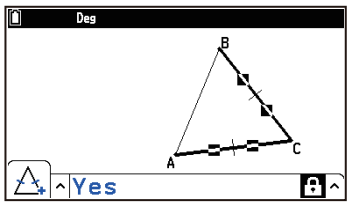
(1) Highlight the up arrow button to the right of the icon and press [OK].

(2) On the menu that appears, select [Lock] and then press [OK].

Example 2: To lock two sides of a triangle to equal lengths

1. Draw a triangle, and then select its side AC and side BC.
2. Press [F1] to display the measurement box.
3. Press ◁ to highlight the up arrow button to the left of the measurement box and then press [OK].
4. On the icon palette that appears, highlight the icon and then press [OK].
   - This causes “No” to appear in the measurement box.
5. Use ▷ to highlight the icon and press [OK].

- This causes the icon to change to 🔒, indicating that the measurement is locked. Also, the measurement box contents change to “Yes”.



To unlock a particular measurement

You can unlock a particular measurement by performing any one of the following operations.

- If the icon to the right of the measurement box is 🔒, use ◁ and ▷ to highlight the icon and press OK. This causes the icon to change to 🔓, indicating that the measurement is unlocked.
- Use ◁ and ▷ to highlight the up arrow button to the right of the 🔒 icon and press OK. On the menu that appears, select [Unlock] and then press OK.

To unlock all objects on the screen

Select ⋯ > [Option] > [Clear Constraint]. This unlocks all locked settings.

Note

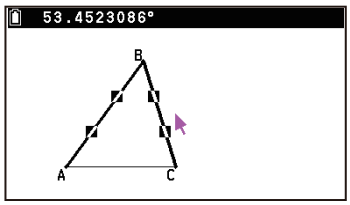
- The above operation unlocks both measurements you locked manually, as well as objects that are locked automatically whenever they are drawn.
  For example, the above operation unlocks the lock condition below:
  - The lock that is applied when you draw an isosceles triangle (ABC) that keeps side AB and side BC equal (side AB and side BC congruence lock)

Pasting Measurements into a Screen Image

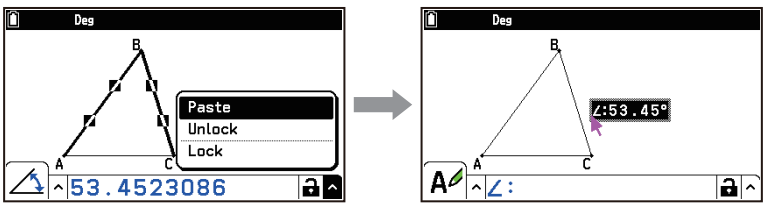
You can use the procedures below to paste object measurements into the image on the screen. The measurements change dynamically as you manipulate the object.

Example: To paste an internal angle measurement into a screen image

1. Draw a triangle and select two of its sides.



2. Press shift to display the measurement box.
3. Use ▷ to highlight the up arrow button on the right side of the measurement box and then press OK.
4. On the menu that appears, select [Paste].
   - This causes the measurement in the measurement box to be pasted into the screen image. At this time, the pasted measurement text is selected.



5. Move the text to another location on the screen, if you want.
   - Press shift and then use the cursor keys to move the pasted measurement around the screen. For details, see “To move an object” (page 159).

Note

- You can also paste the measurement that is currently in the measurement box into the screen image by pressing shift . (📋) while the measurement box is highlighted in step 2 of the above procedure.

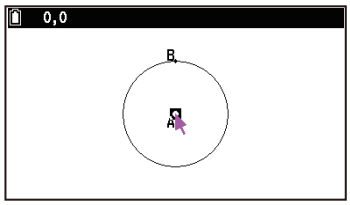
- The following types of measurements can be pasted into a screen image: coordinates, distance/length, slope, radius, circumference, perimeter, area, angle, supplementary angle, equation, vector components.
- The pasted measurement is prefixed with a name (or symbol) depending on its type. In the example above, ∠: is appended to indicate an angle. “Area:” is appended to indicate an area, and “Eq:” is appended to indicate an equation or vector components. You can use the measurement box to edit an appended name (or symbol). See “Changing a Label or Adding a Name to an Object” (page 173) for information about editing operations.

Changing a Label or Adding a Name to an Object

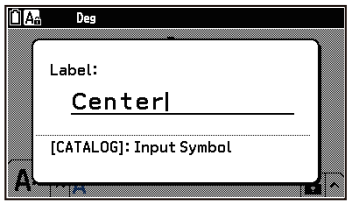
You can change the label name of a point, vector, or pasted measurement, or add a name to each element as explained in the following example.

Example: To change the label name of the center of a circle from “A” to “Center”

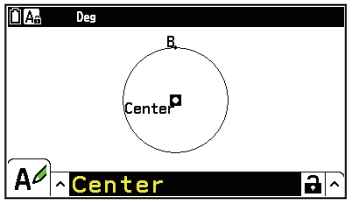
1. Draw the circle, and then select its center point.



2. Press [F1] to display the measurement box.
   - If this causes the A icon to appear, advance to step 6 of this procedure.
3. Press ◀ to highlight the up arrow button to the left of the measurement box and then press [OK].
4. On the icon palette that appears, highlight the A icon and then press [OK].
5. Press ▶ to highlight the measurement box and then press [OK].
6. On the label edit dialog box that appears, input “Center”.
   - You can input up to 14 characters for the label name.
   - To delete the label name, press [AC].



7. Press [OK].
   - This displays the changed name on the screen as shown here.

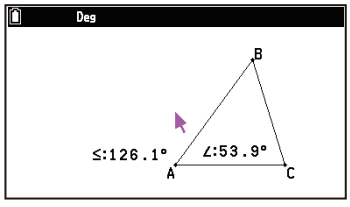


Displaying the Result of a Calculation that Uses On-screen Measurement Values

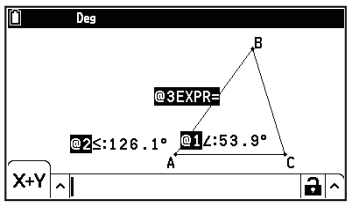
You can use the procedure in this section to perform calculations using the angle value, line length, and other measurement values attached to an object, and display the result on the screen.

Example 1: To input the expression that determines the sum of one angle of a triangle and its supplementary angle and paste the result on the screen.

1. Draw a triangle and paste the measurements of the ∠BAC angle and supplementary angle on the screen.
   - For information about pasting measurements on the screen, see “Pasting Measurements into a Screen Image” (page 172).

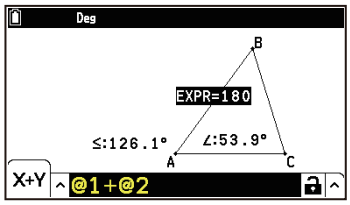


2. Select ⋯ > [Option] > [Expression].
   - This displays “EXPR=” at the pointer location and displays the measurement box.
   - The above also displays labels (@n, where n is a serial number) for each measurement currently on the screen.



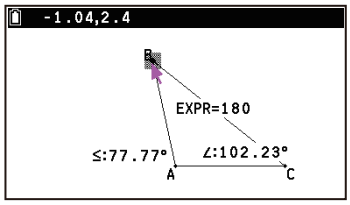
3. Now you can use the labels to specify measurement values in the calculation you input in the measurement box.
   - To input a measurement value in the measurement box, input the “@” symbol followed by the numeric label of the value: @1, @2, etc. Since we want to calculate the sum of the angle (@1) and the supplementary angle (@2) here, you would input the following: @1+@2.
   - You can input “@” by pressing ⌘ and then OK.

4. After inputting the calculation expression, press OK.
   - The calculation result is displayed to the right of “EXPR=”.



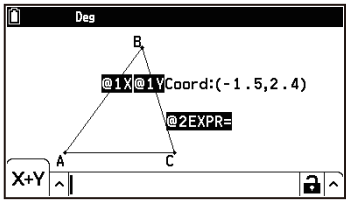
5. Press ↩ twice to hide the measurement box.

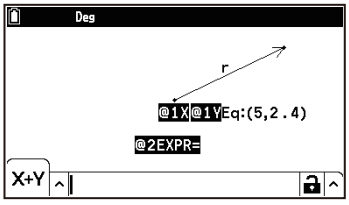
6. Try moving the vertex B to somewhere else on the screen.
   - This way you can confirm that the calculation results for the entered expression are constant.
   - For information about moving a point, see “To move an object” (page 159).



Note

- When a measurement is a coordinate or vector component, the label format becomes, “@1X”, “@1Y”, etc. “@1X” indicates the x-value of a coordinate or the x-component value of a vector, while “@1Y” indicates the y-value of a coordinate or the y-component value of a vector.

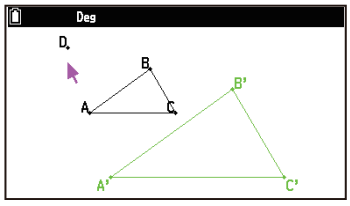




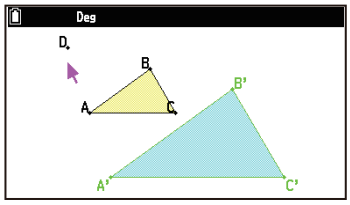
Example 2: To draw △ABC and then draw △A’B’C’ by doubling the length of each side of △ABC. Next, divide the area of △A’B’C’ by the area of △ABC.

In this example, the Area Calc command is used, which allows input of the area of a filled figure into a formula.

1. Draw and select △ABC and then use ⋯ > [Transformations] > [Dilation] to draw the double scale △A’B’C’.
   - For details about using the Dilation operation, see “Other Transformation Operations” (page 167).

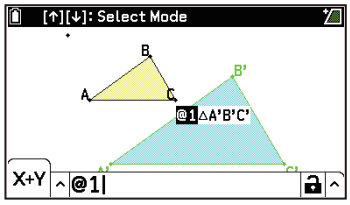


2. Specify yellow as the fill color for △ABC and cyan as the fill color for △A’B’C’.
   - For information about changing the fill color of figures, see “To specify fill color and intensity of a closed figure (polygon, circle, etc.)” (page 161)



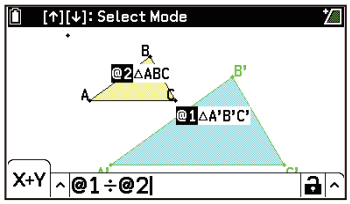
3. Select ⋯ > [Option] > [Area Calc].
   - This selects one of the filled triangles (in this case △ABC) and displays the message "[←][→]: Select Figure" in the status bar.

4. Use ◁ and ▷ to select △A'B'C' and then press OK.
   - This inputs "@1", which represents the area of △A'B'C', into the measurement box.

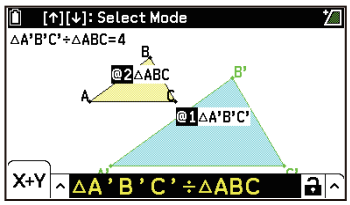


5. Press ÷ and then ∧.
   - This causes the message "[←][→]: Select Figure" to reappear in the status bar.

6. Use ◁ and ▷ to select △ABC and then press OK.
   - This inputs "@2", which represents the area of △ABC, into the measurement box.



7. Press OK.
   - The measurement box contents change from "@1÷@2" to "△A'B'C'÷△ABC", and the calculation result appears in the upper left corner of the screen.



8. Press ↩ to hide the measurement box.

Specifying the Number Format of a Measurement

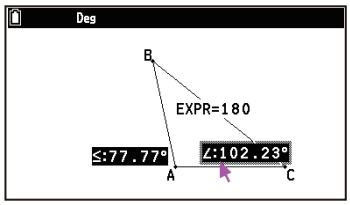
You can specify the number format for each measurement on the screen.

Note

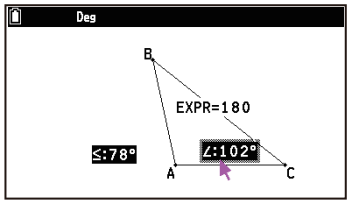
- The initial default number format is "Fix2: 0.12". For details about number format options, see "Display (General)" (page 218).
- Regardless of the current number format setting, integer values are always displayed with their decimal parts cut off.

Example: After completing Example 1 under "Displaying the Result of a Calculation that Uses On-screen Measurement Values" (page 173), change the display format of the two angle measurements to Fix0: 0. (rounded to one decimal place)

1. Select the measurements whose number format you want to change.
   - Here we select measurements for two angles (∠BAC and its supplementary angle).



2. Select ⋯ > [Option] > [Number Format] > [Fix0: 0.].
   - The selected measurements are displayed according to the currently specified number format.



Working with Animations

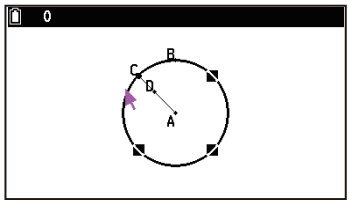
An animation consists of one or more point/curve pairs, in which the curve can be a line segment, circle, semi-circle, arc, or function. You build an animation by selecting a point/curve pair and then adding it to an animation.

Creating and Running an Animation

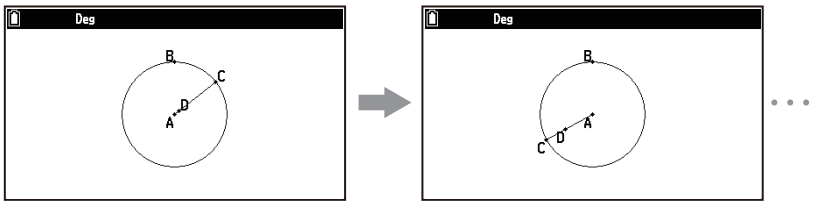
To add an animation and run it

Example 1: To draw a circle and its radius (line segment AC), and draw point D on the radius. Next, create an animation that moves point C on the circumference and point D on line segment AC at the same time.

1. Draw a circle and its radius line segment AC (A: center, C: point on the circumference), and draw point D on the radius.
2. Select point C and the circumference.



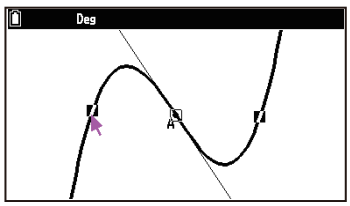
3. Select ⋯ > [Animate] > [Add Animation].
   • This adds an animation that moves point C on the circumference.
4. Press AC to deselect all figures and then select point D and line segment AC.
5. Select ⋯ > [Animate] > [Add Animation].
   • This adds an animation that moves point D on line segment AC.
6. To run the animation, select ⋯ > [Animate] > [Go(once)] or [Go(repeat)].
   • Point C moves on the circumference and point D moves on line AC at the same time.



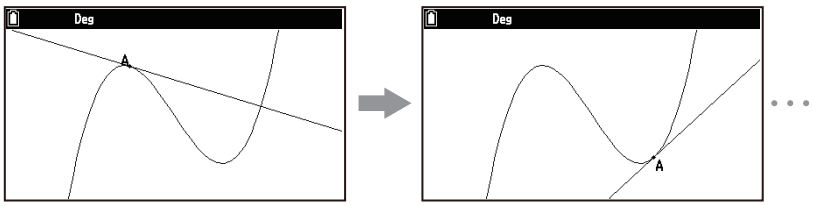
7. To stop the animation, press ↩ or AC.

Example 2: To graph the cubic function $f(x) = 0.1x^3 - 1.5x$ and draw tangents to the graph. Next, create an animation to move the points of contact on the graph and observe the change in the tangent line.

1. Graph $f(x) = 0.1x^3 - 1.5x$ and draw tangents to the graph.
   • To draw the graph, use ⋯ > [Draw Special] > [Function f(x)] (page 155).
   • To draw the tangent line, use ⋯ > [Construct] > [Tangent] (page 164).
2. Select point A (contact point) and the graph.



3. Select ⋯ > [Animate] > [Add Animation].
4. To run the animation, select ⋯ > [Animate] > [Go(once)].
   • This causes point A (contact point) to move on the graph and the tangent line to move accordingly.



Note

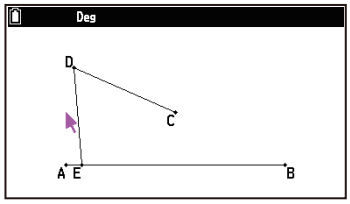
- While a point and curve are selected, selecting ⋯ > [Animate] > [Replace Animation] discards the current animations and sets up an animation for the new point and curve set.
- The calculator's auto power-off feature turns off power if an animation is being performed. If calculator power is turned off (either by auto power off or manually) while an animation is being performed, the animation is stopped.

To trace a locus of points

Example 1: To draw a parabola using Trace

1. Use the steps below to draw the required line segments.

   (1) Draw three line segments AB, CD, DE as shown on the example screen to the right.
   - When drawing line segment DE, locate point E on line segment AB.



   For information about how to use the measurement box to lock objects in steps (2) through (4) below, see "Locking or Unlocking a Measurement of an Object" (page 171).

   (2) i) Select point C. ii) Display the measurement box. iii) Select the [X,Y] icon and lock the coordinates. iv) Close the measurement box.

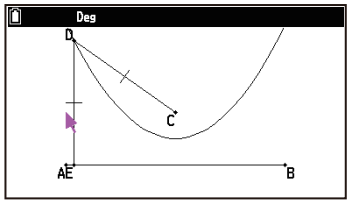
   (3) i) Press [AC], and then select line segment AB and line segment DE. ii) Display the measurement box. iii) Select the icon and lock the angle between the two lines at 90 degrees. iv) Close the measurement box.

   (4) i) Press [AC], and then select line segment DE and line segment CD. ii) Display the measurement box. iii) Select the icon to lock the length of both segments to the same length. iv) Close the measurement box.

2. Press [AC], select point E and line segment AB, and then select ⋯ > [Animate] > [Add Animation].

3. Press [AC], select point D, and then select ⋯ > [Animate] > [Trace].
   - This specifies point D as the "trace point".

4. Select ⋯ > [Animate] > [Go(once)].
   - This should cause a parabola to be traced on the display. Note that line segment AB is the directrix and point C is the focus of the parabola.

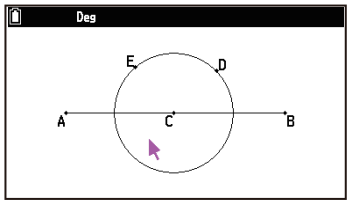


Example 2: To draw a sine curve using Trace

1. Use the steps below to draw a figure.

   (1) Draw line segment AB, a circle, and point E as shown on the example screen to the right.
   - Locate the center of the circle (point C) on line segment AB.

• Draw point E on the circumference of the circle.



For information about how to use the measurement box to lock objects in steps (2) through (4) below, see “Locking or Unlocking a Measurement of an Object” (page 171).

(2) Select the circumference of the circle, and then displays the measurement box.

(3) Select the icon and lock the length of the radius.

(4) Close the measurement box.

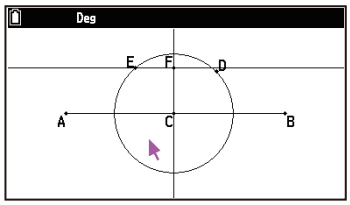
For information about how to draw perpendicular lines and intersections in steps (5) through (7), see “Using the Construct Menu” (page 164).

(5) Draw a line that is perpendicular to line segment AB and passes through point C.

(6) Draw a line that is perpendicular to the line you drew in step (3) and passes through point E.

(7) Draw two perpendicular lines that intersect at point F.

• The screen to the right shows what the screen should look like following steps (5) through (7) are complete.

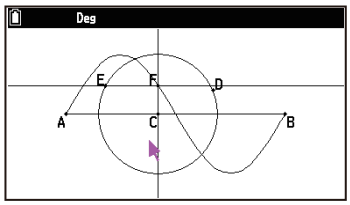


2. Select point C and line segment AB, and then select > [Animate] > [Add Animation].

3. Press AC, select point E and the circumference of the circle, and then select > [Animate] > [Add Animation].

4. Press AC, select point F, and then select > [Animate] > [Trace].
   • This specifies point F as the “trace point”.

5. Select > [Animate] > [Go(once)].
   • This should cause a sine curve to be traced on the display.



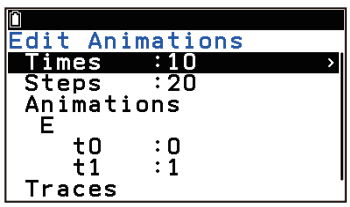
Note

- All of the points that are currently selected on the screen become trace points when you select > [Animate] > [Trace].
- Specifying a new trace point causes all currently specified trace points to be discarded.
- Any traces drawn using Trace are cleared each time an animation is run.
- Traces drawn using Trace can be selected and deleted, but they cannot be moved.

To edit an animation

The steps below continue from the procedure of **Example 1** under “To trace a locus of points” (page 177).

1. While the animation you want to edit is on the screen, select > [Animate] > [Edit Animation].
   • This displays the Edit Animations screen.



2. Edit the animation following the procedure below.
   • **Times:**

This setting specifies how many times the animation should be executed when you select ⋯ > [Animate] > [Go(repeat)]. The initial default value is 10, which can be changed to a value from 0 to 20. Inputting 0 here causes the animation to repeat until you press ↩ or AC to stop it.

- **Steps:**
  This setting specifies how many steps point E takes to move line segment AB. The initial default value is 20, which can be changed to a value from 2 to 100.
- **Animations:**
  The “E” under “Animations” indicates that point E is the point moved by the animation. When you are building multiple animations, a list of all applicable points appears here. Selecting ⋯ > [Delete] while a letter is highlighted deletes the applicable animation. Selecting ⋯ > [Delete] while “Animations” is highlighted deletes all the animations.
  “t0” and “t1” specify the range of movement of point E on line segment AB. The initial default values are t0 = 0 and t1 = 1. During animation, the length of AB is considered to be one unit. The default values specify that movement of point E is from start point A (point where length equals 0) up to end point B (point where length equals 1). You can input a number from -10 to 10 for t0 and t1.
  Changing the value of t0 to 0.5 causes point E to move from the middle of line segment AB to point B. Changing the value of t0 to -1 causes point E to begin at a point outside line segment AB (in this case, the distance from point A to point E equals the length of line AB) and end with point B. Changing the values to t0 = 1, t1 = 0 causes point E to move from point B to point A.
- **Traces:**
  This item shows the specified trace point. Selecting ⋯ > [Delete] while a letter is highlighted cancels the applicable trace point setting. Selecting ⋯ > [Delete] while “Traces” is highlighted cancels all the trace point settings.

3. After all the settings are the way you want, press ↩.

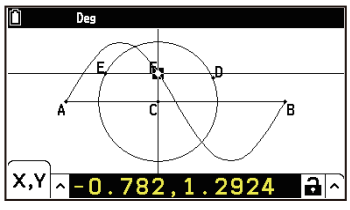
Generating an Animation Table

Under default settings, an animation causes a specified point to move along a specified line segment, circle, arc, or function in 20 steps. You can configure the calculator to generate a table, called an “animation table”, which records the coordinates of each step, the length of the line segment, the area of the object, etc.
Any of the following data can be added to the animation table: coordinates (x, y), distance/length, slope, radius, circumference, perimeter, area, angle, supplementary angle, vector segments (x, y), and expression.
You can also select a single column of the animation table and save it as a list, or save the entire animation table as spreadsheet data. The saved data can then be used for analysis with the Statistics app or the Spreadsheet app.

To add columns to the animation table

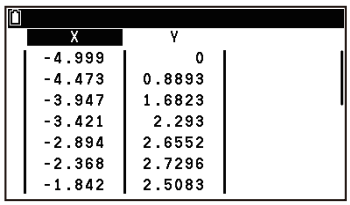
The steps below continue from the procedure of **Example 2** under “To trace a locus of points” (page 177).
First, the coordinates of point F are added to the animation table. Then the angles of line segments EC and AB connecting point E and point C are added to the animation table.

1. Here we will generate an animation table for the coordinates (x, y) of point F, so first select point F.
2. Press ⇧ to display the measurement box.*1
   - If the X,Y (coordinates) icon does not appear on the left edge of the screen, highlight the up arrow to the left of the measurement box and then press OK. On the icon palette that appears, select the X,Y icon.



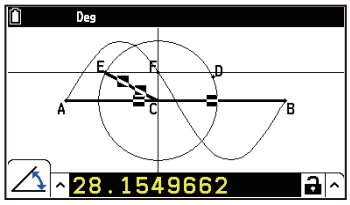
3. Use ▷ to highlight the up arrow button on the right side of the measurement box and then press OK.
4. On the menu that appears, select [Add Table] and then press OK.

- This displays an animation table that shows the coordinates of point F at each step of the animation in columns labeled “X” and “Y”.

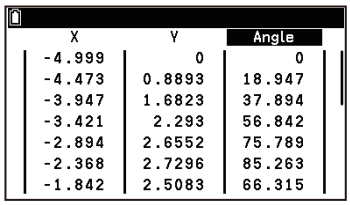


X	Y
-4.999	0
-4.473	0.8893
-3.947	1.6823
-3.421	2.293
-2.894	2.6552
-2.368	2.7296
-1.842	2.5083

5. Press ⑤ to close the animation table screen.
6. Press ⑤ twice to make the drawing screen active.
7. Press AC, and then draw a line segment that connects point E and point C (line segment CE).
8. Select line segments CE and AB, and then press ⑥.*1
   - If the (angle) icon does not appear on the left edge of the screen, highlight the up arrow to the left of the measurement box and then press OK. On the icon palette that appears, select the icon.



9. Perform steps 3 through 4 above.
   - An “Angle” column is added to the right of the “X” and “Y” columns that were added in step 4, above.*2



X	Y	Angle
-4.999	0	0
-4.473	0.8893	18.947
-3.947	1.6823	37.894
-3.421	2.293	56.842
-2.894	2.6552	75.789
-2.368	2.7296	85.263
-1.842	2.5083	66.315

10. To exit the animation table screen, press ⑤.

*1 Instead of using the measurement box, you can also add an animation table by selecting ⑨ > [Animate] > [Add Table]. However, this operation does not allow you to specify the type of measurement to be added to the table. The first measurement that appears when the measurement box is displayed is added.

*2 When angle and supplementary angle are added to the animation table, the angle unit follows the setting of ⑧ > [Angle] that is in effect at the time of addition. Changing the ⑧ > [Angle] setting does not affect the values in the animation table that are already added.

Note

- You can add up to 26 columns to an animation table.
- Animation table contents are cleared whenever one of the operations below is performed.
  - Using the Edit Animations screen to change an animation
  - Adding or replacing an animation
  - Specifying a new trace point
  - Deleting a geometric element (line segment, point, etc.) used in an animation
  - Launching an application other than the Geometry app

To display the animation table

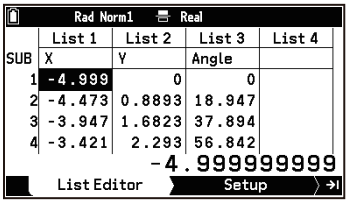
To display the animation table you generated with the procedure under “To add columns to the animation table” (page 179), select ⑨ > [Animate] > [Display Table].

To save an animation table column to a list

1. Display the animation table.
2. Use ◁ and ▷ to highlight the column you want to save as list data.
3. Select ⑨ > [Store] > [List].
4. Use the dialog that appears to input a list number and then press OK.

Note

- The lists saved during the above operation can be viewed using the Statistics app's List Editor. For example, following step 9 of the procedure under "To add columns to the animation table" (page 179), you can save each column of the animation table to a list from List 1 to List 3, and then launch the Statistics app to view a list as shown on the example screen to the right.

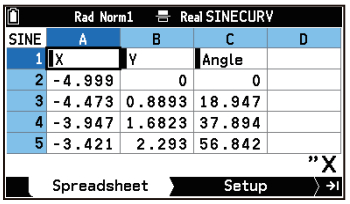


To save an entire animation table as a spreadsheet file

1. Display the animation table.
2. Select ⋯ > [Store] > [Spreadsheet].
3. Use the dialog that appears to input up to eight characters for the file name and then press OK.

Note

- The spreadsheet file saved by the above operation opens automatically the next time you start up the Spreadsheet app. For example, if you save the animation table to a spreadsheet file following step 9 of "To add columns to the animation table" (page 179), starting up the Spreadsheet app displays the table as shown on the example screen to the right.



To delete a particular column from an animation table

1. Display the animation table.
2. Use ◁ and ▷ to highlight the column you want to delete.
3. Select ⋯ > [Delete] > [Delete].

To delete all of the columns from an animation table

1. Display the animation table.
2. Select ⋯ > [Delete] > [Delete All].
3. In response to the confirmation dialog that appears, select [OK].

Using Key Help

Pressing the 0 key or selecting ⋯ > [Key Help] displays the Key Help window, which provides information about the function assigned to each key in the Geometry app. Note that the key operations shown on the Key Help window apply to the drawing screen only.

Geometry App Settings Menu Items

The Settings menu items (page 214) described below are specific to the Geometry app.

☰ > [Angle Unit] …	Specifies whether to include units when displaying angles for a figure on the drawing screen.
☰ > [Length Unit] …	Specifies whether to include units when displaying lengths for a figure on the drawing screen.
☰ > [Grid Space] …	Specifies the pitch (spacing) of the grid points and lines on the drawing screen.

Database App

The Database app contains element and physical constant data. You can browse the stored data, edit values, and use the values in other applications.*

* Values of atomic weights and physical constants can be saved to alpha variables. You can also batch-save element data as Spreadsheet app data.

Note

- Elements and physical constant notations and values are subject to change. Refer to the beginning of each section of this chapter ("Periodic Table" (page 182) and "Fundamental Physical Constants" (page 185)) for the original data to which this calculator conforms.
- The Database app has a function for editing and saving recorded atomic weight and physical constant values. The values you edit and save are retained even if you update the Database app to a newer version. To overwrite saved values with the values of the updated version, use the operations under "Initializing All Atomic Weight Values" (page 183) and "To initialize all physical constant values" (page 187) to restore the atomic weight and physical constant values to their initial default values.

Periodic Table

You can select an element from the periodic table of elements and display information about it. You can also search for elements by name or atomic weight.

Note

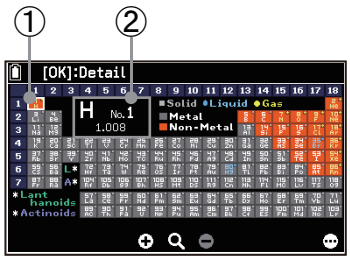
- The atomic weights displayed by the Database app are in accordance with the IUPAC (International Union of Pure and Applied Chemistry), 2021.
- The electron configuration displayed by the Database app complies with the CRC Handbook of Chemistry and Physics, 91st Edition.

Selecting an Element from the Periodic Table to Display Its Information

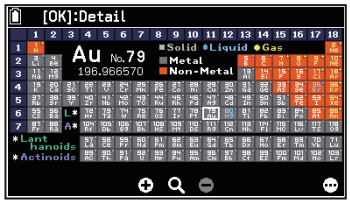
Example: On the periodic table, select gold (element symbol: Au), atomic number 79 to display its detailed information.

1. ⌂ > Database

2. Highlight [Periodic Table] and then press OK or >.
   - This displays the periodic table. In this case, the cursor (①) appears at hydrogen (element symbol: H) with atomic number 1. The symbol, atomic number, and atomic weight of the element at the cursor location are also displayed at location ②.

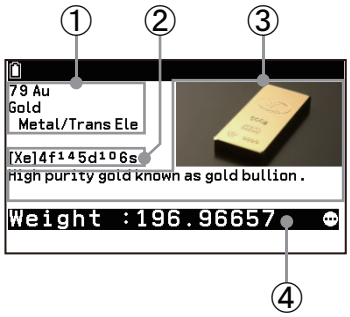


3. Use the cursor keys to move the cursor to atomic number 79.
   - Instead of using the cursor keys to move the cursor, you can also search for an element by its name or atomic number. The following is an example of how to search by atomic number.
     (1) Select ⋯ > [Search] > [Atomic No.].
     (2) Use the dialog box that appears to input 79, and then press OK.



4. To display detailed information about the element where the cursor is located, press OK.

- This displays detailed information about the element. The following is the detailed information that appears.
  ① Atomic number, element symbol, element name, properties
  ② Electron configuration
  ③ Image of the element and explanation of the image
  ④ Atomic weight*



* Atomic weights of elements that do not have stable isotopes are enclosed within square brackets ([ ]). For example, a number like [209] shows the mass number of the longest-lived isotope of that element. However, since thorium (Th), protactinium (Pa), and uranium (U) do have a characteristic terrestrial isotopic composition, their atomic weights are not enclosed in square brackets. The names of elements whose atomic weights are enclosed in square brackets have an asterisk (*) next to them.

5. To return to the periodic table, press ⮌ or OK.

Highlighting Elements of a Specific Classification on the Periodic Table

You can use the operations below to highlight the elements of a specific classification.

To highlight the elements of this classification:	Select this menu item:
Transition Elements	⋯ > [Series] > [Transition]
Alkali Metals	⋯ > [Series] > [Alkali Metals]
Alkali Earth Metals	⋯ > [Series] > [Alkaline Earth Metal]
Halogens	⋯ > [Series] > [Halogens]
Noble Gases	⋯ > [Series] > [Noble Gases]
Rare Earth Elements	⋯ > [Series] > [Rare Earth]

To unhighlight a classification, select ⋯ > [Clear].

Note

- The classification of elements is not definitive. Classifications displayed by the Database app are those that are commonly accepted at the time this app was developed.

Saving Periodic Table Information as a Spreadsheet File

You can use the operation below to save periodic table information as a spreadsheet file.

1. Select ⋯ > [Store].
2. Use the dialog that appears to input up to eight characters for the file name and then press OK.
   - The spreadsheet file contains the information below in columns A through D, in that order.
     Atomic number (numeric), element symbol (text), electron sequence (text), atomic weight (numeric)*

* If the atomic weight value has been changed, the new value is saved. For information about changing the atomic weight value, see “To edit an atomic weight value” (page 184).

Initializing All Atomic Weight Values

You can use the operation below to restore all atomic weight values that have been edited using the operation under “To edit an atomic weight value” (page 184) to their initial Database app values.

1. Select ⋯ > [Initialize Weight].
2. In response to the confirmation dialog that appears, select [OK].

Searching for an Element

You can use the methods shown in the table below to search for an element. If the element you are searching for is found, the cursor jumps to the element.

To search by this:	Perform this operation:
Element Name	1. Select ⋯ > [Search] > [Name]. 2. Select the desired element name from the alphabetical list*1 and then press OK.
Element symbol	1. Select ⋯ > [Search] > [Symbol]. 2. Select an element symbol from the alphabetical list*1 and then press OK.
Atomic number	1. Select ⋯ > [Search] > [Atomic No.]. 2. Use the dialog that appears to input an atomic number and then press OK.
Atomic weight	1. Select ⋯ > [Search] > [Weight]. 2. Use the dialog that appears to input an atomic weight up to 12 digits long (including decimal point) and then press OK.*2

*1 While the alphabetical list is displayed, you can press a key from A to Z to jump to the top of the list for the letter whose key you pressed.

*2 This searches for the element with the smallest atomic weight that is greater than or equal to the input value.

Enlarging the Periodic Table

Pressing + or ⇤ while viewing the periodic table zooms in on the area in the vicinity of the current cursor position. Pressing −, ⇥, or ⮌ returns to the full table display. Note that the ⋯ key operation is disabled while the periodic table is zoomed.

Using the Detailed Information Screen

Pressing OK while the periodic table is displayed switches to the detailed information screen for the element where the cursor is currently located. For details about the display contents of the detailed information screen, see “Selecting an Element from the Periodic Table to Display Its Information” (page 182). This section describes the operations you can perform while the detailed information screen is displayed.

To edit an atomic weight value

1. Display the detailed information screen for the element whose atomic weight value you want to edit.
2. Select ⋯ > [Edit] or press >.*
   - This causes the cursor to appear to the left of the current atomic weight value.
3. Use < and > to move the cursor to the digit you want to edit and then edit it as required.
   - You can input only numbers and the decimal point for an atomic weight, which can be up to 12 digits long.
   - To cancel the editing operation, press ⮌ here.
4. To save an edited value, press OK.

* Instead of performing this operation, you can also press a number key to start editing.

To show/hide atomic weight value square brackets

1. Display the detailed information screen for the element whose square brackets you want to show or hide.
2. Select ⋯ > [1 ⇔ [1]].
   - Each time you perform this operation, the square brackets ([ ]) around the atomic weight value are toggled between show and hide.
   - For information about the meaning of square brackets around an atomic weight, see the step 4 note under “Selecting an Element from the Periodic Table to Display Its Information” (page 182).

To restore edited atomic weight values to their initial default Database app values

Select ⋯ > [Initialize].
This returns the atomic weight value and the show/hide square brackets setting to their Database app initial default settings.

To store an atomic weight value to an alpha variable

1. Display the detailed information screen for the element whose atomic weight value you want to store.

2. Select ⋯ > [Store].

3. Use the dialog that appears to input one letter from A to Z and then press OK.
   - This stores the atomic weight value to the alpha variable of the letter you input.
   - For details about alpha variables, see “Using Alpha Variables” (page 18).

Fundamental Physical Constants

The Database app maintains the values of the physical constants shown in the table below and displays them in a list grouped by category. You can edit the physical constant values and store them to an alpha variable for use in other applications.

Note

- The values and names of the physical constants included in the Database app are based on 2022 CODATA.

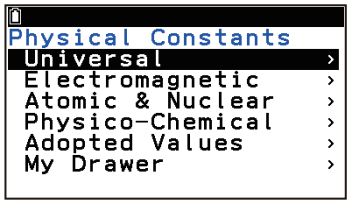
Categorized List of Physical Constants

Category	Symbol	Name
Universal	c	speed of light in vacuum
	μ_0	vacuum magnetic permeability $4\pi\alpha\hbar/(e^2c)$
	ε_0	vacuum electric permittivity $1/\mu_0c^2$
	Z_0	characteristic impedance of vacuum $\sqrt{\mu_0/\varepsilon_0} = \mu_0c$
	G	Newtonian constant of gravitation
	h	Planck constant
	$\hbar$	reduced Planck constant
	m_P	Planck mass $(\hbar c/G)^{1/2}$
	l_P	Planck length $\hbar/m_Pc = (\hbar G/c^3)^{1/2}$
	t_P	Planck time $l_P/c = (\hbar G/c^5)^{1/2}$
Electromagnetic	e	elementary charge
	Φ_0	magnetic flux quantum $2\pi\hbar/2e$
	G_0	conductance quantum $2e^2/2\pi\hbar$
	K_J	Josephson constant $2e/h$
	R_K	von Klitzing constant $\mu_0c/2\alpha = 2\pi\hbar/e^2$
	μ_B	Bohr magneton $e\hbar/2m_e$
	μ_N	nuclear magneton $e\hbar/2m_p$
Atomic & Nuclear	α	fine-structure constant $e^2/4\pi\varepsilon_0\hbar c$
	R_∞	Rydberg constant
	a_0	Bohr radius $\hbar/\alpha m_ec = 4\pi\varepsilon_0\hbar^2/m_ee^2$
	m_e	electron mass
	μ_e	electron magnetic moment
	m_μ	muon mass
	μ_μ	muon magnetic moment
	m_τ	tau mass
	m_p	proton mass
	μ_p	proton magnetic moment
	m_n	neutron mass

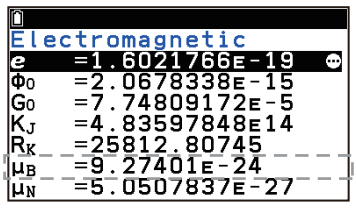
	μ_n	neutron magnetic moment
Physico-Chemical	N_A	Avogadro constant
	m_u	atomic mass constant $\frac{1}{12}m(^{12}C)=2hc/R_\infty\alpha^2c^2A_r(e)$
	F	Faraday constant N_Ae
	R	molar gas constant $R=N_Ak$
	k	Boltzmann constant
	V_m	molar volume of ideal gas RT/p (273.15K, p=100kPa)
	σ	Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3c^2$
Adopted Values	K_{J-90}	conventional value of Josephson constant
	R_{K-90}	conventional value of von Klitzing constant
	g_n	standard acceleration of gravity

Displaying a Physical Constant and Its Information

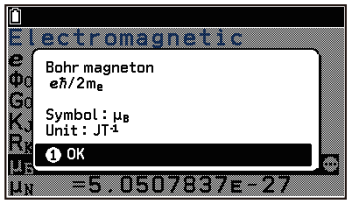
1. ⌂ > Database
2. Highlight [Fundamental Physical Constants] and then press OK or ▷.
   - This displays a list of Physical Constants categories.



3. Highlight the physical constant category whose values you want to display and then press OK or ▷. For example, to display the value of Bohr magneton (μ_B), highlight [Electromagnetic] and then press OK or ▷.
   - This displays a list of Electromagnetic category physical constants and their values.
   - See "Categorized List of Physical Constants" (page 185) for information about the physical constants included in which category.
   - See "Using a Physical Constant in a Calculation" (page 187) for information about operations that use physical constant values for calculations.



4. To display information about Bohr magneton, highlight the [μ_B] row and then press OK or select ⋯ > [Description].
   - This displays a dialog with the applicable information (name, symbol, units). To close the dialog, press OK or ↩.



5. To return to the category list, press ↩.

Editing a Physical Constant Value

To edit a physical constant value

1. Perform the first three steps of the procedure under "Displaying a Physical Constant and Its Information" (page 186) to highlight the physical constant whose value you want to edit.
2. Select ⋯ > [Edit] or press ▷.*
   - This displays the input cursor to the left of the value of the physical constant.
3. Use ◁ and ▷ to move the cursor to the digit you want to edit and then edit it as required.
   - Only up to 15 significant digits are stored, even if you input more than 15 digits.
   - An error (Syntax ERROR) occurs if you attempt to edit a constant using incorrect input.

- An error (Math ERROR) occurs if you input a mathematically incorrect expression while editing a constant.
- To cancel the editing operation, press ⟲ here.

4. To save an edited value, press [OK].

* Instead of performing this operation, you can also press a number key to start editing.

To initialize a single physical constant value

1. Perform the first three steps of the procedure under "Displaying a Physical Constant and Its Information" (page 186) to highlight the physical constant whose value you want to initialize.
2. Select ⋯ > [Initialize] > [Selected Constant].

To initialize all physical constant values

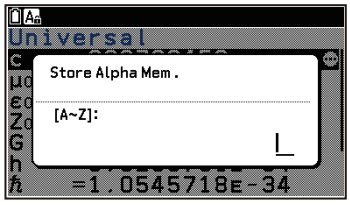
1. While the physical constant list screen is displayed, select ⋯ > [Initialize] > [All].
2. In response to the confirmation dialog that appears, select [OK].

Using a Physical Constant in a Calculation

The physical constant values can be stored to alpha variables for use in calculations by Calculate and other apps.

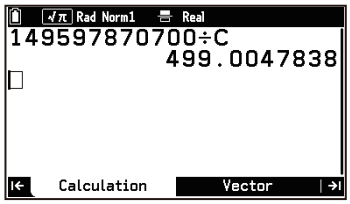
Example: To calculate the time required for light to reach the Earth from the Sun. This calculation uses the average distance from the Sun to the Earth (1 au = 149,597,870,700 m) and the speed of light in vacuum (c = 299792458 m/s), which is the calculator's default value.

1. In the Physical Constants category list, select [Universal] and then press [OK].
2. Highlight [c] (speed of light in vacuum) and then select ⋯ > [Store Const. as Variable].
   - This displays a dialog for specifying the alpha variable storage destination.



3. Input one letter from A to Z and then press [OK].
   - Here, press √■ C [OK], which stores the value to alpha variable C.
4. Select ⌂ > Calculate to start up the Calculate app.
5. Execute the calculation.

149597870700 ÷ [ALPHA] √■ (C) [EXE]



- The calculation result shows it takes approximately 499 seconds for light to reach the Earth from the Sun.
- For details about alpha variables, see "Using Alpha Variables" (page 18).

Using My Drawer

You can use My Drawer to store often-used physical constants.

To save a physical constant to My Drawer

1. Perform the first three steps of the procedure under "Displaying a Physical Constant and Its Information" (page 186) to highlight the physical constant you want to store in My Drawer.
2. Select ⋯ > [Store in My Drawer].

To display physical constants saved to My Drawer

In the Physical Constants category list, select [My Drawer].

To delete a single physical constant that was saved to My Drawer

1. In the Physical Constants category list, select [My Drawer].
2. Highlight the physical constant you want to delete from My Drawer.
3. Select ⋯ > [Delete] > [Selected Constant].

To delete all physical constants saved to My Drawer

1. In the Physical Constants category list, select [My Drawer].
2. Select ⋯ > [Delete] > [All].
3. In response to the confirmation dialog that appears, select [OK].

Prob Sim App

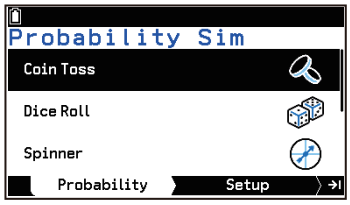
The Prob Sim app performs the six types of simulations described below.

- Coin Toss
- Dice Roll
- Spinner
- Marble Grab
- Card Draw
- Random Numbers (Random Integers)

Operation Flow

Step 1: Select a simulation type (Probability tab).

1. ⌂ > Prob Sim
   - This displays a menu for selecting a simulation type.

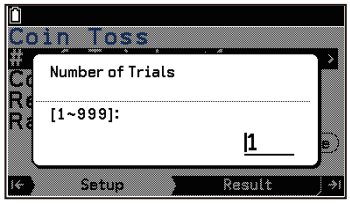


2. Highlight the type of simulation you want to run and then press ⇥ (or OK).
   - This displays the Setup tab, which shows the settings for the type of simulation you chose.

Step 2: Specify the number of simulation trials and configure other settings (Setup tab).

3. Specify the number of simulation trials.

   (1) Highlight [# of Trials] and then press OK.



   (2) In the dialog box that appears, input an integer between 1 and 999 and then press OK.

4. Configure other settings.

Setting Items Specific to Particular Simulation Types

Type	Item	Description	Setting*1
Coin Toss	Coins	Specifies the number of coins.	1, 2, 3
Dice Roll	Dice	Specifies the number of dice.	1, 2, 3
	Die Sides	Specifies the number of faces for each die.	4, 6, 8, 12, 20
Spinner	Sections	Specifies the number of divisions on the spinner.	2, 3, 4 to 8
Marble Grab	Marble Types	Specifies the types of marbles. Selecting 2 for this setting will specify A, B for the marble types, while selecting 5 will specify A, B, C, D, E.	2, 3, 4, 5
	Replacement	Specifies whether a drawn marble is replaced (On) or not (Off) after being drawn. "⟲" is displayed in the upper left corner of the result screen when On is selected for replacement.	On, Off
Card Draw	Decks	Specifies the number of card decks.	1, 2, 3
	Deck Size	Specifies the number of cards in a deck.	32, 52
	Replacement	Specifies whether a drawn card is replaced (On) or not (Off) after being drawn. "⟲" is displayed in the upper left corner of the result screen when On is selected for replacement.	On, Off

Random Numbers	# of RanNums	Specifies the number of random numbers to be generated.	1 to 6
	Range Start	Specifies the lower limit of the random number generation range.	0, 1 to 98
	Range End	Specifies the upper limit of the random number generation range.	1 to 40 to 99
	Repeat*2	Specifies whether the same value can be repeatedly generated (On) or not (Off). "↺" is displayed in the upper left corner of the result screen when On is selected for repeat.	On, Off

Setting Items Common to All Simulation Types

Item	Description	Setting*1
Refresh Freq	Specifies how often (in terms of the number of results) the result screen should be refreshed. Specifying "After Last Trial" here causes the screen to be refreshed after the last trial.	After 1 Trial, After 20 Trials, After 50 Trials, After Last Trial
Random Seed	Specifies a seed value to use for generation of pseudo-random numbers.	1 to 99999

*1 Underlined settings indicate initial defaults.

*2 When Off is specified for the Repeat setting, the random number range must be set to a value that is greater than the number of random numbers to be generated.

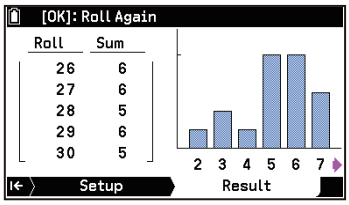
Note

- To restore all Setup tab setting items to their initial default settings, select ⋯ > [Initialize].
- For Coin Toss, Dice Roll, Spinner, and Marble Grab, you can specify an occurrence rate bias (for example, probability that Coin Toss will produce heads or tails). See "Specifying an Occurrence Rate Bias (Bias)" (page 191) for details.

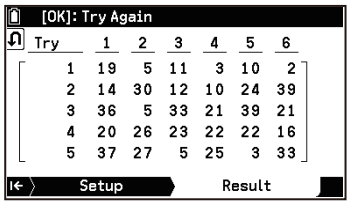
Step 3: Run the simulation and display its results (Result tab).

5. On the Setup tab, press ⇥, or highlight Execute and then press OK.
   - The results of the simulation are displayed on the Result tab. See "Using the Result Tab" (page 192) for information about the results displayed for each simulation type.

Example simulation result display:



Dice Roll



Random Numbers

- The leftmost column of the table shows the number of trials.
- You can use ∧ and ∨ to scroll a table up and down. You can use < and > to scroll a graph left and right.
- The table below shows operations you can perform on the Result tab.

To do this:	Perform this operation:
Re-run a simulation for the same number of trials as the original	Press OK.
Re-run the simulation for a specified number of trials	On the dialog box that appears when you press a number key or select ⋯ > [Increase trials (n)], input the desired number of trials and then press OK.

Select Table, Graph, or Graph + Table as result display format[*1]	Select ⋯ > [Results Display].
Store the simulation results to a list variable	Select ⋯ > [Store].[*2]
Delete the current simulation results and return to the Setup tab	Select ⋯ > [Delete].
Display a crosshair pointer (✛) and read the bar chart values (frequency and probability)[*3]	Select ⋯ > [Trace].

*1 This operation can be performed for Coin Toss, Dice Roll, Spinner, and Marble Grab.

*2 See “To store simulation results to a list variable” (page 192) for details.

*3 This operation can be performed while ⋯ > [Results Display] > [Graph] is selected. For more information, see “To read bar chart frequency and probability values” (page 193).

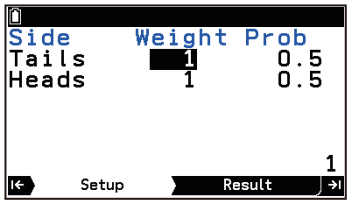
6. To return to the Setup tab, press ⏮ (or ↩).
   - In response to a dialog box that appears asking if you want to delete the current simulation results, select [OK].

Specifying an Occurrence Rate Bias (Bias)

In real life, one side of a coin tends to appear more often than the other side, and one number of a die tends to appear more often than the others. This is due to the physical shape of the coin or die, or an offset of its center of gravity. Also, the number of Marble Grab marbles may differ depending on the marble type. This kind of occurrence rate bias can be specified for each simulation type. Occurrence rate bias can be specified for Coin Toss, Dice Roll, Spinner, and Marble Grab.

To specify Bias for Coin Toss, Dice Roll, or Spinner

1. Display the Setup tab for Coin Toss, Dice Roll, or Spinner.
2. Select ⋯ > [Bias].
   - This displays a screen for changing the weight (Weight) and probability (Prob) of a particular outcome.



3. Change the Weight or Prob value for each outcome.

Weight:	Specify a value between 0 and 999 (initial default: 1). Changing the Weight of one outcome causes the Prob values of all outcomes to be recalculated accordingly.
Prob:	Specify a value with up to four decimal places. Changing the Prob of one outcome causes the Prob and Weight values of all outcomes to be recalculated accordingly.

   - To initialize all Weight and Prob values, select ⋯ > [Initialize].
4. After everything is the way you want, press ↩ to close the editing screen.

To specify Bias for Marble Grab

1. Display the Setup tab for Marble Grab.
2. Select ⋯ > [Bias].
   - This displays a screen for editing the number of each type of marble.

3. For each marble type, specify the number of marbles between 0 and 999 (initial default: 10).
   - To initialize this setting, select ⋯ > [Initialize].
4. After everything is the way you want, press ↩ to close the editing screen.

Using the Result Tab

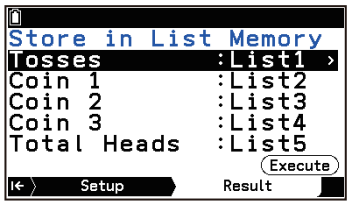
The table below shows the Result tab contents for each simulation type.

Type		Table	Graph
Coin Toss	1 coin	Cumulative number of heads over multiple tosses	Head/tail frequencies over multiple tosses
	2 coins/3 coins	Number of heads for a single toss	Cumulative frequencies of number of heads over multiple tosses
Dice Roll	1 die	Number produced by a single roll	Frequencies of each number over multiple rolls
	2 dice/3 dice	Total of numbers produced by a single roll	Frequencies of roll totals over multiple rolls
Spinner		Spinner number by a single spin	Frequencies of each number over multiple spins
Marble Grab		Types of marbles for a single grab	Frequencies of each type of marble over multiple grabs
Card Draw		Rank and suit of drawn card	-
Random Numbers		Generated random integer	-

To store simulation results to a list variable

Example 1: To store the results of a simulation of 20 tosses of 3 coins to a list variable

1. Display the Setup tab for Coin Toss.
2. Highlight [# of Trials], input “20” and then press (OK).
3. Highlight [Coins] and then press (OK).
4. On the menu that appears, select [3] and then press (OK).
5. Press (⇥).
   - The results of the simulation are displayed on the Result tab.
6. Select (○○○) > [Store].
   - This displays a screen for specifying the store destination list variable.



7. If necessary, change the list variable number to specify the destination where each row of data should be stored.
   (1) Highlight the line you wish to change and then press (OK).
   (2) Use the dialog box that appears to input a list number and then press (OK).
   - Inputting a list number that is already specified in another line causes the message “Data is in use” to appear. Press (OK) to close the message and then specify a different list number.
8. Highlight [Execute] and then press (OK).
   - This stores the simulation results to the specified list variable.

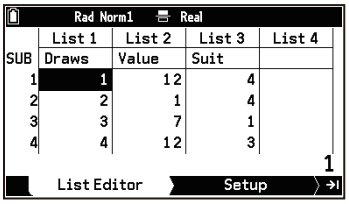
Note

- You can check what has been stored by starting up the Statistics app and displaying the List Editor.

- For Card Draw results, the Value (rank) and Suit results are stored in separate lists. Also, the A, J, Q, and K ranks and the heart, club, spade, and diamond suits are stored as the values shown below.

  A = 1, J = 11, Q = 12, K = 13

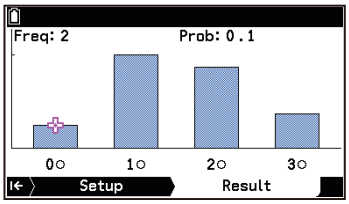
  ♥ = 1, ♣ = 2, ♠ = 3, ♦ = 4



To read bar chart frequency and probability values

Example 2: To display a full-screen bar graph of the simulation results of Example 1 and display the frequency and probability values for each bar

1. Perform steps 1 through 5 of Example 1.
2. Select ⋯ > [Results Display] > [Graph].
   - This displays a full-screen bar chart.
3. Select ⋯ > [Trace].
   - This causes a crosshair pointer (✛) to appear at the left-most bar, along with the frequency (Freq) and probability (Prob) values at the top of the screen.
   - You can use ◁ and ▷ to move the pointer to the left and right.



4. To clear the pointer from the bar chart, press ↩.

Prob Sim App Settings Menu Items

The Settings menu items (page 214) described below are specific to the Prob Sim app.

☰ > [Maximum Scale] …	Specifies whether the maximum value of the vertical axis on the Result tab is shown or hidden on the graph.
☰ > [Animation] …	Specifies whether an animation should be displayed before results when a simulation is performed.

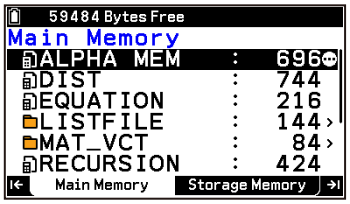
Memory App

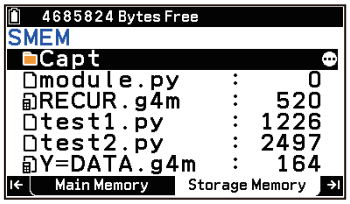
Your calculator has two data storage areas named Main Memory and Storage Memory. You can use the Memory app to manage these two memory areas.

Main Memory: This area is used for storage of input data, variables, and configuration data for apps such as Statistics and Graph&Table.

Storage Memory: This area is used to store relatively large-volume data such as image files and py files. This area can also be used to create backup files of Main Memory data.

When you select ⌂ > Memory to start up the Memory app, the Main Memory tab contents appear first. You can use ⇤ and ⇥ to navigate between the Main Memory tab and the Storage Memory tab.





Using the Main Memory Tab

Data Displayed on the Main Memory Tab

The Main Memory tab shows calculator data using the names shown below.

Data Name	Contents
ALPHA MEM	Alpha variables
CONICS	Conic Graphs app data
DIST	Distribution app data
DYNA MEM	Dyna Graph app data
EQUATION	Equation app data
FINANCE	Financial app data
LISTFILE	List variable group
LIST n	List variables (n = 1 to 26 and ANS)
LISTFILE n	List files (n = 1 to 6)
MAT_VCT	Matrix and vector variable group
MAT n	Matrix variables (n = A to Z and ANS)
VCT n	Vector variables (n = A to Z and ANS)
NUMINEQ (fx-CG100 only)	Num Ineq app data
RECURSION	Recursion app data
SETUP	Settings data and other setup data
STAT	Statistics app data
SYSTEM	Operating system and shared app data (clipboard, calculation history, etc.)
S-SHEET	Spreadsheet app group
_SETTING	Spreadsheet app setting data
SHEET	Spreadsheet app data (“SHEET” is the initial default spreadsheet file name.)
Each spreadsheet name	Spreadsheet app data
TABLE	Graph&Table app table data
Y=DATA	Function variables

3DGRAPH	3D Graph app group
3DGRAPH	3D Graph app data
DBASE	Database app group
Periodic	Database app periodic table data
Adopted, Atomic, Electoro, Physico, Univers, User	Database app fundamental physical constants data
GEOM	Geometry app group
@IMAGE	Geometry app current data
Each geometry file name	Geometry app data
PROBSIM	Prob Sim app group
PROBSIM	Prob Sim app data

Main Memory Tab Operations

To create a backup file of all data

Use the procedure below to store a backup file of all Main Memory data in Storage Memory. The name of the file is always “BACKUP.g4m” and cannot be changed. If you want to create a save destination folder, go to the Storage Memory tab and create the folder in advance.

1. Select ⋯ > [Backup] > [Save Backup Data].
   • This displays a dialog you can use to select a folder to save the data.
2. Use the operation below to select the save destination folder.

To select this folder:	Perform this operation:
Root directory	Highlight ROOT and then press (OK).
Other folders	(1) Highlight the folder you want to select and then press (OK). This will take you into the selected folder. (2) Highlight the folder’s name and then press (OK) again.

To restore all data from a backup file

You can use the procedure below to restore all data in Main Memory from a backup file stored in Storage Memory.

1. Select ⋯ > [Backup] > [Load Backup Data].
   • This displays a dialog for selecting the folder where the backup file is stored.
2. Use the operation below to select the folder where the backup file is stored.

To select this folder:	Perform this operation:
Root directory	Highlight ROOT and then press (OK).*
Other folders	(1) Highlight the folder you want to select and then press (OK). This will take you into the selected folder. (2) Highlight the folder’s name and then press (OK) again.*

   • This displays a confirmation message asking if you want to overwrite existing data.
3. Select [OK] to overwrite all existing data in Main Memory with the contents of the backup file, or [Cancel] to cancel the operation.

* If the selected folder does not contain a backup file, the message “No Data” will appear.

To save specific data or groups as a single file in Storage Memory

1. Highlight the data or group you wish to save to a file.
2. Select ⋯ > [Save As].
   • This displays a dialog you can use to select a folder to save the data.

3. Use the operation below to select the save destination folder.

To select this folder:	Perform this operation:
Root directory	Highlight ROOT and then press (OK).
Other folders	(1) Highlight the folder you want to select and then press (OK). This will take you into the selected folder. (2) Highlight the folder's name and then press (OK) again.

4. Use the dialog that appears to input up to eight characters for the file name and then press (OK).
   - The file name extension of the saved file is .g4m.
   - Saved files can be loaded into Main Memory using the operations on the Storage Memory tab. See "To load a g4m file into Main Memory" (page 197).

To delete specific data or groups

1. Highlight the data or group you want to delete.
2. Select (oooo) > [Delete].
   - This causes a delete confirmation message to appear.
3. To delete, select [OK]. To cancel the operation, select [Cancel].

Using the Storage Memory Tab

Files Displayed on the Storage Memory Tab

Files created with the calculator and files transferred from a computer to the calculator are displayed on the Storage Memory tab.

File Extension	Description
.g4m	File that contains Main Memory data.
.g4p*1	File that contains a screen image captured with the calculator.*2
.bmp	Bitmap format image file.
.g3p*1	File that contains a screen image captured with an earlier Color Graph scientific calculator.
.py	Python script file (py file)
.csv	CSV files
Other file name extensions	These files are not supported by this calculator, but you can use this calculator to delete them.

*1 Files of these formats can be used as background images (page 219) of graph windows.

*2 The Geometry app data with background image is also saved as a g4p file. For more information, see "Displaying a Geometry App Screen Background Image" (page 162).

Note

- Folders are indicated by the icon on the Storage Memory tab.
- If the name of a file transferred to Storage Memory from your computer has a file name that is more than eight characters long, its name will be abbreviated to eight characters when displayed on the Storage Memory tab (Example: AAAABBBBCC.py > AAAABB~1.py). Also, if a file name extension has more than three characters, everything after the third character of the file name extension will be trimmed off.
- Up to 200 files per folder can be displayed on the Storage Memory tab. If a folder has more than 200 files and you need to display them all, divide them among multiple folders so the total number of files in a single folder is not greater than 200.
- Though you can create folders on your computer nested to more than three levels in Storage Memory, this calculator will display only up to the third level.

• The following are single-byte characters that can be used in file names and folder names.
A-Z, a-z, 0-9, !, #, $, %, ,(comma), (,), +, –, ., ;, =, @, [,], ^, _, `, space
Note that file names and extensions are not case-sensitive.

Storage Memory Tab Operations

To load a g4m file into Main Memory

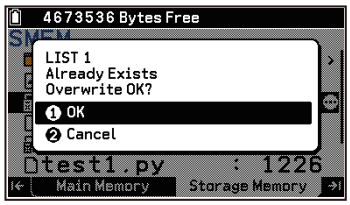
You can use the operation below to load g4m files* into Main Memory.

* Backup files created with Main Memory tab operations or individually saved files with Main Memory tab operations.

Important!

- If duplicates of the data items below are found in step 2 of the procedure below, a confirmation message will appear asking if you want to overwrite the existing data.
  DYNA MEM, LIST n, LISTFILE n, MAT n, VCT n, Spreadsheet app data, data in the DBASE group, data in the GEOM group
  The data items below are always overwritten without displaying a confirmation message.
  ALPHA MEM, CONICS, DIST, EQUATION, FINANCE, NUMINEQ (fx-CG100 only), RECURSION, SETUP, STAT, SYSTEM, S-SHEET (_SETTING), TABLE, Y=DATA, 3DGRAPH, PROBSIM
  For details about data contents, see “Data Displayed on the Main Memory Tab” (page 194).

1. Highlight the g4m file you want to load into Main Memory.
2. Select ⋯ > [Load].
   - This starts the load operation. During loading, a confirmation message like the one on the right may appear. For more information, see “Important!” above. To overwrite, select [OK]. To cancel the operation, select [Cancel].
   - The message Complete! appears on the display when the load operation is complete.



Note

- In the cases described below, the load operation does not start when you select ⋯ > [Load] in step 2.
  - When battery power is low (Low Battery error)
  - When there is not enough free space in Main Memory (Memory Full error)
  - When there are too many data items in Main Memory (Too Much Data error)
  - When a file that is not a g4m file is selected (Invalid Type error)

To create a folder

1. Display the location (in the root directory or folder) where you want to create a folder.
   - You can nest folders up to three levels.
2. Select ⋯ > [Folder] > [Make Folder].
3. Use the dialog that appears to input up to eight characters for the folder name and then press OK.

To rename a folder

1. Highlight the folder you want to rename.
2. Select ⋯ > [Folder] > [Rename Folder].
3. Use the dialog that appears to input up to eight characters for the folder name and then press OK.

To view detailed information about a file

1. Highlight the file whose details you want to view.

2. Select ⊙ > [Detail].
   - This displays the detailed information screen.
   - With a g4p or g3p file, you can preview images by pressing ⊙.
   - Pressing ⊙ or ⊙ while a detailed information screen (or image preview screen) is displayed will scroll either up or down to the detailed information screen (or image preview screen) of the next file in the sequence that the files are listed on the Storage Memory tab.

To delete a file or folder

1. Highlight the file or folder you want to delete.

2. Select ⊙ > [Delete].
   - This causes a delete confirmation message to appear.

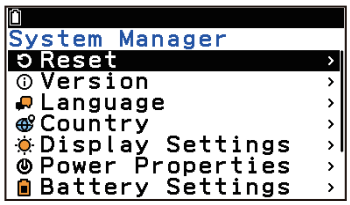
3. To delete, select [OK]. To cancel the operation, select [Cancel].

System App

Use the System app to reset the calculator or to change settings that affect the overall calculator operation.

System Manager Menu

After you select ⌂ > System to launch the app, the System Manager menu appears first. All of the operations described in this section start from this menu.



System Manager Menu Items

Resetting the Calculator (Reset)

1. From the System Manager menu, select [Reset].
2. Select the menu item for the type of reset operation you want to perform.

To reset/delete this:	Select this menu item:
Main Memory SETUP (page 194) contents System app settings listed below: CSV Format	[Settings]
All the Main Memory data Main Memory SETUP (page 194) contents	[Main Memory]
All the Storage Memory data	[Storage Memory]
All the Main Memory and Storage Memory data Main Memory SETUP (page 194) contents	[Main&Storage]
All the Main Memory and Storage Memory data Main Memory SETUP (page 194) contents System app settings listed below: Display Settings, Auto Power Off, Battery Settings, CSV Format, Capture Format	[Initialize All]

   • Selecting a menu item causes a confirmation message to appear for the type of reset you selected.

3. To reset, select [OK]. To cancel the operation, select [Cancel].

Important!

• After selecting [Initialize All], you need to perform several initial setup operations, just as you would immediately after turning on the calculator for the first time. The setup screens appear automatically in the following sequence. Configure the settings on each screen.
  - Display language selection (page 200)
  - Country Setting (fx-CG100 only) (page 200)
  - Display brightness adjustment (page 200)
  - Auto power off and backlight duration settings (page 200)
  - Battery type selection (page 201)

Viewing Version Information (Version)

You can view the OS version of the calculator on the Version information screen that appears when you select [Version] from the System Manager menu.

Note

- While the Version information screen is displayed, pressing ⋯ will display the menu item [OS Update].

Selecting a Display Language (Language)

1. From the System Manager menu, select [Language].
   - This displays the currently selected language.
2. Press OK.
3. From the menu that appears, select the display language you want.

Changing the Country Setting (Country) (fx-CG100 only)

The four available options for the Country setting are shown below. The default setting is “International”.

- International
- Portugal
- United Kingdom
- United States

The Country setting affects this calculator as described below.

- The arrangement of the HOME screen app icons
- The Catalog menu configuration and content
  - Display sequence in which categories appear on the menu
  - Items included in each category and the sequence in which they appear (except for the All category)
- Exam Modes that can be selected with the Exam Mode app and the sequence in which they appear on the menu.

Note

- Change the Country setting as required to use this calculator in specific countries. Otherwise, use the default setting (International).

Use the operation below to change the Country setting.

1. From the System Manager menu, select [Country].
   - This displays the currently selected Country setting.
2. Press OK.
   - This displays a menu of Country setting options.
3. Highlight the option you want and then press OK.

Adjusting Display Brightness (Display Settings)

1. From the System Manager menu, select [Display Settings].
2. Use ◁ and ▷ to adjust display brightness.

Configuring Auto Power Off and Backlight Duration Settings (Power Properties)

1. From the System Manager menu, select [Power Properties].
2. Perform one of the operations below to configure the setting you want.

To configure this setting:	Perform this operation:
Auto Power Off duration	(1) Highlight [Auto Power Off] and then press OK. (2) From the menu that appears, select [10 Min.] to specify approximately 10 minutes or [60 Min.] to specify approximately 60 minutes.

Backlight illumination duration	(1) Highlight [Backlight] and then press [OK]. (2) From the menu that appears, select [30 Sec.], [1 Min.], or [3 Min.].

Specifying the Battery Type (Battery Settings)

Important!

- After replacing the batteries, be sure to perform the operation below to select the battery type of the new batteries.

1. From the System Manager menu, select [Battery Settings].
   - This displays the currently selected battery type.

2. Press [OK].
3. From the menu that appears, select [Alkaline batteries] or [Ni-MH].
   - Read the warning message that appears on the display.
4. To register the selected battery type, select [OK]. To cancel the operation, select [Cancel].

Specifying the CSV File Import and Export Format (CSV Format)

When importing a CSV file that has been transferred from a computer to the calculator, specify the delimiter symbol and decimal point in accordance with the settings you specified on the application when outputting the CSV file. The comma (,) or semi-colon (;) can be specified for the delimiter, while the period (.) or comma (,) can be specified as the decimal point.

1. From the System Manager menu, select [CSV Format].
2. Use [^] and [v] to move the highlighting to [Separator], and then press [OK].
3. From the menu that appears, select [Comma] or [Semi-Colon], and then press [OK].
4. Use [^] and [v] to move the highlighting to [Decimal Separator], and then press [OK].
5. From the menu that appears, select [Period] or [Comma], and then press [OK].
   - If you chose [Comma] in step 2 above, you cannot choose [Comma] here.

Specifying the Image Capture Format (Capture Format)

Use the procedure below to specify the format of an image that was saved using screen capture (page 13).

1. From the System Manager menu, select [Capture Format].
   - This displays the currently selected image format.
2. Press [OK].
3. From the menu that appears, select [Memory] (to save in .g4p format) or [Bitmap] (to save in .bmp format).

Registering a User Name (User Name)

You can register a user name and organization name on your calculator. The registered user name and organization name are displayed on the screen when you turn off the calculator.

1. From the System Manager menu, select [User Name].
2. Highlight the line below “User Name.”
3. Input up to 19 characters for the user name and then press [OK].
4. Highlight the line below “Organization.”
5. Input up to 19 characters for the organization name and then press [OK].

Note

- Select ⋯ > [Delete All] to delete all input on this screen.
- “ID” at the bottom of the screen where you register your user name and organization name indicates the ID number of the device.

Exam Mode App (for fx-CG100)

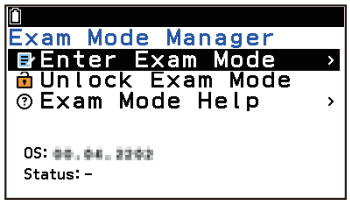
The Exam Mode puts some limits on calculator functions, which allows it to be used when taking an exam or test. Enter the Exam Mode only when actually taking an exam or test.

Your calculator has four* different Exam Modes.

- IB (International Baccalaureate)
- Portugal
- United Kingdom
- Texas (USA)

Select ⌂ > Exam Mode to start up the app and display the Exam Mode Manager menu.

You can use this menu to enter any one of the Exam Modes or to unlock an Exam Mode of another calculator.



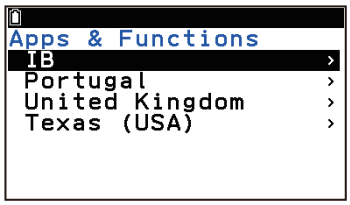
* You can choose from among four Exam Modes when “International” (default setting) is selected for the Country setting of the System app. If you select a different setting for Country, only the Exam Mode specific to that country and IB can be selected.

Restrictions While in an Exam Mode

Entering an Exam Mode affects calculator operation as described below.

- Some of the apps and functions are disabled. For more information, refer to the help that appears when you perform the operation below.

(1) On the Exam Mode Manager menu, select [Exam Mode Help] > [Apps & Functions].
  - This displays a menu for selecting Exam Mode type.



(2) Select the Exam Mode whose restrictions you want to view and then press OK.

- The calculator will back up user data (main memory) when you enter an Exam Mode. Backed-up data will be restored when you exit the current Exam Mode. Data you created while in an Exam Mode is deleted when you exit the mode.
- The information below applies to the Python app operations.
  - You can enter up to five characters for a py file name.
  - You can use single-byte numeric and alphabetic characters (lowercase only) for a py file name.
  - py files are stored in the calculator’s main memory.
  - The “Memory ERROR” message appears when main memory capacity is low. If this happens, delete any unnecessary files in order to increase available free space.
- Only the settings below are saved before entering an Exam Mode.

  Angle, Complex Mode, Display, Fraction Result, $\sqrt{\pi}$ Result, ×10■Key, Show Option Numbers, FORMAT Key, pinned input history, Q1Q3 Type, Language, Country, Battery Settings

  However, some are forced to change as shown below while in an Exam Mode.
  - System app’s Auto Power Off setting: Always “60 Min.”
  - System app’s User Name and Organization entries: Always blank

  Both of the above items are restored to their previous settings when you exit the Exam Mode.

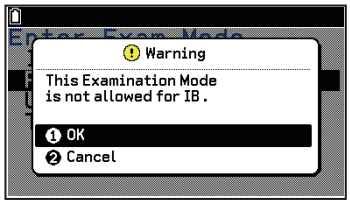
Important!

- Replacing batteries with a set of fresh ones is recommended before using an Exam Mode.

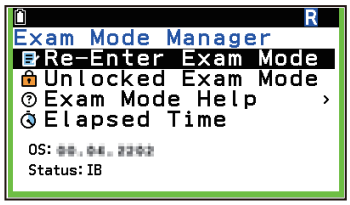
- In an Exam Mode, the backlight brightness level will change to the darkest setting automatically if you do not perform any operation on the calculator for about 30 seconds. Note that in an Exam Mode the backlight will not turn off, so battery power runs down faster. Exit the Exam Mode as soon as possible after you get through using it.

Entering an Exam Mode

1. ⌂ > Exam Mode
   - This displays the Exam Mode Manager menu.
2. Highlight [Enter Exam Mode] and then press [OK].
3. From the menu that appears, select the Exam Mode you want to enter.
4. Press [OK].
   - This displays the “Enter Exam Mode?” dialog on the calculator.
5. Press [OK].
   - If, in step 3 of this procedure, you select any Exam Mode besides IB, a warning dialog will appear at this time. To continue with the operation and enter the Exam Mode you selected in step 3, select [OK]. If you are about to take an IB exam, select [Cancel] to return to step 3, and then select IB.



   - After displaying the message Entering Exam Mode. for about three seconds, the calculator enters the Exam Mode you selected in step 3 above and displays the Exam Mode Manager menu.



Exam Mode Calculator Operations

- Exam Mode screens are identified by a boundary around the screen and a flashing icon in the upper right corner. The color of the boundary and the icon type depend on the Exam Mode.

Exam Mode	Boundary Color	Icon
IB	Green	R
Portugal	Blue	P
United Kingdom	Magenta	R
Texas (USA)	Cyan	T

The flashing interval of the icon slows down about 15 minutes after you enter an Exam Mode.

- In an Exam Mode, the Auto Power Off trigger setting is fixed at approximately 60 minutes.
- Selecting [Elapsed Time] on an Exam Mode Manager menu causes the dialog box shown below to appear. The dialog box shows the elapsed time in an Exam Mode.

You can restart the elapsed time count by performing one of the operations below.

- Press the RESTART button.
- Remove the calculator’s batteries.
- Delete Main Memory data.
- If you are already in an Exam Mode, re-enter it.*

* If you are already in one Exam Mode you will not be able to enter the other Exam Mode. To change to the other Exam Mode, exit the current Exam Mode and then enter the other one.

- The table below shows how certain operations affect the Exam Mode.

If you do this:	The calculator stays in the Exam Mode.	Data input in the Exam Mode is retained.
Turn power off and then back on again	Yes	Yes
Press the RESTART button	Yes	No
Remove the calculator's batteries	Yes	No
Delete Main Memory data	Yes	No

Re-entering the Exam Mode You are Currently In

You can re-enter an Exam Mode even if you are currently in an Exam Mode. Doing so discards any data you input and settings you configured while currently in the Exam Mode and returns them to what they were when you first entered the Exam Mode.*

* The only settings retained is the Battery Settings in the System app.

1. While in an Exam Mode, highlight [Re-Enter Exam Mode] and then press [OK].
   • This displays the "Re-Enter Exam Mode?" dialog on the calculator.

2. Press [OK].
   • After the message "Re-Entering Exam Mode." is displayed for about three seconds, the calculator automatically restarts and re-enters the Exam Mode.

Exiting an Exam Mode

There are three ways to exit an Exam Mode.

(1) Exiting an Exam Mode by Connecting to a Computer

1. Use a USB cable*1 to connect the calculator that is in an Exam Mode to a computer.
   • This displays the "Select Connection Mode" dialog on the calculator.

2. Highlight [USB Flash / Unlock Exam Mode] and then press [OK].
   • The message "Preparing USB" will appear on the calculator screen. Stand by and do not perform any operation on the calculator.
   • The screen shown to the right appears when a connection is established between the calculator and the computer.

3. On the computer, open the calculator drive.

4. On the computer, copy or delete any file that is on the calculator drive.

5. On the computer, terminate the connection between the calculator and computer.
   • Terminating a connection automatically causes the calculator to restart. This causes the calculator to exit an Exam Mode and return to the state it was in before the Exam Mode was entered.

*1 Use of a genuine CASIO USB cable is recommended. If you plan to use a commercially available USB cable, be sure to use a cable that can transfer data.

(2) Exiting an Exam Mode by Allowing 12 Hours to Elapse

Approximately 12 hours after entering an Exam Mode, turning on the calculator will cause it to exit the Exam Mode automatically.

Important!

• If you press the RESTART button or if you replace batteries before turning on the calculator, it will re-enter the Exam Mode when turned on, even if 12 hours have elapsed.

(3) Exiting an Exam Mode by Connecting to another Calculator

1. On the calculator that is in an Exam Mode (Calculator A), display the Exam Mode Manager menu.

2. Use a 2.5mm plug cable*2 to connect Calculator A to another calculator that is not in an Exam Mode (Calculator B).

3. On Calculator A, highlight [Unlocked Exam Mode] and then press (OK).

4. On Calculator B, select (⌂) > Exam Mode, highlight [Unlock Exam Mode] and then press (OK).
   • When the “Complete!” message appears on Calculator B, Calculator A automatically restarts. Calculator A exits an Exam Mode and the data on Calculator A returns to the state it was in before the Exam Mode was entered.

*2 Included in the optionally-available SB-2000 package (USB cable and 2.5mm plug cable).

Note

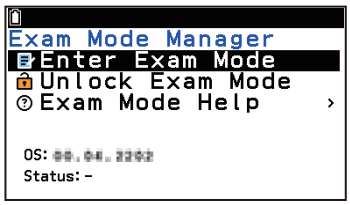
- You can also connect your calculator to another calculator model that has an exam mode and unlock your calculator’s Exam Mode from the other model or unlock the other model’s exam mode from your calculator.
  For details about the required operation on the other model, see the information below.
  - Exam Mode Manager menu’s [Exam Mode Help] > [How to Exit]
  - User’s documentation of the other calculator model

Exam Mode App (for fx-1AU GRAPH)

The Exam Mode puts some limits on calculator functions, which allows it to be used when taking an exam or test. Enter the Exam Mode only when actually taking an exam or test.

Select ⌂ > Exam Mode to start up the app and display the Exam Mode Manager menu.

You can use this menu to enter the Exam Mode or to unlock the Exam Mode of another calculator.



Restrictions While in the Exam Mode

Entering the Exam Mode affects calculator operation as described below.

- Some of the apps and functions are disabled. For details, see [Exam Mode Help] > [Apps & Functions] on the Exam Mode Manager menu.
- The calculator will back up user data (main memory) when you enter the Exam Mode. Backed-up data will be restored when you exit the Exam Mode. Data you created while in the Exam Mode is deleted when you exit the mode.
- Only the settings below are saved before entering the Exam Mode.

  Angle, Complex Mode, Display, Fraction Result, $\sqrt{\pi}$ Result, ×10■Key, Show Option Numbers, FORMAT Key, pinned input history, Q1Q3 Type, Language, Battery Settings

  However, some are forced to change as shown below while in the Exam Mode.
  - System app's Auto Power Off setting: Always "60 Min."
  - System app's User Name and Organization entries: Always blank

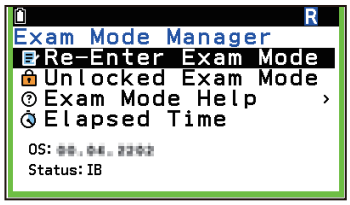
  Both of the above items are restored to their previous settings when you exit the Exam Mode.

Important!

- Replacing batteries with a set of fresh ones is recommended before using the Exam Mode.
- In the Exam Mode, the backlight brightness level will change to the darkest setting automatically if you do not perform any operation on the calculator for about 30 seconds. Note that in the Exam Mode the backlight will not turn off, so battery power runs down faster. Exit the Exam Mode as soon as possible after you get through using it.

Entering the Exam Mode

1. ⌂ > Exam Mode
   - This displays the Exam Mode Manager menu.
2. Highlight [Enter Exam Mode] and then press OK.
   - This displays the "Enter Exam Mode?" dialog on the calculator.
3. Press OK.
   - After displaying the message Entering Exam Mode. for about three seconds, the calculator enters the Exam Mode and displays the Exam Mode Manager menu.



Exam Mode Calculator Operations

- Entering the Exam Mode causes the entire display screen to be surrounded by a green boundary. A flashing display icon (R) will also appear on the display. The flash rate of the icon slows down about 15 minutes after entering the Exam Mode.

• In the Exam Mode, the Auto Power Off trigger setting is fixed at approximately 60 minutes.
• Selecting [Elapsed Time] on the Exam Mode Manager menu causes the dialog box shown below to appear. The dialog box shows the elapsed time in the Exam Mode.

You can restart the elapsed time count by performing one of the operations below.
- Press the RESTART button.
- Remove the calculator's batteries.
- Delete Main Memory data.
- If you are already in the Exam Mode, re-enter it.

• The table below shows how certain operations affect the Exam Mode.

If you do this:	The calculator stays in the Exam Mode.	Data input in the Exam Mode is retained.
Turn power off and then back on again	Yes	Yes
Press the RESTART button	Yes	No
Remove the calculator's batteries	Yes	No
Delete Main Memory data	Yes	No

Re-entering the Exam Mode

You can re-enter the Exam Mode even if you are currently in the Exam Mode. Doing so discards any data you input and settings you configured while currently in the Exam Mode and returns them to what they were when you first entered the Exam Mode.*

* The only settings that are retained are the System app's Battery Settings.

1. While in the Exam Mode, highlight [Re-Enter Exam Mode] and then press (OK).
   • This displays the "Re-Enter Exam Mode?" dialog on the calculator.

2. Press (OK).
   • After the message "Re-Entering Exam Mode." is displayed for about three seconds, the calculator automatically restarts and re-enters the Exam Mode.

Exiting the Exam Mode

There are three ways to exit the Exam Mode.

(1) Exiting the Exam Mode by Connecting to a Computer

1. Use a USB cable*1 to connect the calculator that is in the Exam Mode to a computer.
   • This displays the "Select Connection Mode" dialog on the calculator.

2. Highlight [USB Flash / Unlock Exam Mode] and then press (OK).
   • The message "Preparing USB" will appear on the calculator screen. Stand by and do not perform any operation on the calculator.
   • The screen shown to the right appears when a connection is established between the calculator and the computer.

3. On the computer, open the calculator drive.

4. On the computer, copy or delete any file that is on the calculator drive.

5. On the computer, terminate the connection between the calculator and computer.
   • Terminating a connection automatically causes the calculator to restart. This causes the calculator to exit the Exam Mode and return to the state it was in before the Exam Mode was entered.

*1 Use of a genuine CASIO USB cable is recommended. If you plan to use a commercially available USB cable, be sure to use a cable that can transfer data.

(2) Exiting the Exam Mode by Allowing 12 Hours to Elapse

Approximately 12 hours after entering the Exam Mode, turning on the calculator will cause it to exit the Exam Mode automatically.

Important!

- If you press the RESTART button or if you replace batteries before turning on the calculator, it will re-enter the Exam Mode when turned on, even if 12 hours have elapsed.

(3) Exiting the Exam Mode by Connecting to another Calculator

1. On the calculator that is in the Exam Mode (Calculator A), display the Exam Mode Manager menu.
2. Use a 2.5mm plug cable*2 to connect Calculator A to another calculator that is not in the Exam Mode (Calculator B).
3. On Calculator A, highlight [Unlocked Exam Mode] and then press (OK).
4. On Calculator B, select ⌂ > Exam Mode, highlight [Unlock Exam Mode] and then press (OK).
   - When the “Complete!” message appears on Calculator B, Calculator A automatically restarts. Calculator A exits the Exam Mode and the data on Calculator A returns to the state it was in before the Exam Mode was entered.

*2 Included in the optionally-available SB-2000 package (USB cable and 2.5mm plug cable).

Note

- You can also connect your calculator to another calculator model that has an exam mode and unlock your calculator’s Exam Mode from the other model or unlock the other model’s exam mode from your calculator.
  For details about the required operation on the other model, see the information below.
  - Exam Mode Manager menu’s [Exam Mode Help] > [How to Exit]
  - User’s documentation of the other calculator model

Other Information

Connecting the Calculator to a Computer

You can connect your calculator to a computer and transfer data between them. You can also use the computer to update the operating system of the calculator.

Important!

- Never touch the USB cable plugs and calculator screen while a data communication operation is in progress.

Connecting and Disconnecting with a Computer

Establishing a Connection between the Calculator and a Computer

Use of a genuine CASIO USB cable is recommended for connection. If you plan to use a commercially available USB cable, be sure to use a cable that can transfer data.

1. Use the USB cable to connect your computer to the calculator.
   - This displays the “Select Connection Mode” dialog on the calculator.

2. Highlight [USB Flash] and then press (OK).
   - The message “Preparing USB” will appear on the calculator screen. Stand by and do not perform any operation on the calculator.
   - The screen shown to the right appears when a connection is established between the calculator and computer. At the same time, your calculator’s storage memory is mounted on the computer as a USB drive. Here, this USB drive is referred to as the “calculator drive.”

3. Open the calculator drive on the computer.
   - Depending on your computer settings, a calculator drive window may automatically open when a connection is established between the calculator and computer. The calculator drive window shows files and folders stored in calculator memory.
   - If the Calculator Window does not open automatically, follow the instructions below that correspond to your computer’s operating system.

     Windows: Use File Explorer to open the calculator drive, which is located in “PC.” Note that “PC” may be a different name depending on the OS version.

     macOS: Double-click the Calculator Drive icon on the desktop to open the calculator drive window.

4. Use the Calculator Drive window to manipulate files and folders as required.
   - You can copy and delete files and folders. Use the same operations that you normally use for such operations on your computer.
   - For information on the files and folders displayed in the Calculator Drive window, see “Calculator Drive Contents” (page 211).

Important!

- Do not format the calculator drive from a computer. Doing so deletes all data in calculator memory. If the USB connection between the calculator and the computer is terminated, the message “File System ERROR” will appear on the calculator screen. See “Error Message Table” (page 247) for more information on what you need to do.

5. After you finish all the operations you want to perform, terminate the connection between the calculator and a computer.
   • See “Terminating the Connection between the Calculator and a Computer” (page 213).

Note

- The “Select Connection Mode” dialog will not appear if you connect the USB cable to the calculator while the  icon is in the status bar or while a graph, Geometry app figure, or other figure is flashing on the display. Wait until the  icon disappears or perform the required operation to stop the flashing of the graph, and then try connecting the USB cable again.
- If the message “Storage Memory Full” appears when you are trying to connect the calculator to a computer, it means that there is not enough calculator storage memory available. If this happens, delete any calculator storage memory files that you no longer need to free up memory and then try connecting again.
- When copying a file from your computer’s local disk to the calculator drive, it may take several minutes before copying starts. This is because copying automatically performs optimization of the calculator’s storage memory. It does not indicate malfunction.
- A USB connection between the calculator and a computer may be terminated automatically if the computer enters a power save mode, sleep mode, or any other standby state.

OS Update

Select [OS Update] on the Select Connection Mode dialog* when using a computer to update the calculator’s operating system. For details, see the text of releases that are issued when a new operating system version is released.

* See step 1 of the procedure under “Establishing a Connection between the Calculator and a Computer” (page 210).

Calculator Drive Contents

Your calculator has a main memory and a storage memory for storing data. You can use the Memory app (page 194) to display the contents of each memory area.

You can also use the calculator drive to display calculator’s Storage Memory contents on a computer screen. The root directory of the calculator drive displays the files and folders described below.

- @MainMem folder ... This folder contains the data of calculator main memory. See “@MainMem folder contents” (page 211). The contents of this folder are copied from main memory to storage memory each time the calculator is connected to a computer via USB.*
- Capt folder ... This folder is automatically created, when you capture a screen image (page 13), to save the captured image. Captured images saved in bmp format can be displayed on a computer screen.
- module.py ... This file is automatically created when you start up the Python app (page 119).
- Other ... Other files that contain calculator data (.g4m file name extension), py files, csv files, etc. are also displayed. For details, see “Files Displayed on the Storage Memory Tab” (page 196).

  * If there is not enough storage memory space available to perform this copy operation, the message “Storage Memory Full” appears when you connect via USB, and the copy operation will not be performed. If this happens, delete any calculator storage memory files that you no longer need to free up memory and then try connecting again.

@MainMem folder contents

All of the files below correspond to data in the calculator’s main memory. For details about data contents, see “Data Displayed on the Main Memory Tab” (page 194).

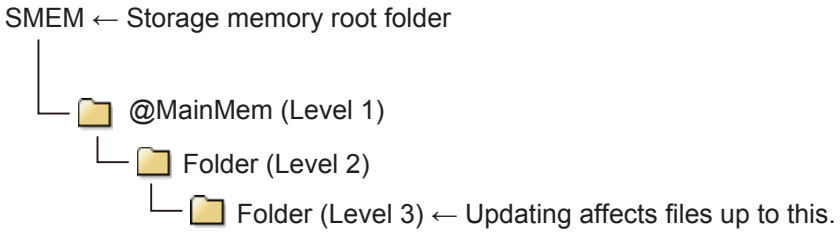
Folder name	File name*
@3DGRAPH	3DGRAPH.g4m
@GEOM	@IMAGE.g4m
	<Data name>.g4m
@DBASE	Adopted.g4m, Atomic.g4m, Electoro.g4m, Periodic.g4m, Physico.g4m, Univers.g4m, User.g4m
@PROBSIM	PROBSIM.g4m
LISTFILE	FILEx.g4m (LISTFILE x), LISTxx.g4m, LISTANS.g4m (LIST ANS)
MAT_VCT	MATx.g4m, MATANS.g4m (MAT ANS), VCTx.g4m, VCTANS.g4m (VCT ANS)
SSHEET	_SETTINGS.g4m, SHEET.g4m, <Data name>.g4m
ROOT	ALPHAMEM.g4m (ALPHA MEM)
	CONICS.g4m
	DIST.g4m
	DYNAMEM.g4m (DYNA MEM)
	EQUATION.g4m
	FINANCE.g4m
	NUMINEQ.g4m (fx-CG100 only)
	RECUR.g4m (RECURSION)
	SETUP.g4m
	STAT.g4m
	SYSTEM.g4m
	TABLE.g4m
	Y=DATA.g4m

* File name extensions are not displayed on the Main Memory tab of the calculator's Memory app. For files that names enclosed in parentheses, the Main Memory tab shows the name in parentheses.

Main Memory Data Updating upon Termination of a USB Connection

While there is a USB connection between the calculator and a computer, you can use the computer to edit the @MainMem folder contents by deleting folders and files, adding files, etc. When you terminate the USB connection, the calculator's main memory data is updated with the current contents of the @MainMem folder. Note the following important points.

- Deleting the @MainMem folder will cause all data in the calculator's main memory to be initialized.
- Updating the @MainMem folder affects up to three levels of folders inside the storage memory root folder.



Any folders and files past Level 3 are moved to a folder named "SAVE-F" in storage memory.

- Adding a g4m file to the @MainMem folder while there is a USB connection between the calculator and a computer will copy the data item(s) included in the g4m file to the calculator's main memory. For details about the main memory data item names that correspond to the g4m file names in the @MainMem folder, see "@MainMem folder contents" (page 211). If there is no folder in main memory that corresponds to the data items included in the g4m file, a corresponding folder will be created automatically and the data items will be copied to that folder.

- Depending on the data type, an overwrite confirmation message will appear if there is already data with the same name in calculator's main memory as the data being copied from @MainMem folder. For information about which types of data cause a confirmation message to appear, see "Important!" under "To load a g4m file into Main Memory" (page 197).
- If you place a file or folder that is not supported by the calculator into the @MainMem folder, it will be transferred to a folder named "SAVE-F" in the calculator's storage memory and will not be shown in main memory.
- If the size of the data in the @MainMem folder exceeds the available capacity of main memory, the message "Memory ERROR" will appear on the calculator when you terminate the USB connection and main memory will not be updated.

Terminating the Connection between the Calculator and a Computer

Important!

- Do not disconnect the USB cable connecting the calculator to the computer until the System Manager menu appears when you complete the operation in step 4 below.

1. If the calculator is connected to a Windows computer, note the drive letter (E, F, G, etc.) assigned to the calculator drive.

2. Depending on your computer's operating system, perform one of the operations below.
   Windows: Click the "Safely Remove Hardware" icon in the task tray in the lower right corner of the display. On the menu that appears, select the drive whose letter matches the calculator drive letter you noted in step 1 above. Check to make sure the "Safe To Remove Hardware" message is displayed.
   macOS: Drag the calculator drive icon to the Eject icon (Trash icon). Check to make sure that the calculator drive icon is no longer on your desktop.

3. While the message "Updating Main Memory" is displayed on the calculator, wait and do not perform any operation.

4. When the message "Complete!" appears on the calculator display, press (OK).
   - This displays the System Manager menu of the System app.
   - You can disconnect the USB cable connecting the calculator to the computer at this time.

Settings Menu Details

Settings Menu and Submenus

The number of items that appear on the Settings menu depends on the app you are configuring. There are several different item types as described below.

Item Type	Description
General	These items are common to most apps.
Graph	These items are displayed for the Graph&Table app. Some of these items also appear in the Recursion, 3D Graph, Dyna Graph, Conic Graphs, Statistics, Distribution, Financial, and Geometry apps.
Statistics	These items appear for the Statistics app.
Spreadsheet	These items appear for the Spreadsheet app.
Financial	These items appear for the Financial app.
Prob Sim	These items appear for the Prob Sim app.
Dyna Graph	These items appear for the Dyna Graph app.
3D Graph	These items appear for the 3D Graph app.
Geometry	These items appear for the Geometry app.
Specific	These items appear for specific apps.

In the following sections, the type of each item is shown in parentheses after the item name. A diamond mark (◆) in the following sections indicates the initial default setting of each item.

Auto Recalculation (Spreadsheet)

Selects whether or not the Spreadsheet app should perform auto recalculation each time data is input.

On◆	Formulas are automatically recalculated each time data is input.
Off	Formulas are not recalculated when data is input.

Edit Box Shows (Spreadsheet)

Specifies what the edit box of the Spreadsheet app shows when the cursor is at a cell that contains a formula.

Formula◆	Displays cell contents as a formula.
Value	Displays cell contents as a value.

Cursor Moves (Spreadsheet)

Specifies the direction the cursor moves after data is input or pasted into a Spreadsheet app cell.

Down◆	Moves down one cell.
Right	Moves right one cell.

Payment Point (Financial)

This setting affects Financial app Compound Interest and Amortization calculations.

Beginning	Specifies the beginning of the period as the payment date.
End◆	Specifies the end of the period as the payment date.

Number of Days/Year (Financial)

This setting affects Financial app Simple Interest, Days Calculation, and Bond Calculation.

365◆	Specifies 365 as the number of days per year for calculations.
360	Specifies 360 as the number of days per year for calculations.

Interest Paid (Financial)

This setting affects the Financial app Bond Calculation.

Annually◆	Specifies an annual interest payment interval.
Semi-annually	Specifies a semi-annual interest payment interval.

Maximum Scale (Prob Sim)

Specifies whether the maximum value of the vertical axis on the Result tab of the Prob Sim app is shown or hidden on the graph.

On	Shows the maximum value.
Off◆	Hides the maximum value.

Animation (Prob Sim)

Specifies whether an animation should be displayed before results when a simulation is performed in the Prob Sim app.

On◆	Plays an animation before displaying results.
Off	Displays only the results without an animation.

Looping (Dyna Graph)

When graphing with the Dyna Graph app, specifies whether the app should automatically return to the Setup tab after a specified number of iterations or continue drawing.

On	Drawing continues until you press AC.
Off◆	The display automatically returns to the Setup tab after 10 iterations of coefficient value increase and decrease.

Locus (Dyna Graph)

Specifies whether to show or hide the loci of all graphs drawn with the Dyna Graph app.

On	Shows loci.
Off◆	Hides loci.

Processing Speed (Dyna Graph)

Specifies whether the Dyna Graph app plots all x-axis dots or plots every other dot. This setting is enabled only when graphing y= type functions.

High	Plot every other x-axis dot. This results in faster graphing than Normal speed.
Normal◆	Plot all x-axis dots.

Angle (General)

Selects the angle unit for input and output.

Degree, Radian◆, Gradian*

* The Geometry app does not have a “Gradian” option.

Table with Graph (Graph)

On	Displays both the numerical table and graph on the Table tab.
Off◆	Displays only the numerical table on the Table tab.

Show V-Win Settings (Graph)

On◆	Causes the View Window dialog to appear when a graph draw operation is started.*

Off	The View Window dialog does not appear when a graph draw operation is started.* Instead, the current View Window settings are applied.

* A graph draw operation is started when you press ⇥ on the Function tab of the Graph&Table application, etc.

3D Axes (3D Graph)

Specifies whether the 3D Graph app shows or hides Cartesian coordinate axes in the graph window.

On◆	Shows Cartesian coordinate axes.
Off	Hides Cartesian coordinate axes.

Box (3D Graph)

Specifies whether the 3D Graph app shows or hides boxed axes in the graph window.

On◆	Shows boxed axes.
Off	Hides boxed axes.

3D Label (3D Graph)

Specifies whether the 3D Graph app shows or hides axis labels in the graph window.

On◆	Shows axis labels.
Off	Hides axis labels.

View Window (Statistics)

Auto◆	View Window settings are automatically adjusted based on the type of graph you are drawing.
Manual	View Window settings are normally applied regardless of the type of graph you are drawing. However, in the case of a pie chart or hypothesis test graph, the calculator always uses automatically-generated View Window settings.

Q1Q3 Type (Statistics)

Use this setting to choose how to calculate the first and third quartiles (Q1 and Q3).

Standard◆	With this method, the data set is divided into two halves at the median (50th percentile, or Q2), and then the upper and lower sets of data are divided into two halves to determine Q1 (25th percentile) and Q3 (75th percentile) respectively.
OnData	When the 25% cumulative frequency percentage determined from the data is a and the 75% percentage is b, this method returns the data value closest to and above a as Q1, and the data value closest to and above b as Q3.

Sub Name (Statistics)

On◆	Shows the SUB (subname) line of the List Editor.
Off	Hides the SUB (subname) line of the List Editor.

List File (Statistics)

Any one of six files (File1◆ to File6) can be selected as the “List Files” (page 32).

Coord (Graph)

This is a display setting that controls what happens when the trace pointer is displayed on a graph while using the graph analysis and trace functions.

On◆	Shows the coordinates of the current trace pointer position.

Off	Hides the coordinates of the current trace pointer position.

Angle Unit (Geometry)

Specifies whether to include units when displaying angles for a figure on the Geometry app drawing screen.

On◆	Displays angles with units.
Off	Displays angles without units.

Length Unit (Geometry)

Specifies whether to include units when displaying lengths for a figure on the Geometry app drawing screen.

mm, cm, m, km, in, ft, yd, mile	Displays lengths with units.
Off◆	Displays lengths without units.

Grid (Graph)

Use this setting to show or hide grid points or grid lines within the graphing area.

On	Shows grid points.
Off*	Hides grid points and lines.
Line◆	Shows grid lines.

* The initial default setting for the Geometry app is “Off”.

Grid Space (Geometry)

Specifies the pitch (spacing) of the grid points and lines on the Geometry app drawing screen. You can specify a value from 0.01 to 1◆ to 1000, in increments of 0.01.

Axes (Graph)

Use this setting to show or hide coordinate axes (x-axis and y-axis) in the graphing area.

On	Shows coordinate axes.
Off*	Hides coordinate axes.
Scale◆	Shows coordinate axes along with a scale on each axis.

* The initial default setting for the Geometry app is “Off”.

Label (Graph)

On◆	Shows x-axis, y-axis, and origin (0) labels.
Off	Hides labels.

Show Equation (Graph)

This is a display setting that controls what happens when the trace pointer is displayed on a graph while using the graph analysis and trace functions.

On◆	Shows the equation of the graph where the trace pointer is currently located.
Off	Hides the equation of the graph where the traces pointer is currently located.

Graph Simultaneously (Graph)

Specifies the graphing method when drawing multiple graphs.

On	All graphs drawn at the same time.
Off◆	Graphs drawn individually.

Plot/Line Color (Graph)

Specifies the color of the points and lines drawn by trace and sketch.
Black, Blue, Red, Magenta, Green◆, Cyan, Yellow

Sketch Line (Graph)

Specifies the type of line drawn by sketch.
Normal◆, Thick, Broken, Dot, Thin

Draw Type (Graph)

Connect◆	Draws a graph using a continuous line.
Plot	Draws a graph by plotting individual points.

Complex Mode (General)

This setting specifies the calculation ranges of real and imaginary numbers, and the display format of complex numbers.

Real◆	Calculates a range of real numbers. An error is displayed if the calculation contains even one function term with a real number argument and an imaginary whose solution is imaginary. However, if a complex number is specified as an argument while “Real” is selected, a complex number calculation will be performed. If the result of a calculation containing a complex number is a complex number, it is displayed in the form a+b***i***.
a+b***i***	Calculates a range of real and imaginary numbers. The result of a complex number calculation is displayed in rectangular form.
r∠θ	Calculates a range of real and imaginary numbers. The result of a complex number calculation is displayed in polar form.

Display (General)

This setting specifies the display format (number of digits) of calculation results. It also specifies engineering symbols appended to calculation results.

Fix0: 0. - Fix9: 0.123456789	Specifies the number of decimal places (0 to 9) for calculation results. Calculation results are rounded to the next digit following the specified digit.
Sci1: 1×10^{-1} - Sci10: 1.234567890×10^{-1}	Specifies the number of significant digits (1 to 10) and the exponent of calculation results. Calculation results are rounded to the next digit following the specified digit.
Norm1: 1.23×10^{-3}◆, Norm2: 0.00123	Displays calculation results in exponential form when they are within the ranges below. Norm1: 1.23×10^{-3} : $\lvert x\rvert < 10^{-2}$, $10^{10} \leq \lvert x\rvert$ Norm2: 0.00123 : $\lvert x\rvert < 10^{-9}$, $10^{10} \leq \lvert x\rvert$

Engineer Symbol

On	Displays calculation results using engineering symbols.*
Off◆	Displays calculation results without engineering symbols.

* m, μ, n, p, f, k, M, G, T, P, E

Fraction Result (General)

🖼◆	Displays the result of a fraction calculation as an improper fraction.
🖼	Displays the result of a fraction calculation as a mixed fraction.

$\sqrt{\pi}$ Result (Specific)

This setting specifies whether the Calculate, Num Ineq (fx-CG100 only) and Equation apps display results that include $\sqrt{}$ and/or π.

On◆	Displays calculation results in a form that includes $\sqrt{}$ and/or π when possible.
Off	Displays calculation results in decimal form even if it is possible to display them in a form that includes $\sqrt{}$ and/or π.

Background (Graph)

This setting selects a background image for the graph window.

None◆	No background image displayed.
Open	Selecting this item displays a dialog you can use to select a background image. For information about images that can be used as backgrounds (.g4p or .g3p), see “Using the Storage Memory Tab” (page 196).

×10■Key (General)

This setting specifies the operation of the ×10ˣ key. For an example of operation of the ×10ˣ key, see “Scientific Function Calculations” (page 19).

×10□ (Power)	Pressing ×10ˣ produces the same input result as pressing ⊗ ① ⓪ ■□.
×10 (Sci Notation)	Pressing ×10ˣ inputs the function ×10. This function takes arguments before and after it with the form $a\times10^n$ (n is an integer) and returns the result of 10^n multiplied by a.
×10□ (Sci Notation)◆	Pressing ×10ˣ inputs the function ×10□. This function takes arguments before and after it with the form $a\times10^n$ (n is an integer) and returns the result of 10^n multiplied by a.

ΣDisplay (Specific)

This setting shows or hides a column of cumulative sums on the Table tab of the Recursion app.

On	Shows the cumulative sum column on the Table tab.
Off◆	Hides the cumulative sum column on the Table tab.

Ineq Region Type (Graph)

This setting specifies how multiple inequality graphs should be filled.

Intersection	Shades only areas where the conditions of all of the graphed inequalities are satisfied.
Union◆	Shades all areas where the conditions of each graphed inequality are satisfied.

Derivative (Graph)

This setting shows or hides a differential coefficient column on the Table tab of the Graph&Table app. This setting also affects whether or not the differential coefficients at the position of the trace pointer on the Graph tab of the Graph&Table app or Conic Graphs app are displayed.

On	Shows a differential coefficient column on the Table tab. When this setting is selected, differential coefficients at the position of the trace pointer on the Graph tab are also displayed.*
Off◆	Hides differential coefficients on both the Table tab and the Graph tab.

* Display of differential coefficients at the trace pointer position is enabled only when the ☰ > [Coord] setting is turned on.

Simplify (Specific)

Use this setting to specify whether or not to reduce fractions produced as calculation results by the Calculate app.

Auto◆	Automatically reduces fractional calculation results.
Manual	Displays fractional calculation results without reducing them.*

* Fractional results are initially displayed without reduction, but you can reduce them later. See “Simplification” (page 223).

Show Option Numbers (General)

Specifies whether to show Option Numbers (numbers and letters to the left of menu items) on menus and dialogs. For details about Option Numbers see “Menu and Dialog Operations (Using Option Numbers)” (page 11).

On◆	Shows Option Numbers.
Off	Hides Option Numbers.

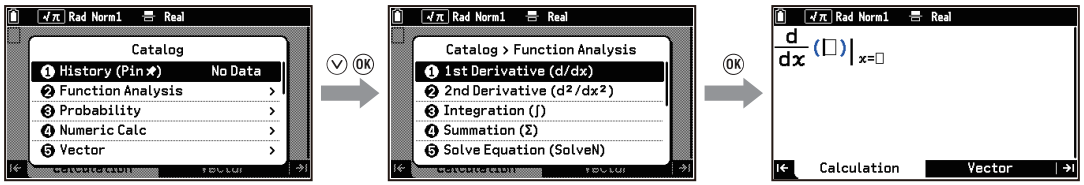
FORMAT Key (General)

You can toggle what happens when FORMAT is pressed between the two operations described below.

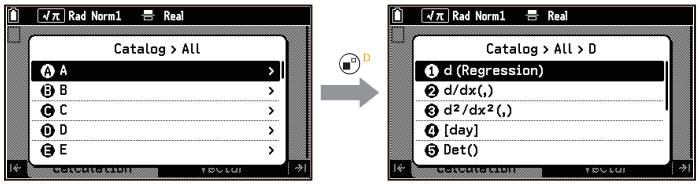
$\frac{\square}{\square}\pi\sqrt{}$ ↔ Decimal◆ (Toggle)	Each press of FORMAT toggles the displayed calculation result between a form that includes fraction/π/$\sqrt{}$ and decimal form. Press ⬆ FORMAT to display the Format Menu (page 17).
Format Menu (Menu)	Press FORMAT to display the Format Menu (page 17). Each press of ⬆ FORMAT toggles the displayed calculation result between a form that includes fraction/π/$\sqrt{}$ and decimal form.

Catalog Menu Details

The Catalog menu, which appears when you press ⌨, is a comprehensive list of all functions, commands, app variables,* and symbols available on the calculator. You can select the item you want on the calculator and enter it into a calculation or expression.



The list produced by ⌨ > [All] contains all items supported by your calculator. While the alphabetical list is displayed, you can press a key from X A to 0 Z to display a list of items beginning with the letter you pressed.



Functions and symbols that are not included in a group from [A] to [Z] can be accessed with ⌨ > [All] > [Symbol].

* Items included in ⌨ > [Variable Data] (input/output variables used in an app)

Note

- Pressing ⌨ while using the Python app or the Base-N app displays a Catalog menu specific to each app. For details, see the chapters explaining each app.
- The Catalog menu displays the names of functions and commands in the menus by category (such as Integration (∫), etc.). On the ⌨ > [All] and Input History menus, the functions and commands are displayed in line input syntax (such as ∫(,,), etc.).

Using Input History

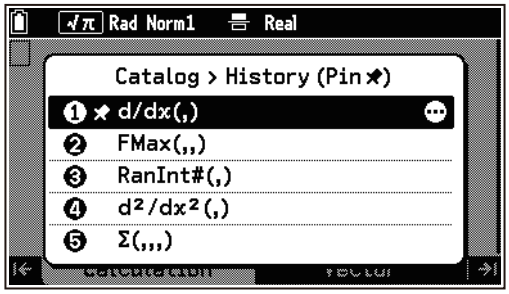
Up to 10 of the latest functions and commands* recently entered from the Catalog menu are maintained as input history. To view the input history, select ⌨ > [History (Pin ✱)].

* Including pinned input history.

Pinning Input History

While viewing input history, select the item you wish to pin and then press ⋯. This causes a pin to appear to the left of the item.

The next time you open the input history, the pinned item will be at the top of the list.



To unpin an item, select the item you wish to unpin and press ⋯.

Category Grouped Item List

Note the following points concerning the syntax of functions and commands, except those in the Unit Conversions category.

- If the natural input syntax and line input syntax are different for a function, the natural input syntax is shown first, followed by the line input syntax.
- Anything that is optional in a syntax is enclosed in square brackets ([ ]). With the syntax $\int(f(x),a,b[,tol])$, the tol argument can be omitted, resulting in $\int(f(x),a,b)$.

Note

- The categories listed in this section and the functions, commands, app variables,* and symbols included in each category are presented in the order they appear when [Country] > [International] is selected in the System app.
- Regardless of the model (fx-CG100 or fx-1AU GRAPH) or configuration, items included in ⓜ > [All] are the same. All items listed in this manual are displayed in alphabetical order.

* Items included in ⓜ > [Variable Data] (input/output variables used in an app)

Function Analysis

1st Derivative (d/dx) d/dx(,)

Uses approximate calculation to determine the first-order differential coefficient of $f(x)$ at $x = a$.

Syntax: $\frac{d}{dx}(f(x))|_{x=a}$ $d/dx(f(x),a)$

Not allowed within this syntax: d/dx, d^2/dx^2, $\int dx$, Σ, FMin, FMax, Solve, RndFix

Example: $\frac{d}{dx}(f(x^3+4x^2+x-6))|_{x=3} = 52$

Precautions

- When $f(x)$ is a trigonometric function, make sure to select the following for the angle unit: ⓢ > [Angle] > [Radian].
- Inaccurate results and errors can be caused by any one of the following:
  - Discontinuous points in x values
  - Extreme changes in x values
  - Inclusion of the local maximum point and local minimum point in x values
  - Inclusion of the inflection point in x values
  - Inclusion of indifferentiable points in x values
  - Calculation results approaching zero

2nd Derivative (d²/dx²) d²/dx²(,)

Uses approximate calculation to determine the second-order differential coefficient of $f(x)$ at $x = a$.

Syntax: $\frac{d^2}{dx^2}(f(x))|_{x=a}$ $d^2/dx^2(f(x),a)$

The items that are not allowed within this syntax and precautions are the same as those for d/dx.

Integration (∫) ∫(,,)

Uses approximate calculation to determine the integral of $f(x)$ at $a \le x \le b$. This function returns a positive value when $f(x)$ is in the positive range and a negative value when $f(x)$ is in the negative range (Example: $\int_2^3 x^2 - 4dx = \frac{7}{3}$; $\int_1^2 x^2 - 4dx = -\frac{5}{3}$).

Syntax: $\int_a^b f(x)dx$ $\int(f(x),a,b[,tol])$

- For tol, input the allowable error (tolerance) range. Default: 1×10^{-5} if omitted and for natural input.

Not allowed within this syntax: d/dx, d^2/dx^2, $\int dx$, Σ, FMin, FMax, Solve, RndFix

Example: $\int_1^5 2x^2 + 3x + 4dx = \frac{404}{3}$

Precautions

- When $f(x)$ is a trigonometric function, make sure to select the following for the angle unit: ☰ > [Angle] > [Radian].
- Because numerical integration is used, large error may result in calculated integration values due to the content of $f(x)$, positive and negative values within the integration interval, or the interval being integrated. (Examples: When there are parts with discontinuous points or abrupt change. When the integration interval is too wide.) In such cases, dividing the integration interval into multiple parts and then performing calculations may improve calculation accuracy.

Summation (Σ) Σ(,,,)

Obtains the sum for a specified range of $f(x)$.

Syntax: $\sum_{x=a}^{b}(f(x))$ $\sum(f(x),x,a,b[,n])$ a, b, n = integers, $a < b$

- x can be any alpha variable. n specifies the step interval. Default: 1 if omitted and for natural input.

Not allowed within this syntax: d/dx, d^2/dx^2, $\int dx$, Σ, FMin, FMax, Solve, RndFix

Example: $\sum_{x=2}^{6}(x^2-3x+5)=55$

Solve Equation (SolveN) SolveN()

Obtains multiple solutions of an equation.

Syntax: SolveN($f(x)$ [= right side] [,x] [,lower limit,upper limit])

- If [=right side] is omitted, $f(x)$ = 0 is assumed. Specify any alpha variable for [,x] and use the same variable for $f(x)$. If [,x] is omitted, the variable x is used.
- Up to 10 solutions are returned in list form.
- "No Solution" is returned if no solution exists.
- If a solution other than one(s) provided might exist, the message "More solutions may exist. " appears on the display.

Not allowed within this syntax: d^2/dx^2, Σ, FMin, FMax, Solve

Example: SolveN(x^2-5x-6) = {-1,6}

Solve Equation (Solve) Solve(,)

Approximates a single solution for $f(x)$ = 0. This function has the same functionality as the Equation app's "Using Solver" (page 116).

Syntax: Solve($f(x)$,initial estimate [,lower limit,upper limit])

Not allowed within this syntax: d^2/dx^2, Σ, FMin, FMax, Solve

Remainder of Integer÷Integer Rmdr

Obtains the remainder when an integer is divided by another integer.

Syntax: dividend Rmdr divisor

Example: 17 Rmdr 7 = 3

Integer Part of Int÷Int Int÷

Obtains the quotient of an integer divided by another integer.

Syntax: dividend Int÷ divisor

Example: 17 Int÷ 7 = 2

Simplification ▶Simp

Reduces a fraction to its lowest terms. With the Calculate application, use the settings below.

☰ > [Simplify] > [Manual] ☰ > [Complex Mode] > [Real]

Use one of the syntaxes below for ▶Simp.

Syntax 1: Fraction▶Simp

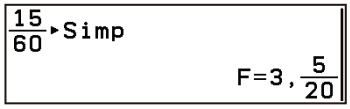
Automatically reduces the fraction in the argument by dividing by the smallest prime number that can be divided. The prime number and the result of the reduction are shown on the display.

Syntax 2: Fraction▶Simp n

Divides the fraction in the argument by the divisor specified by n. The result of the division is shown on the display.

Example 1: $\frac{15}{60} = \frac{5}{20} = \frac{1}{4}$

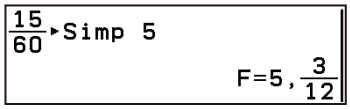
15 (▤) 60 (>)
(MENU) > [Function Analysis] > [Simplification] (EXE)



(MENU) > [History (Pin 📌)] > [▶Simp] (EXE)

Example 2: $\frac{15}{60} = \frac{3}{12}$ (Specifies a divisor of 5.)

15 (▤) 60 (>)
(MENU) > [Function Analysis] > [Simplification]5 (EXE)



Precautions

- When [a+b*i*] or [r∠θ] is selected for (SHIFT) > [Complex Mode], fraction calculation results always are simplified before being displayed, even if (SHIFT) > [Simplify] is set to [Manual].

Function Minimum FMin(,,)

Returns, in list form, the coordinates of the minimum values of $f(x)$ at $a \leq x \leq b$.

Syntax: FMin($f(x)$,a,b[,n]) n: Calculation accuracy (n = integer from 1 to 9)

Not allowed within this syntax: d/dx, d^2/dx^2, $\int dx$, Σ, FMin, FMax, Solve, RndFix

Example: FMin(x^2,-2,1) = {0,0}

Precautions

- Discontinuous points or sections with drastic fluctuation can adversely affect precision or cause an error.
- Inputting a larger value for n increases the precision of the calculation, but it also increases the amount of time required to perform the calculation.

Function Maximum FMax(,,)

Returns, in list form, the coordinates of the maximum values of $f(x)$ at $a \leq x \leq b$.

Syntax: FMax($f(x)$,a,b[,n]) n: Calculation accuracy (n = integer from 1 to 9)

The items that are not allowed within this syntax and precautions are the same as those for FMin.

Probability

Factorial (!) !

Obtains the factorial of 0 or a positive integer.

Syntax: $n!$ n = integer

Permutation (P) P

Obtains the total number of r-permutations taken from set n.

Syntax: nPr n, r = integers

Combination (C) C

Obtains the total number of r-combinations from set n.

Syntax: nCr n, r = integers

Random Number (0 to 1) Ran#

Each execution returns a 10 digit random number (from 0 to 1).

Syntax: Ran# [a] $1 \le a \le 9$ (a = integer)

- a: Specifies the random number sequence. If omitted, a true random number is returned. If specified, the corresponding calculator random number sequence is invoked, and a fixed random number is returned. For example, executing Ran# 1 after initializing the sequences* always returns random numbers from Sequence 1 in order (0.701320948, 0.9297706456, 0.2939058016, ...)

* To initialize the sequences, execute Ran# 0. This also initializes the sequences in RanList#. The sequences can also be initialized by using Ran# or RanList# to generate a series of random numbers that is different from the last executed series or by generating a true random number.

Random Integer (n to m) RanInt#(,)

Generates an integer random number between two specified integers n and m.

Syntax: RanInt#(n,m[,a]) $n < m$, $|n| < 1\times10^{10}$, $|m| < 1\times10^{10}$, $m - n < 1\times10^{10}$, $1 \le a \le 999$

- a: Specifies the number of random numbers. If omitted, one random number is returned. If specified, returns the specified number of random numbers in list form.

Random Number (Normal) RanNorm#(,)

Uses normal distribution to generate a 10-digit random number based on the specified mean μ and standard deviation σ.

Syntax: RanNorm#(σ,μ[,n]) $\sigma > 0$, $1 \le n \le 999$

- n: Specifies the number of random numbers. If omitted, one random number is returned. If specified, returns the specified number of random numbers in list form.

Example: To generate a random number of height values obtained according to a normal distribution for a group of children less than one year old with a mean height of 68 cm. Assume that the standard deviation is 8: RanNorm#(8,68)

Random Number (Binomial) RanBin#(,)

Uses binomial distribution based on the specified number of trials n, and the value of probability p to generate a random integer.

Syntax: RanBin#(n,p[,m]) $1 \le n \le 100000$, $1 \le m \le 999$, $0 \le p \le 1$

- m: Specifies the number of random numbers. If omitted, one random number is returned. If specified, returns the specified number of random numbers in list form.

Random Num (0 to 1) to List RanList#()

Each execution returns, in list form, the specified number of random numbers (0 to 1, 10 digits).

Syntax: RanList#(n[,a]) $1 \le a \le 9$, $1 \le n \le 999$ (a, n = integers)

- n: Specifies the number of trials. This parameter specifies the number of random numbers to be generated.
- a: Same as Ran#.

Example: (Immediately after Ran# 0 is executed) RanList#(3,1) = {0.701320948,0.9297706456,0.2939058016}

Random Sample from List RanSamp#(,)

Randomly samples elements from a list and returns the result in list form.

Syntax: RanSamp#(List,n[,m])

- List: A list variables (List 1 through List 26 or List Ans)* or a list

* List variables can also be specified using sub-names (page 27).

- n: Number of trials ($1 \le n \le 999$ when $m = 0$, $1 \le n \le$ number of elements in List when $m = 1$)
- m: Specifies 0 or 1 (0 when omitted). When $m = 0$, each element can be extracted multiple times. When $m = 1$, each element can be extracted only once.

Example: To extract two random elements from {1,3,6,7}: RanSamp#({1,3,6,7},2,1)
To extract five random elements from {1,3,6,7}: RanSamp#({1,3,6,7},5)

Numeric Calc

GCD GCD(,)

Obtains the greatest common divisor of multiple integers.

Syntax: GCD(n,m)

LCM LCM(,)

Obtains the least common multiple of multiple integers.

Syntax: LCM(n,m)

Absolute Value Abs()

Finds the absolute value of argument n.

Syntax: |n| Abs(n)

Integer Part Int()

Extracts the integer part of argument n.

Syntax: Int(n)

Example: Int(-3.5) = -3

Fraction Part Frac()

Extracts the fractional part of argument n.

Syntax: Frac(n)

Example: Frac(-3.5) = -0.5

Round Off Rnd

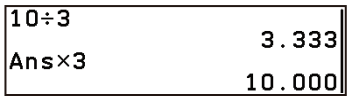
This function is available on the Calculation tab of the Calculate app. It rounds the value of the last calculation result (Ans) on the result display in accordance with the ☰ > [Display] setting.

Syntax: Rnd (no argument, valid for previous calculation result only)

Example: While [Display] > [Fix3: 0.123], to divide 10 by 3 and then multiply Ans by 3

Rnd not used:

10 ÷ 3 EXE
× 3 EXE



Rnd used:

10 ÷ 3 EXE
▤ > [Numeric Calc] > [Round Off] EXE
× 3 EXE

- When the setting is [Display] > [Fix3: 0.123], 10÷3=3.333 is displayed, but 15 digits is retained internally, so Ans×3=10.000. If the result of 10÷3 is rounded using Rnd as shown, Ans×3=9.999.

Largest Integer Intg()

Returns the largest integer that does not exceed argument n.

Syntax: Intg(n)

Example: Intg(-10.56) = -11

Round Internal RndFix()

Rounds argument n to the place following the number of decimal places specified by m (0 to 9).

Syntax: RndFix(n[,m])

- If m is omitted, rounding is performed in accordance with the ☰ > [Display] setting, the same as with the Rnd function.

Not allowed within this syntax: d/dx, d^2/dx^2, $\int dx$, Σ, FMin, FMax, Solve, RndFix, logab

Example: RndFix(1.23456,3) = 1.235

Division Remainder MOD(,)

This function obtains the remainder of a division operation. It returns the remainder when n is divided by m.

Syntax: MOD(n,m) (n, m = integers)

Example: MOD(17,3) = 2

Remainder Exponentiation MOD_Exp(,,)

This function calculates a modular exponent. It returns the remainder when n is multiplied by p power and then divided by m.

Syntax: MOD_Exp(n,p,m) (n, p, m = integers)

Example: MOD(2,4,3) = 1

Vector

Vct n and Vct m can be vectors or vector variables.

The vectors listed the example (such as [1 2]) are entered using ⋯ > [m×n]. For details, see "Inputting a Vector into a Calculation" (page 22).

> **Note**
> • When calculating a dot product, cross product, and angle formed by two vectors, the dimensions of the two vectors must be the same.

Vector Vct

Enters "Vct ". Next, specify a vector variable by entering a letter from A to Z, or Ans.

Dot Product DotP(,)

Obtains the dot product of two vectors.

Syntax: DotP(Vct n,Vct m)

Example: DotP([1 2],[3 4]) = 11

Cross Product CrossP(,)

Obtains the cross product of two vectors.

Syntax: CrossP(Vct n,Vct m) (The dimensions of Vct n and Vct m must be 1 × 2, 1 × 3, 2 × 1, or 3 × 1.)

Example: CrossP([1 2],[3 4]) = [0 0 -2]

2-Vector Angle Angle(,)

Obtains the angle between two vectors.

Syntax: Angle(Vct n,Vct m)

Example: When ☰ > [Angle] > [Radian], Angle([1 1],[-1 1]) = $\frac{1}{2}\pi$

Unit Vector UnitV()

Calculates the unit vector of the vector specified by the argument.

Syntax: UnitV(Vct n)

Example: UnitV([5 5]) = $\begin{bmatrix} \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{bmatrix}$

Vector Norm Norm()

Calculates the norm (magnitude) of a specified vector or matrix.

Syntax: Norm(Vct n) ; Norm(Mat n) (Mat n = matrix or matrix variable)

Example: Norm([1 3]) = $\sqrt{10}$; Norm($\begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix}$) = $\sqrt{30}$

Matrix

Mat n and Mat m are matrices or matrix variables.

The matrices shown in the example (such as $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$) are entered using ⋯ > [m×n]. For details, see "Inputting a Matrix into a Calculation" (page 25).

Note

- Determinants and inverse matrices are subject to error due to dropped digits.
- The row echelon form and reduced row echelon form operation may not produce accurate results due to dropped digits.

Matrix Mat

Enters “Mat ”. Next, enter a letter from A to Z or Ans to specify a matrix variable.

Inverse Matrix $^{-1}$

Obtains the inverse of the specified square matrix.

Syntax: Mat n^{-1}

Example: $\begin{bmatrix}0 & -1\\1 & 0\end{bmatrix}^{-1} = \begin{bmatrix}0 & 1\\-1 & 0\end{bmatrix}$

Precautions

- Calculation precision is affected for matrices whose determinant is near zero.

Determinant Det()

Obtains the determinant of the specified square matrix.

Syntax: Det(Mat n)

Example: $\mathrm{Det}\left(\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}\right) = -2$

Matrix Transpose Trn()

Obtains the transpose matrix of the specified matrix.

Syntax: Trn(Mat n)

Example: $\mathrm{Trn}\left(\begin{bmatrix}1 & 2\\3 & 4\\5 & 6\end{bmatrix}\right) = \begin{bmatrix}1 & 3 & 5\\2 & 4 & 6\end{bmatrix}$

Note

- The “Trn” command can be used with a vector as well. It converts a 1-row × n-column vector to an n-row × 1-column vector, or an m-row × 1-column vector to a 1-row × m-column vector.

Matrix Identity Identity()

Creates an identity matrix with the specified number of rows and columns.

Syntax: Identity(n) (n = integer)

Example: $\mathrm{Identity}(2) = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$

Row Echelon Form Ref()

This command uses the Gaussian elimination algorithm to find the row echelon form of a matrix.

Syntax: Ref(Mat n)

Example: $\mathrm{Ref}\left(\begin{bmatrix}1 & 2 & 3\\4 & 5 & 6\end{bmatrix}\right) = \begin{bmatrix}1 & \frac{5}{4} & \frac{3}{2}\\0 & 1 & 2\end{bmatrix}$

Reduced Row Echelon Form Rref()

Obtains the reduced row echelon form of the specified matrix.

Syntax: Rref(Mat n)

Example: $\mathrm{Rref}\left(\begin{bmatrix}1 & 3 & 5\\2 & 4 & 6\end{bmatrix}\right) = \begin{bmatrix}1 & 0 & -1\\0 & 1 & 2\end{bmatrix}$

Matrix Augment Augment(,)

Combines two matrices (or vectors), each of which contains the same number of rows, into a single matrix.

Syntax: Augment(Mat m,Mat n) ; Augment(Vct m,Vct n)

- Either or both of the matrices (Mat m, Mat n) can be replaced with Vct m, Vct n, respectively.

Example: Augment($\begin{bmatrix}1 & 3\\2 & 4\end{bmatrix}$,$\begin{bmatrix}2 & 6\\4 & 8\end{bmatrix}$) = $\begin{bmatrix}1 & 3 & 2 & 6\\2 & 4 & 4 & 8\end{bmatrix}$; Augment($\begin{bmatrix}1\\2\end{bmatrix}$,$\begin{bmatrix}2 & 6\\4 & 8\end{bmatrix}$) = $\begin{bmatrix}1 & 2 & 6\\2 & 4 & 8\end{bmatrix}$

Fill Matrix Fill(,)

Replaces all elements in a matrix variable (or vector variable) with the specified value m.

Syntax: Fill(m,Mat n) ; Fill(m,Vct n)

Dimensions Dim()

(1) Obtains the dimensions of a matrix (or vector) and outputs them in list form.

Syntax 1: Dim(Mat n) ; Dim(Vct n)

- Since the result of the Dim command is a list, it is stored in List Ans.

(2) Specifies dimensions in list form and creates a matrix (or vector) with all zero elements.

Syntax 2: $\{a,b\} \rightarrow$ Dim(Mat n) (a, b = integers, $1 \le a \le 999$, $1 \le b \le 999$) ;

$\{a,b\} \rightarrow$ Dim(Vct n) (a, b = integers, $1 \le b \le 999$ when $a = 1$, $1 \le a \le 999$ when $b = 1$)

Complex Number

The letter z in the syntax below represents a complex number. Calculations using Arg, ▶r∠θ, and ▶a+bi are affected by the ☰ > [Angle] setting.

Note

- The calculator regards a complex number in the form a+bi as a coordinate on a Gaussian plane, and calculates absolute value $|z|$ and argument Arg(z).

Norm of a Complex Number Abs()

Obtains the absolute value of a complex number.

Syntax: $|z|$ Abs(z)

Example: $|1+i| = \sqrt{2}$

Argument Arg()

Obtains the argument of a complex number.

Syntax: Arg(z)

Example: Arg(1+i) = $\frac{1}{4}\pi$ (☰ > [Angle] > [Radian])

Complex Conjugate Conjg()

Obtains the conjugate complex number.

Syntax: Conjg(z)

Example: Conjg(1+i) = 1−i

Real Part ReP()

Extracts the real part of a complex number.

Syntax: ReP(z)

Example: ReP(1+2i) = 1

Imaginary Part ImP()

Extracts the imaginary part of a complex number.

Syntax: ImP(z)

Example: ImP(1+2i) = 2

▶r∠θ ▶r∠θ

Converts a rectangular form value to polar form.

Syntax: z▶r∠θ

Example: $1+\sqrt{3}i$▶r∠θ = $2\angle\frac{1}{3}\pi$ (> [Angle] > [Radian])

▶a+b*i* ▶a+b*i*

Converts a polar form to rectangular form.

Syntax: z▶a+b*i*

Example: $2\angle\frac{1}{3}\pi$▶a+b*i* = $1+\sqrt{3}i$ (> [Angle] > [Radian])

Statistics

In all of the syntaxes below, "List n" and "List m" are lists or list variables. For list variables, n, m can be a value from 1 to 26, or Ans. List variables can also be specified using sub-names (page 27).

{} {}

Inputs curly brackets ({ }) to enter a new list.

List List

Inputs "List ". Following "List ", input a value from 1 to 26, or Ans to specify a list variable.

Dimensions Dim()

(1) Determines the number of elements in a list.
Syntax 1: Dim(List n)

(2) Specifies the number of list elements and creates a list variable with zero in all elements.
Syntax 2: Number of Elements a → Dim(List n) (a = integer, $1 \le a \le 999$)

Fill List Fill(,)

Replaces the values in all elements in a list variable with the same value (a).

Syntax: Fill(a,List n)

Generate Sequence Seq(,,,,)

Defines a function to generate a number sequence and return it in list form.

Syntax: Seq($f(x)$,x,Start Value,End Value,Increment)

- x can be any alpha variable.

Example: Seq(x^2,x,1,11,5) = {1,36,121}

Minimum Min()

Syntax 1: Min(List n) Extracts the minimum value from all elements in a list.
Syntax 2: Min(List n,List m) Extracts the lesser element at the same position in two lists.

Maximum Max()

Syntax 1: Max(List n) Extracts the maximum value from all elements in a list.
Syntax 2: Max(List n,List m) Extracts the larger element at the same position in two lists.

Mean Mean()

Finds the mean value of all elements in a list.

Syntax: Mean(List n)

Median Median()

Finds the median of two lists, one of which is data and the other is frequencies.

Syntax: Median(List n,List m)

- List n : Data list, List m : Frequency list
  The number of elements in List n and List m must be the same.

Example: When List 1 = {36,16,58,46,56}, List 2 = {75,89,98,72,67}, Median(List 1,List 2) = 46

Combine Lists Augment(,)

Combines two lists into one.

Syntax: Augment(List n,List m)

Sum of List Elements Sum()

Finds the sum of all elements in a list.

Syntax: Sum(List n)

List Product Prod()

Finds the sum product of all the elements in a list.

Syntax: Prod(List n)

Cumulative Frequency Cuml()

Calculates the cumulative frequency of the elements of a list.

Syntax: Cuml(List n)

Example: When List 1 = {2,3,6,5,4}, Cuml(List 1) = {2,5,11,16,20}

Data Percentages Percent()

Calculates the percentage of each element relative to the sum of all elements in a list.

Syntax: Percent(List n)

List Data Diff ΔList

Calculates {Element 2 − Element 1, Element 3 − Element 2, ... Element n − Element n−1} in a list of n ($n \geq 2$) elements and returns the result in list form.

Syntax: ΔList a (a = List variable number)

Note: You can save the result to List 2 by typing "ΔList 1→List 2".

Estimated x-Data $\hat{x}$
Estimated y-Data $\hat{y}$

These functions are used immediately after performing a regression calculation* with the Statistics app. For a value specified for one variable (x or y) they, estimate the other variable, based on a regression model.

Syntax: y-value $\hat{x}$ (Calculates an estimated x-value for the y-value.)

x-value $\hat{y}$ (Calculates an estimated y-value for the x-value.)

* Estimated values cannot be calculated for the following types of regression model: Med-Med Regression, Quadratic Regression, Cubic Regression, Quartic Regression, Sinusoidal Regression, Logarithm Regression.

Sample Standard Deviation StdDev()

Finds the sample standard deviation of data specified by a list.

Syntax: StdDev(List n[,List m]) (List n ... Sample data, List m ... Frequency data)

Example: StdDev({10,20,30,40},{3,5,4,1}) = 9.26808696

Population Standard Deviation StdDev_σ()

Finds the population standard deviation of data specified by a list.

Syntax: StdDev_σ(List n[,List m]) (List n ... Sample data, List m ... Frequency data)

Unbiased Variance Variance()

Finds the unbiased variance of data specified by a list.

Syntax: Variance(List n[,List m]) (List n ... Sample data, List m ... Frequency data)

Population Variance Variance_σ^2()

Finds the population variance of data specified by a list.

Syntax: Variance_σ^2(List n[,List m]) (List n ... Sample data, List m ... Frequency data)

List to Matrix List→Mat()

Saves list contents to Mat Ans.

Syntax: List→Mat(List n,List m)

(The number of elements in List n and List m must be the same.)

Example: When List 1 = {2,3,4}, List 2 = {20,30,40}, List→Mat(List 1,List 2) = $\begin{bmatrix} 2 & 20 \\ 3 & 30 \\ 4 & 40 \end{bmatrix}$

Matrix to List Mat→List()

Saves the specified columns of a matrix variable to List Ans.

Syntax: Mat→List(Mat n,m)

(n is a letter from A to Z, or Ans, and m is a column number.)

Example: When Mat A = $\begin{bmatrix} 2 & 20 \\ 3 & 30 \\ 4 & 40 \end{bmatrix}$, Mat→List(Mat A,1) = {2,3,4}

Note: You can assign the elements of Column 1 of Mat A to List 1 by inputting "Mat→List(Mat A,1)→List 1".

Distribution: Probability Calculation for Standard Normal Distribution

Attention fx-1AU GRAPH Users

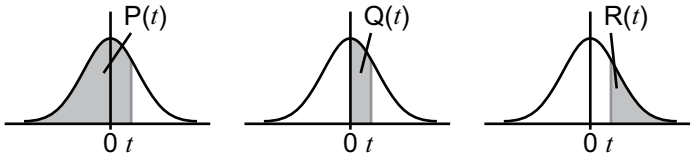
- The fx-1AU GRAPH does not have a Distribution category, but all commands described in this section can be called from ⓜ > [All].
  Example: To call "P()", select ⓜ > [All] > [P] > [P()].

Each mathematical function described in this section is intended for use immediately after you perform a 1-Variable statistical calculation with the Statistics app.

Normal Probability P(t) P()
Normal Probability Q(t) Q()
Normal Probability R(t) R()

Taking normalized variable t as an argument, these functions find the probability values for the standard normal distribution shown in the figures below. The t-value is determined using the function t().

Syntax: P(t) ; Q(t) ; R(t)



Normal Variable t(x) t()

Normalized variable t(x) at data value x is determined using the formula below based on the mean $\bar{x}$ and population standard deviation σ_x, which is obtained as the result of 1-Variable statistical calculation.

$$\mathrm{t}(x) = \frac{x - \bar{x}}{\sigma_x}$$

Syntax: t(x)

This function is used in combination with P(), Q(), and R() to find the probability values of the standard normal distribution.

Example: The height data of 20 students at a university were input with the Statistics app and a 1-Variable statistical calculation was performed. Determine what percentile does the 180 cm tall student fall.

R(t(180))

Distribution: Distribution Calculations

Attention fx-1AU GRAPH Users

- The fx-1AU GRAPH does not have a Distribution category, but all commands described in this section can be called from ⊞ > [All].
  Example: To call "NormPD()", select ⊞ > [All] > [N] > [NormPD()].

Each function in this section performs a different type of distribution calculation.

Syntax Notes

- The list below shows the meanings of the symbols and abbreviations in the syntax.

x: data value
Lower: lower boundary
Upper: upper boundary
μ : population mean
σ : population standard deviation ($\sigma > 0$)
λ : mean ($\lambda > 0$)
p: probability ($0 \leq p \leq 1$)
df: degrees of freedom ($df > 0$)
n:df: degrees of freedom of numerator (positive integer)
d:df: degrees of freedom of denominator (positive integer)
P: success probability ($0 \leq P \leq 1$)
n: number of trials from population ($0 \leq n$ integer)
M: number of successes in population ($0 \leq M$ integer)
N: population size ($n \leq N$, $M \leq N$ integer)

- The following values are substituted whenever any of the arguments enclosed in brackets ([ ]) are omitted.
  μ=0, σ=1, tail="L" (Left)

Calculation Result Storage Variables

Variables (p, xInv, x1InvN, x2InvN, zLow, zUp, tLow, tUp) to which the calculation results of each function are stored can be accessed from ⊞ > [Variable Data] > [Distribution].

Normal Probability Density NormPD()

Returns the normal probability density (p value) for the specified data.

Syntax: NormPD(x[,μ,σ])

- A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (List Ans when x is a list).

Example: NormPD(1) = 0.2419707245 ; NormPD({0.5,1}) = {0.3520653268,0.2419707245}

Normal Cumulative Dist NormCD(,)

Returns the normal cumulative distribution (p value) for the specified data.

Syntax: NormCD(Lower,Upper[,μ,σ])

- Single values or lists can be specified for Lower and Upper. Calculation results p, zLow, and zUp are assigned respectively to variables p, zLow, and zUp. Calculation result p also is assigned to Ans (List Ans when Lower and Upper are lists).

Example: NormCD(-1,1) = 0.6826894921 ; NormCD({-1,-2},{1,2}) = {0.6826894921,0.9544997361}

Inverse Normal Cumul Dist InvNormCD()

Returns the inverse normal cumulative distribution (Lower and/or Upper value(s)) for the specified p-value.

Syntax: InvNormCD([tail,]p[,μ,σ])

- You can specify Left, Right, or Center for "tail". To specify the "tail" setting, input the numbers or letters below.

Left : -1 or "L" Center : 0 or "C" Right : 1 or "R"

- A single value or a list can be specified for p. Calculation results are output in accordance with the tail setting as described below.

tail = Left	The Upper value is assigned to variables x1InvN and Ans (List Ans when p is a list).
tail = Right	The Lower value is assigned to variables x1InvN and Ans (List Ans when p is a list).
tail = Central	The Lower and Upper values are assigned respectively to variables x1InvN and x2InvN. Lower only is assigned to Ans (List Ans when p is a list).

Example: InvNormCD("L",0.7,35,2) = 36.04880103
InvNormCD({0.5,0.7},35,2) = {35,36.04880103}

t Probability Density tPD(,)

Returns the Student-t probability density (p value) for the specified data.

Syntax: tPD(x,df) See "PD Syntax" (page 236).

Example: tPD(1,1) = 0.1591549431 ; tPD({0,1},1) = {0.3183098862,0.1591549431}

t Cumulative Distribution tCD(,,)

Returns the Student-t cumulative distribution (p value) for the specified data.

Syntax: tCD(Lower,Upper,df)

- Single values or lists can be specified for Lower and Upper. Calculation results p, tLow, and tUp are assigned respectively to variables p, tLow, and tUp. Calculation result p also is assigned to Ans (List Ans when Lower and Upper are lists).

Example: tCD(0,1,1) = 0.25 ; tCD({0,0},{1,2},1) = {0.25,0.3524163823}

Inverse t Cumulative Dist InvTCD(,)

Returns the inverse Student-t cumulative distribution (Lower value) for the specified p value.

Syntax: InvTCD(p,df) See "Inverse CD Syntax (continuous distributions)" (page 236).

Example: InvTCD(0.25,1) = 1 ; InvTCD({0.25,0.75},1) = {1,-1}

χ^2 Probability Density ChiPD(,)

Returns the χ^2 probability density (p value) for the specified data.

Syntax: ChiPD(x,df) See "PD Syntax" (page 236).

Example: ChiPD(1,1) = 0.2419707245 ; ChiPD({0,1},1) = {0,0.2419707245}

χ^2 Cumulative Distribution ChiCD(,,)

Returns the χ^2 cumulative distribution (p value) for the specified data.

Syntax: ChiCD(Lower,Upper,df) See "CD Syntax" (page 236).

Example: ChiCD(0,1,1) = 0.6826894921 ; ChiCD({0,0},{1,2},1) = {0.6826894921,0.8427007929}

Inverse χ^2 Cumulative Dist InvChiCD(,)

Returns the inverse χ^2 cumulative distribution (Lower value) for the specified p value.

Syntax: InvChiCD(p,df) See "Inverse CD Syntax (continuous distributions)" (page 236).

Example: InvChiCD(0.319,1) = 0.9930420738 ; InvChiCD({0.64,0.319},1) = {0.2187421667,0.9930420738}

F Probability Density FPD(,,)

Returns the F probability density (p value) for the specified data.

Syntax: FPD(x,n:df,d:df) See "PD Syntax" (page 236).

Example: FPD(1,1,2) = 0.1924500897 ; FPD({1,2},1,2) = {0.1924500897,0.08838834765}

F Cumulative Distribution FCD(,,,)

Returns the F cumulative distribution (p value) for the specified data.

Syntax: FCD(Lower,Upper,n:df,d:df) See "CD Syntax" (page 236).

Example: FCD(0,1,1,2) = 0.5773502692 ; FCD({0,0},{1,2},1,2) = {0.5773502692,0.7071067812}

Inverse F Cumulative Dist InvFCD(,,)

Returns the inverse F cumulative distribution (Lower value) for the specified p value.

Syntax: InvFCD(p,n:df,d:df) See "Inverse CD Syntax (continuous distributions)" (page 236).

Example: InvFCD(0.43,1,2) = 0.9625240705 ; InvFCD({0.86,0.43},1,2) = {0.03998368013,0.9625240705}

Binomial Probability BinomialPD(,)

Returns the binomial probability (p value) for the specified data.

Syntax: BinomialPD([x,]n,P) See "PD Syntax" (page 236).

Example: BinomialPD(3,5,0.5) = 0.3125 ; BinomialPD({3,5},5,0.5) = {0.3125,0.03125}

Binomial Cumulative Dist BinomialCD(,)

Returns the binomial cumulative distribution (p value) for the specified data.

Syntax: BinomialCD([[Lower,]Upper,]n,P) See "CD Syntax" (page 236).

Example: BinomialCD(5,10,0.5) = 0.623046875 ; BinomialCD({0,5},{5,8},10,0.5) = {0.623046875,0.6123046875}

Inverse Binomial Cumulative Dist InvBinomialCD(,,)

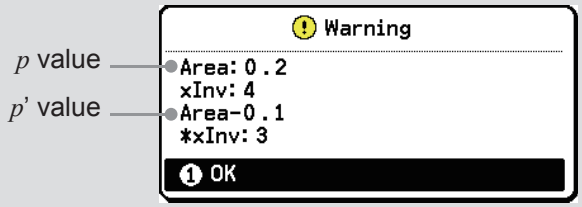
Returns the inverse binomial cumulative distribution for the specified p value.

Syntax: InvBinomialCD(p,n,P) See "Inverse CD Syntax (discrete distributions)" (page 236).

Example: InvBinomialCD(0.6,10,0.5) = 5 ; InvBinomialCD({0.6,0.3},10,0.5) = {5,4}

Precautions

- When executing the Inverse Binomial Cumulative Distribution calculation, the calculator uses the specified p value and the value that is one less than the p value minimum number of significant digits (p' value) to calculate minimum number of trials values. The results are assigned to variables xInv (calculation result using p) and ∗xInv (calculation result using p'). The calculator always displays the xInv value only. However, when the xInv and ∗xInv values are different, the message shown below will appear with both values.



The calculation results of Inverse Binomial Cumulative Distribution are integers. Accuracy may be reduced when the p value has 10 or more digits. Note that even a slight difference in calculation accuracy affects calculation results. If a warning message appears, check the displayed values.

Poisson Probability PoissonPD(,)

Returns the Poisson probability (p value) for the specified data.

Syntax: PoissonPD(x,λ) See "PD Syntax" (page 236).

Example: PoissonPD(1,1.2) = 0.3614330543 ; PoissonPD({1,2},1.2) = {0.3614330543,0.2168598326}

Poisson Cumulative Dist PoissonCD(,)

Returns the Poisson cumulative distribution (p value) for the specified data.

Syntax: PoissonCD([Lower,]Upper,λ) See "CD Syntax" (page 236).

- If Lower is omitted, Lower = 0 is assumed.

Example: PoissonCD(1,2,1.2) = 0.5782928869 ; PoissonCD({1,1},{2,3},1.2) = {0.5782928869,0.6650368199}

Inverse Poisson Cumul Dist InvPoissonCD(,)

Returns the inverse Poisson cumulative distribution for the specified p value.

Syntax: InvPoissonCD(p,λ) See "Inverse CD Syntax (discrete distributions)" (page 236).

Example: InvPoissonCD(0.58,1.2) = 1 ; InvPoissonCD({0.58,0.75},1.2) = {1,2}

Precautions are the same as those for "Inverse Binomial Cumulative Dist" (page 235).

Geometric Probability GeoPD(,)

Returns the geometric probability (p value) for the specified data.

Syntax: GeoPD(x,P) See "PD Syntax" (page 236).

Example: GeoPD(2,0.8) = 0.16 ; GeoPD({2,3},0.8) = {0.16,0.032}

Geometric Cumulative Dist GeoCD(,)

Returns the geometric cumulative distribution (p value) for the specified data.

Syntax: GeoCD([Lower,]Upper,P) See "CD Syntax" (page 236).

- If Lower is omitted, Lower = 0 is assumed.

Example: GeoCD(1,2,0.8) = 0.96 ; GeoCD({1,1},{2,3},0.8) = {0.96,0.992}

Inverse Geometric Cumul Dist InvGeoCD(,)

Returns the inverse geometric cumulative distribution for the specified p value.

Syntax: InvGeoCD(p,P) See "Inverse CD Syntax (discrete distributions)" (page 236).

Example: InvGeoCD(0.96,0.8) = 2 ; InvGeoCD({0.96,0.992},0.8) = {2,3}

Precautions are the same as those for "Inverse Binomial Cumulative Dist" (page 235).

Hypergeometric Probability HypergeoPD(,,,)

Returns the hypergeometric probability (p value) for the specified data.

Syntax: HypergeoPD(x,n,M,N) See "PD Syntax" (page 236).

Example: HypergeoPD(1,5,10,20) = 0.1354489164 ; HypergeoPD({1,2},5,10,20) = {0.1354489164,0.3482972136}

Hypergeometric Cumul Dist HypergeoCD(,,,)

Returns the hypergeometric cumulative distribution (p value) for the specified data.

Syntax: HypergeoCD([Lower,]Upper,n,M,N) See "CD Syntax" (page 236).

- If Lower is omitted, Lower = 0 is assumed.

Example: HypergeoCD(1,2,5,10,20) = 0.48374613 ; HypergeoCD({1,1},{2,3},5,10,20) = {0.48374613,0.8320433437}

Inverse Hypergeo Cumul Dist InvHypergeoCD(,,,)

Returns the inverse hypergeometric cumulative distribution for the specified p value.

Syntax: InvHypergeoCD(p,n,M,N) See "Inverse CD Syntax (discrete distributions)" (page 236).

Example: InvHypergeoCD(0.48,5,10,20) = 2 ; InvHypergeoCD({0.48,0.83},5,10,20) = {2,3}

Precautions are the same as those for "Inverse Binomial Cumulative Dist" (page 235).

Syntax and description

Syntax	Description
PD Syntax	A single value or a list can be specified for x. Calculation result p is assigned to variables p and Ans (List Ans when x is a list).
CD Syntax	Single values or lists can be specified for Lower and Upper. Calculation result p is assigned to variables p and Ans (List Ans when Lower and Upper are lists).
Inverse CD Syntax (continuous distributions)	A single value or a list can be specified for p. The Lower value is assigned to the xInv and Ans variables (List Ans when p is a list).
Inverse CD Syntax (discrete distributions)	A single value or a list can be specified for p. The calculation result X value is assigned to the xInv and Ans variables (List Ans when p is a list).

Angle/Coord/Sexa

Degrees °

Specifies degrees as the angle unit.

Syntax: $n°$

Example: When ☰ > [Angle] > [Radian], $90° = \frac{1}{2}\pi$

Radians r

Specifies radians as the angular unit.

Syntax: n^{r}

Example: When ☰ > [Angle] > [Degree], $\frac{\pi}{2}^{r} = 90$

Gradians g

Specifies gradians as the angle unit.

Syntax: n^{g}

Example: When ☰ > [Angle] > [Degree], $100^{g} = 90$

Rectangular to Polar Pol(,)

Converts rectangular coordinate values to polar coordinates and returns them in list form.

Syntax: Pol(x,y) = (r,θ)

- The resulting polar coordinates θ are displayed in the range as follows, depending on the ☰ > [Angle] setting.

  Degree: $-180 < \theta \leq 180$ Radian: $-\pi < \theta \leq \pi$ Gradian: $-200 < \theta \leq 200$

Example: When ☰ > [Angle] > [Radian], $\text{Pol}(\sqrt{2},\sqrt{2}) = \{2,\frac{1}{4}\pi\}$

Polar to Rectangular Rec(,)

Converts polar coordinate values to rectangular coordinates and returns them in list form.

Syntax: Rec(r,θ) = (x,y)

Example: When ☰ > [Angle] > [Radian], $\text{Rec}(2,\frac{1}{4}\pi) = \{\sqrt{2},\sqrt{2}\}$

Degs Mins Secs °

Inputs a sexagesimal value.

Syntax: Degree Value°[Minute Value°[Seconds Value°]]

Example: 1°15° = 1.25 ; 0°75° = 1.25 ; 0°15° = 0.25 ; 0°0°900° = 0.25

Note: To display calculation results as sexagesimal values, select ⇧ FORMAT > [Sexagesimal]. For more information, see “Changing the Display Format of Calculation Results (Format Menu)” (page 17).

Decimal to Sexagesimal ▶DMS

Converts a decimal value to a sexagesimal value (degrees (hours), minutes, seconds).

Syntax: n▶DMS

Example: 1.25▶DMS = 1°15’00”

Hyperbolic Calc

Hyperbolic and inverse hyperbolic functions can be input using the menu items below.

Menu item	Function
sinh	sinh()
cosh	cosh()
tanh	tanh()

Menu item	Function
$\sinh^{-1}$	$\sinh^{-1}$()
$\cosh^{-1}$	$\cosh^{-1}$()
$\tanh^{-1}$	$\tanh^{-1}$()

Example: sinh(1) = 1.175201194 ; $\sinh^{-1}$(Ans) = 1

Engineer Symbol

Engineering symbols can be input using the menu items below.

Menu item	Symbol	10^n
Milli	m	10^{-3}
Micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}
Femto	f	10^{-15}

Menu item	Symbol	10^n
Kilo	k	10^3
Mega	M	10^6
Giga	G	10^9
Tera	T	10^{12}
Peta	P	10^{15}
Exa	E	10^{18}

- Appending an engineering symbol immediately after a value causes the value to be 10^n (where n is an integer multiple of 3).

Example: 7.1k = 7100 ; 2G÷100M = 20

Note: To display calculation results with engineering symbols, turn on ☰ > [Display] > [Engineer Symbol]. For details, see “Display (General)” (page 218).

Unit Conversions

Converts a value of one unit to a different unit.

Syntax: n unit command ▶ unit command (n= real number or list of real numbers)

- The two unit commands are linked with "▶" and used as a single unit conversion command. The two unit commands must be from the same category. Refer to the "Unit Command List" below for available unit commands.

Example: 25.4 [cm] ▶ [in] = 10 ; {175,162} [m^2] ▶ [ha] = {0.0175,0.0162}

Unit Command List

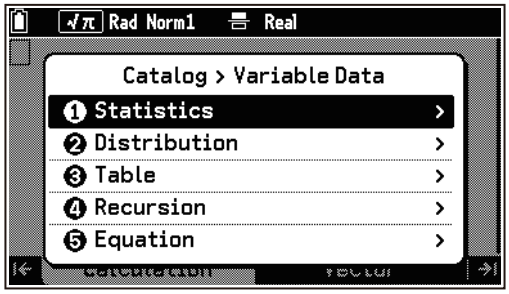
Category	Unit Command
Length	[fm]
	[Å]
	[μm]
	[mm]
	[cm]
	[m]
	[km]
	[AU]
	[l.y.]
	[pc]
	[Mil]
	[in]
	[ft]
	[yd]
	[fath]
	[rd]
	[mile]
	[n mile]
Area	[cm^2]
	[m^2]
	[ha]
	[km^2]
	[in^2]
	[ft^2]
	[yd^2]
	[acre]
	[$mile^2$]
Volume	[cm^3]
	[mL]
	[L]
	[m^3]
	[in^3]
	[ft^3]
	[fl_oz(UK)]
	[fl_oz(US)]

Category	Unit Command
Volume	[gal(US)]
	[gal(UK)]
	[pt]
	[qt]
	[tsp]
	[tbsp]
	[cup]
Time	[ns]
	[μs]
	[ms]
	[s]
	[min]
	[h]
	[day]
	[week]
	[yr]
	[s-yr]
	[t-yr]
Temperature	[°C]
	[K]
	[°F]
	[°R]
Velocity	[m/s]
	[km/h]
	[knot]
	[ft/s]
	[mile/h]
Mass	[u]
	[mg]
	[g]
	[kg]
	[mton]
	[oz]
	[lb]
	[slug]
	[ton(short)]

Category	Unit Command
Mass	[ton(long)]
Force	[N]
	[lbf]
	[tonf]
	[dyne]
	[kgf]
Pressure	[Pa]
	[kPa]
	[mmH_2O]
	[mmHg]
	[atm]
	[inH_2O]
	[inHg]
	[lbf/in^2]
	[bar]
	[kgf/cm^2]
Energy	[eV]
	[J]
	[cal_{th}]
	[cal_{15}]
	[cal_{IT}]
	[$kcal_{th}$]
	[$kcal_{15}$]
	[$kcal_{IT}$]
	[l-atm]
	[kW·h]
	[ft·lbf]
	[Btu]
	[erg]
	[kgf·m]
Power	[W]
	[cal_{th}/s]
	[hp]
	[ft·lbf/s]
	[Btu/min]

Variable Data

The Variable Data category contains variables that store input and output values of each app. The menu items that appear when you select ⊜ > [Variable Data] are app names.



Variable Data > Statistics

Variables in this category store input values and calculation results for statistical calculations performed and graphs drawn using the Statistics app.

Statistics > X

Single-variable or paired-variable statistical calculation x-data values:

Menu item	Variable
Data Items	n
Data x Mean	$\bar{x}$
Data x Sum	Σx
x-Data Sum of Squares	Σx^2

Menu item	Variable
x-Data Population Std Dev	σx
x-Data Sample Std Dev	sx
X-Data Minimum	minX
X-Data Maximum	maxX

Statistics > Y

Paired-variable statistical calculation y-data values:

Menu item	Variable
Data y Mean	$\bar{y}$
Data y Sum	Σy
y-Data Sum of Squares	Σy^2
xy-Data Products Sum	Σxy

Menu item	Variable
y-Data Population Std Dev	σy
y-Data Sample Std Dev	sy
Y-Data Minimum	minY
Y-Data Maximum	maxY

Statistics > Graph

Regression model information values:

Menu item	Variable
a Regression Coefficient	a
b Regression Coefficient	b
c Regression Coefficient	c
d Regression Coefficient	d

Menu item	Variable
e Regression Coefficient	e
Correlation Coefficient	r
Coefficient of Determination	r^2
Error Mean Square	MSe

Single-variable statistical calculation output values:

Menu item	Variable
1st Quartile	Q_1
Input Data Median	Med

Menu item	Variable
3rd Quartile	Q_3
Input Data Mode	Mod

Statistics > Point Coordinates

Coordinates of summary points when Med-Med Regression is performed:

Menu item	Variable
Summary Point Coords x_1	x_1
Summary Point Coords x_2	x_2
Summary Point Coords x_3	x_3

Menu item	Variable
Summary Point Coords y_1	y_1
Summary Point Coords y_2	y_2
Summary Point Coords y_3	y_3

Statistics > Input

Statistical calculation input values:

Menu item	Variable
Sample Size	n
Sample Mean	$\bar{x}$
Sample Standard Deviation	sx
Sample 1 Size	n1
Sample 2 Size	n2

Menu item	Variable
Sample 1 Mean	$\bar{x}1$
Sample 2 Mean	$\bar{x}2$
Sample 1 Standard Deviation	sx1
Sample 2 Standard Deviation	sx2
Sample p Standard Deviation	sp

Statistics > Result > Test

Test calculation results:

Menu item	Variable
p	p
z	z
t	t
χ^2	χ^2
F	F
Estimated Sample Proportion	$\hat{p}$
Estim Sample 1 Proportion	$\hat{p}1$
Estim Sample 2 Proportion	$\hat{p}2$
Degree of Freedom	df
Standard Error	se
Correlation Coefficient	r
Coefficient of Determination	r^2
p Value of Factor A	pa
F Value of Factor A	Fa
Factor A Degrees of Freedom	Adf

Menu item	Variable
Factor A Sum of Squares	SSa
Factor A Mean Squares	MSa
p Value of Factor B	pb
F Value of Factor B	Fb
Factor B Degrees of Freedom	Bdf
Factor B Sum of Squares	SSb
Factor B Mean Squares	MSb
Factor AB p Value	pab
Factor AB F Value	Fab
Factor AB Deg of Freedom	ABdf
Factor AB Sum of Squares	SSab
Factor AB Mean Squares	MSab
Error Degrees of Freedom	Edf
Error Sum of Squares	SSe
Error Mean Square	MSe

Statistics > Result > Confidence Interval

Confidence interval calculation results:

Menu item	Variable
Confidence Int Lower Limit	Lower
Confidence Int Upper Limit	Upper
Estimated Sample Proportion	$\hat{p}$

Menu item	Variable
Estim Sample 1 Proportion	$\hat{p}1$
Estim Sample 2 Proportion	$\hat{p}2$
Degree of Freedom	df

Variable Data > Distribution

Variables in this category store the results of distribution calculations performed using the Distribution app.

Menu item	Variable
p	p
x Inverse	xInv
x1 Inverse	x1InvN
x2 Inverse	x2InvN

Menu item	Variable
Normal Cumulative Dist Lower	zLow
Normal Cumulative Dist Upper	zUp
t Cumulative Dist Lower	tLow
t Cumulative Dist Upper	tUp

Variable Data > Table

Menu item	Variable	Description
Function Table Result	F Result	Outputs the Graph&Table app's Table tab contents in matrix form.

Variable Data > Recursion

Menu item	Variable	Description
Recursion Table Result	R Result	Outputs the Recursion app's Table tab contents in matrix form.

Variable Data > Equation

Variables in this category store input values and calculation results for higher-order equations or simultaneous equations solved using the Equation app.

Menu item	Variable	Description
Hi-Ord Coeff	Ply Coef	Outputs higher-order equation input coefficients in matrix form.
Hi-Ord Solutions	Ply Result	Outputs higher-order equation calculation results in matrix form.
Linear Coeffs	Sim Coef	Outputs simultaneous equation input coefficients in matrix form.
Linear Solutions	Sim Result	Outputs simultaneous equation calculation results in matrix form.

All > A to Z

(menu) > [All] displays an alphabetized list of all the calculator's functions, commands, and app variables. For details, see "Catalog Menu Details" (page 221).

All > Symbol

This menu includes the function and symbols in the table below.

$\sqrt[3]{}()$	!	∠	E (Engineer Symbol)
$_{10}\wedge()$	° (Degrees)	:	P (Engineer Symbol)
{	ʳ (Radians)	▶	T (Engineer Symbol)
}	ᵍ (Gradians)	=	G (Engineer Symbol)
≠	°	$	M (Engineer Symbol)
<	$\sqrt{}()$	,	k (Engineer Symbol)
>	$\sqrt[x]{}$	(	m (Engineer Symbol)
≤	$^{-1}$	)	μ (Engineer Symbol)
≥	^{2}	[	n (Engineer Symbol)
”	^	]	p (Engineer Symbol)
~	⌟	×10 (Sci Notation)	f (Engineer Symbol)
π	-	×10□ (Sci Notation)	

Appendix

Using CSV Files

You can save the data stored in the list variables, matrix variables or the Spreadsheet app as CSV files. You can also load CSV files saved in the Storage Memory of the calculator into list or matrix variables, or into the Spreadsheet app.

Important!

- Storage Memory (page 196) is used as the memory area for saving and importing CSV files.
- When saving and importing CSV files, take care to specify the delimiter and decimal point. For details, see "Specifying the CSV File Import and Export Format (CSV Format)" (page 201).

Import CSV File Requirements

A CSV file that has been output from the Calculate app, Statistics app, Spreadsheet app, or a CSV file transferred from a computer to Storage Memory can be used for import. The following types of CSV files are supported for import.

- A CSV file that uses the comma (,) or semi-colon (;) as its delimiter, and the period (.) or comma (,) as its decimal point. A CSV file that uses the tab as its delimiter is not supported.
- CR, LF and CRLF are supported for the line break code.
- When importing a CSV file to the calculator, if the data in Line 1 of each column of the file (or Line 1 of Column 1 of the file) is a character string enclosed with double quotation marks (") or single quotation marks ('), Line 1 of all of the columns of the CSV file will be ignored, and data will be input starting from Line 2.
- A CSV file name can have up to eight single-byte characters.

Exporting to and Importing From a CSV File

Important!

- When saving matrix variables, list variables or the Spreadsheet app data to a CSV file, some data is converted as described below.
  - Fraction data: Converted to calculation line format (Example: 2⌟3⌟4 → =2+3/4)
  - $\sqrt{}$ and π data: Converted to a decimal value (Example: $\sqrt{5}$ → 2.236067977)
- When a matrix or list variable is saved as a CSV file, the imaginary part of complex number data stored by the variable is omitted. This means only the real part is saved.
- Attempting to import the following types of CSV files will result in an error.
  - A CSV file containing data (expression or string) that cannot be converted. In this case, an error message will appear showing the location in the CSV file (Example: row 2, column 3) where the data that cannot be converted is located.
  - A CSV file with more than 999 columns or 999 rows into a matrix variable.
    A CSV file with more than 26 columns or 999 rows into a list variable or a spreadsheet.
    In this case, an "Invalid Data Size" error will occur.

To save matrix variables to a CSV file (Calculate app)

1. Display the Calculate app's Matrix tab.
2. Highlight the matrix variable you want to save to a CSV file and then select ⋯ > [CSV] > [Save As].
   - This displays a dialog you can use to select a folder to save the data.
3. Use the operation below to select the save destination folder.

To select this folder:	Perform this operation:
Root directory	Highlight ROOT and then press OK.

Other folders	(1) Highlight the folder you want to select and then press [OK]. This will take you into the selected folder. (2) Highlight the folder's name and then press [OK] again.

4. Use the dialog that appears to input up to eight characters for the file name and then press [OK].

To import a CSV file into a matrix variable (Calculate app)

1. Display the Calculate app's Matrix tab.
2. Highlight the matrix variable into which you want to import the CSV file.
   - If the matrix variable you highlighted already contains data, the next step will cause the existing data to be overwritten.
3. Select [⋯] > [CSV] > [Load].
4. On the dialog that appears, highlight the CSV file you want to import and then press [OK].

To save a list variable to a CSV file (Statistics app)

The operation below saves the contents of the currently open List Files (page 32) (all list variables on List Editor) as a CSV file.

1. Display the Statistics app's List Editor tab.
2. Select [⋯] > [CSV] > [Save As].
   - This displays a dialog you can use to select a folder to save the data.
3. Use the operation below to select the save destination folder.

To select this folder:	Perform this operation:
Root directory	Highlight ROOT and then press [OK].
Other folders	(1) Highlight the folder you want to select and then press [OK]. This will take you into the selected folder. (2) Highlight the folder's name and then press [OK] again.

4. Use the dialog that appears to input up to eight characters for the file name and then press [OK].

To import a CSV file into List Editor (Statistics app)

1. Display the Statistics app's List Editor tab.
2. Depending on the method you want to use to import the CSV file, perform one of the operations below.

To do this:	Select this menu item:
Start importing from a specific column	[⋯] > [CSV] > [Load] > [List]
Overwrite all current List Editor contents	[⋯] > [CSV] > [Load] > [File]

3. On the dialog that appears, highlight the CSV file you want to import and then press [OK].
   - If you chose [List] in step 2 above, import starts from the column that contains the cell where the cursor is currently located. The columns on List Editor are overwritten by the number of columns contained in the CSV file.

To save a spreadsheet to a CSV file (Spreadsheet app)

1. Display the Spreadsheet app's Spreadsheet tab.
2. If required, select [⋯] > [Recalculate] to recalculate the spreadsheet contents.
   - Note that recalculation is not performed automatically when you save spreadsheet contents to a CSV file. Be sure to perform recalculation if the spreadsheet contains a formula, which starts with an equals symbol (=).
   - Formulas are not saved to the CSV file. Only calculation results are saved.

- All ERROR cell data on the spreadsheet is saved as blank data.

3. Select ⋯ > [CSV] > [Save As].
   - This displays a dialog you can use to select a folder to save the data.
   - For the remainder of this procedure, perform the steps from step 3 under "To save matrix variables to a CSV file (Calculate app)" (page 244).

To import a CSV file into a spreadsheet (Spreadsheet app)

1. Display the Spreadsheet app's Spreadsheet tab.
2. Select ⋯ > [CSV] > [Load].
3. On the dialog that appears, highlight the CSV file you want to import and then press (OK).
   - This imports the contents of the CSV file you specified to the spreadsheet.

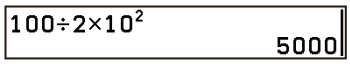
Calculation Priority Sequence

The calculator performs calculations according to a calculation priority sequence.
- Basically, calculations are performed from left to right.
- Expressions within parentheses have the highest priority.
- The following shows the priority sequence for each individual command.

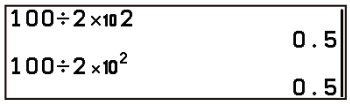
1	Parenthetical expressions
2	Type A functions - Functions that take arguments within parentheses: sin(), log(), d/dx(), etc. - Prefixes for list, matrix, and vector variables: List, Mat, Vct - Composite functions (page 77) : yn, rn, Xtn, Ytn, Xn (n: 1-20)
3	Type B functions (functions that come after the input value) - x^2, x^{-1}, $x!$, ° ’ ”, °, r, g - engineering symbols
4	powers ($x^{\blacksquare}$), roots ($\sqrt[\blacksquare]{\square}$)
5	Fractions
6	Implied multiplication format in front of π, memory name, or variable name: 2π, 5A, etc.
7	Negative sign ((-)) Type C functions (functions that come before the input value) - List calculation function (Δlist) - Base Prefix (d, h, b, o)
8	Implied multiplication format in front of Type A functions, Type C functions, and parenthesis: $2\sqrt{3}$, A log(2), etc.
9	Permutation (nPr), combination (nCr), complex number polar coordinate symbol ($\angle$)
10	Metric conversion commands
11	× , ÷, Int÷, Rmdr
12	+, –
13	Relational operators: =, ≠, >, <, ≥, ≤
14	And (logical operator), and (bitwise operator)
15	Or, Xor (logical operator), or, xor, xnor (bitwise operator)

Note
- When functions with the same priority are used in series, execution is performed from right to left.
- Compound functions are executed from right to left.

- If a calculation contains a negative value, you may need to enclose the negative value in parentheses.
  If you want to square the value -2, for example, you need to input: $(-2)^2$. This is because x^2 is a function preceded by a value (Priority 3, above), whose priority is greater than the negative sign, which is a prefix symbol (Priority 7).
  Example: ⬆ ⊖ (−) 2 x^2 EXE $-2^2 = -4$
  (⬆ ⊖ (−) 2) x^2 EXE $(-2)^2 = 4$
- The data that is input when you press the ×10ⁿ key depends on the current ☰ > [×10ⁿ Key] (page 219) setting. Calculation priority depends on the syntax of the formula that is input. Because of this, changing the above setting may affect calculation results even if the formula is input using identical key operations.
  Example: 100 ÷ 2 ×10ⁿ 2 EXE
  ☰ > [×10ⁿ Key] > [×10ⁿ (Power)]:
  100 ÷ 2 calculation priority is higher, so the result is $(100 \div 2) \times 10^2 = 5000$.

  ☰ > [×10ⁿ Key] > [×10 (Sci Notation)] or [×10ⁿ (Sci Notation)]:
  2×10^2 calculation priority is higher, so the result is $100 \div (2 \times 10^2) = 0.5$.

Error Message Table

General calculation errors

When you see this message:	It means this:	So you need to do this:
Syntax ERROR	There is a problem with the format of the calculation you are performing.	Make necessary corrections.
Math ERROR	• Calculation result that exceeds the calculation range. • Intermediate or final calculation result is outside the allowable calculation range. • Mathematical error (division by zero, etc.)	Check input values and make corrections to ensure that values are within allowable limits.
Stack ERROR	The calculation you are performing has caused the capacity of the numeric stack or the command stack to be exceeded.	Simplify the calculation expression so it does not exceed the capacity of the stack.
	The calculation you are performing has caused the capacity of the matrix or vector stack to be exceeded.	Try splitting the calculation into two or more parts.
Input value must be integer	Attempting to input a non-integer value in a location that requires integer input.	Input an integer value.
Input value must be a matrix	Attempting to input a non-matrix value in a location that requires matrix input.	Input a matrix value.
Input value must be a matrix or vector	Attempt to input a non-matrix or non-vector value in a location where a matrix or vector should be input.	Input a matrix or vector.
Input value must be a list	Attempting to input a non-list value in a location that requires list input.	Input a list value.
Input value must be a real number	Attempting to input a non-real number value in a location that requires real number input.	Input a real number value.
Invalid Polar Form	Attempting to input an imaginary number for polar form ($r\angle\theta$) r or θ.	Check the polar form.

Wrong argument size relationship.	The size relationship between two arguments is opposite from what it should be. Example: 3**C**10	Change the values so the size relationship required by the syntax is maintained.
Non-Real ERROR	Calculation that produces a complex number when ☰ > [Complex Mode] > [Real] is specified, even though the argument is a real number.	Change the [Complex Mode] setting to something other than [Real].
Can't Simplify	Fraction simplification was attempted using the ▶Simp function (page 223), but simplification could not be performed using the specified divisor. Example: Specifying a divisor of 3 to simplify the fraction 4/8.	Specify a different divisor or execute ▶Simp without specifying any divisor.
Can't Solve! Adjust initial value or bounds. Then try again.	A Solve calculation could not obtain a solution within the specified initial default estimated value.	Change the specified initial default estimated value or correct the input expression.
Time Out	A Solve calculation was unable to satisfy convergence conditions.	If you are performing a Solve calculation, try changing the initial default estimated value closer to the expected solution.
Conversion ERROR	• Attempting to use the unit conversion command to convert between two units in different categories. • Executing a conversion calculation using the same command twice in a conversion expression.	In a conversion expression, specify two different commands that are in the same category.
Invalid Type	An illegal data type is specified.	Specify valid data.

List, matrix, and vector calculation errors

When you see this message:	It means this:	So you need to do this:
Invalid list, matrix or vector	Incorrect use of a list, matrix, or vector.	Press ↩ to display the location of an error and make necessary corrections.
Dimension ERROR	Illegal dimension used during matrix, vector, or list calculations.	Check the matrix, vector, or list dimension.
Complex Number In List	List containing complex number used in a calculation or operation for which complex number data is invalid.	Change all elements in the list to real numbers.
Complex Number In Matrix	Matrix containing complex number used in a calculation or operation for which complex number data is invalid.	Change all elements in the matrix to real numbers.
Complex Number In Matrix or Vector	Matrix or vector containing complex number used in a calculation or operation for which complex number data is invalid.	Change all elements in the matrix or vector to real numbers.
Improper Number of Elements	You attempted to create a list, matrix, or vector whose number of elements exceeds the maximum limit.	A list cannot have more than 999 elements, and a matrix cannot exceed 999 rows × 999 columns. For vector elements, specify within 1 row × 999 columns or 999 rows × 1 column.

Equation app errors

When you see this message:	It means this:	So you need to do this:
Infinitely Many Solutions	An infinite number of solutions for simultaneous linear equations.	–
No Solution	No solution for simultaneous linear equations.	–
No Variable	No variable within a Solver (page 116) equation.	Input an equation that includes a variable.

Graph&Table, Recursion, Dyna Graph, Conic Graphs app errors

When you see this message:	It means this:	So you need to do this:
Range ERROR	View Window range settings exceeded when a graph is drawn.	Redraw using the proper View Window settings.
Circular ERROR	The two recursion formulas that were input cross-reference each other.	Edit the recursion formulas to resolve the cross-referencing. For details, see the Note under "To input or edit a recursion formula" (page 109).
No Variable	No variable specified within a function being used for dynamic graphing in the Dyna Graph app.	Specify a variable for the graph function.
No item is selected	Attempting to draw a graph or create a table while there is no data selected.	Select data and try again.
Equation does not have a parameter.	You attempted to execute a Modify function operation while no expression that contains a variable is selected.	Select at least one and only one expression that contains a variable.
Condition ERROR	You attempted to execute a Modify operation while multiple expressions containing variables are selected.	
Expression in use	Attempting to copy the expression of a graph while Modify is running to an area where an expression that is being used for graphing is located.	Select a different area and try again.
Too Many Variables	Attempting to execute the Modify function using an expression with more than five variables.	Change the expression so it contains no more than five variables.
Invalid Graph Type	• You selected one of the mathematical function expressions ((a) through (d)) in the Graph&Table app and tried to execute ⋯ > [Modify]. • You selected one of the mathematical function expressions ((a) through (d)) in the Graph&Table app and attempted to create a number table. (a) Function expression containing alpha variables, with specification of values assigned to the variables (Example: y=Ax − 1,[A=1,2,3]) (b) Function expression containing a list (Example: y={1,2,3}x) (c) Function expression with a range of variables (Example: y=x,[0,2])	Choose another type of function and try again.

	(d) Inequality (Example: y>sin(x))	
Too Many Sectors	You attempted to perform a calculation using [$\int dx$] > [Root], [$\int dx$] > [Intersection], or [$\int dx$] > [Mixed] with graph analysis (Graph Solve), but there are 21 or more roots (or intersections) within the specified range.	Specify a range that is narrower and try again.

Statistics app errors

When you see this message:	It means this:	So you need to do this:
Condition ERROR	You are attempting to display multiple statistical graphs of different types.	See “Drawing Graphs Using Multiple Graph Setups” (page 42).
Data is in use	Use the dialog that appears after you select ⋯ > [Save Residuals in List] or ⋯ > [Save Result in List] to make the list you are currently using the save destination.	Specify the number of an empty list.

Spreadsheet app errors

When you see this message:	It means this:	So you need to do this:
Range ERROR	The spreadsheet cell range was exceeded by paste, recall, or other cell operation.	Repeat the procedure taking care that the cell range is not exceeded.
Circular ERROR	There is a circular reference (such as “=A1” in cell A1) in the spreadsheet.	Change cell contents to remove the circular references.

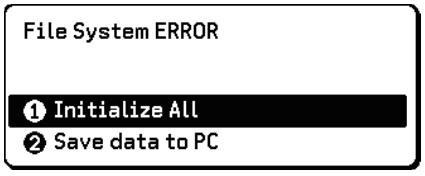
Memory app errors

When you see this message:	It means this:	So you need to do this:
Memory ERROR	Calculation or memory storage operation exceeds remaining memory capacity.	• Simplify the data you are trying to store to keep it within the available memory capacity. • Delete no longer needed data to make room for the new data.
Folder has over 200 files. Some will be skipped.	The number of files in the storage memory folder you are trying to open in the Memory app exceeds 200.	Use your computer (page 210) to distribute the files among multiple folders so no folder in storage memory contains more than 200 files.
Sub-folders in this folder cannot be displayed.	In the Memory app, a level 3 nested storage memory folder is displayed, and it contains a level 4 nested folder. (The level 4 folder will be displayed, but it cannot be opened.)	Use your computer (page 210) to store all files you want to access in the top three folder nesting levels.
Too Much Data	The number of data items is too large.	Delete unneeded data.
Invalid Name	The file name you input includes invalid characters.	Use the correct characters to input a valid file name.
Invalid Type	An illegal data type is specified.	Specify valid data.
Storage Memory Full	The storage memory is full.	Delete unneeded data.
Data ERROR	A data error occurred.	Check to make sure you are writing correct type of data and try again.
Memory Full	You attempted to load a g4m file into the main memory, but there is not enough space available.	Delete no longer needed data to make room for loading g4m files.

File System ERROR	After establishing a connection between the calculator and a computer, the calculator memory has been accidentally formatted by an operation from the computer. This message appears when the USB cable is disconnected following formatting.	Formatting deletes all data remaining in calculator memory. See “If you accidentally format calculator memory” (page 251) for what you need to do.
	The memory area has been fatally corrupted due an electronic component in the device reaching the end of its service life, or some other reason.	From the menu that appears along with the message, select [Initialize All] and then press [OK]. If this does not resolve the problem, contact your retailer or your nearest CASIO service center.

If you accidentally format calculator memory

If the calculator displays the File System ERROR message because its memory was accidentally formatted, you need to initialize the calculator.



Perform one of the operations shown in the table below.

To do this:	Perform this operation:
If you transferred data to the calculator after executing the formatting operation, save the transferred data to your computer before initializing the calculator.	(1) Highlight [Save data to PC] and then press [OK]. (2) Perform the operations under “Connecting the Calculator to a Computer” (page 210) to save calculator data to your computer and then disconnect the calculator from the computer. • This causes the calculator to display the File System ERROR message again. (3) Highlight [Initialize All] and then press [OK].
Initialize the calculator, which discards all data remaining in its memory.	Highlight [Initialize All] and then press [OK].

Data communication errors

When you see this message:	It means this:	So you need to do this:
CSV error in row [A] or column [B]	The imported CSV file included data that cannot be converted.	Use your computer to check the row A, column B data in the file and change it to data that can be converted.
USB Connect ERROR	USB cable connection broken during data communication.	Use the USB cable to correctly connect the calculator and computer.

3D Graph app errors

When you see this message:	It means this:	So you need to do this:
No item is selected	Attempting to draw a graph while there is no data selected.	Select data and try again.
Intersection requires two or more objects. (fx-CG100 only)	You tried to determine a point of intersection without first using the Line	Use the Line template or Plane template to draw multiple 3D graphs and try again.

	template or Plane template to draw multiple 3D graphs.	
Relationship requires two or more objects. (fx-CG100 only)	You tried to determine relationship without first using the Line template or Plane template to draw multiple 3D graphs.	Use the Line template or Plane template to draw multiple 3D graphs and try again.

Geometry app errors

When you see this message:	It means this:	So you need to do this:
First select a segment.	You are attempting to construct a perpendicular bisector without first selecting a line segment.	Select the required object(s) and then try again.
First select a line and point.	You are attempting to construct a perpendicular or parallel without first selecting a line segment and point.	
First select 2 points or a segment.	You are trying to construct a midpoint without first selecting two points or a line segment.	
First select the applicable figure.	• You are trying to construct a point of intersection without first selecting two lines. • You are trying to execute ⋯ > [Animate] > [Add Animation] or [Replace Animation] without first selecting the required object. • You are trying to execute ⋯ > [Animate] > [Add Table] without first selecting the required object.	
First select 2 segments.	You are trying to construct an angle bisector without first selecting two line segments.	
Range ERROR	View Window range settings exceeded.	Press FORMAT (Zoom to Fit) or select ⋯ > [View] > [View Window] > [Pre-set Windows] > [Initialize].
	You are trying to specify t0 = t1 on the Edit Animations screen.	Specify different values for t0 and t1.
Too Many Objects!	Work memory became almost full.	Delete objects you no longer need or open a new file.
Too Many Objects! Work memory cleared.	Work memory became full.	Delete objects you no longer need or open a new file.
Invalid Measurement	You are attempting to use the Expression command (⋯ > [Option] > [Expression]) to input an expression that contains a measurement that does not exist.	Check to make sure that the expression you are inputting contains only measurements that are currently on the screen.
Too Many Animations	You are trying to add more than 10 animations.	Use the Edit Animations screen to delete animations you no longer need, or create a new file and add new animations.
First select point(s).	You are trying to execute ⋯ > [Animate] > [Trace] without first selecting a point.	Select one or more points and try again.
Too Many Trace Points	You are trying to specify more than 10 trace points.	Select up to 10 points and try again.

Too Many Columns	You are trying to add more than 26 columns to an animation table.	Delete columns from the animation table that you do not need and try again.
First configure animation settings.	• You are trying to run an animation without first configuring its settings. • You are trying to execute ⋯ > [Animate] > [Add Table] without first configuring animation settings.	Configure animation settings and try again.
Cannot Add Animation	• The point you selected for an Add Animation or Replace Animation command operation cannot be used in an animation because it is locked, etc. • The point you selected for an Add Animation or Replace Animation command operation cannot be used in an animation because it is already being used in the animation you are configuring or in another animation.	Select a point to which animation can be added and try again.
Select the applicable measurement icon.	You are trying to execute ⋯ > [Animate] > [Add Table] without first selecting the appropriate measurement icon.	Select the icon of a measurement that can be added to an animation table.
First configure animation settings and create a table.	You tried to execute ⋯ > [Animate] > [Display Table] without generating an animation table.	Generate an animation table first.
Create at least one figure with a fill color.	You are attempting to execute a surface area calculation (⋯ > [Option] > [Area Calc]) when there is no figure on the screen with a fill color.	Draw a figure with a fill color and try again.

Settings errors

When you see this message:	It means this:	So you need to do this:
Out of Domain	Attempting to input a value that is outside the allowable input range.	Input a value that is within the allowable range.
Invalid Setting	Input of an improper View Window value.	Change the View Window value so it is within range.
	Input of an improper value on the range screen and use of that value for execution.	Input a proper range value.
	Attempting to create a table with a Step value of 0.	Specify a Step value other than 0.
	Attempting to input illegal View Window setting combinations. Example: x Minimum = 10, x Maximum = 10	Enter values that have the proper relationship with each other.
	Attempting to create a table in the Recursion app when the Start value is greater than or equal to the End value.	Change the value so the Start value is less than the End value.
	Internal calculation generated a mathematical error (division by zero, etc.) when executing a function calculation or a calculation in the Statistics or Financial app.	Since the calculation contains one or more values that cannot be calculated, input different values and try again.
	Improper values were input in the 3D Graph app for a template coefficient.	Input coefficient values that can define the 3D graph.

Out of Range	Calculation result that exceeds the calculator display range.	Change the calculation formula.

Other errors

When you see this message:	It means this:	So you need to do this:
No Data	The specified data does not exist. (Occurs when a list or variable that does not contain data is referenced.)	Change the data specification.
Not Enough Elements	The list you specified for a calculation does not contain the number of elements required to perform the calculation.	Check the number of elements required by the calculation you are trying to perform and adjust the number of list elements accordingly.
	You attempted to execute a statistical calculation using a list whose elements are all zero for the Frequency data.	For Frequency data, use a list whose elements contain values greater than zero.

Calculation Ranges, Number of Digits, and Precision

Calculation Range and Precision

Calculation Range	$\pm 1 \times 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$ or 0
Number of Digits for Internal Calculation	15 digits
Precision	In general, ±1 at the 10th digit for a single calculation. Precision for exponential display is ±1 at the least significant digit. Errors are cumulative in the case of consecutive calculations.

Function Calculation Input Ranges and Precision

Functions	Input Range	
$\sin x$ $\cos x$	Degree	$\lvert x\rvert < 9 \times 10^{9}$
	Radian	$\lvert x\rvert < 5 \times 10^{7}\pi$
	Gradian	$\lvert x\rvert < 1 \times 10^{10}$
$\tan x$	Degree	Same as $\sin x$, except when $\lvert x\rvert \neq 90(2n-1)$
	Radian	Same as $\sin x$, except when $\lvert x\rvert \neq \pi/2(2n-1)$
	Gradian	Same as $\sin x$, except when $\lvert x\rvert \neq 100(2n-1)$
$\sin^{-1} x$ $\cos^{-1} x$	$\lvert x\rvert \leq 1$	
$\tan^{-1} x$	$\lvert x\rvert < 1 \times 10^{100}$	
$\sinh x$ $\cosh x$	$\lvert x\rvert \leq 230.9516564$	
$\tanh x$	$\lvert x\rvert < 1 \times 10^{100}$	
$\sinh^{-1} x$	$\lvert x\rvert < 1 \times 10^{100}$	
$\cosh^{-1} x$	$1 \leq x < 1 \times 10^{100}$	
$\tanh^{-1} x$	$\lvert x\rvert < 1$	
$\log x$ * $\ln x$ *	$1 \times 10^{-99} \leq x < 1 \times 10^{100}$	
10^{x} *	$-1 \times 10^{100} < x < 100$	

e^x *	$-1 \times 10^{100} < x \leq 230.2585092$
$\sqrt{x}$ *	$0 \leq x < 1 \times 10^{100}$
x^2 *	$\lvert x \rvert < 1 \times 10^{50}$
x^{-1} *	$\lvert x \rvert < 1 \times 10^{100}$; $x \neq 0$
$x!$	$0 \leq x \leq 69$ (x is an integer)
$n\mathrm{P}r$	$0 \leq r \leq n$, $n < 1 \times 10^{10}$ (n, r are integers) $1 \leq \{n!/(n-r)!\} < 1 \times 10^{100}$
$n\mathrm{C}r$	$0 \leq r \leq n$, $n < 1 \times 10^{10}$ (n, r are integers) $1 \leq n!/r! < 1 \times 10^{100}$ or $1 \leq n!/(n-r)! < 1 \times 10^{100}$
Pol(x,y)	$\sqrt{x^2 + y^2} < 1 \times 10^{100}$
Rec(r,θ)	$\lvert r \rvert < 1 \times 10^{100}$ θ: Same as sin$x$, cos$x$, tan$x$
$a°b'c"$	$\lvert a \rvert$, b, $c < 1 \times 10^{100}$; $0 \leq b$, c
$a°b'c" = x$	$\lvert x \rvert < 1 \times 10^{100}$ Sexagesimal display: $\lvert x \rvert < 1 \times 10^7$
x^y *	$x > 0$: $-1 \times 10^{100} < y\log x < 100$ $x = 0$: $y > 0$ $x < 0$: $y = n$, $\frac{m}{2n+1}$ (m, n are integers) However: $-1 \times 10^{100} < y\log \lvert x \rvert < 100$
$\sqrt[x]{y}$ *	$y > 0$: $x \neq 0$, $-1 \times 10^{100} < \frac{1}{x} \log y < 100$ $y = 0$: $x > 0$ $y < 0$: $x = 2n+1$, $\frac{2n+1}{m}$ ($m \neq 0$; m, n are integers) However: $-1 \times 10^{100} < \frac{1}{x} \log \lvert y \rvert < 100$
$a\frac{b}{c}$	Total of integer, numerator, and denominator must be 10 digits or less (including separator symbol).
GCD(a,b)	$\lvert a \rvert$, $\lvert b \rvert < 1 \times 10^{10}$ (a, b are integers)
LCM(a,b)	$0 \leq a$, $b < 1 \times 10^{10}$ (a, b are integers)

* Complex numbers can be used as arguments.

- Precision is basically the same as that described under “Calculation Range and Precision” (page 254).
- x^y, $\sqrt[x]{y}$, $x!$, $n\mathrm{P}r$, $n\mathrm{C}r$ type functions require consecutive internal calculation, which can cause accumulation of errors that occur with each calculation.
- Error is cumulative and tends to be large in the vicinity of a function’s singular point and inflection point.

MicroPython license information
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CASIO®

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