CFX-9970G

CASIO®

GUIDELINES LAID DOWN BY FCC RULES FOR USE OF THE UNIT IN THE U.S.A. (not applicable to other areas).

NOTICE

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC WARNING

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
Proper connectors must be used for connection to host computer and/or peripherals in order to meet FCC emission limits.

Connector SB-62	Power Graphic Unit to Power Graphic Unit
Connector FA-122	Power Graphic Unit to PC for IBM/Macintosh Machine

Declaration of Conformity

Model Number:	CFX-9970G
Trade Name:	CASIO COMPUTER CO., LTD.
Responsible Party:	CASIO, INC.
Address:	570 MT PLEASANT AVENUE, DOVER, NEW JERSEY 07801
Telephone Number:	973-361-5400

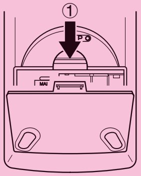
This device complies with Part 15 of FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

SA9808-003101A Printed in Japan

BEFORE USING THE CALCULATOR FOR THE FIRST TIME ONLY...

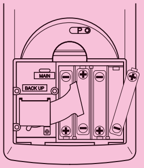
This calculator does not contain any main batteries when you purchase it. Be sure to perform the following procedure to load batteries, reset the calculator, and adjust the color contrast before trying to use the calculator for the first time.

1. Slide the back cover from the unit by pulling with your finger at the point marked ①.

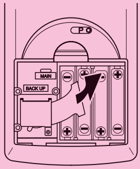


2. Load the four batteries that come with calculator.

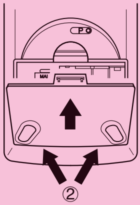
- Make sure that the positive (+) and negative (–) ends of the batteries are facing correctly.

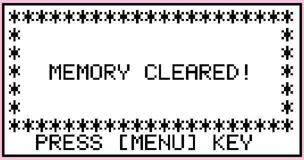


3. Remove the insulating sheet at the location marked "BACK UP" by pulling in the direction indicated by the arrow.



4. Replace the back cover, making sure that its tabs enter the holes marked ② in the illustration.

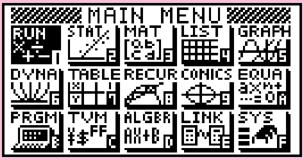




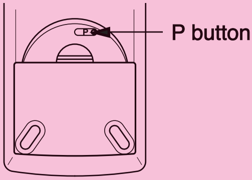
MEMORY CLEARED!

PRESS [MENU] KEY

5. Press MENU .

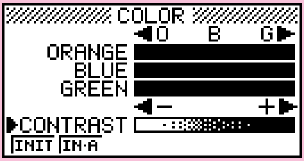


If the Main Menu shown to the right is not on the display, press the P button on the back of the calculator to perform memory reset.



6. Use the cursor keys (▲, ▼, ◀, ▶) to select the **SYS** icon and press **EXE** or simply press **F** **tan** .

7. Use the cursor keys (▼, ▲) to highlight **Color Contrast** and then press **EXE** to display the contrast adjustment screen.



8. Adjust the display color.

•To adjust the color contrast

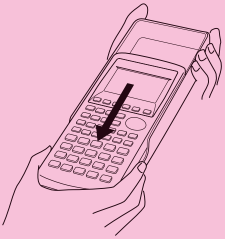
1. Use ▲ and ▼ to move the pointer to CONTRAST.
2. Press ▶ to make the figures on the display darker, and ◀ to make them lighter.

•To adjust the tint

1. Use ▲ and ▼ to move the pointer to the color you want to adjust (ORANGE, BLUE, or GREEN).
2. Press ▶ to add more green to the color, and ◀ to add more orange.

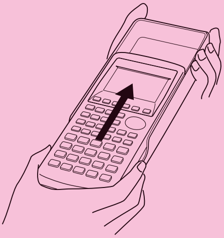
9. To exit display color adjustment, press **MENU** .

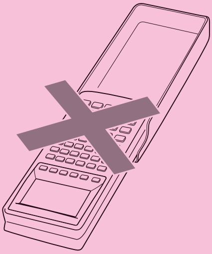
REMOVING AND REPLACING THE CALCULATOR'S COVER



To remove the cover

Grasp the top of the cover, and slide the unit out from the bottom.





To replace the cover

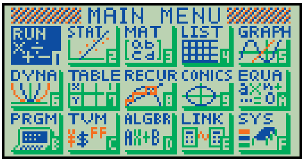
Grasp the top of the cover, and slide the unit in from the bottom.

Always slide the unit into the cover with the unit's display end first. Never slide the keyboard end of the unit into the cover.

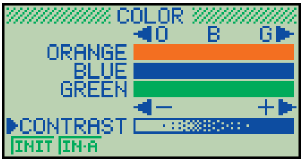
ABOUT THE COLOR DISPLAY

The display uses three colors: orange, blue, and green, to make data easier to understand.

• Main Menu



• Display Color Adjustment



• Graph Function Menu

Graph Func :Y=

Y1=2X²−5

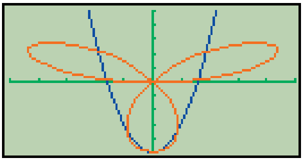
r2=5sin 3θ

Y3:

Y4:

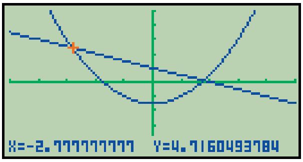
Y5:

Y6:



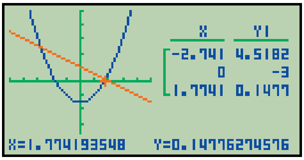
• Graph Display (Example 1)

• Graph Display (Example 2)



X=-2.777777777 Y=4.7160493784

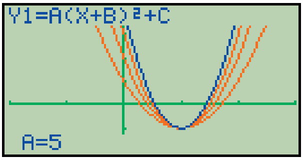
• Graph-To-Table Display



X	Y1
-2.741	4.5182
0	-3
1.7741	0.1477

X=1.774193548 Y=0.14776274576

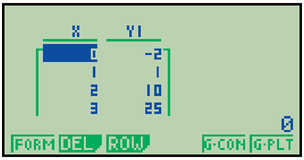
• Dynamic Graph Display



Y1=A(X+B)²+C

A=5

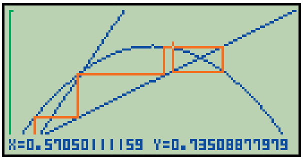
• Table & Graph Numeric Table



X	Y1
0	-2
1	1
2	10
3	25

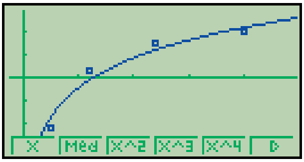
0

• Recursion Formula Convergence/ Divergence Graph Example



X=0.5705011159 Y=0.7350887979

• Statistical Regression Graph Example



- When you draw a graph or run a program, any comment text normally appears on the display in blue. You can, however, change the color of comment text to orange or green.

Example: To draw a sine curve

1. Enter the GRAPH Mode and input the following.

   F3 (TYPE) F1 (Y=)

   (Specifies rectangular coordinates.)

   sin X,θ,T EXE ▲

   (Stores the expression.)


Graph Func :Y=
Y1≡sin X
Y2:
Y3:
Y4:
Y5:
Y6:

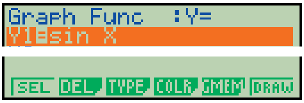
2. F4 (COLR)

- Press the function key that corresponds to the color you want to use for the graph:
  F1 for blue, F2 for orange, F3 for green.

3. F2 (Orng)

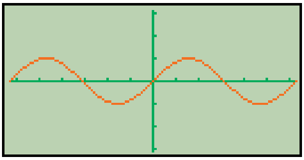
   (Specifies the graph color.)

   EXIT


Graph Func :Y=
Y1≡sin X

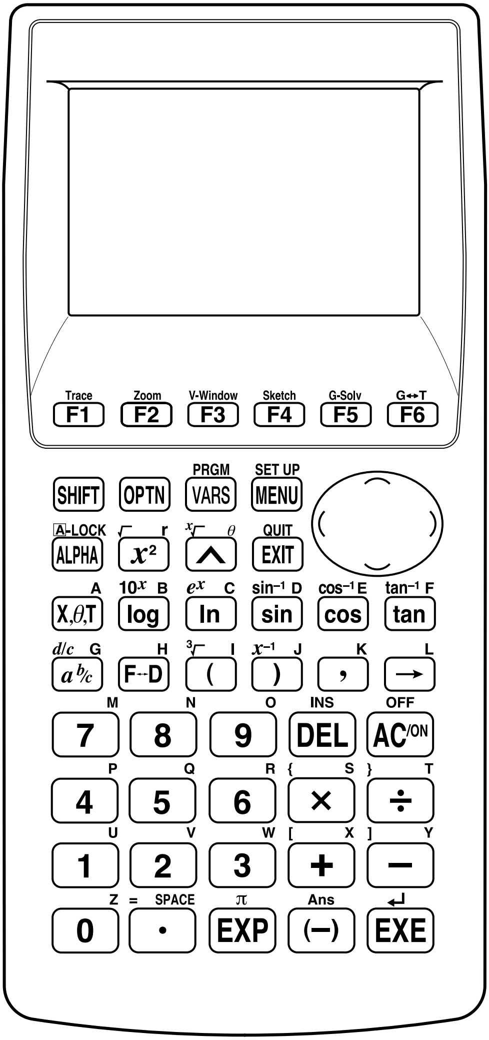
4. F6 (DRAW)

   (Draws the graph)



You can also draw multiple graphs of different color on the same screen, making each one distinct and easy to view.

KEYS

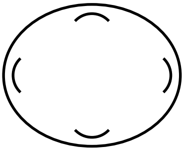


Note that pressing ÷ displays the character "/" for division, not "÷".

Alpha Lock

Normally, once you press ALPHA and then a key to input an alphabetic character, the keyboard reverts to its primary functions immediately. If you press SHIFT and then ALPHA, the keyboard locks in alpha input until you press ALPHA again.

KEY TABLE

	Page		Page		Page		Page		Page		Page
Trace F1	128	Zoom F2	132	V-Window F3	113	Sketch F4	154	G-Solv F5	144	G↔T F6	120
SHIFT	2	OPTN	27	PRGM VARS	383 28	SET UP MENU	4 3				
A-LOCK ALPHA	2	√ r x^2	47 47	$^x\sqrt{}$ θ ^	46 46	QUIT EXIT					
A X,θ,T		10^x B log	46 46	e^x C ln	46 46	$\sin^{-1}$ D sin	45 45	$\cos^{-1}$ E cos	45 45	$\tan^{-1}$ F tan	45 45
d/c G $a\,^b/_c$	49 49	H F↔D	49	$^3\sqrt{}$ I (	47 36	x^{-1} J)	47 36	K ,		L →	22

	Page		Page		Page		Page		Page
M 7		N 8		O 9		INS DEL	21 20	OFF AC/ON	
P 4		Q 5		R 6		{ S ×	36	} T ÷	36
U 1		V 2		W 3		[X +	36	] Y −	36
Z 0		= SPACE •		π EXP	45 36	Ans (−)	39 36	↵ EXE	

Quick-Start

Quick-Start

Welcome to the world of color graphing calculators and the CASIO “CFX-9970G”.

Quick-Start is not a complete tutorial, but it takes you through many of the most common functions, from turning the power on, to specifying colors, and on to graphing complex equations. When you’re done, you’ll have mastered the basic operation of the “CFX-9970G” and will be ready to proceed with the rest of this user’s guide to learn the entire spectrum of functions available.

Each step of the examples in Quick-Start is shown graphically to help you follow along quickly and easily. When you need to enter the number 57, for example, we’ve indicated it as follows:

Press 5 7

Whenever necessary, we’ve included samples of what your screen should look like. If you find that your screen doesn’t match the sample, you can restart from the beginning by pressing the “All Clear” button AC/ON .

TURNING POWER ON AND OFF

To turn power on, press AC/ON .

OFF

To turn power off, press SHIFT AC/ON.

AUTO POWER OFF FUNCTION

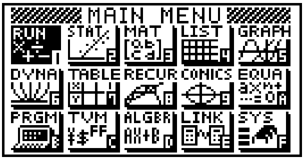
Note that the unit automatically turns power off if you do not perform any operation for about six minutes (about 60 minutes when a calculation is stopped by an output command (◢)).

USING MODES

The “CFX-9970G” makes it easy to perform a wide range of calculations by simply selecting the appropriate mode. Before getting into actual calculations and operation examples, let’s take a look at how to navigate around the modes.

To select the RUN Mode

1. Press MENU to display the Main Menu.



2. Use ◀ ▶ ▲ ▼ to highlight **RUN** and then press EXE.

   This is the initial screen of the RUN mode, where you can perform manual calculations, and run programs.

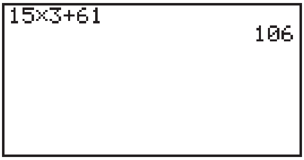
```
_
```

BASIC CALCULATIONS

With manual calculations, you input formulas from left to right, just as they are written on paper. With formulas that include mixed arithmetic operators and parentheses, the calculator automatically applies true algebraic logic to calculate the result.

Example: 15 × 3 + 61

1. Press AC/ON to clear the calculator.
2. Press 1 5 × 3 + 6 1 EXE.

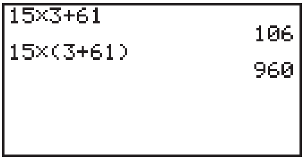


```
15×3+61
                 106
```

Parentheses Calculations

Example: 15 × (3 + 61)

1. Press 1 5 × (3 + 6 1) EXE.



```
15×3+61
                 106
15×(3+61)
                 960
```

Built-In Functions

The “CFX-9970G” includes a number of built-in scientific functions, including trigonometric and logarithmic functions.

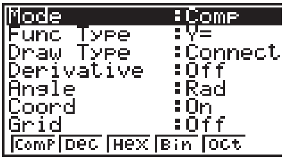
Example: 25 × sin 45˚

Important!

Be sure that you specify Deg (degrees) as the angle unit before you try this example.

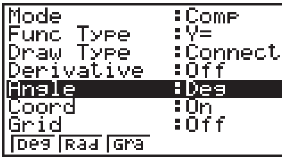
1. Press AC/ON .

2. Press SHIFT MENU (SET UP) to switch the set up display.



```
Mode          :Comp
Func Type     :Y=
Draw Type     :Connect
Derivative    :Off
Angle         :Rad
Coord         :On
Grid          :Off
Comp Dec Hex Bin Oct
```

3. Press ▼ ▼ ▼ ▼ F1 (Deg) to specify degrees as the angle unit.

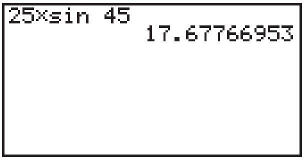


```
Mode          :Comp
Func Type     :Y=
Draw Type     :Connect
Derivative    :Off
Angle         :Deg
Coord         :On
Grid          :Off
Deg Rad Gra
```

4. Press EXIT to clear the menu.

5. Press AC/ON to clear the unit.

6. Press 2 5 × sin 4 5 EXE .



```
25×sin 45
            17.67766953
```

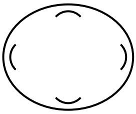
REPLAY FEATURES

With the replay feature, simply press ◀ or ▶ to recall the last calculation that was performed. This recalls the calculation so you can make changes or re-execute it as it is.

Example: To change the calculation in the last example from (25 × sin 45˚) to (25 × sin 55˚)

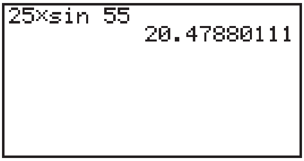
---

1. Press ◀ to display the last calculation.



2. Press ◀ twice to move the cursor under the 4.

3. Press 5 .



```
25×sin 55
            20.47880111
```

4. Press EXE to execute the calculation again.

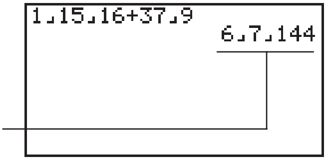
FRACTION CALCULATIONS

You can use the a b/c key to input fractions into calculations. The symbol “ ⌟ ” is used to separate the various parts of a fraction.

Example: 1 $^{15}/_{16}$ + $^{37}/_{9}$

1. Press AC/ON .

2. Press 1 a b/c 1 5 a b/c 1 6 + 3 7 a b/c 9 EXE .



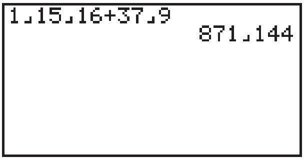
```
1⌟15⌟16+37⌟9
      6⌟7⌟144
```

Indicates 6 $^{7}/_{144}$

Converting a Mixed Fraction to an Improper Fraction

While a mixed fraction is shown on the display, press SHIFT a b/c (*d/c*) to convert it to an improper fraction.

Press SHIFT a b/c (*d/c*) again to convert back to a mixed fraction.

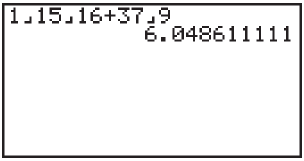


```
1⌟15⌟16+37⌟9
      871⌟144
```

Converting a Fraction to Its Decimal Equivalent

While a fraction is shown on the display, press F↔D to convert it to its decimal equivalent.

Press F↔D again to convert back to a fraction.

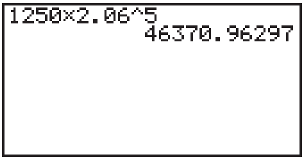


```
1⌟15⌟16+37⌟9
  6.048611111
```

EXPONENTS

Example: 1250×2.06^5

1. Press AC/ON .
2. Press 1 2 5 0 × 2 • 0 6 .
3. Press ^ and the **^** indicator appears on the display.
4. Press 5 . The **^5** on the display indicates that 5 is an exponent.
5. Press EXE .



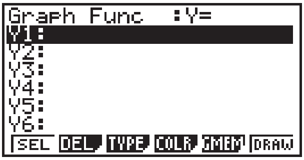
```
1250×2.06^5
           46370.96297
```

GRAPH FUNCTIONS

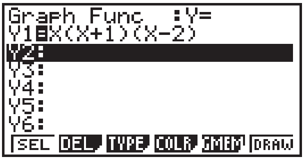
The graphing capabilities of this calculator makes it possible to draw complex graphs using either rectangular coordinates (horizontal axis: x ; vertical axis: y) or polar coordinates (angle: θ ; distance from origin: r).

***Example* 1:** To graph Y = X(X + 1)(X – 2)

1. Press MENU .
2. Use ◀, ▶, ▲, and ▼ to highlight **GRAPH**, and then press EXE .

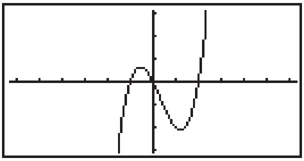

Graph Func :Y=
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:

3. Input the formula.
X,θ,T (X,θ,T + 1)
(X,θ,T − 2) EXE


Graph Func :Y=
Y1■X(X+1)(X-2)
Y2:
Y3:
Y4:
Y5:
Y6:

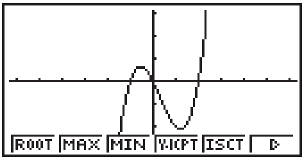
F6

4. Press F6 (DRAW) or EXE to draw the graph.



***Example* 2:** To determine the roots of Y = X(X + 1)(X – 2)

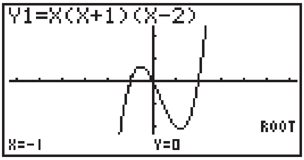
1. Press SHIFT F5 (G-Solv).



F1

2. Press F1 (ROOT).

   Press ▶ for other roots.



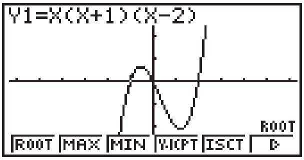
Y1=X(X+1)(X-2)

X=-1 Y=0

***Example* 3:** Determine the area bounded by the origin and the X = –1 root obtained for Y = X(X + 1)(X – 2)

---

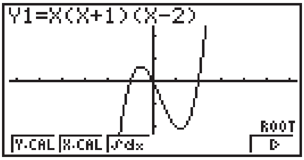
1. Press SHIFT F5 (G-Solv).



Y1=X(X+1)(X-2)

F6

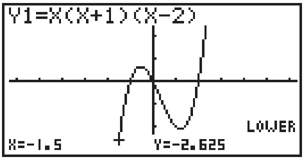
2. Press F6 (▷).



Y1=X(X+1)(X-2)

F3

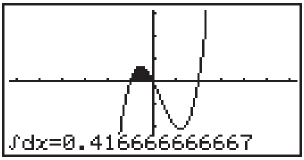
3. Press F3 (∫*dx*).



Y1=X(X+1)(X-2)

X=-1.5 Y=-2.625

4. Use ▶ to move the pointer to the location where X = –1, and then press EXE. Next, use ▶ again to move the pointer to the location where X = 0, and then press EXE to input the integration range, which becomes shaded on the display.



∫dx=0.41666666667

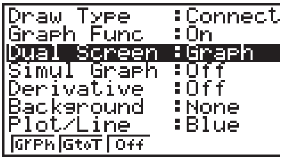
DUAL GRAPH

With this function you can split the display between two areas and display two graphs on the same screen.

Example: To draw the following two graphs and determine the points of intersection

Y1 = X(X + 1)(X – 2)
Y2 = X + 1.2

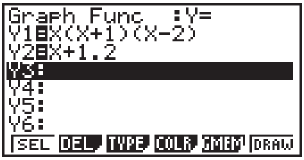
1. Press SHIFT SET UP ▼ ▼ F1 (Grph) to specify "Graph" for the Dual Screen setting.



```
Draw Type   :Connect
Graph Func  :On
Dual Screen :Graph
Simul Graph :Off
Derivative  :Off
Background  :None
Plot/Line   :Blue
```

F1

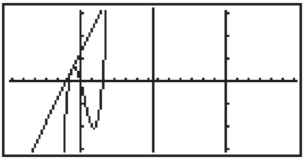
2. Press EXIT, and then input the two functions.
   X,θ,T (X,θ,T + 1)
   (X,θ,T − 2) EXE
   X,θ,T + 1 • 2 EXE



```
Graph Func  :Y=
Y1■X(X+1)(X-2)
Y2■X+1.2
Y3:
Y4:
Y5:
Y6:
```

F6

3. Press F6 (DRAW) or EXE to draw the graphs.

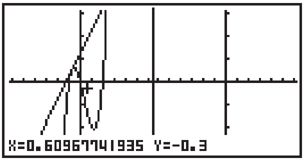


BOX ZOOM

Use the Box Zoom function to specify areas of a graph for enlargement.

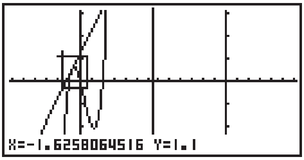
1. Press SHIFT F2 (Zoom) F1 (BOX).

2. Use ◀, ▶, ▲, and ▼ to move the pointer to one corner of the area you want to specify and then press EXE.



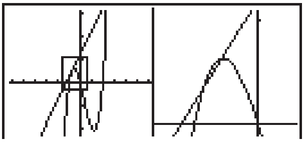
X=0.60967741935 Y=-0.3

3. Use ◀, ▶, ▲, and ▼ to move the pointer again. As you do, a box appears on the display. Move the pointer so the box encloses the area you want to enlarge.



X=-1.6258064516 Y=1.1

4. Press EXE, and the enlarged area appears in the inactive (right side) screen.



DYNAMIC GRAPH

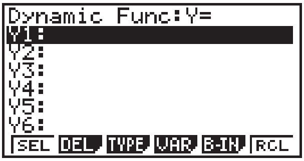
Dynamic Graph lets you see how the shape of a graph is affected as the value assigned to one of the coefficients of its function changes.

Example: To draw graphs as the value of coefficient A in the following function changes from 1 to 3

$$Y = AX^2$$

1. Press MENU.

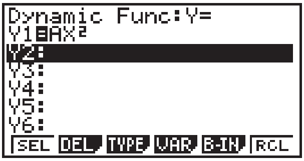
2. Use ◀, ▶, ▲, and ▼ to highlight **DYNA**, and then press EXE.



Dynamic Func:Y=
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:

3. Input the formula.

ALPHA A X,θ,T x^2 EXE



Dynamic Func:Y=
Y1=AX^2
Y2:
Y3:
Y4:
Y5:
Y6:

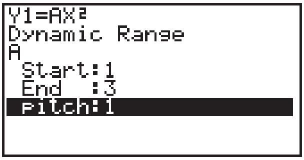
F4

4. Press F4 (VAR) 1 EXE to assign an initial value of 1 to coefficient A.


$Y1=AX^2$
Dynamic Var :A
A=1

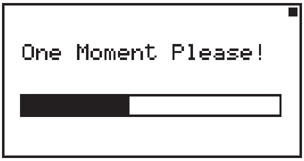
F2

5. Press F2 (RANG) 1 EXE 3 EXE 1 EXE to specify the range and increment of change in coefficient A.

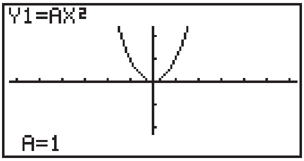

$Y1=AX^2$
Dynamic Range
A
Start:1
End :3
Pitch:1

6. Press EXIT .

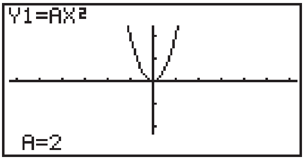
7. Press F6 (DYNA) to start Dynamic Graph drawing. The graphs are drawn 10 times.


One Moment Please!

↓



↓ ↑



↓ ↑

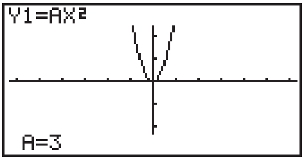


TABLE FUNCTION

The Table Function makes it possible to generate a table of solutions as different values are assigned to the variables of a function.

Example: To create a number table for the following function

Y = X (X+1) (X–2)

1. Press MENU .

2. Use ◀, ▶, ▲, and ▼ to highlight **TABLE**, and then press EXE .

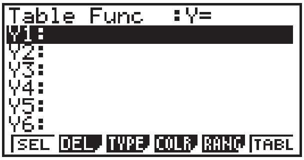


Table Func :Y=
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:

3. Input the formula.
X,θ,T (X,θ,T + 1)
(X,θ,T − 2) EXE

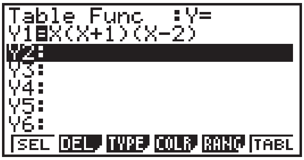
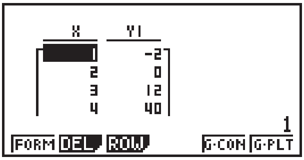


Table Func :Y=
Y1▪X(X+1)(X-2)
Y2:
Y3:
Y4:
Y5:
Y6:

F6

4. Press F6 (TABL) or EXE to generate the number table.



X	Y1
1	-2
2	0
3	12
4	40

1

After you've completed this Quick-Start section, you are well on your way to becoming an expert user of the CASIO "CFX-9970G" Calculator.

To learn all about the many powerful features of the "CFX-9970G", read on and explore!

Handling Precautions

- Your calculator is made up of precision components. Never try to take it apart.
- Avoid dropping your calculator and subjecting it to strong impact.
- Do not store the calculator or leave it in areas exposed to high temperatures or humidity, or large amounts of dust. When exposed to low temperatures, the calculator may require more time to display results and may even fail to operate. Correct operation will resume once the calculator is brought back to normal temperature.
- The display will go blank and keys will not operate during calculations. When you are operating the keyboard, be sure to watch the display to make sure that all your key operations are being performed correctly.
- Replace the main batteries once every 2 years regardless of how much the calculator is used during that period. Never leave dead batteries in the battery compartment. They can leak and damage the unit.
- Keep batteries out of the reach of small children. If swallowed, consult with a physician immediately.
- Avoid using volatile liquids such as thinner or benzine to clean the unit. Wipe it with a soft, dry cloth, or with a cloth that has been dipped in a solution of water and a neutral detergent and wrung out.
- Always be gentle when wiping dust off the display to avoid scratching it.
- In no event will the manufacturer and its suppliers be liable to you or any other person for any damages, expenses, lost profits, lost savings or any other damages arising out of loss of data and/or formulas arising out of malfunction, repairs, or battery replacement. The user should prepare physical records of data to protect against such data loss.
- Never dispose of batteries, the liquid crystal panel, or other components by burning them.
- When the “Low battery!” message appears on the display, replace the main power supply batteries as soon as possible.
- Be sure that the power switch is set to OFF when replacing batteries.
- If the calculator is exposed to a strong electrostatic charge, its memory contents may be damaged or the keys may stop working. In such a case, perform the Reset operation to clear the memory and restore normal key operation.
- If the calculator stops operating correctly for some reason, use a thin, pointed object to press the P button on the back of the calculator. Note, however, that this clears all the data in calculator memory.
- Note that strong vibration or impact during program execution can cause execution to stop or can damage the calculator’s memory contents.
- Using the calculator near a television or radio can cause interference with TV or radio reception.
- Before assuming malfunction of the unit, be sure to carefully reread this user’s guide and ensure that the problem is not due to insufficient battery power, programming or operational errors.

Be sure to keep physical records of all important data!

The large memory capacity of the unit makes it possible to store large amounts of data. You should note, however, that low battery power or incorrect replacement of the batteries that power the unit can cause the data stored in memory to be corrupted or even lost entirely. Stored data can also be affected by strong electrostatic charge or strong impact.

Since this calculator employs unused memory as a work area when performing its internal calculations, an error may occur when there is not enough memory available to perform calculations. To avoid such problems, it is a good idea to leave 1 or 2 kbytes of memory free (unused) at all times.

- The contents of this user's guide are subject to change without notice.
- No part of this user's guide may be reproduced in any form without the express written consent of the manufacturer.
- The options described in Chapter 22 of this user's guide may not be available in certain geographic areas. For full details on availability in your area, contact your nearest CASIO dealer or distributor.

CFX-9970G

Contents

Chapter 7 Equation Calculations 99

Getting Acquainted
— Read This First!

About this User's Guide

•Function Keys and Menus

- Many of the operations performed by this calculator can be executed by pressing function keys F1 through F6. The operation assigned to each function key changes according to the mode the calculator is in, and current operation assignments are indicated by function menus that appear at the bottom of the display.
- This user's guide indicates the current operation assigned to a function key in parentheses following the key cap marking for that key. F1 (Comp), for example, indicates that pressing F1 selects {Comp}, which is also indicated in the function menu.
- When {▷} is indicated in the function menu for key F6, it means that pressing F6 displays the next page or previous page of menu options.

•Menu Titles

- Menu titles in this user's guide include the key operation required to display the menu being explained. The key operation for a menu that is displayed by pressing OPTN and then {COLR} would be shown as: **[OPTN]-[COLR]**.
- F6 (▷) key operations to change to another menu page are not shown in menu title key operations.

•Command List

- The Program Mode Command List (page 468) provides a graphic flowchart of the various function key menus that shows how to maneuver to the menu of commands you need.

  Example: The following operation displays Xfct: **[VARS]-[FACT]-[Xfct]**

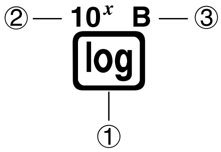
•Icons Used in This User's Guide

- The following are the meanings of the icons used in this user's guide.

: Important ✎ : Note P.000 : Reference page

1. Key Markings

Many of the calculator's keys are used to perform more than one function. The functions marked on the keyboard are color coded to help you find the one you need quickly and easily.



	Function	Key Operation
①	log	log
②	10^x	SHIFT log
③	B	ALPHA log

The following describes the color coding used for key markings.

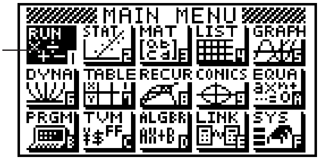
Color	Key Operation
Orange	Press SHIFT and then the key to perform the marked function.
Red	Press ALPHA and then the key to perform the marked function.

2. Selecting Icons and Entering Modes

This section describes how to select an icon in the Main Menu to enter the mode you want.

•To select an icon

1. Press MENU to display the Main Menu.



Currently selected icon

2. Use the cursor keys (◀, ▶, ▲, ▼) to move the highlighting to the icon you want.
3. Press EXE to display the initial screen of the mode whose icon you selected.

- You can also enter a mode without highlighting an icon in the Main Menu by inputting the number or letter marked in the lower right corner of the icon.
- Use only the procedures described above to enter a mode. If you use any other procedure, you may end up in a mode that is different than the one you thought you selected.

The following explains the meaning of each icon.

Icon	Mode Name	Description
RUN	RUN	Use this mode for arithmetic calculations and function calculations, and for calculations involving binary, octal, decimal and hexadecimal values.
STAT	STATistics	Use this mode to perform single-variable (standard deviation) and paired-variable (regression) statistical calculations, to perform tests, to analyze data and to draw statistical graphs.
MAT	MATrix	Use this mode for storing and editing matrices.
LIST	LIST	Use this mode for storing and editing numeric data.
GRAPH	GRAPH	Use this mode to store graph functions and to draw graphs using the functions.
DYNA	DYNAmic graph	Use this mode to store graph functions and to draw multiple versions of a graph by changing the values assigned to the variables in a function.

Icon	Mode Name	Description
TABLE	TABLE	Use this mode to store functions, to generate a numeric table of different solutions as the values assigned to variables in a function change, and to draw graphs.
RECUR	RECURsion	Use this mode to store recursion formulas, to generate a numeric table of different solutions as the values assigned to variables in a function change, and to draw graphs.
CONICS	CONICS	Use this mode to draw graphs of implicit functions.
EQUA	EQUAtion	Use this mode to solve linear equations with two through six unknowns, quadratic equations, and cubic equations.
PRGM	PRoGraM	Use this mode to store programs in the program area and to run programs.
TVM	Time Value of Money	Use this mode to perform financial calculations and to draw cash flow and other types of graphs.
ALGBR	ALGeBRa	Use this mode to obtain mathematical expression results using natural mathematical display notation.
LINK	LINK	Use this mode to transfer memory contents or back-up data to another unit.
SYS	SYStem	Use this mode to check how much memory is used and remaining, to delete data from memory, and to initialize (reset) the calculator. It also lets you adjust display contrast.

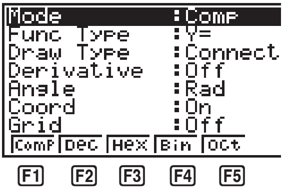
■ Using the Set Up Screen

The mode's set up screen shows the current status of mode settings and lets you make any changes you want. The following procedure shows how to change a set up.

•To change a mode set up

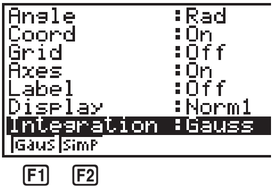
1. Select the icon you want and press EXE enter a mode and display its initial screen. Here we will enter the RUN Mode.

2. Press SHIFT SET UP to display the mode's set up screen.
   - This set up screen is just one possible example. Actual set up screen contents will differ according to the mode you are in and that mode's current settings.



Mode :Comp
Func Type :Y=
Draw Type :Connect
Derivative :Off
Angle :Rad
Coord :On
Grid :Off

⋮



Angle :Rad
Coord :On
Grid :Off
Axes :On
Label :Off
Display :Norm1
Integration :Gauss

3. Use the ▲ and ▼ cursor keys to move the highlighting to the item whose setting you want to change.
4. Press the function key (F1 to F6) that is marked with the setting you want to make.
5. After you are finished making any changes you want, press EXIT to return to the initial screen of the mode.

■ Set Up Screen Function Key Menus

This section details the settings you can make using the function keys in the set up display.

•Mode (calculation /binary, octal, decimal, hexadecimal mode)

- {**Comp**} ... {arithmetic calculation mode}
- P.75 {**Dec**}/{**Hex**}/{**Bin**}/{**Oct**} ... {decimal}/{hexadecimal}/{binary}/{octal}

•Func Type (graph function type)

- P.123 ~P.125 {**Y=**}/{**r=**}/{**Parm**}/{**X=c**} ... {rectangular coordinate}/{polar coordinate}/{parametric coordinate}/{X = constant} graph
- P.126 {**Y>**}/{**Y<**}/{**Y≥**}/{**Y≤**} ... {$y>f(x)$}/{$y<f(x)$}/{$y\geq f(x)$}/{$y\leq f(x)$} inequality graph

- The X,θ,T key inputs one of three different variable names. Which variable name it inputs is determined by the {Func Type} setting you make.

•Draw Type (graph drawing method)

- P.128 {**Con**}/{**Plot**} ... {connected points}/{unconnected points}

•Derivative (derivative value display)

- P.129 P.177 P.209 {**On**}/{**Off**} ... {display on}/{display off} while Graph-to-Table, Table & Graph, and Trace are being used

•Angle (default unit of angular measurement)

- P.14 {**Deg**}/{**Rad**}/{**Gra**} ... {degrees}/{radians}/{grads}

•Coord (graph pointer coordinate display)

- P.130 {**On**}/{**Off**} ... {display on}/{display off}

•Grid (graph gridline display)

P.121 • {**On**}/{**Off**} ... {display on}/{display off}

•Axes (graph axis display)

P.121 • {**On**}/{**Off**} ... {display on}/{display off}

•Label (graph axis label display)

P.121 • {**On**}/{**Off**} ... {display on}/{display off}

•Display (display format)

P.14
P.15 • {**Fix**}/{**Sci**}/{**Norm**}/{**Eng**} ... {fixed number of decimal places specification}/{number of significant digits specification}/{exponential format display range toggle}/{Engineering Mode}

•Integration (Integration calculation)

P.60 • {**Gaus**}/{**Simp**} ... integration calculation using {Gauss-Kronrod rule}/{Simpson's rule}.

•Stat Wind (statistical graph view window setting method)

P.251 • {**Auto**}/{**Man**} ... {automatic}/{manual}

•Graph Func (function display during graph drawing and trace)

P.187 • {**On**}/{**Off**} ... {display on}/{display off}

•Background (graph display background)

P.140 • {**None**}/{**PICT**} ... {no background}/{graph background picture specification}

•Plot/Line (plot and line graph color setting)

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

•Resid List (residual calculation)

P.266 • {**None**}/{**LIST**} ... {no calculation}/{list specification for the calculated residual data}

•List File (list file specification)

P.248 • {**File 1**} to {**File 6**} ... {specification of which list file to display while using the List function}

•Dual Screen (Dual Screen Mode status)

The Dual Screen Mode settings you can make depends on whether you pressed SHIFT SET UP while in the GRAPH Mode, TABLE Mode, or RECUR Mode.

GRAPH Mode

P.168 P.176
- {**Grph**}/{**GtoT**}/{**Off**} ... {graphing on both sides of Dual Screen}/{graph on one side and numeric table on the other side of Dual Screen}/{Dual Screen off}

TABLE/RECUR Mode

P.215
- {**T+G**}/{**Off**} ... {graph on one side and numeric table on the other side of Dual Screen}/{Dual Screen off}

•Simul Graph (simultaneous graphing mode)

- {**On**}/{**Off**} ... {simultaneous graphing on (all graphs drawn simultaneously)}/{simultaneous graphing off (graphs drawn in area numeric sequence)}

•Dynamic Type (Dynamic Graph type)

P.186 P.187
- {**Cnt**}/{**Stop**} ... {non-stop (continuous)}/{automatic stop after 10 draws}

•Locus (Dynamic Graph Locus Mode)

P.188
- {**On**}/{**Off**} ... {locus identified by color}/{locus not drawn}

•Variable (Table Generation and Graph Draw settings)

P.208
- {**Rang**}/{**LIST**} ... {use table range}/{use list data}

•Σ Display (Σ value display in recursion table)

P.224
- {**On**}/{**Off**} ... {display on}/{display off}

•Slope (display of derivative at current pointer location in implicit function graph)

- {**On**}/{**Off**} ... {display on}/{display off}

•Payment (payment period setting)

P.329
- {**BGN**}/{**END**} ... {beginning}/{end} setting of payment period

•Date Mode (number of days per year setting)

P.322
- {**365**}/{**360**} ... interest calculations using {365}/{360} days per year

* The 365-day year must be used for date calculations in the Financial Mode. Otherwise, an error occurs.

•Answer Type (type of numbers for results)

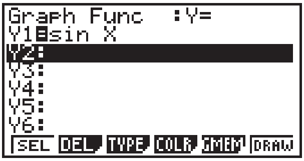
P.362
- {Real}/{Cplx} ... {use real numbers only}/{include imaginary numbers} when displaying results of processes with real number expressions.

3. Display

About the Display Screen

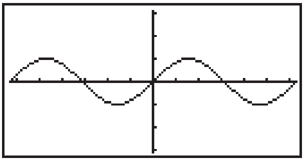
This calculator uses two types of display: a text display and a graphic display. The text display can show 21 columns and eight lines of characters, with the bottom line used for the function key menu, while the graph display uses an area that measures 127 (W) × 63 (H) dots.

Text Display



```
Graph Func   :Y=
Y1■sin X
Y2:
Y3:
Y4:
Y5:
Y6:
```

Graph Display



About Display Colors

[OPTN]-[COLR]

The calculator can display data in three colors: orange, blue, and green. The default color for graphs and comment text is blue, but you can specify orange or green if you want.

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

- The above setting affects the color of graphs and comment text. Specify the color you want to use before inputting the graph's function or the program comment text.

About Menu Item Types

This calculator uses certain conventions to indicate the type of result you can expect when you press a function key.

- **Next Menu**

Example: HYP

Selecting HYP displays a menu of hyperbolic functions.

- **Command Input**

Example: sinh

Selecting sinh inputs the sinh command.

- **Direct Command Execution**

Example: DRAW

Selecting DRAW executes the DRAW command.

Exponential Display

The calculator normally displays values up to 10 digits long. Values that exceed this limit are automatically converted to and displayed in exponential format. You can specify one of two different ranges for automatic changeover to exponential display.

Norm 1 .... 10^{-2} (0.01) > $|x|$, $|x| \geqq 10^{10}$

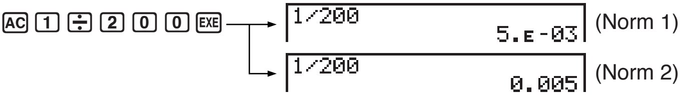
Norm 2 .... 10^{-9} (0.000000001) > $|x|$, $|x| \geqq 10^{10}$

•To change the exponential display range

1. Press SHIFT SETUP to display the set up screen.
2. Use ⏶ and ⏷ to move the highlighting to “Display”.
3. Press F3 (Norm).

The exponential display range switches between Norm 1 and Norm 2 each time you perform the above operation. There is no display indicator to show you which exponential display range is currently in effect, but you can always check it by seeing what results the following calculation produces.

AC 1 ÷ 2 0 0 EXE



```
1/200
               5.E-03
```

(Norm 1)

```
1/200
                0.005
```

(Norm 2)

All of the examples in this manual show calculation results using Norm 1.

•How to interpret exponential format

```
1.2E12
              1.2E+12
```

1.2E+12 indicates that the result is equivalent to 1.2 × 10^{12}. This means that you should move the decimal point in 1.2 twelve places to the right, because the exponent is positive. This results in the value 1,200,000,000,000.

```
1.2E-3
              1.2E-03
```

1.2E–03 indicates that the result is equivalent to 1.2 × 10^{-3}. This means that you should move the decimal point in 1.2 three places to the left, because the exponent is negative. This results in the value 0.0012.

Special Display Formats

This calculator uses special display formats to indicate fractions, hexadecimal values, and sexagesimal values.

•Fractions

```
456⌟12⌟23
          456⌟12⌟23
```

..... Indicates: $456\frac{12}{23}$

•Hexadecimal Values

```
ABCDEF12
           ABCDEF12
```

..... Indicates: ABCDEF12$_{(16)}$, which equals –1412567278$_{(10)}$

•Sexagesimal Values

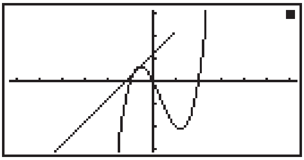
```
12.58244
       12°34’56.78”
```

..... Indicates: 12° 34’ 56.78"

- In addition to the above, this calculator also uses other indicators or symbols, which are described in each applicable section of this manual as they come up.

Calculation Execution Indicator

Whenever the calculator is busy drawing a graph or executing a long, complex calculation or program, a black box (■) flashes in the upper right corner of the display. This black box tells you that the calculator is performing an internal operation.



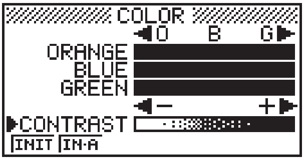
4. Color Adjustment

Adjust the color whenever objects on the display appear dim or difficult to see. There are two different settings you can make to get color the way you want it.

- Color contrast
- Tint adjustment for each color

•To display the color adjustment screen

1. Highlight the **SYS** icon in the Main Menu and then press EXE.
2. Highlight **Color Contrast** and then press EXE.



• {**INIT**}/{**IN·A**} ... {initialize highlighted color}/
{initialize all colors}

Use the following procedures while the color adjustment screen is on the display to adjust the color contrast and tint settings.

•To adjust the color contrast

1. Use the cursor ▲ and ▼ keys to move the pointer so it is next to CONTRAST.
2. Press the ► cursor key to make the display darker and the ◄ cursor key to make it lighter. Holding down either key changes the setting at high speed.

•To adjust the color tint

1. Use the cursor ▲ and ▼ keys to move the pointer so it is next to the color (ORANGE, BLUE, GREEN) whose tint you want to adjust.
2. Press the ► cursor key to give the color a greener tint and the ◄ cursor key to give it an orange tint. Holding down either key changes the setting at high speed.

•To exit the color adjustment screen

Press MENU to return to the Main Menu.

- It is recommended that you always adjust the CONTRAST setting first, and then adjust the tint settings for individual colors.

- You can change the CONTRAST setting at any time without displaying the color adjustment screen. Simply press SHIFT and then ◄ or ► to change the setting. Press SHIFT once again after get the display looking the way you want.

5. When you keep having problems…

If you keep having problems when you are trying to perform operations, try the following before assuming that there is something wrong with the calculator.

■ Get the Calculator Back to its Original Mode Settings

P.3

1. In the Main Menu, select the **RUN** icon and press EXE.
2. Press SHIFT SET UP to display the set up screen.
3. Highlight “Angle” and press F2 (Rad).
4. Highlight “Display” and press F3 (Norm) to select the exponential display range (Norm 1 or Norm 2) that you want to use.
5. Now enter the correct mode and perform your calculation again, monitoring the results on the display.

■ In Case of Hang Up

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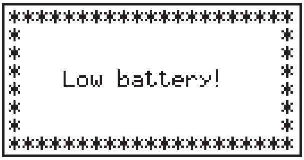
- Should the unit hang up and stop responding to input from the keyboard, press the P button on the back of the calculator to reset the memory. Note, however, that this clears all the data in calculator memory.

■ Low Battery Message

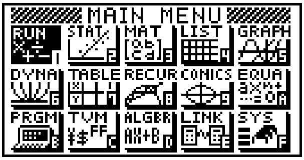
The low battery message appears whenever you press AC/ON to turn power on or MENU to display the Main Menu while the main battery power is below a certain level.

AC/ON or MENU



Low battery!

↓ *About 3 seconds later*



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If you continue using the calculator without replacing batteries, power will automatically turn off to protect memory contents. Once this happens, you will not be able to turn power back on, and there is the danger that memory contents will be corrupted or lost entirely.

- You will not be able to perform data communications operations once the low battery message appears.

Chapter 1

Basic Operation

1-1 Before Starting Calculations...

Before performing a calculation for the first time, you should use the set up screen to specify the angle unit and display format.

■ Setting the Angle Unit (Angle)

1. Display the set up screen and use the ▲ and ▼ keys to highlight “Angle”.

2. Press the function key for the angle unit you want to specify.
   - {**Deg**}/{**Rad**}/{**Gra**} ... {degrees}/{radians}/{grads}

3. Press EXIT to return to the screen that was on the display when you started the procedure.
   - The relationship between degrees, grads, and radians is shown below.

     360° = 2π radians = 400 grads

     90° = π/2 radians = 100 grads

■ Setting the Display Format (Display)

1. Display the set up screen and use the ▲ and ▼ keys to highlight “Display”.

2. Press the function key for the item you want to set.
   - {**Fix**}/{**Sci**}/{**Norm**}/{**Eng**} ... {fixed number of decimal places specification}/{number of significant digits specification}/{exponential format display range toggle}/{Engineering Mode}

3. Press EXIT to return to the screen that was on the display when you started the procedure.

• To specify the number of decimal places (Fix)

Example **To specify two decimal places**

F1 (Fix) F3 (2)

Press the function key that corresponds to the number of decimal places you want to specify (n = 0 to 9).

Display :Fix2

- Displayed values are rounded off to the number of decimal places you specify.

• To specify the number of significant digits (Sci)

Example **To specify three significant digits**

F2 (Sci) F4 (3)

Press the function key that corresponds to the number of significant digits you want to specify (n = 0 to 9).

Display :Sci3

- Displayed values are rounded off to the number of significant digits you specify.
- Specifying 0 makes the number of significant digits 10.

• To specify the exponential display range (Norm 1/Norm 2)

Press F3 (Norm) to switch between Norm 1 and Norm 2.

Norm 1: 10^{-2} (0.01)>$|x|$, $|x| \geqq 10^{10}$

Norm 2: 10^{-9} (0.000000001)>$|x|$, $|x| \geqq 10^{10}$

• To specify the engineering notation display (Eng)

Press F4 (Eng) to switch between engineering notation and standard notation. The indicator "/E" is on the display while engineering notation is in effect.

The following are the 11 engineering notation symbols used by this calculator.

Symbol	Meaning	Unit	Symbol	Meaning	Unit
E	Exa	10^{18}	m	milli	10^{-3}
P	Peta	10^{15}	μ	micro	10^{-6}
T	Tera	10^{12}	n	nano	10^{-9}
G	Giga	10^{9}	p	pico	10^{-12}
M	Mega	10^{6}	f	femto	10^{-15}
k	kilo	10^{3}			

- The engineering symbol that makes the mantissa a value from 1 to 1000 is automatically selected by the calculator when engineering notation is in effect.

Inputting Calculations

When you are ready to input a calculation, first press AC to clear the display. Next, input your calculation formulas exactly as they are written, from left to right, and press EXE to obtain the result.

Example 1 **2 + 3 – 4 + 10 =**

AC 2 + 3 – 4 + 1 0 EXE

```
2+3-4+10
                 11
```

Example 2 **2(5 + 4) ÷ (23 × 5) =**

AC 2 (5 + 4) ÷
(2 3 × 5) EXE

```
2(5+4)/(23×5)
       0.1565217391
```

Calculation Priority Sequence

This calculator employs true algebraic logic to calculate the parts of a formula in the following order:

① Coordinate transformation Pol (x, y), Rec (r, θ)

Differentials, quadratic differentials, integrations, Σ calculations

d/dx, d^2/dx^2, $\int dx$, Σ, Mat, Solve, FMin, FMax, List→Mat, Fill, Seq, SortA, SortD, Min, Max, Median, Mean, Augment, Mat→List, List

ALGBR Mode unique commands

expand(, factor(, tExpand(, tCollect(, ∫ (, diff(, solve(, tanLine(, collect(, combine(, sequence(, sumSeq(, expToTrig(, trigToExp(, signum(

② Type A functions

With these functions, the value is entered and then the function key is pressed.

x^2, x^{-1}, $x\,!$, ° ’ ”, ENG symbols

③ Power/root ^(x^y), $\sqrt[x]{\ }$

④ Fractions $a\,{}^b/_c$

⑤ Abbreviated multiplication format in front of π, memory name, or variable name.

2π, 5A, X min, F Start, etc.

⑥ Type B functions

With these functions, the function key is pressed and then the value is entered.

$\sqrt{\ }$, $\sqrt[3]{\ }$, log, In, e^x, 10^x, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, (–), d, h, b, o, Neg, Not, Det, Trn, Dim, Identity, Sum, Prod, Cuml, Percent, ⊿List

⑦ Abbreviated multiplication format in front of Type B functions

$2\sqrt{3}$, A log2, etc.

⑧ Permutation, combination nPr, nCr

⑨ × , / (÷)

⑩ +, –

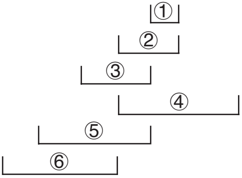
⑪ Relational operator
=, ≠, >, <, ≥, ≤

⑫ And, and

⑬ Or, or, xor, xnor

- Execution is normally performed from left to right, except in the following cases when it is performed from right to left.
  - ·When functions with the same priority are used in series:
    $e^x\text{ln}\sqrt{120} \rightarrow e^x\{\text{ln}(\sqrt{120})\}$
  - ·When power calculations are used in series in the ALGBR Mode:
    [5^3^2 → 5^(3^2)]
  - ·To produce the same result in the RUN Mode, the above calculation should be input: (5^3)^2
- Compound functions are executed from right to left.
- Anything contained within parentheses receives highest priority.

Example **2 + 3 × (log sin2π^2 + 6.8) = 22.07101691 (angle unit = Rad)**



■ Multiplication Operations without a Multiplication Sign

You can omit the multiplication sign (×) in any of the following operations.

Example **2sin30, 10log1.2, 2$\sqrt{3}$, 2Pol(5, 12), etc.**

- Before constants, variable names, memory names

Example **2π, 2AB, 3Ans, 3Y_1, etc.**

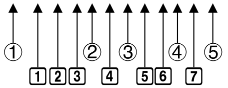
- Before an open parenthesis

Example **3(5 + 6), (A + 1)(B – 1), etc.**

■ Stacks

The unit employs memory blocks, called *stacks*, for storage of low priority values and commands. There is a 10-level *numeric value stack*, a 26-level *command stack*, and a 10-level *program subroutine stack*. An error occurs if you perform a calculation so complex that it exceeds the capacity of available numeric value stack or command stack space, or if execution of a program subroutine exceeds the capacity of the subroutine stack.

Example 2 × ((3 + 4 × (5 + 4) ÷ 3) ÷ 5) + 8 =



Numeric Value Stack

①	**2**
②	**3**
③	**4**
④	**5**
⑤	**4**
⋮	

Command Stack

$\boxed{1}$	×
$\boxed{2}$	(
$\boxed{3}$	(
$\boxed{4}$	+
$\boxed{5}$	×
$\boxed{6}$	(
$\boxed{7}$	+
⋮	

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- Calculations are performed according to the priority sequence. Once a calculation is executed, it is cleared from the stack.
- Storing a complex number takes up two numeric value stack levels.

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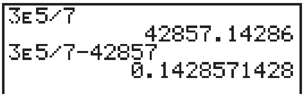
- Storing a two-byte function takes up two command stack levels.

■ Input, Output and Operation Limitations

The allowable range for both input and output values is 10 digits for the mantissa and 2 digits for the exponent. Internally, however, the unit performs calculations using 15 digits for the mantissa and 2 digits for the exponent.

Example **$3 \times 10^5 \div 7 - 42857 =$**

AC 3 EXP 5 ÷ 7 EXE
3 EXP 5 ÷ 7 −
4 2 8 5 7 EXE



```
3E5/7
          42857.14286
3E5/7-42857
         0.1428571428
```

Overflow and Errors

Exceeding a specified input or calculation range, or attempting an illegal input causes an error message to appear on the display. Further operation of the calculator is impossible while an error message is displayed. The following events cause an error message to appear on the display.

- When any result, whether intermediate or final, or any value in memory exceeds ±9.999999999 × 10^{99} (Ma ERROR).
- P.453 When an attempt is made to perform a function calculation that exceeds the input range (Ma ERROR).
- When an illegal operation is attempted during statistical calculations (Ma ERROR). For example, attempting to obtain 1VAR without data input.
- When the capacity of the numeric value stack or command stack is exceeded (Stk ERROR). For example, entering 25 successive (followed by 2 + 3 × 4 EXE.
- When an attempt is made to perform a calculation using an illegal formula (Syn ERROR). For example, 5 × × 3 EXE.
- When you try to perform a calculation that causes memory capacity to be exceeded (Mem ERROR).
- When you use a command that requires an argument, without providing a valid argument (Arg ERROR).
- When an attempt is made to use an illegal dimension during matrix calculations (Dim ERROR).
- When no solution exists for an ALGBR Mode operation (Undefined).
- When the result of an ALGBR Mode operation exceeds the range of the calculator (Overflow ERROR).
- When a value input in the ALGBR Mode is outside the domain of the operation being performed (Domain ERROR).
- P.7 When an ALGBR Mode operation in which only real numbers have been input produces a result that is a complex number while the set up screen's Answer Type item is specified as **"Real"** (Non-Real ERROR).
- When no solution can be obtained using the Solve Function in the ALGBR Mode (No Solution).
- When an attempt is made to use **approx** with an expression that generates an error unique to the ALGBR Mode (Ma ERROR).

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- Other errors can occur during program execution. Most of the calculator’s keys are inoperative while an error message is displayed. You can resume operation using one of the two following procedures.
- Press the AC key to clear the error and return to normal operation.
- P.41 Press ◀ or ▶ to display the error.

Memory Capacity

Each time you press a key, either one byte or two bytes is used. Some of the functions that require one byte are: [1], [2], [3], sin, cos, tan, log, In, $\sqrt{\ }$, and π. Some of the functions that take up two bytes are d/dx(, Mat, Xmin, If, For, Return, DrawGraph, SortA(, PxlOn, Sum, and a_{n+1}.

When the number of bytes remaining drops to five or below, the cursor automatically changes from " _ " to " ▮ ". If you still need to input more, you should divide your calculation into two or more parts.

- As you input numeric values or commands, they appear flush left on the display. Calculation results, on the other hand, are displayed flush right, except in the ALGBR Mode.

Graphic Display and Text Display

The unit uses both a graphic display and a text display. The graphic display is used for graphics, while the text display is used for calculations and instructions. The contents of each type of display are stored in independent memory areas.

●To switch between the graphic display and text display

Press [SHIFT] [F6](G↔T). You should also note that the key operations used to clear each type of display are different.

●To clear the graphic display

Press [SHIFT] [F4](Sketch) [F1](Cls) [EXE].

●To clear the text display

Press [AC].

Editing Calculations

Use the [◀] and [▶] keys to move the cursor to the position you want to change, and then perform one of the operations described below. After you edit the calculation, you can execute it by pressing [EXE], or use [▶] to move to the end of the calculation and input more.

●To change a step

Example **To change cos60 to sin60**

[cos] [6] [0]

cos 60_

[◀] [◀] [◀]

cos 60

[sin]

sin 60

•To delete a step

Example **To change 369 × × 2 to 369 × 2**

3 6 9 × × 2


369××2_

◀ ◀ DEL


369×2

•To insert a step

Example **To change 2.36^2 to $\sin 2.36^2$**

2 • 3 6 x^2


2.36^2_

◀ ◀ ◀ ◀ ◀


2.36^2

SHIFT INS


[2].36^2

sin


sin [2].36^2

- When you press SHIFT INS the insert location is indicated by the symbol "[]". The next function or value you input is inserted at the location of "[]". To abort the insert operation without inputting anything, move the cursor, press SHIFT INS again, or press ◀, ▶ or EXE.

1-2 Memory

■ Variables

This calculator comes with 28 variables as standard. You can use variables to store values to be used inside of calculations. Variables are identified by single-letter names, which are made up of the 26 letters of the alphabet, plus r and θ. The maximum size of values that you can assign to variables is 15 digits for the mantissa and 2 digits for the exponent. Variable contents are retained even when you turn power off.

•To assign a value to a variable

[value] → [variable name] EXE

Example **To assign 123 to variable A**

AC 1 2 3 → ALPHA A EXE

```
123→A
                 123
```

Example **To add 456 to variable A and store the result in variable B**

AC ALPHA A + 4 5 6 → ALPHA B EXE

```
A+456→B
                 579
```

•To display the contents of a variable

Example **To display the contents of variable A**

AC ALPHA A EXE

```
A
                 123
```

•To clear a variable

Example **To clear variable A**

AC 0 → ALPHA A EXE

```
0→A
                   0
```

- To clear all variables, select “Memory Usage” from the **SYS** Mode.

•To assign the same value to more than one variable

[value] → [first variable name] ALPHA F3 (~) [last variable name] EXE

- You cannot use “r” or “θ” as a variable name in the above operation.

Example **To assign a value of 10 to variables A through F**

AC 1 0 → SHIFT ALPHA A
F3 (~) F EXE

```
10→A~F
                  10
```

■ Function Memory

[OPTN]-[FMEM]

Function memory is convenient for temporary storage of often-used expressions. For longer term storage, we recommend that you use the GRAPH Mode for expressions and the PRGM Mode for programs.

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- {**STO**}/{**RCL**}/{**fn**}/{**SEE**} ... {function store}/{function recall}/{function area specification as a variable name inside an expression}/{function list}

●To store a function

Example **To store the function (A+B) (A–B) as function memory number 1**

OPTN F6(▷) F6(▷) F3(FMEM) AC
(ALPHA A + ALPHA B)
(ALPHA A − ALPHA B)

```
(A+B)(A-B)_
```

F1(STO) F1(f_1)

```
== Function Memory ==
f1:(A+B)(A-B)
```

- If the function memory number you assign a function to already contains a function, the previous function is replaced with the new one.

●To recall a function

Example **To recall the contents of function memory number 1**

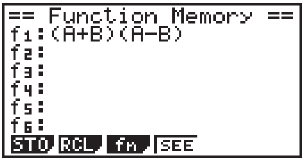
OPTN F6(▷) F6(▷) F3(FMEM) AC
F2(RCL) F1(f_1)

```
(A+B)(A-B)_
```

- The recalled function appears at the current location of the cursor on the display.

●To display a list of available functions

OPTN F6(▷) F6(▷) F3(FMEM)
F4(SEE)



```
== Function Memory ==
f1:(A+B)(A-B)
f2:
f3:
f4:
f5:
f6:
```

•To delete a function

Example **To delete the contents of function memory number 1**

OPTN F6(▷)F6(▷)F3(FMEM)AC
F1(STO) F1(f₁)

```
== Function Memory ==
f1:
```

- Executing the store operation while the display is blank deletes the function in the function memory you specify.

•To use stored functions

Once you store a function in memory, you can recall it and use it for a calculation. This feature is very useful for quick and easy input of functions when programming or graphing.

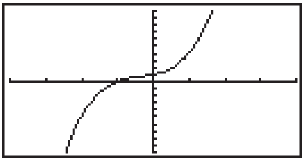
Example **To store $x^3 + 1$, $x^2 + x$ into function memory, and then graph:**
$y = x^3 + x^2 + x + 1$

Use the following View Window parameters.

Xmin	**= –4**	**Ymin**	**= –10**
Xmax	**= 4**	**Ymax**	**= 10**
Xscale	**= 1**	**Yscale**	**= 1**

SHIFT SET UP ▼ F1(Y=)EXIT OPTN F6(▷)F6(▷)F3(FMEM)
AC X,θ,T ^ 3 + 1 F1(STO)F1(f₁)(stores (x^3 + 1))
AC X,θ,T x^2 + X,θ,T F1(STO)F2(f₂)(stores (x^2 + x))

AC SHIFT F4(Sketch)F1(Cls)EXE
SHIFT F4(Sketch)F5(GRPH)F1(Y=)
OPTN F6(▷)F6(▷)F3(FMEM)
F3(f$_n$)F1(f₁)+ F2(f₂)EXE



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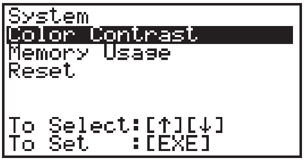
- For full details about graphing, see “8. Graphing”.

■ Memory Status

You can check how much memory is used for storage for each type of data. You can also see how many bytes of memory are still available for storage.

•To check the memory status

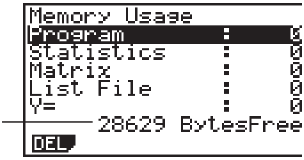
1. In the Main Menu, select the **SYS** icon and press EXE.



```
System
Color Contrast
Memory Usage
Reset


To Select:[↑][↓]
To Set   :[EXE]
```

2. Press ▼ EXE to display the memory status screen.



```
Memory Usage
Program       :    0
Statistics    :    0
Matrix        :    0
List File     :    0
Y=            :    0
     28629 BytesFree
DEL
```

Number of bytes still free

3. Use ▲ and ▼ to move the highlighting and view the amount of memory (in bytes) used for storage of each type of data.

The following table shows all of the data types that appear on the memory status screen.

Data Type	Meaning
Program	Program data
Statistics	Statistical calculations and graphs
Matrix	Matrix memory data
List File	List data
Y=	Graph functions
Draw Memory	Graph drawing conditions (View Window, enlargement/reduction factor, graph screen)
Graph Memory	Graph memory data
View Window	View Window memory data
Picture	Graph screen data
Dynamic Graph	Dynamic Graph data
Table	Function Table & Graph data
Recursion	Recursion Table & Graph data
Equation	Equation calculation data
Alpha Memory	Alpha memory data
Function Mem	Function memory data
Financial	Financial data

Clearing Memory Contents

Use the following procedure to clear data stored in memory.

1. In the memory status screen, use ▲ and ▼ to move the highlighting to the data type you want to clear.

If the data type you select in step 1 allows deletion of specific data

2. Press F1 (DEL).

** This menu appears when you select List File.*

3. Press the function key that corresponds to the data you want to delete.

- The above example shows the function menu that appears when you highlight {List File} in step 1.

4. Press F1 (YES).

If the data type you select in step 1 allows deletion of all data only

2. Press F1 (DEL).

3. Press F1 (YES) to delete all of the data.

1-3 Option (OPTN) Menu

The option menu gives you access to scientific functions and features that are not marked on the calculator's keyboard. The contents of the option menu differ according to the mode you are in when you press the OPTN key.

See the Command List at the back of this user's guide for details on the option (OPTN) menu.

•Option Menu in the RUN and PRGM Modes

- P.237 {**LIST**} ... {list function menu}
- P.88 {**MAT**} ... {matrix operation menu}
- P.68 {**CPLX**} ... {complex number calculation menu}
- {**CALC**} ... {functional analysis menu}
- P.271 {**STAT**} ... {paired-variable statistical estimated value menu}
- {**COLR**} ... {graph color menu}
- P.43 {**HYP**} ... {hyperbolic calculation menu}
- P.43 {**PROB**} ... {probability/distribution calculation menu}
- P.43 {**NUM**} ... {numeric calculation menu}
- P.44 {**ANGL**} ... {menu for angle/coordinate conversion, sexagesimal input/conversion}
- P.44 {**ESYM**} ... {engineering symbol menu}
- P.139 {**PICT**} ... {graph save/recall menu}
- P.23 {**FMEM**} ... {function memory menu}
- P.51 {**LOGIC**} ... {logic operator menu}

Pressing OPTN causes the following function key menu to appear while binary, octal, decimal, or hexadecimal is set as the default number system.

- {**COLR**} ... {graph color menu}

•Option Menu during numeric data input in the STAT, MAT, LIST, TABLE, RECUR and EQUA Modes

- {**LIST**}/{**HYP**}/{**PROB**}/{**NUM**}/{**ANGL**}/{**ESYM**}/{**FMEM**}/{**LOGIC**}

•Option Menu during formula input in the GRAPH, DYNA, TABLE, RECUR and EQUA Modes

- {**List**}/{**CALC**}/{**HYP**}/{**PROB**}/{**NUM**}/{**FMEM**}/{**LOGIC**}

•Option Menu during expression input in the ALGBR Mode

- {**Abs**}/{**HYP**}/{ **i** }/{x**!**}/{**sign**}/{**FMEM**}

The meanings of the option menu items are described in the sections that cover each mode.

1-4 Variable Data (VARS) Menu

To recall variable data, press VARS to display the variable data menu.

{**V-WIN**}/{**FACT**}/{**STAT**}/{**GRPH**}/{**DYNA**}/{**TABL**}/{**RECR**}/{**EQUA**}/{**TVM**}

See the Command List at the back of this user's guide for details on the variable data (VARS) menu.

- Note that the EQUA and TVM items appear for function keys (F3 and F4) only when you access the variable data menu from the **RUN** or **PRGM** Mode.
- The variable data menu does not appear if you press VARS while binary, octal, decimal, or hexadecimal is set as the default number system.

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■ V-WIN — Recalling View Window values

Selecting {V-WIN} from the VARS menu displays the View Window value recall menu.

- {**X**}/{**Y**}/{**T,** θ} ... {x-axis menu}/{y-axis menu}/{T, θ menu}
- {**R-X**}/{**R-Y**}/{**R-T,** θ} ... {x-axis menu}/{y-axis menu}/{T, θ menu} for right side of Dual Graph

The following are the items that appear in the above menus.

- {**min**}/{**max**}/{**scal**}/{**ptch**} ... {minimum value}/{maximum value}/{scale}/{pitch}

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■ FACT — Recalling enlargement/reduction factors

Selecting {FACT} from the VARS menu displays the enlargement/reduction factor recall menu.

- {**Xfct**}/{**Yfct**} ... {x-axis factor}/{y-axis factor}

■ STAT — Recalling Single/Paired-variable Statistical Data

Selecting {STAT} from the VARS menu displays the single/paired-variable statistical data recall menu.

{**X**}/{**Y**}/{**GRPH**}/{**PTS**}/{**TEST**}/{**RESLT**}

- {**X**}/{**Y**} ... {x-data menu}/{y-data menu}

The following are the items that appear in the above menus.

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- {n} ... {number of data}
- {$\bar{x}$}/{$\bar{y}$} ... mean of {x-data}/{y-data}
- {Σx}/{Σy} ... sum of {x-data}/{y-data}
- {Σx^2}/{Σy^2} ... sum of squares of {x-data}/{y-data}
- {Σxy} ... {sum of products of x-data and y-data}

- {$x\sigma_n$}/{$y\sigma_n$} ... population standard deviation of {x-data}/{y-data}
- {$x\sigma_{n-1}$}/{$y\sigma_{n-1}$} ... sample standard deviation of {x-data}/{y-data}
- {**minX**}/{**minY**} ... minimum value of {x-data}/{y-data}
- {**maxX**}/{**maxY**} ... maximum value of {x-data}/{y-data}

● {**GRPH**} ...{graph data menu}
The following are the items that appear in the above menu.

- {a}/{b}/{c}/{d}/{e} ... {regression coefficient and multinomial coefficients}
- {r} ... {correlation coefficient}
- {**Q1**}/{**Q3**} ... {first quartile}/{third quartile}
- {**Med**}/{**Mod**} ... {median}/{mode} of input data
- {**Strt**}/{**Pitch**} ... histogram {start division}/{pitch}
- {**Iter**}/{**Perid**} ... sine regression {number of iterations}/{period}

● {**PTS**} ... {summary point data menu}
The following are the items that appear in the above menu.

- {$x1$}/{$y1$}/{$x2$}/{$y2$}/{$x3$}/{$y3$} ... {coordinates of summary points}

● {**TEST**} ... {test data recall}
The following are the items that appear in the above menu.

- {n}/{$\bar{x}$}/{$x\sigma_{n-1}$} ... {number of data}/{data mean}/{sample standard deviation}
- {n_1}/{n_2} ... number of {data 1}/{data 2}
- {$\bar{x}_1$}/{$\bar{x}_2$} ... mean of {data 1}/{data 2}
- {$x_1\sigma$}/{$x_2\sigma$} ... sample standard deviation of {data 1}/{data 2}
- {$x_p\sigma$} ... {pooled sample standard deviation}
- {F} ... {F value}
- {Fdf}/{SS}/{MS} ... factor {degrees of freedom}/{sum of squares}/{mean of squares}
- {Edf}/{SSe}/{MSe} ... error {degrees of freedom}/{sum of squares}/{mean of squares}

● {**RESLT**} ... {test result recall}
The following are the items that appear in the above menu.

- {p} ... {p value}
- {z}/{t}/{**Chi**}/{F} ... {Z test results}/{t test results}/{χ^2 test results}/{F test results}
- {**Left**}/{**Right**} ... {interval lower limit (left edge)}/{interval upper limit (right edge)}
- {$\hat{p}$}/{$\hat{p}_1$}/{$\hat{p}_2$} ... {expected probability value}/{expected probability value 1}/{expected probability value 2}
- {df}/{s}/{r}/{r^2} ... {degrees of freedom}/{standard error}/{correlation coefficient}/{coefficient of determination}

■ GRPH — Recalling Graph Functions

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Selecting {GRPH} from the VARS menu displays the graph function recall menu.

- {**Y**}/{r} ... {rectangular coordinate or inequality function}/{polar coordinate function}
- {**Xt**}/{**Yt**} ... parametric graph function {Xt}/{Yt}
- {**X**} ... {X=constant graph function}

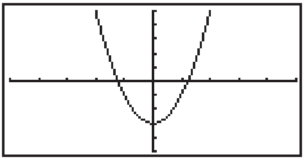
(Press these keys before inputting a value to specify a storage area.)

Example **To recall and draw the graph for the rectangular coordinate function $y = 2x^2 - 3$, which is stored in storage area Y2**

Use the following View Window parameters to draw the graph.

Xmin = –5 **Ymin = –5**
Xmax = 5 **Ymax = 5**
Xscale = 1 **Yscale = 1**

SHIFT F4 (Sketch) F5 (GRPH) F1 (Y=)
VARS F4 (GRPH) F1 (Y) 2 EXE



■ DYNA — Recalling Dynamic Graph Set Up Data

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Selecting {DYNA} from the VARS menu displays the Dynamic Graph set up data recall menu.

- {**Strt**}/{**End**}/{**Pitch**} ... {coefficient range start value}/{coefficient range end value}/{coefficient value increment}

■ TABL — Recalling Table & Graph Set Up and Content Data

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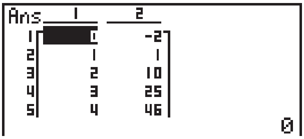
Selecting {TABL} from the VARS menu displays the Table & Graph set up and content data recall menu.

- {**Strt**}/{**End**}/{**Pitch**} ... {table range start value}/{table range end value}/{table value increment}
- {**Reslt**} ... {matrix of table contents}
- The Reslt item appears for function key F4 only when the above menu is displayed in the **RUN** or **PRGM** Mode.

Example **To recall the contents of the numeric table for the function $y = 3x^2 - 2$, while the table range is Start=0 and End=6, and pitch=1**

F4 (Reslt) EXE



Ans	1	2
1	0	-2
2	1	1
3	2	10
4	3	25
5	4	46

0

RECR — Recalling Recursion Formula, Table Range, and Table Content Data

Selecting {RECR} from the VARS menu displays the recursion data recall menu.

- {**FORM**} ... {recursion formula data menu}

  The following are the items that appear in the above menu.

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  - {a_n}/{a_{n+1}}/{a_{n+2}}/{b_n}/{b_{n+1}}/{b_{n+2}} ... {a_n}/{a_{n+1}}/{a_{n+2}}/{b_n}/{b_{n+1}}/{b_{n+2}} expressions

- {**RANG**} ... {table range data menu}

  The following are the items that appear in the above menu.

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  - {**Strt**}/{**End**} ... {table range start value}/{table range end value}
  - {a_0}/{a_1}/{a_2} ... {zero term a_0 value}/{first term a_1 value}/{second term a_2 value}
  - {b_0}/{b_1}/{b_2} ... {zero term b_0 value}/{first term b_1 value}/{second term b_2 value}
  - {a_n**St**}/{b_n**St**} ... origin of {a_n}/{b_n} recursion formula convergence/divergence graph (WEB graph)

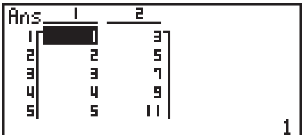
- {**Reslt**} ... {matrix of table contents}

  Selecting {Reslt} displays a matrix that shows the contents of the recursion table.

  - This operation is available only in the **RUN** and **PRGM** modes.

Example **To recall the contents of the numeric table for recursion formula $a_n = 2n + 1$, while the table range is Start=1 and End=6**

F3 (Reslt) EXE



Ans	1	2
1	1	3
2	2	5
3	3	7
4	4	9
5	5	11

1

- The table contents recalled by the above operation are stored automatically in Matrix Answer Memory (MatAns).
- An error occurs if you perform the above operation when there is no function or recursion formula numeric table in memory.

EQUA — Recalling Equation Coefficients and Solutions

Selecting {EQUA} from the VARS menu displays the equation coefficient and solution recall menu.

- P.101 {**S-Rlt**}/{**S-Cof**} ... matrix of {solutions}/{coefficients} for linear equations with two through six unknowns
- P.104 {**P-Rlt**}/{**P-Cof**} ... matrix of {solution}/{coefficients} for a quadratic or cubic equation

Example 1 **To recall the solutions for the following linear equations with two unknowns**

$$\begin{aligned} 2x + 3y &= 8 \\ 3x + 5y &= 14 \end{aligned}$$

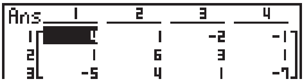
F1 (S-Rlt) EXE

```
Ans   1
 1 [  -2]
 2 [   4]
```

Example 2 **To recall the coefficients for the following linear equations with three unknowns**

$$\begin{aligned} 4x + y - 2z &= -1 \\ x + 6y + 3z &= 1 \\ -5x + 4y + z &= -7 \end{aligned}$$

F2 (S-Cof) EXE



```
Ans   1     2     3     4
 1 [  4     1    -2    -1]
 2 [  1     6     3     1]
 3 [ -5     4     1    -7]
```

Example 3 **To recall the solutions for the following quadratic equation**

$$2x^2 + x - 10 = 0$$

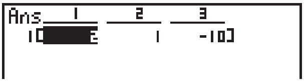
F3 (P-Rlt) EXE

```
Ans   1
 1 [   2]
 2 [-2.5]
```

Example 4 **To recall the coefficients for the following quadratic equation**

$$2x^2 + x - 10 = 0$$

F4 (P-Cof) EXE



```
Ans   1     2     3
 1 [  2     1   -10]
```

- The coefficients and solutions recalled by the above operation are stored automatically in Matrix Answer Memory (MatAns).
- When the solutions for a linear equation with 2 through 6 unknowns contain complex numbers, only the real number parts are stored in Matrix Answer Memory (MatAns).
- Coefficient and solution memory data for a linear equation with 2 though 6 unknowns cannot be recalled at the same time.
- The following conditions cause an error to be generated.
  - — When there are no coefficients input for the equation
  - — When there are no solutions obtained for the equation

■ TVM — Recalling Financial Calculation Data

Selecting {TVM} from the VARS menu displays the financial calculation data recall menu.

- {***n***}/{***I***%}/{***PV***}/{***PMT***}/{***FV***} ... {payment periods (installments)}/{interest (%)}/{present value}/{payment amount}/{future value}
- {***P***/***Y***}/{***C***/***Y***} ... {number of installment periods per year}/{number of compounding periods per year}

1-5 Program (PRGM) Menu

To display the program (PRGM) menu, first enter the **RUN** or **PRGM** Mode from the Main Menu and then press SHIFT PRGM. The following are the selections available in the program (PRGM) menu.

- {**COM**} … {program command menu}
- {**CTL**} … {program control command menu}
- {**JUMP**} … {jump command menu}
- {**?**} … {input command}
- {◢} … {output command}
- {**CLR**} … {clear command menu}
- {**DISP**} … {display command menu}
- {**REL**} … {conditional jump relational operator menu}
- {**I/O**} … {input/output control command menu}
- { **:** } … {multistatement connector}

The function key menu appears if you press SHIFT PRGM in the RUN Mode or the PRGM Mode while binary, octal, decimal, or hexadecimal is set as the default number system.

- {**Prog**}/{**JUMP**}/{**?**}/{◢}/{**REL**}/{ **:** }

The functions assigned to the function keys are the same as those in the Comp Mode.

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For details on the commands that are available in the various menus you can access from the program menu, see “21. Programming”.

Chapter 2

Manual Calculations

2-1 Basic Calculations

Arithmetic Calculations

- Enter arithmetic calculations as they are written, from left to right.
- Use the (−) key to input the minus sign before a negative value.
- Calculations are performed internally with a 15-digit mantissa. The result is rounded to a 10-digit mantissa before it is displayed.
- For mixed arithmetic calculations, multiplication and division are given priority over addition and subtraction.

Example	Operation	Display
$23 + 4.5 - 53 = -25.5$	**23 + 4.5 − 53 EXE**	**–25.5**
$56 \times (-12) \div (-2.5) = 268.8$	**56 × (−) 12 ÷ (−) 2.5 EXE**	**268.8**
$(2 + 3) \times 10^2 = 500$	**(2 + 3) × 1 EXP 2 EXE** *1	**500**
$1 + 2 - \underline{3 \times 4 \div 5} + 6 = 6.6$	**1 + 2 − 3 × 4 ÷ 5 + 6 EXE**	**6.6**
$100 - (2 + 3) \times 4 = 80$	**100 − (2 + 3) × 4 EXE**	**80**
$2 + 3 \times (4 + 5) = 29$	**2 + 3 × (4 + 5 EXE** *2	**29**
$(7 - 2) \times (8 + 5) = 65$	**(7 − 2) (8 + 5) EXE** *3	**65**
$\frac{6}{4 \times 5} = 0.3$	**6 ÷ (4 × 5) EXE** *4	**0.3**

*1 "(2 + 3) EXP 2" does not produce the correct result. Be sure to enter this calculation as shown.

*2 Final closed parentheses (immediately before operation of the EXE key) may be omitted, no matter how many are required.

*3 A multiplication sign immediately before an open parenthesis may be omitted.

*4 This is identical to 6 ÷ 4 ÷ 5 EXE.

Number of Decimal Places, Number of Significant Digits, Exponential Notation Range

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- These settings can be made while setting up the display format (Display) with the set up screen.
- Even after you specify the number of decimal places or the number of significant digits, internal calculations are still performed using a 15-digit mantissa, and displayed values are stored with a 10-digit mantissa. Use Rnd (F4) of the Numeric Calculation Menu (NUM) to round the displayed value off to the number of decimal place and number of significant digit settings.

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- Number of decimal place (Fix) and number of significant digit (Sci) settings normally remain in effect until you change them or until your change the exponential display range (Norm) setting. Note also, however, that Sci setting is automatically initialized to Norm 1 whenever you enter the Financial Mode.
- To change the exponential display range (Norm) setting, press F3 (Norm) while the display format (Display) menu is on the screen. Each time you perform this operation, the range toggles between the following two settings.

  Norm 1 .... exponential display for values outside the range of 10^{-2} to 10^{10}

  Norm 2 .... exponential display for values outside the range of 10^{-9} to 10^{10}

Example **100 ÷ 6 = 16.66666666...**

Condition	Operation	Display
	100 ÷ **6** EXE	**16.66666667**
4 decimal places	SHIFT SETUP ▼▼▼▼▼▼▼▼▼ F1(Fix) F5(4) EXIT EXE	**16.6667**[*1]
5 significant digits	SHIFT SETUP ▼▼▼▼▼▼▼▼▼ F2(Sci) F6(▷) F1(5) EXIT EXE	**1.6667E+01**[*1]
Cancels specification	SHIFT SETUP ▼▼▼▼▼▼▼▼▼ F3(Norm) EXIT EXE	**16.66666667**

[*1] Displayed values are rounded off to the place you specify.

Example **200 ÷ 7 × 14 = 400**

Condition	Operation	Display
	200 ÷ **7** × **14** EXE	**400**
3 decimal places	SHIFT SETUP ▼▼▼▼▼▼▼▼▼ F1(Fix) F4(3) EXIT EXE	**400.000**
Calculation continues using display capacity of 10 digits	**200** ÷ **7** EXE	**28.571**
	×	**Ans** × _
	14 EXE	**400.000**

- If the same calculation is performed using the specified number of digits:

The value stored internally is cut off to the number of decimal places you specify.	**200** ÷ **7** EXE	**28.571**
	OPTN F6(▷) F4(NUM) F4(Rnd) EXE	**28.571**
	×	**Ans** × _
	14 EXE	**399.994**

Calculations Using Variables

Example	Operation	Display
	193.2 [→] [ALPHA] [A] [EXE]	**193.2**
193.2 ÷ 23 = 8.4	[ALPHA] [A] [÷] **23** [EXE]	**8.4**
193.2 ÷ 28 = 6.9	[ALPHA] [A] [÷] **28** [EXE]	**6.9**

2-2 Special Functions

Answer Function

The unit’s Answer Function automatically stores the last result you calculated by pressing EXE (unless the EXE key operation results in an error). The result is stored in the answer memory.

●To use the contents of the answer memory in a calculation

Example 123 + 456 = 579

789 – 579 = 210

AC 1 2 3 + 4 5 6 EXE

7 8 9 – SHIFT Ans EXE

```
123+456
                 579
789-Ans
                 210
```

- The largest value that the answer memory can hold in any mode besides the ALGBR Mode is one with 15 digits for the mantissa and 2 digits for the exponent.
- Answer memory contents are not cleared when you press the AC key or when you switch power off.
- Note that answer memory contents are not changed by an operation that assigns values to value memory (such as: 5 → ALPHA A EXE).

Performing Continuous Calculations

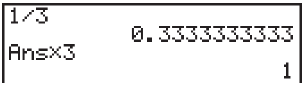
The unit lets you use the result of one calculation as one of the arguments in the next calculation. To do so, use the result of the previous calculation, which is currently stored in Answer Memory.

Example 1 ÷ 3 =

1 ÷ 3 × 3 =

AC 1 ÷ 3 EXE

(Continuing) × 3 EXE



```
1/3
        0.3333333333
Ans×3
                   1
```

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Continuous calculations can also be used with Type A functions (x^2, x^{-1}, $x!$), +, –, ^(x^y), $\sqrt[x]{\ }$, ° ’ ”.

Using the Replay Function

The Replay Function automatically stores the last calculation performed into replay memory. You can recall the contents of the replay memory by pressing ◀ or ▶.
If you press ▶, the calculation appears with the cursor at the beginning. Pressing ◀ causes the calculation to appear with the cursor at the end. You can make changes in the calculation as you wish and then execute it again.

Example **To perform the following two calculations**

4.12 × 6.4 = 26.368

4.12 × 7.1 = 29.252

AC 4 • 1 2 × 6 • 4 EXE

```
4.12×6.4
                26.368
```

◀ ◀ ◀ ◀

```
4.12×6.4
```

7 • 1

```
4.12×7.1_
```

EXE

```
4.12×7.1
                29.252
```

- A calculation remains stored in replay memory until you perform another calculation or change modes.
- The contents of the replay memory are not cleared when you press the AC key, so you can recall a calculation and execute it even after performing the all clear operation. Note, however, that replay memory contents are cleared whenever you change to another mode or menu.
- After you press AC, you can press ▲ or ▼ to recall previous calculations, in sequence from the newest to the oldest (Multi-Replay Function). Once you recall a calculation, you can use ▶ and ◀ to move the cursor around the calculation and make changes in it to create a new calculation. Note, however, that multi-replay memory contents are cleared whenever you change to another menu.

Example

AC 1 2 3 + 4 5 6 EXE
2 3 4 − 5 6 7 EXE

```
123+456
                   579
234-567
                  -333
```

AC

```
_
```

▲ (One calculation back)

```
234-567
```

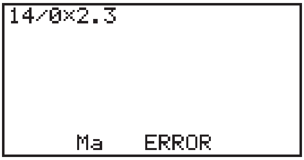
▲ (Two calculations back)

```
123+456
```

■ Making Corrections in the Original Calculation

Example **14 ÷ 0 × 2.3 entered by mistake for 14 ÷ 10 × 2.3**

AC 1 4 ÷ 0 × 2 . 3 EXE



14/0×2.3

Ma ERROR

Press ◀ or ▶.

14/0×2.3

Cursor is positioned automatically at the location of the cause of the error.

Make necessary changes.

◀ SHIFT INS 1

14/10×2.3

Execute it again.

EXE

14/10×2.3

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■ Using Multistatements

Multistatements are formed by connecting a number of individual statements for sequential execution. You can use multistatements in manual calculations and in programmed calculations. There are two different ways that you can use to connect statements to form multistatements.

- **Colon (:)**

Statements that are connected with colons are executed from left to right, without stopping.

- **Display Result Command (◢)**

When execution reaches the end of a statement followed by a display result command, execution stops and the result up to that point appears on the display. You can resume execution by pressing the EXE key.

Example $6.9 \times \underline{123} = 848.7$

$\underline{123} \div 3.2 = 38.4375$

AC 1 2 3 → ALPHA A SHIFT PRGM F6 (▷)
F5 (:) 6 • 9 × ALPHA A SHIFT PRGM
F5 (◢) ALPHA A ÷ 3 • 2 EXE

```
123→A:6.9×A◢
A/3.2
                848.7
              - Disp -
```

Intermediate result at point where "◢" is used.

EXE

```
123→A:6.9×A◢
A/3.2
                848.7
              38.4375
```

- Note that the final result of a multistatement is always displayed, regardless of whether it ends with a display result command.
- You cannot construct a multistatement in which one statement directly uses the result of the previous statement.

Example $123 \times 456\underline{:\ \times}\ 5$

Invalid

2-3 Function Calculations

Function Menus

This calculator includes five function menus that give you access to scientific functions that are not printed on the key panel.

- The contents of the function menu differ according to the mode you entered from the Main Menu before you pressed the OPTN key. The following examples show function menus that appear in the **RUN** or **PRGM** Mode.

•Hyperbolic Calculations (HYP) **[OPTN]-[HYP]**

- {**sinh**}/{**cosh**}/{**tanh**} ... hyperbolic {sine}/{cosine}/{tangent}
- {**sinh**$^{-1}$}/{**cosh**$^{-1}$}/{**tanh**$^{-1}$} ... inverse hyperbolic {sine}/{cosine}/{tangent}

•Probability/Distribution Calculations (PROB) **[OPTN]-[PROB]**

- {***x*!**} ... {press after inputting a value to obtain the factorial of the value.}
- {***n*P*r***}/{***n*C*r***} ... {permutation}/{combination}
- {**Ran#**}... {pseudo random number generation (0 to 1)}

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

•Numeric Calculations (NUM) **[OPTN]-[NUM]**

- {**Abs**} ... {select this item and input a value to obtain the absolute value of the value.}
- {**Int**}/{**Frac**} ... select the item and input a value to extract the {integer}/{fraction} part.
- {**Rnd**} ... {rounds off the value used for internal calculations to 10 significant digits (to match the value in the Answer Memory), or to the number of decimal places (Fix) and number of significant digits (Sci) specified by you.}
- {**Intg**} ... {select this item and input a value to obtain the largest integer that is not greater than the value.}

•Angle Units, Coordinate Conversion, Sexagesimal Operations (ANGL)

[OPTN]-[ANGL]

- {**°**}/{**r**}/{**g**} ... {degrees}/{radians}/{grads} for a specific input value
- {° ' "} ... {specifies degrees (hours), minutes, seconds when inputting a sexagesimal value}
- {$\overleftarrow{\circ\ '\ ''}$} ... {converts decimal value to sexagesimal value}
- The {$\overleftarrow{\circ\ '\ ''}$} menu option appears only when there is a calculation result shown on the display.
- {**Pol(**}/{**Rec(**} ... {rectangular-to-polar}/{polar-to-rectangular} coordinate conversion

•Engineering Notation Calculations (ESYM)

[OPTN]-[ESYM]

- {**m**}/{**μ**}/{**n**}/{**p**}/{**f**} ... {milli (10^{-3})}/{micro (10^{-6})}/{nano (10^{-9})}/{pico (10^{-12})}/{femto (10^{-15})}
- {**k**}/{**M**}/{**G**}/{**T**}/{**P**}/{**E**} ... {kilo (10^{3})}/{mega (10^{6})}/{giga (10^{9})}/{tera (10^{12})}/{peta (10^{15})}/{exa (10^{18})}
- {**ENG**}/{$\overleftarrow{\textbf{ENG}}$} ... shifts the decimal place of the displayed value three digits to the {left}/{right} and {decreases}/{increases} the exponent by three. When you are using engineering notation, the engineering symbol is also changed accordingly.
- The {ENG} and {$\overleftarrow{\text{ENG}}$} menu options appear only when there is a calculation result shown on the display.

■ Angle Units

P.5

- Once you specify an angle unit, it remains in effect until you specify a different one. The specification is retained even if you turn power off.
- Be sure to specify "Comp" for Calculation/binary, octal, decimal, hexadecimal mode.

Example	Operation	Display
To convert 4.25 rad to degrees:	SHIFT SET UP ▼ ▼ ▼ ▼ F1 (Deg) EXIT **4.25** OPTN F6 (▷) F5 (ANGL) F2 (r) EXE	**243.5070629**
47.3° + 82.5rad = 4774.20181°	**47.3** + **82.5** F2 (r) EXE	**4774.20181**

Trigonometric and Inverse Trigonometric Functions

P.5

- Be sure to set the angle unit before performing trigonometric function and inverse trigonometric function calculations.

$$(90° = \frac{\pi}{2} \text{ radians} = 100 \text{ grads})$$

P.5

- Be sure to specify “Comp” for Calculation/binary, octal, decimal, hexadecimal mode.

Example	Operation	Display
sin 63° = 0.8910065242	SHIFT SET UP ▼ ▼ ▼ ▼ F1 (Deg) EXIT sin **63** EXE	**0.8910065242**
cos ($\frac{\pi}{3}$rad) = 0.5	SHIFT SET UP ▼ ▼ ▼ ▼ F2 (Rad) EXIT cos (SHIFT π ÷ 3) EXE	**0.5**
tan (– 35gra) = – 0.6128007881	SHIFT SET UP ▼ ▼ ▼ ▼ F3 (Gra) EXIT tan (–) **35** EXE	**–0.6128007881**
2 · sin 45° × cos 65° = 0.5976724775	SHIFT SET UP ▼ ▼ ▼ ▼ F1 (Deg) EXIT **2** × sin **45** × cos **65** EXE *1	**0.5976724775**
cosec 30° = $\frac{1}{\sin 30°}$ = 2	**1** ÷ sin **30** EXE	**2**
$\sin^{-1}$0.5 = 30° (x when sin$x$ = 0.5)	SHIFT $\sin^{-1}$ **0.5** *2 EXE	**30**

*1 × can be omitted.

*2 Input of leading zero is not necessary.

P.5

Logarithmic and Exponential Functions

- Be sure to specify "Comp" for Calculation/binary, octal, decimal, hexadecimal mode.

Example	Operation	Display
log 1.23 ($\log_{10}1.23$) = $8.990511144 \times 10^{-2}$	log **1.23** EXE	**0.08990511144**
In 90 ($\log_e 90$) = 4.49980967	ln **90** EXE	**4.49980967**
$10^{1.23}$ = 16.98243652 (To obtain the antilogarithm of common logarithm 1.23)	SHIFT 10^x **1.23** EXE	**16.98243652**
$e^{4.5}$ = 90.0171313 (To obtain the antilogarithm of natural logarithm 4.5)	SHIFT e^x **4.5** EXE	**90.0171313**
$(-3)^4 = (-3) \times (-3) \times (-3) \times (-3) = 81$	((−) **3**) ^ **4** EXE	**81**
$-3^4 = -(3 \times 3 \times 3 \times 3) = -81$	(−) **3** ^ **4** EXE	**– 81**
$\sqrt[7]{123}$ $(= 123^{\frac{1}{7}})$ = 1.988647795	**7** SHIFT $\sqrt[x]{\ }$ **123** EXE	**1.988647795**
$2 + 3 \times \sqrt[3]{64} - 4 = 10$	**2** + **3** × **3** SHIFT $\sqrt[x]{\ }$ **64** − **4** EXE *1	**10**

*1 ^ (x^y) and $\sqrt[x]{\ }$ take precedence over multiplication and division.

P.5

Hyperbolic and Inverse Hyperbolic Functions

- Be sure to specify "Comp" for Calculation/binary, octal, decimal, hexadecimal mode.

Example	Operation	Display
sinh 3.6 = 18.28545536	OPTN F6 (▷) F2 (HYP) F1 (sinh) **3.6** EXE	**18.28545536**
cosh 1.5 – sinh 1.5 = 0.2231301601 = $e^{-1.5}$ (Proof of cosh x ± sinh x = $e^{\pm x}$)	OPTN F6 (▷) F2 (HYP) F2 (cosh) **1.5** − F1 (sinh) **1.5** EXE ln SHIFT Ans EXE	**0.2231301601** **– 1.5**
$\cosh^{-1}\left(\frac{20}{15}\right) = 0.7953654612$	OPTN F6 (▷) F2 (HYP) F5 ($\cosh^{-1}$) (**20** ÷ **15**) EXE	**0.7953654612**
Determine the value of x when tanh 4 x = 0.88 $x = \frac{\tanh^{-1}0.88}{4}$ = 0.3439419141	OPTN F6 (▷) F2 (HYP) F6 ($\tanh^{-1}$) **0.88** ÷ **4** EXE	**0.3439419141**

P.5

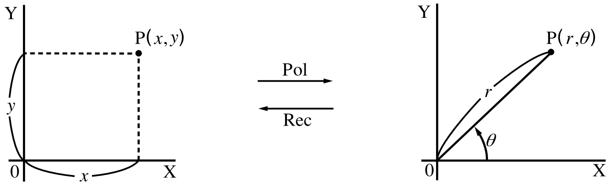
Other Functions

- Be sure to specify “Comp” for Calculation/binary, octal, decimal, hexadecimal mode.

Example	Operation	Display
$\sqrt{2}+\sqrt{5}=3.65028154$	SHIFT √ **2** + SHIFT √ **5** EXE	**3.65028154**
$(-3)^2 = (-3) \times (-3) = 9$	((–) **3**) x^2 EXE	**9**
$-3^2 = -(3 \times 3) = -9$	(–) **3** x^2 EXE	**– 9**
$\dfrac{1}{\dfrac{1}{3}-\dfrac{1}{4}} = 12$	(**3** SHIFT x^{-1} − **4** SHIFT x^{-1}) SHIFT x^{-1} EXE	**12**
8! (= 1 × 2 × 3 × .... × 8) = 40320	**8** OPTN F6 (▷) F3 (PROB) F1 (x!) EXE	**40320**
$\sqrt[3]{36 \times 42 \times 49} = 42$	SHIFT ∛ (**36** × **42** × **49**) EXE	**42**
Random number generation (pseudo random number between 0 and 1)	OPTN F6 (▷) F3 (PROB) F4 (Ran#) EXE	**(Ex.) 0.4810497011**
What is the absolute value of the common logarithm of $\frac{3}{4}$? $\left\| \log \frac{3}{4} \right\| = 0.1249387366$	OPTN F6 (▷) F4 (NUM) F1 (Abs) log (**3** ÷ **4**) EXE	**0.1249387366**
What is the integer part of – 3.5?	OPTN F6 (▷) F4 (NUM) F2 (Int) (–) **3.5** EXE	**– 3**
What is the decimal part of – 3.5?	OPTN F6 (▷) F4 (NUM) F3 (Frac) (–) **3.5** EXE	**– 0.5**
What is the nearest integer not exceeding – 3.5?	OPTN F6 (▷) F4 (NUM) F5 (Intg) (–) **3.5** EXE	**– 4**

Coordinate Conversion

- **Rectangular Coordinates**
- **Polar Coordinates**



- With polar coordinates, θ can be calculated and displayed within a range of –180°< $\theta \leqq$ 180° (radians and grads have same range).

P.5

- Be sure to specify “Comp” for Calculation/binary, octal, decimal, hexadecimal mode.

Example **To calculate r and $\theta°$ when x = 14 and y = 20.7**

Operation	Display
SHIFT SET UP ▼ ▼ ▼ ▼ F1(Deg) EXIT OPTN F6(▷) F5(ANGL) F6(▷) F1(Pol()**14** , **20.7**) EXE	Ans 1 $\boxed{24.989}$ → 24.98979792 (r) 2 55.928 → 55.92839019 (θ)

Example **To calculate x and y when r = 25 and θ = 56°**

Operation	Display
SHIFT SET UP ▼ ▼ ▼ ▼ F1(Deg) EXIT OPTN F6(▷) F5(ANGL) F6(▷) F2(Rec()**25** , **56**) EXE	Ans 1 $\boxed{13.979}$ → 13.97982259 (x) 2 20.725 → 20.72593931 (y)

Permutation and Combination

- **Permutation**

$$nPr = \frac{n!}{(n-r)!}$$

- **Combination**

$$nCr = \frac{n!}{r!\,(n-r)!}$$

P.5

- Be sure to specify “Comp” for Calculation/binary, octal, decimal, hexadecimal mode.

Example **To calculate the possible number of different arrangements using 4 items selected from among 10 items**

Formula	Operation	Display
$_{10}P_4 = 5040$	**10** OPTN F6 (▷) F3 (PROB) F2 ($_nP_r$)**4** EXE	**5040**

Example **To calculate the possible number of different combinations of 4 items that can be selected from among 10 items**

Formula	Operation	Display
$_{10}C_4 = 210$	**10** OPTN F6 (▷) F3 (PROB) F3 ($_nC_r$)**4** EXE	**210**

■ Fractions

P.5

- Fractional values are displayed with the integer first, followed by the numerator and then the denominator.
- Be sure to specify “Comp” for Calculation/binary, octal, decimal, hexadecimal mode.

Example	Operation	Display
$\frac{2}{5} + 3\frac{1}{4} = 3\frac{13}{20}$ $= 3.65$	**2** a b/c **5** + **3** a b/c **1** a b/c **4** EXE (Conversion to decimal[*1]) F↔D	**3⌟13⌟20** **3.65**
$\frac{1}{2578} + \frac{1}{4572}$ $= 6.066202547 \times 10^{-4}$	**1** a b/c **2578** + **1** a b/c **4572** EXE	**6.066202547E–04**[*2] (Norm 1 display format)
$\frac{1}{2} \times 0.5 = 0.25$	**1** a b/c **2** × . **5** EXE	**0.25**[*3]
$\frac{1}{\frac{1}{3} + \frac{1}{4}} = 1\frac{5}{7}$	**1** a b/c (**1** a b/c **3** + **1** a b/c **4**) EXE[*4]	**1⌟5⌟7**

[*1] Fractions can be converted to decimal values and vice versa.

[*2] When the total number of characters, including integer, numerator, denominator and delimiter marks exceeds 10, the input fraction is automatically displayed in decimal format.

[*3] Calculations containing both fractions and decimals are calculated in decimal format.

[*4] You can include fractions within the numerator or denominator of a fraction by putting the numerator or denominator in parentheses.

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Engineering Notation Calculations

Input engineering symbols using the engineering notation menu.

- Be sure to specify “Comp” for Calculation/binary, octal, decimal, hexadecimal mode.

Example	Operation	Display
999k (kilo) + 25k (kilo) = 1.024M (mega)	SHIFT SET UP ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ F4 (Eng) EXIT **999** OPTN F6 (▷) F6 (▷) F1 (ESYM) F6 (▷) F1 (k) + **25** F1 (k) EXE	**1.024M**
9 ÷ 10 = 0.9 = 900m (milli)	**9** ÷ **10** EXE	**900.m**
	OPTN F6 (▷) F6 (▷) F1 (ESYM) F6 (▷) F6 (▷)	
	F3 $\overleftarrow{\text{(ENG)}}$*1	**0.9**
	F3 $\overleftarrow{\text{(ENG)}}$*1	**0.0009k**
	F2 (ENG)*2	**0.9**
	F2 (ENG)*2	**900.m**

---

*1 Converts the displayed value to the next higher engineering unit, by shifting the decimal point three places to the right.

*2 Converts the displayed value to the next lower engineering unit, by shifting the decimal point three places to the left.

■ Logical Operators (AND, OR, NOT) [OPTN]-[LOGIC]

The logical operator menu provides a selection of logical operators.

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- {**And**}/{**Or**}/{**Not**} ... {logical multiplication}/{logical addition}/{negation}
- Be sure to specify "Comp" for Calculation/binary, octal, decimal, hexadecimal mode.

Example **What is the logical product of A and B when A = 3 and B = 2?**

A AND B = 1

Operation	Display
3 → ALPHA A EXE **2** → ALPHA B EXE ALPHA A OPTN F6 (▷) F6 (▷) F4 (LOGIC) F1 (And) ALPHA B EXE	 **1**

Example **What is the logical sum of A and B when A = 5 and B = 1?**

A OR B = 1

Operation	Display
5 → ALPHA A EXE **1** → ALPHA B EXE ALPHA A OPTN F6 (▷) F6 (▷) F4 (LOGIC) F2 (Or) ALPHA B EXE	 **1**

Example **Negate A when A = 10.**

NOT A = 0

Operation	Display
10 → ALPHA A EXE OPTN F6 (▷) F6 (▷) F4 (LOGIC) F3 (Not) ALPHA A EXE	 **0**

About Logical Operations

- A logical operation always produces either 0 or 1 as its result.
- The following table shows all of possible results that can be produced by AND and OR operations.

Value or Expression A	Value or Expression B	A AND B	A OR B
$A \neq 0$	$B \neq 0$	1	1
$A \neq 0$	$B = 0$	0	1
$A = 0$	$B \neq 0$	0	1
$A = 0$	$B = 0$	0	0

- The following table shows the results produced by the NOT operation.

Value or Expression A	NOT A
$A \neq 0$	0
$A = 0$	1

Chapter 3

Numerical Calculations

3-1 Before Performing a Calculation

The following describes the items that are available in the menus you use when performing Solve, differential/ quadratic differential, integration, maximum/ minimum value, and Σ calculations.

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When the option menu is on the display, press F4 (CALC) to display the function analysis menu. The items of this menu are used when performing specific types of calculations.

- {**Solve**}/{d/dx}/{d^2/dx^2}/{$\int dx$} ... {solve}/{differential}/{quadratic differential}/{integration} calculations
- {**FMin**}/{**FMax**}/{**Σ(**} ... {minimum value}/{maximum value}/{Σ (sigma)} calculations

Solve calculations

The following is the syntax for using the Solve function in a program.

Solve($f(x)$, n, a, b)

b — *Upper limit*

a — *Lower limit*

n — *Initial estimated value*

- There are two different input methods that can be used for Solve calculations: direct assignment and variable table input.

  P.408 With the direct assignment method (the one described here), you assign values directly to variables. This type of input is identical to that used with the Solve command used in the PRGM Mode.

  P.107 Variable table input is used with the Solve function in the EQUA Mode. This input method is recommend for most normal Solve function input.

- P.355 Note that the Solve function can also be used in the ALGBR Mode to display results using natural display notation.

3-2 Differential Calculations

[OPTN]-[CALC]-[d/dx]

To perform differential calculations, first display the function analysis menu, and then input the values shown in the formula below.

$$\boxed{\text{F2}}\,(d/dx)\,f(x)\,\boxed{,}\,a\,\boxed{,}\,\Delta x\,\boxed{)}$$

Increase/decrease of x

Point for which you want to determine the derivative

$$d/dx\,(f(x),\,a,\,\Delta x) \Rightarrow \frac{d}{dx}f(a)$$

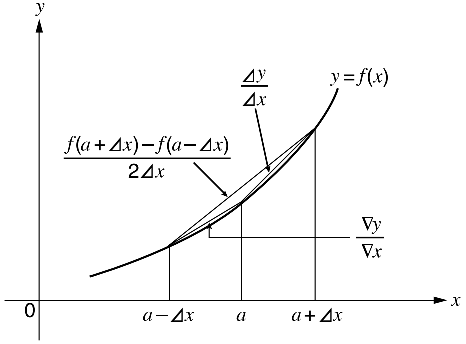
The differentiation for this type of calculation is defined as:

$$f'(a) = \lim_{\Delta x \to 0} \frac{f(a+\Delta x) - f(a)}{\Delta x}$$

In this definition, *infinitesimal* is replaced by a *sufficiently small* Δx, with the value in the neighborhood of $f'(a)$ calculated as:

$$f'(a) \fallingdotseq \frac{f(a+\Delta x) - f(a)}{\Delta x}$$

In order to provide the best precision possible, this unit employs central difference to perform differential calculations. The following illustrates central difference.



The slopes of point a and point $a + \Delta x$, and of point a and point $a - \Delta x$ in function $y = f(x)$ are as follows:

$$\frac{f(a+\Delta x) - f(a)}{\Delta x} = \frac{\Delta y}{\Delta x}\ ,\ \frac{f(a) - f(a-\Delta x)}{\Delta x} = \frac{\nabla y}{\nabla x}$$

In the above, $\Delta y/\Delta x$ is called the forward difference, while $\nabla y/\nabla x$ is the backward difference. To calculate derivatives, the unit takes the average between the value of $\Delta y/\Delta x$ and $\nabla y/\nabla x$, thereby providing higher precision for derivatives.

This average, which is called the *central difference*, is expressed as:

$$f'(a) = \frac{1}{2}\left(\frac{f(a+\Delta x)-f(a)}{\Delta x}+\frac{f(a)-f(a-\Delta x)}{\Delta x}\right)$$

$$= \frac{f(a+\Delta x)-f(a-\Delta x)}{2\Delta x}$$

●To perform a differential calculation

Example **To determine the derivative at point $x = 3$ for the function $y = x^3 + 4x^2 + x - 6$, when the increase/decrease of x is defined as $\Delta x = 1\text{E}-5$**

Input the function $f(x)$.

AC OPTN F4 (CALC) F2 (d/dx) X,θ,T ^ 3 + 4 X,θ,T x^2 + X,θ,T − 6 ,

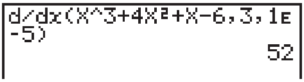
Input point $x = a$ for which you want to determine the derivative.

3 ,

Input Δx, which is the increase/decrease of x.

1 EXP (−) 5)

EXE



```
d/dx(X^3+4X²+X-6,3,1E
-5)
                     52
```

- In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of Δx and the closing parenthesis can be omitted. If you omit Δx, the calculator automatically uses a value for Δx that is appropriate for the derivative value you are trying to determine.
- Discontinuous points or sections with drastic fluctuation can adversely affect precision or even cause an error.

Applications of Differential Calculations

- Differentials can be added, subtracted, multiplied and divided with each other.

$$\frac{d}{dx} f(a) = f'(a),\ \frac{d}{dx} g(a) = g'(a)$$

Therefore:

$$f'(a) + g'(a),\ f'(a) \times g'(a), \text{etc.}$$

- Differential results can be used in addition, subtraction, multiplication, and division, and in functions.

$$2 \times f'(a), \log(f'(a)), \text{etc.}$$

- Functions can be used in any of the terms ($f(x)$, a, Δx) of a differential.

$$\frac{d}{dx}(\sin x + \cos x, \sin 0.5), \text{etc.}$$

- Note that you cannot use a Solve, differential, quadratic differential, integration, maximum/minimum value or Σ calculation expression inside a differential calculation term.

- Pressing AC during calculation of a differential (while the cursor is not shown on the display) interrupts the calculation.
- Always use radians (Rad Mode) as the angle unit when performing trigonometric differentials.

3-3 Quadratic Differential Calculations

[OPTN]-[CALC]-[d^2/dx^2]

After displaying the function analysis menu, you can input quadratic differentials using either of the two following formats.

F3 $(d^2/dx^2)\ f(x)$, a , n)

Final boundary (n = 1 to 15)

Differential coefficient point

$$\frac{d^2}{dx^2}(f(x), a, n) \Rightarrow \frac{d^2}{dx^2} f(a)$$

Quadratic differential calculations produce an approximate differential value using the following second order differential formula, which is based on Newton's polynomial interpretation.

$$f''(x) = \frac{-f(x-2h) + 16f(x-h) - 30f(x) + 16f(x+h) - f(x+2h)}{12h^2}$$

In this expression, values for "sufficiently small increments of x" are sequentially calculated using the following formula, with the value of m being substituted as m = 1, 2, 3 and so on.

$$h = \frac{1}{5^m}$$

The calculation is finished when the value of $f''(x)$ based on the value of h calculated using the last value of m, and the value of $f''(x)$ based on the value of h calculated using the current value of m are identical before the upper n digit is reached.

- Normally, you should not input a value for n. It is recommended that you only input a value for n when required for calculation precision.
- Inputting a larger value for n does not necessarily produce greater precision.

●To perform a quadratic differential calculation

Example **To determine the quadratic differential coefficient at the point where x = 3 for the function $y = x^3 + 4x^2 + x - 6$**
Here we will use a final boundary value of n = 6.

Input the function $f(x)$.

AC OPTN F4 (CALC) F3 (d^2/dx^2) X,θ,T ^ 3 +
4 X,θ,T x^2 + X,θ,T − 6 ,

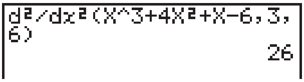
Input 3 as point a, which is differential coefficient point.

3 ,

Input 6 as n, which is final boundary.

6)

EXE



```
d²/dx²(X^3+4X²+X-6,3,
6)
                   26
```

- In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of the final boundary value n and the closing parenthesis can be omitted.
- Discontinuous points or sections with drastic fluctuation can adversely affect precision or even cause an error.

Quadratic Differential Applications

- Arithmetic operations can be performed using two quadratic differentials.

$$\frac{d^2}{dx^2} f(a) = f''(a), \quad \frac{d^2}{dx^2} g(a) = g''(a)$$

Therefore:

$$f''(a) + g''(a), \ f''(a) \times g''(a), \text{etc.}$$

- The result of a quadratic differential calculation can be used in a subsequent arithmetic or function calculation.

$$2 \times f''(a), \ \log(f''(a)), \text{etc.}$$

- Functions can be used within the terms ($f(x)$, a, n) of a quadratic differential expression.

$$\frac{d^2}{dx^2} (\sin x + \cos x, \sin 0.5), \text{etc.}$$

- Note that you cannot use a Solve, differential, quadratic differential, integration, maximum/minimum value or Σ calculation expression inside of a quadratic differential calculation term.

- Use only integers within the range of 1 to 15 for the value of final boundary n. Use of a value outside this range produces an error.
- You can interrupt an ongoing quadratic differential calculation by pressing the AC key.
- Always use radians (Rad Mode) as the angle unit when performing trigonometric quadratic differentials.

3-4 Integration Calculations

[OPTN]-[CALC]-[∫dx]

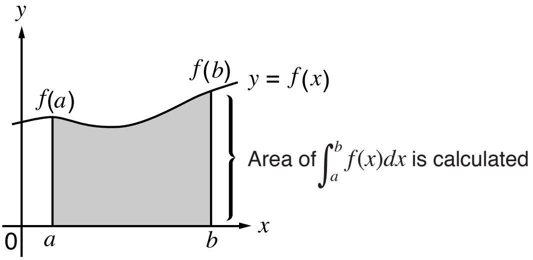
To perform integration calculations, first display the function analysis menu and then input the values in one of the formulas shown below.

Gauss-Kronrod Rule

$\boxed{\text{F4}}(\int dx)\ f(x)\ \boxed{,}\ \underline{a}\ \boxed{,}\ \underline{b}\ \boxed{,}\ \underline{tol}\ \boxed{)}$

Tolerance
End point
Start point

$$\int(f(x), a, b, tol) \Rightarrow \int_a^b f(x)dx$$



Simpson's Rule

$\boxed{\text{F4}}(\int dx)\ f(x)\ \boxed{,}\ \underline{a}\ \boxed{,}\ \underline{b}\ \boxed{,}\ \underline{n}\ \boxed{)}$

Number of divisions (value for n in $N = 2^n$, n is an integer from 1 through 9)
End point
Start point

$$\int(f(x), a, b, n) \Rightarrow \int_a^b f(x)dx, N = 2^n$$

As shown in the illustration above, integration calculations are performed by calculating integral values from a through b for the function $y = f(x)$ where $a \leqq x \leqq b$, and $f(x) \geqq 0$*. This in effect calculates the surface area of the shaded area in the illustration.

* If $f(x) < 0$ where $a \leqq x \leqq b$, the surface area calculation produces negative values (surface area × – 1).

■ Changing Integration Calculation Methods

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This calculator can use either Gauss-Kronrod Rule or Simpson's Rule to perform integration calculations. To select a method, display the set up screen and select either "**Gaus**" (for Gauss-Kronrod Rule) or "**Simp**" (for Simpson's Rule) for the Integration item.

All of the explanations in this manual use Gauss-Kronrod Rule.

●To perform an integration calculation

Example **To perform the integration calculation for the function shown below, with a tolerance of "tol" = 1E - 4**

$$\int_1^5 (2x^2 + 3x + 4)\, dx$$

Input the function $f(x)$.

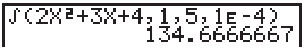
AC OPTN F4 (CALC) F4 (∫dx) 2 X,θ,T x^2 + 3 X,θ,T + 4 ,

Input the start point and end point.

1 , 5 ,

Input the tolerance value.

1 EXP (−) 4) EXE



```
∫(2X²+3X+4,1,5,1E-4)
             134.6666667
```

- In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of "tol" in Gauss-Kronrod Rule, "n" in Simpson's Rule, and closing parenthesis with both rules can be omitted. If you omit "tol", the calculator automatically uses a value of 1E - 5. In the case of "n", the calculator automatically selects the most appropriate value.
- Integration calculations can take a long time to complete.

■ Application of Integration Calculation

- Integrals can be used in addition, subtraction, multiplication and division.

$$\int_a^b f(x)\, dx + \int_c^d g(x)\, dx, \text{etc.}$$

- Integration results can be used in addition, subtraction, multiplication and division, in functions.

$$2 \times \int_a^b f(x)\, dx, \text{etc.} \quad \log\left(\int_a^b f(x)\, dx\right), \text{etc.}$$

- Functions can be used in any of the terms ($f(x)$, a, b, n) of an integral.

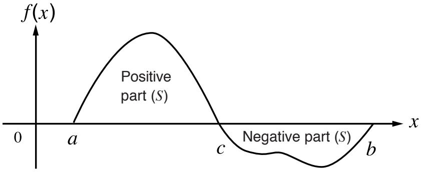
$$\int_{\sin 0.5}^{\cos 0.5} (\sin x + \cos x)\, dx = \int(\sin x + \cos x, \sin 0.5, \cos 0.5, 5)$$

- Note that you cannot use a Solve, differential, quadratic differential, integration, maximum/minimum value or Σ calculation expression inside of an integration calculation term.

- Pressing AC during calculation of an integral (while the cursor is not shown on the display) interrupts the calculation.
- Always use radians (Rad Mode) as the angle unit when performing trigonometric integrations.
- Factors such as the type of function being used, positive and negative values within divisions, and the division where integration is being performed can cause significant error in integration values and erroneous calculation results.

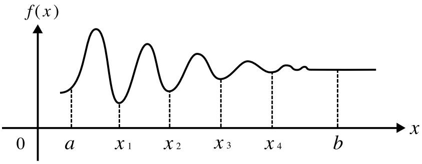
Note the following points to ensure correct integration values.

(1) When cyclical functions for integration values become positive or negative for different divisions, perform the calculation for single cycles, or divide between negative and positive, and then add the results together.



$$\int_a^b f(x)dx = \underbrace{\int_a^c f(x)dx}_{\textit{Positive part } (S)} + \underbrace{(-\int_c^b f(x)dx)}_{\textit{Negative part } (S)}$$

(2) When minute fluctuations in integration divisions produce large fluctuations in integration values, calculate the integration divisions separately (divide the large fluctuation areas into smaller divisions), and then add the results together.



$$\int_a^b f(x)dx = \int_a^{x_1} f(x)dx + \int_{x_1}^{x_2} f(x)dx + ...+ \int_{x_4}^b f(x)dx$$

3-5 Maximum/Minimum Value Calculations

[OPTN]-[CALC]-[FMin]/[FMax]

After displaying the function analysis menu, you can input maximum/minimum calculations using the formats below, and solve for the maximum and minimum of a function within interval $a \leqq x \leqq b$.

•Minimum Value

F6 (▷) F1 (FMin) $f(x)$, a , b , n)

Precision (n = 1 to 9)
End point of interval
Start point of interval

•Maximum Value

F6 (▷) F2 (FMax) $f(x)$, a , b , n)

Precision (n = 1 to 9)
End point of interval
Start point of interval

•To perform maximum/minimum value calculations

Example 1 **To determine the minimum value for the interval defined by start point a = 0 and end point b = 3, with a precision of n = 6 for the function $y = x^2 - 4x + 9$**

Input $f(x)$.

AC OPTN F4 (CALC) F6 (▷) F1 (FMin) X,θ,T x^2 − 4 X,θ,T + 9 ,

Input the interval a = 0, b = 3.

0 , 3 ,

Input the precision n = 6.

6)

EXE

```
Ans
 1[   2]
 2[   5]
```

Example 2 **To determine the maximum value for the interval defined by start point a = 0 and end point b = 3, with a precision of n = 6 for the function $y = -x^2 + 2x + 2$**

Input $f(x)$.

AC OPTN F4(CALC) F6(▷) F2(FMax) (−) X,θ,T x^2 + 2 X,θ,T + 2 ,

Input the interval a = 0, b = 3.

0 , 3 ,

Input the precision n = 6.

6)

EXE

Ans
1[ ]
2[3]

- In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of n and the closing parenthesis following the precision value can be omitted.
- Discontinuous points or sections with drastic fluctuation can adversely affect precision or even cause an error.
- Note that you cannot use a Solve, differential, quadratic differential, integration, maximum/minimum value or Σ calculation expression inside of a maximum/minimum calculation term.
- 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.

- The value you input for the end point of the interval (b) must be greater than the value you input for the start point (a). Otherwise an error is generated.
- You can interrupt an ongoing maximum/minimum calculation by pressing the AC key.
- You can input an integer in the range of 1 to 9 for the value of n. Using any value outside this range causes an error.

3-6 Σ Calculations

[OPTN]-[CALC]-[Σ(]

To perform Σ calculations, first display the function analysis menu, and then input the values shown in the formula below.

F6 (▷) F3 (Σ() a_k , k , α , β , n)

Distance between partitions (n)

Last term of sequence a_k (β)

Initial term of sequence a_k (α)

Variable used by sequence a_k (k)

$$\sum (a_k, k, \alpha, \beta, n) \Rightarrow \sum_{k=\alpha}^{\beta} a_k$$

Σ calculation is the calculation of the partial sum of sequence a_k, using the following formula.

$$S = a_\alpha + a_{\alpha+1} + \text{........} + a_\beta = \sum_{k=\alpha}^{\beta} a_k$$

Example Σ Calculation

Example **To calculate the following:**

$$\sum_{k=2}^{6} (k^2 - 3k + 5)$$

Use n = 1 as the distance between partitions.

Input sequence a_k.

AC OPTN F4 (CALC) F6 (▷) F3 (Σ() ALPHA K x^2 − 3 ALPHA K + 5 ,

Input variable used by sequence a_k.

ALPHA K ,

Input the initial term of sequence a_k and last term of sequence a_k.

2 , 6 ,

Input n.

1)

EXE

```
Σ(K²-3K+5,K,2,6,1)
                 55
```

- You can use only one variable in the function for input sequence a_k.
- Input integers only for the initial term of sequence a_k and last term of sequence a_k .
- Input of n and the closing parentheses can be omitted. If you omit n, the calculator automatically uses n = 1.

■ Σ Calculation Applications

- Arithmetic operations using Σ calculation expressions

Expressions: $\mathrm{S}_n = \sum_{k=1}^{n} a_k,\ \mathrm{T}_n = \sum_{k=1}^{n} b_k$

Possible operations: $\mathrm{S}_n + \mathrm{T}_n,\ \mathrm{S}_n - \mathrm{T}_n$, etc.

- Arithmetic and function operations using Σ calculation results

$2 \times \mathrm{S}_n,\ \log(\mathrm{S}_n)$, etc.

- Function operations using Σ calculation terms (a_k, k)

$\Sigma\ (\sin k, k, 1, 5)$, etc.

- Note that you cannot use a Solve, differential, quadratic differential, integration, maximum/minimum value or Σ calculation expression inside of a Σ calculation term.

- Make sure that the value used as the final term β is greater than the value used as the initial term α. Otherwise, an error will occur.
- To interrupt an ongoing Σ calculation (indicated when the cursor is not on the display), press the AC key.

Chapter 4

Complex Numbers

This calculator is capable of performing the following operations using complex numbers.

- Arithmetic operations (addition, subtraction, multiplication, division)
- Calculation of the reciprocal, square root, and square of a complex number
- Calculation of the absolute value and argument of a complex number
- Calculation of conjugate complex numbers
- Extraction of the real number part
- Extraction of the imaginary number part

4-1 Before Beginning a Complex Number Calculation

Before beginning a complex number calculation, press OPTN F3 (CPLX) to display the complex number calculation menu.

- {i} ... {imaginary unit i input}
- {**Abs**}/{**Arg**} ... obtains {absolute value}/{argument}
- {**Conj**} ... {obtains conjugate}
- {**ReP**}/{**ImP**} ... {real number}/{imaginary number} part extraction

4-2 Performing Complex Number Calculations

The following examples show how to perform each of the complex number calculations available with this calculator.

Arithmetic Operations **[OPTN]-[CPLX]-[*i*]**

Arithmetic operations are the same as those you use for manual calculations. You can even use parentheses and memory.

Example 1 **(1 + 2*i*) + (2 + 3*i*)**

AC OPTN F3 (CPLX)
(1 + 2 F1 (*i*))
\+ (2 + 3 F1 (*i*)) EXE

```
(1+2i)+(2+3i)
             3+5i
```

Example 2 **(2 + *i*) × (2 – *i*)**

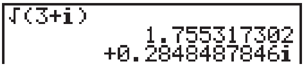
AC OPTN F3 (CPLX)
(2 + F1 (*i*))
× (2 – F1 (*i*)) EXE

```
(2+i)×(2-i)
                5
```

Reciprocals, Square Roots, and Squares

Example $\sqrt{(3 + i)}$

AC OPTN F3 (CPLX)
SHIFT √ (3 + F1 (*i*)) EXE

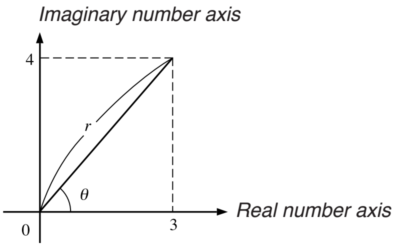


```
√(3+i)
      1.755317302
  +0.2848487846i
```

Absolute Value and Argument **[OPTN]-[CPLX]-[Abs]/[Arg]**

The unit regards a complex number in the format Z = $a + bi$ as a coordinate on a Gaussian plane, and calculates absolute value $|Z|$ and argument (arg).

Example **To calculate absolute value (r) and argument (θ) for the complex number 3 + 4*i*, with the angle unit set for degrees**



AC OPTN F3 (CPLX) F2 (Abs)
(3 + 4 F1 (*i*)) EXE
(Calculation of absolute value)


```
Abs (3+4i)
                  5
```

AC OPTN F3 (CPLX) F3 (Arg)
(3 + 4 F1 (*i*)) EXE
(Calculation of argument)


```
Arg (3+4i)
        53.13010235
```

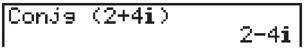
- The result of the argument calculation differs in accordance with the current angle unit setting (degrees, radians, grads).

■ Conjugate Complex Numbers **[OPTN]-[CPLX]-[Conj]**

A complex number of the format $a + bi$ becomes a conjugate complex number of the format $a - bi$.

Example **To calculate the conjugate complex number for the complex number 2 + 4*i***

AC OPTN F3 (CPLX) F4 (Conj)
(2 + 4 F1 (*i*)) EXE


```
Conjg (2+4i)
               2-4i
```

■ Extraction of Real and Imaginary Number Parts

[OPTN]-[CPLX]-[ReP]/[ImP]

Use the following procedure to extract real part a and imaginary part b from a complex number with the format $a + bi$.

Example **To extract the real and imaginary parts of the complex number 2 + 5*i***

AC OPTN F3 (CPLX) F5 (ReP)
(2 + 5 F1 (*i*)) EXE
(Real part extraction)


```
ReP (2+5i)
                  2
```

AC OPTN F3 (CPLX) F6 (ImP)
(2 + 5 F1 (*i*)) EXE
(Imaginary part extraction)


```
ImP (2+5i)
                  5
```

Complex Number Calculation Precautions

- The input/output range of complex numbers is normally 10 digits for the mantissa and two digits for the exponent.
- When a complex number has more than 21 digits, the real number part and imaginary number part are displayed on separate lines.
- When either the real number part or imaginary number part equals zero, that part is not displayed.

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- 20 bytes of memory are used whenever you assign a complex number to a variable.
- The following functions can be used with complex numbers.

  $\sqrt{\ }$, x^2, x^{-1}

  Int, Frac, Rnd, Intg, Fix, Sci, ENG, $\overleftarrow{\text{ENG}}$, ° ’ ”, $\overleftarrow{\text{° ’ ”}}$, $a\,{}^b/_c$, d/c, F⇔D

Chapter 5

Binary, Octal, Decimal, and Hexadecimal Calculations

This calculator is capable of performing the following operations involving different number systems.

- Number system conversion
- Arithmetic operations
- Negative values
- Logical operations

5-1 Before Beginning a Binary, Octal, Decimal, or Hexadecimal Calculation

You can use the **RUN Mode** and binary, octal, decimal, and hexadecimal settings to perform calculations that involve binary, octal, decimal and hexadecimal values. You can also convert between number systems and perform logical operations.

- You cannot use scientific functions in binary, octal, decimal, and hexadecimal calculations.
- You can use only integers in binary, octal, decimal, and hexadecimal calculations, which means that fractional values are not allowed. If you input a value that includes a decimal part, the unit automatically cuts off the decimal part.
- If you attempt to enter a value that is invalid for the number system (binary, octal, decimal, hexadecimal) you are using, the calculator displays an error message. The following shows the numerals that can be used in each number system.

  Binary: 0, 1

  Octal: 0, 1, 2, 3, 4, 5, 6, 7

  Decimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

  Hexadecimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

- The alphabetic characters used in the hexadecimal number appear differently on the display to distinguish them from text characters.

  Normal Text: A, B, C, D, E, F

  Hexadecimal Values: A, B, C, D, E, F

- Negative binary, octal, and hexadecimal values are produced using the two's complement of the original value.
- The following are the display capacities for each of the number systems.

Number System	Display Capacity
Binary	16 digits
Octal	11 digits
Decimal	10 digits
Hexadecimal	8 digits

- The following are the calculation ranges for each of the number systems.

Binary Values

Positive: $0 \leqq x \leqq 111111111111111$
Negative: $1000000000000000 \leqq x \leqq 1111111111111111$

Octal Values

Positive: $0 \leqq x \leqq 17777777777$
Negative: $20000000000 \leqq x \leqq 37777777777$

Decimal Values

Positive: $0 \leqq x \leqq 2147483647$
Negative: $-2147483648 \leqq x \leqq -1$

Hexadecimal Values

Positive: $0 \leqq x \leqq$ 7FFFFFFF
Negative: $80000000 \leqq x \leqq$ FFFFFFFF

●To perform a binary, octal, decimal, or hexadecimal calculation

1. In the main menu, select **RUN**.

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2. Press [SHIFT] [SETUP] and then specify the defalut number system by pressing [F2] (Dec), [F3] (Hex), [F4] (Bin), or [F5] (Oct).

3. Press [EXIT] to change to the screen for calculation input. This causes a function menu with the following items to appear.

- {**d~o**}/{**LOG**} ... {number system specification}/{logical operation} menu

5-2 Selecting a Number System

You can specify decimal, hexadecimal, binary, or octal as the default number system using the set up screen. After you press the function key that corresponds to the system you want to use, press EXE.

•To convert a displayed value from one number system to another

Example **To convert 22_{10} (default number system) to its binary or octal value**

AC SHIFT SET UP F2(Dec) EXIT F1(d~o) F1(d)
2 2 EXE

```
d22
                 22
```

SHIFT SET UP F4(Bin) EXIT EXE

```
   0000000000010110
```

SHIFT SET UP F5(Oct) EXIT EXE

```
        00000000026
```

•To specify a number system for an input value

You can specify a number system for each individual value you input. While binary, octal, decimal, or hexadecimal is set as the default number system, press F1 (d~o) to display a menu of number system symbols. Press the function key that corresponds to the symbol you want to select and then input the value you want.

- {**d**}/{**h**}/{**b**}/{**o**} ... {decimal}/{hexadecimal}/{binary}/{octal}

•To input values of mixed number systems

Example **To input 123_{10} or 1010_2, when the default number system is hexadecimal**

SHIFT SET UP F3(Hex) EXIT
AC F1(d~o) F1(d) 1 2 3 EXE

```
d123
           0000007B
```

F3(b) 1 0 1 0 EXE

```
b1010
           0000000A
```

5-3 Arithmetic Operations

Example 1 **To calculate $10111_2 + 11010_2$**

SHIFT SETUP F4(Bin) EXIT

AC 1 0 1 1 1 +

1 1 0 1 0 EXE

```
10111+11010
     0000000000110001
```

Example 2 **To input and execute 123_8 × ABC_{16}, when the default number system is decimal or hexadecimal**

SHIFT SETUP F2(Dec) EXIT

AC F1(d~o) F4(o) 1 2 3 ×

F2(h) A B C EXE

```
o123×hABC
               228084
```

SHIFT SETUP F3(Hex) EXIT EXE

```
             00037AF4
```

5-4 Negative Values and Logical Operations

While binary, octal, decimal, or hexadecimal is set as the default number system, press F2 (LOG) to display a menu of negation and logical operators.

- {**Neg**} ... {negation}
- {**Not**}/{**and**}/{**or**}/{**xor**}/{**xnor**} ... {NOT}/{AND}/{OR}/{XOR}/{XNOR}

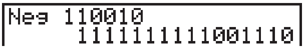
■ Negative Values

Example **To determine the negative of 110010_2**

SHIFT SET UP F4 (Bin) EXIT

AC F2 (LOG) F1 (Neg)

1 1 0 0 1 0 EXE



```
Neg 110010
    1111111111001110
```

■ Logical Operations

Example 1 **To input and execute "120_{16} and AD_{16}"**

SHIFT SET UP F3 (Hex) EXIT

AC 1 2 0 F2 (LOG)

F3 (and) A D EXE

```
120andAD
            00000020
```

Example 2 **To display the result of "36_8 or 1110_2" as an octal value**

SHIFT SET UP F5 (Oct) EXIT EXIT

AC 3 6 F2 (LOG)

F4 (or) EXIT F1 (d~o) F3 (b)

1 1 1 0 EXE

```
36orb1110
         00000000036
```

Example 3 **To negate $2FFFED_{16}$**

SHIFT SET UP F3 (Hex) EXIT EXIT

AC F2 (LOG) F2 (Not)

2 F F F E D EXE

```
Not 2FFFED
            FFD00012
```

Chapter 6

Matrix Calculations

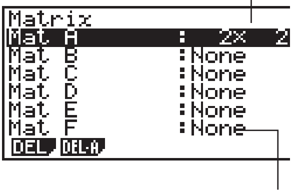
26 matrix memories (Mat A through Mat Z) plus a Matrix Answer Memory (MatAns), make it possible to perform the following matrix operations.

- Addition, subtraction, multiplication
- Scalar product calculations
- Determinant calculations
- Matrix transposition
- Matrix inversion
- Matrix squaring
- Raising a matrix to a specific power
- Absolute value, integer part extraction, fractional part extraction, maximum integer calculations
- Matrix modification using matrix commands

6-1 Before Performing Matrix Calculations

In the Main Menu, select the **MAT** icon to enter the Matrix Mode and display its initial screen.

2 (row) × 2 (column) matrix



```
Matrix
Mat A        :  2×  2
Mat B        :None
Mat C        :None
Mat D        :None
Mat E        :None
Mat F        :None
DEL  DEL·A
```

Not dimension preset

- {**DEL**}/{**DEL·A**} ... deletes {a specific matrix}/{all matrices}

- The maximum number of rows that can be specified for a matrix is 255, and the maximum number of columns is 255.

About Matrix Answer Memory (MatAns)

The calculator automatically stores matrix calculation results in Matrix Answer Memory. Note the following points about Matrix Answer Memory.

- Whenever you perform a matrix calculation, the current Matrix Answer Memory contents are replaced by the new result. The previous contents are deleted and cannot be recovered.
- Inputting values into a matrix does not affect Matrix Answer Memory contents.

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Creating a Matrix

To create a matrix, you must first define its dimensions (size) in the MATRIX list. Then you can input values into the matrix.

•To specify the dimensions of a matrix

Example **To create a 2-row × 3-column matrix in the area named Mat B**

Highlight Mat B.

▼

```
Matrix
Mat A        :  2×  2
Mat B        :None
```

Specify the number of rows.

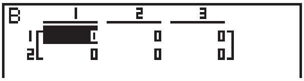
2 EXE

Specify the number of columns.

3

Matrix
Mat A : 2× 2
Mat B : 2×3_

EXE



B	1	2	3
1	0	0	0
2	0	0	0

- All of the cells of a new matrix contain the value 0.
- If "Mem ERROR" remains next to the matrix area name after you input the dimensions, it means there is not enough free memory to create the matrix you want.

●To input cell values

Example **To input the following data into Matrix B :**

$$\begin{bmatrix} \mathbf{1} & \mathbf{2} & \mathbf{3} \\ \mathbf{4} & \mathbf{5} & \mathbf{6} \end{bmatrix}$$

Select Mat B.

▼

Matrix
Mat A : 2× 2
Mat B : 2× 3

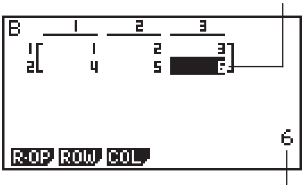
EXE

1 EXE 2 EXE 3 EXE

4 EXE 5 EXE 6 EXE

(Data is input into the highlighted cell. Each time you press EXE, the highlighting move to the next cell to the right.)

Highlighted cell (up to six digits can be displayed)



B	1	2	3
1	1	2	3
2	4	5	6

6

Value in currently highlighted cell

- Displayed cell values show positive integers up to six digits, and negative integers up to five digits (one digit used for the negative sign). Exponential values are shown with up to two digits for the exponent. Fractional values are not displayed.
- You can see the entire value assigned to a cell by using the cursor keys to move the highlighting to the cell whose value you want to view.
- The amount of memory required for a matrix is ten bytes per cell. This means that a 3 × 3 matrix requires 90 bytes of memory (3 × 3 × 10 = 90).

Deleting Matrices

You can delete either a specific matrix or all matrices in memory.

•To delete a specific matrix

1. While the MATRIX list is on the display, use ▲ and ▼ to highlight the matrix you want to delete.

2. Press F1 (DEL).

3. Press F1 (YES) to delete the matrix or F6 (NO) to abort the operation without deleting anything.

- The indicator “None” replaces the dimensions of the matrix you delete.

•To delete all matrices

1. While the MATRIX list is on the display, press F2 (DEL·A).

2. Press F1 (YES) to delete all matrices in memory or F6 (NO) to abort the operation without deleting anything.

- The indicator “None” is shown for all the matrices.

6-2 Matrix Cell Operations

Use the following procedure to prepare a matrix for cell operations.

1. While the MATRIX list is on the display, use ▲ and ▼ to highlight the name of the matrix you want to use.

2. Press EXE and the function menu with the following items appears.

- {**R·OP**} ... {row calculation menu}
- {**ROW**}/{**COL**} ... {row}/{column} operation menu

All of the following examples use Matrix A recalled by the above operation.

Row Calculations

The following menu appears whenever you press F1 (R·OP) while a recalled matrix is on the display.

- {**Swap**} ... {row swap}
- {×**Rw**} ... {scalar product of specified row}
- {×**Rw+**} ... {addition of scalar product of specified row to another row}
- {**Rw+**} ... {addition of specified row to another row}

●To swap two rows

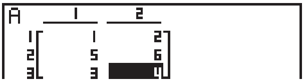
Example **To swap rows two and three of the following matrix :**

Matrix A = $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$

F1(R·OP) F1(Swap)

Input the number of the rows you want to swap.

2 EXE 3 EXE



A	1	2
1	1	2
2	5	6
3	3	4

•To calculate the scalar product of a row

Example **To calculate the scalar product of row 2 of the following matrix, multiplying by 4 :**

$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

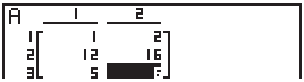
F1 (R·OP) F2 (×Rw)

Input multiplier value.

4 EXE

Specify row number.

2 EXE



```
A     1     2
1[    1     2]
2[   12    16]
3[    5      ]
```

•To calculate the scalar product of a row and add the result to another row

Example **To calculate the scalar product of row 2 of the following matrix, multiplying by 4 and add the result to row 3 :**

$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F1 (R·OP) F3 (×Rw+)

Input multiplier value.

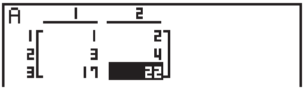
4 EXE

Specify number of row whose scalar product should be calculated.

2 EXE

Specify number of row where result should be added.

3 EXE



```
A     1     2
1[    1     2]
2[    3     4]
3[   17    22]
```

•To add two rows together

Example **To add row 2 to row 3 of the following matrix :**

$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

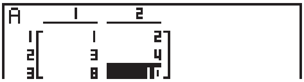
F1 (R·OP) F4 (Rw+)

Specify number of row to be added.

2 EXE

Specify number of row to be added to.

3 EXE



```
A     1     2
1[    1     2]
2[    3     4]
3[    8      ]
```

Row Operations

The following menu appears whenever you press F2 (ROW) while a recalled matrix is on the display.

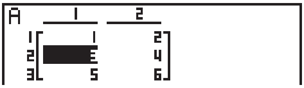
- {**DEL**} ... {delete row}
- {**INS**} ... {insert row}
- {**ADD**} ... {add row}

●To delete a row

Example **To delete row 2 of the following matrix :**

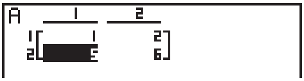
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F2(ROW)▼



A	1	2
1	1	2
2	3	4
3	5	6

F1(DEL)



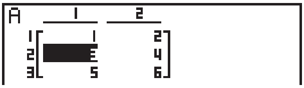
A	1	2
1	1	2
2	5	6

●To insert a row

Example **To insert a new row between rows one and two of the following matrix :**

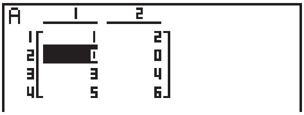
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F2(ROW)▼



A	1	2
1	1	2
2	3	4
3	5	6

F2(INS)



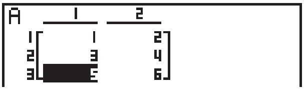
A	1	2
1	1	2
2	0	0
3	3	4
4	5	6

•To add a row

Example **To add a new row below row 3 of the following matrix :**

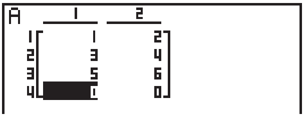
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F2(ROW) ▼ ▼



A	1	2
1	1	2
2	3	4
3	5	6

F3(ADD)



A	1	2
1	1	2
2	3	4
3	5	6
4	0	0

Column Operations

The following menu appears whenever you press F3 (COL) while a recalled matrix is on the display.

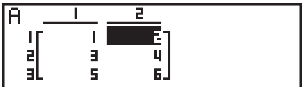
- {**DEL**} ... {delete column}
- {**INS**} ... {insert column}
- {**ADD**} ... {add column}

•To delete a column

Example **To delete column 2 of the following matrix :**

$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F3(COL) ▶



A	1	2
1	1	2
2	3	4
3	5	6

F1(DEL)

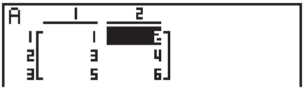
A	1
1	1
2	3
3	5

•To insert a column

Example To insert a new column between columns 1 and 2 of the following matrix :

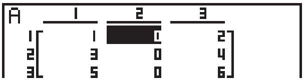
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F3(COL)▶



$$\begin{array}{c|cc} \text{A} & 1 & 2 \\ 1 & 1 & 2 \\ 2 & 3 & 4 \\ 3 & 5 & 6 \end{array}$$

F2(INS)



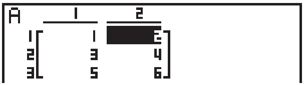
$$\begin{array}{c|ccc} \text{A} & 1 & 2 & 3 \\ 1 & 1 & 0 & 2 \\ 2 & 3 & 0 & 4 \\ 3 & 5 & 0 & 6 \end{array}$$

•To add a column

Example To add a new column to the right of column 2 of the following matrix :

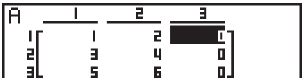
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F3(COL)▶



$$\begin{array}{c|cc} \text{A} & 1 & 2 \\ 1 & 1 & 2 \\ 2 & 3 & 4 \\ 3 & 5 & 6 \end{array}$$

F3(ADD)



$$\begin{array}{c|ccc} \text{A} & 1 & 2 & 3 \\ 1 & 1 & 2 & 0 \\ 2 & 3 & 4 & 0 \\ 3 & 5 & 6 & 0 \end{array}$$

6-3 Modifying Matrices Using Matrix Commands

[OPTN]-[MAT]

•To display the matrix commands

P.27

1. From the Main Menu, select the **RUN** icon and press EXE.
2. Press OPTN to display the option menu.
3. Press F2 (MAT) to display the matrix operation menu.

The following describes only the matrix command menu items that are used for creating matrices and inputting matrix data.

P.91

- {**Mat**} ... {Mat command (matrix specification)}
- {**M→L**} ... {Mat→List command (assign contents of selected column to list file)}
- {**Aug**} ... {Augment command (link two matrices)}
- {**Iden**} ... {Identity command (identity matrix input)}
- {**Dim**} ... {Dim command (dimension check)}
- {**Fill**} ... {Fill command (identical cell values)}

■ Matrix Data Input Format

The following shows the format you should use when inputting data to create a matrix using the matrix operation menu's Mat command.

$$\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$$

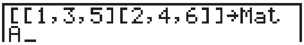
$= [\ [a_{11}, a_{12}, \dots, a_{1n}]\ [a_{21}, a_{22}, \dots, a_{2n}]\ \dots.\ [a_{m1}, a_{m2}, \dots, a_{mn}]\ ]$
→ Mat [letter A through Z]

- The maximum value of both m and n is 255.

Example 1 **To input the following data as Matrix A :**

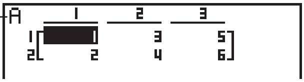
$$\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$$

OPTN F2 (MAT)
SHIFT [SHIFT [1 , 3 , 5
SHIFT] SHIFT [2 , 4 , 6
SHIFT] SHIFT] → F1 (Mat) ALPHA A



```
[[1,3,5][2,4,6]]→Mat
A_
```

EXE



Matrix name

A	1	2	3
1	1	3	5
2	2	4	6

- An error occurs if memory becomes full as you are inputting data.
- You can also use the above format inside a program that inputs matrix data.

•To input an identity matrix

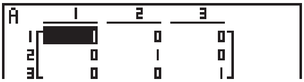
Use the matrix operation menu's Identity command (F1) to create an identity matrix.

Example 2 **To create a 3 × 3 identity matrix as Matrix A**

OPTN F2(MAT) F6(▷) F1(Iden)

3 → F6(▷) F1(Mat) ALPHA A EXE

Number of rows/columns



A	1	2	3
1	1	0	0
2	0	1	0
3	0	0	1

•To check the dimensions of a matrix

Use the matrix operation menu's Dim command (F2) to check the dimensions of an existing matrix.

Example 3 **To check the dimensions of Matrix A, which was input in Example 1**

OPTN F2(MAT) F6(▷) F2(Dim) F6(▷)

F1(Mat) ALPHA A EXE

Number of rows

Ans	
1	2
2	3

Number of columns

The display shows that Matrix A consists of two rows and three columns.

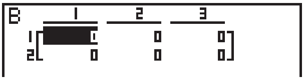
You can also use {Dim} to specify the dimensions of the matrix.

Example 4 **To specify dimensions of 2 rows and 3 columns for Matrix B**

SHIFT { 2 , 3 SHIFT } → OPTN

F2(MAT) F6(▷) F2(Dim) F6(▷)

F1(MAT) ALPHA B EXE



B	1	2	3
1	0	0	0
2	0	0	0

Modifying Matrices Using Matrix Commands

You can also use matrix commands to assign values to and recall values from an existing matrix, to fill in all cells of an existing matrix with the same value, to combine two matrices into a single matrix, and to assign the contents of a matrix column to a list file.

•To assign values to and recall values from an existing matrix

Use the following format with the matrix operation menu's Mat command (F1) to specify a cell for value assignment and recall.

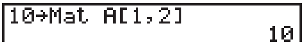
Mat X [m, n]

X .... matrix name (A through Z, or Ans)
m .... row number
n .... column number

Example 1 **Assign 10 to the cell at row 1, column 2 of the following matrix :**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

1 0 → OPTN F2 (MAT) F1 (Mat)
ALPHA A SHIFT [1 , 2 SHIFT] EXE



```
10→Mat A[1,2]
               10
```

Example 2 **Multiply the value in the cell at row 2, column 2 of the above matrix by 5**

OPTN F2 (MAT) F1 (Mat)
ALPHA A SHIFT [2 , 2 SHIFT]
× 5 EXE

```
Mat A[2,2]×5
               20
```

•To fill a matrix with identical values and to combine two matrices into a single matrix

Use the matrix operation menu's Fill command (F3) to fill all the cells of an existing matrix with an identical value and the Augment command (F5) to combine two existing matrices into a single matrix.

Example 1 **To fill all of the cells of Matrix A with the value 3**

OPTN F2 (MAT) F6 (▷) F3 (Fill)
3 , F6 (▷) F1 (Mat) ALPHA A EXE

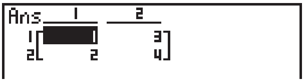
Filler value

```
Fill(3,Mat A
             Done
```

Example 2 **To combine the following two matrices :**

$$A = \begin{bmatrix} 1 \\ 2 \end{bmatrix} \qquad B = \begin{bmatrix} 3 \\ 4 \end{bmatrix}$$

OPTN F2 (MAT) F5 (Aug) F1 (Mat)
ALPHA A , F1 (Mat) ALPHA B EXE



```
Ans    1      2
 1[           3]
 2[    2      4]
```

- The two matrices you combine must have the same number of rows. An error occurs if you try to combine two matrices that have different numbers of rows.

•To assign the contents of a matrix column to a list file

Use the following format with the matrix operation menu's Mat→List command (F2) to specify a column and a list file.

Mat → List (Mat X, m) → List n
X = matrix name (A through Z, or Ans)
m = column number
n = list number

Example **To assign the contents of column 2 of the following matrix to list file 1 :**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

OPTN F2 (MAT) F2 (M→L) F1 (Mat)
ALPHA A , 2) →
Column number
OPTN F1 (LIST) F1 (List) 1 EXE

```
Mat→List(Mat A,2)→Lis
t 1
                 Done
```

You can use Matrix Answer Memory to assign the results of the above matrix input and edit operations to a matrix variable. To do so, use the following syntax.

- Fill (n, Mat α) → Mat β
- Augment (Mat α, Mat β) → Mat γ

In the above, α, β, and γ are any variable names A through Z, and n is any value.
The above does not affect the contents of Matrix Answer Memory.

6-4 Matrix Calculations

[OPTN]-[MAT]

Use the matrix command menu to perform matrix calculation operations.

•To display the matrix commands

P.27

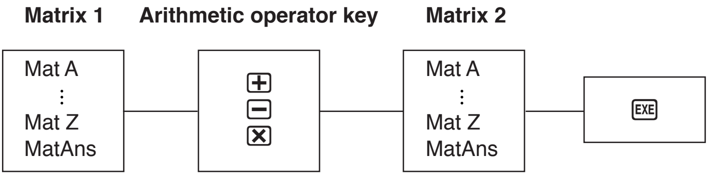
1. From the Main Menu, select the **RUN** icon and press EXE.
2. Press OPTN to display the option menu.
3. Press F2 (MAT) to display the matrix command menu.

The following describes only the matrix commands that are used for matrix arithmetic operations.

- {**Mat**} ... {Mat command (matrix specification)}
- {**Det**} ... {Det command (determinant command)}
- {**Trn**} ... {Trn command (transpose matrix command)}
- {**Iden**} ... {Identity command (identity matrix input)}

All of the following examples assume that matrix data is already stored in memory.

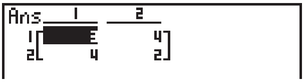
■ Matrix Arithmetic Operations



Example 1 **To add the following two matrices (Matrix A + Matrix B) :**

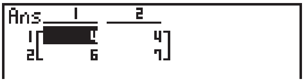
$$A = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix} \qquad B = \begin{bmatrix} 2 & 3 \\ 2 & 1 \end{bmatrix}$$

F1 (Mat) ALPHA A +
F1 (Mat) ALPHA B EXE



Example 2 **To multiply the two matrices in Example 1 (Matrix A × Matrix B)**

F1 (Mat) ALPHA A ×
F1 (Mat) ALPHA B EXE



- The two matrices must have the same dimensions in order to be added or subtracted. An error occurs if you try to add or subtract matrices of different dimensions.
- For multiplication, the number of columns in Matrix 1 must match the number of rows in Matrix 2. Otherwise, an error occurs.

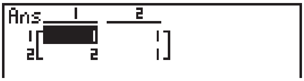
- You can use an identity matrix in place of Matrix 1 or Matrix 2 in the matrix arithmetic format. Use the matrix command menu's Identity command (F1) to input the identity matrix.

Example 3 **To multiply Matrix A (from Example 1) by a 2 × 2 identity matrix**

F1 (Mat) ALPHA A ×

F6 (▷) F1 (Iden) 2 EXE

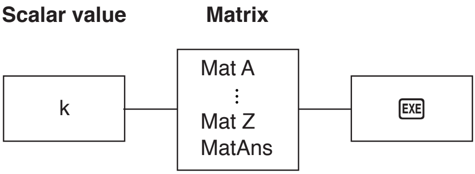
Number of rows and columns.



```
Ans   1      2
  1[  1      1]
  2[  2      1]
```

Matrix Scalar Product

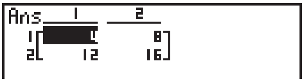
The following is the format for calculating a matrix scalar product, which multiplies the value in each cell of the matrix by the same value.



Example **Calculate the scalar product of the following matrix using a multiplier value of 4 :**

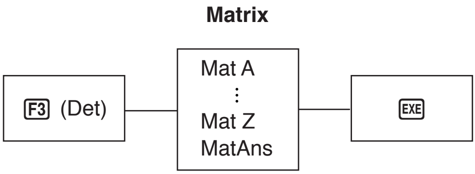
$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

4 F1 (Mat) ALPHA A EXE



```
Ans   1      2
  1[  4      8]
  2[ 12     16]
```

Determinant



Example **Obtain the determinant for the following matrix :**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ -1 & -2 & 0 \end{bmatrix}$$

F3 (Det) F1 (Mat) ALPHA A EXE

```
Det Mat A
                  -9
```

- Determinants can be obtained only for square matrices (same number of rows and columns). Trying to obtain a determinant for a matrix that is not square produces an error.

- The determinant of a 2 × 2 matrix is calculated as shown below.

$$|A| = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = a_{11}a_{22} - a_{12}a_{21}$$

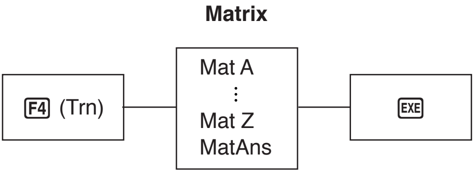
- The determinant of a 3 × 3 matrix is calculated as shown below.

$$|A| = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

$$= a_{11}a_{22}a_{33} + a_{12}a_{23}a_{31} + a_{13}a_{21}a_{32} - a_{11}a_{23}a_{32} - a_{12}a_{21}a_{33} - a_{13}a_{22}a_{31}$$

Matrix Transposition

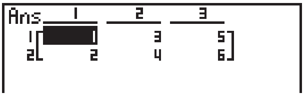
A matrix is transposed when its rows become columns and its columns become rows. The following is the format for matrix transposition.



Example **To transpose the following matrix :**

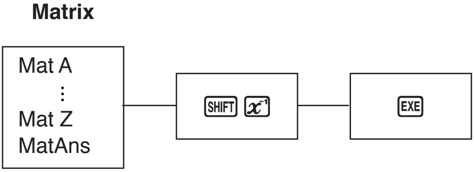
$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

F4 (Trn) F1 (Mat) ALPHA A EXE



```
Ans    1     2     3
 1 [   1     3     5 ]
 2 [   2     4     6 ]
```

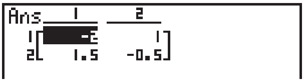
Matrix Inversion



Example **To invert the following matrix :**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

F1 (Mat) ALPHA A SHIFT x^{-1} EXE



```
Ans   1      2
 1[  -2      1]
 2[  1.5  -0.5]
```

- Only square matrices (same number of rows and columns) can be inverted. Trying to invert a matrix that is not square produces an error.
- A matrix with a value of zero cannot be inverted. Trying to invert a matrix with value of zero produces an error.
- Calculation precision is affected for matrices whose value is near zero.

- A matrix being inverted must satisfy the conditions shown below.

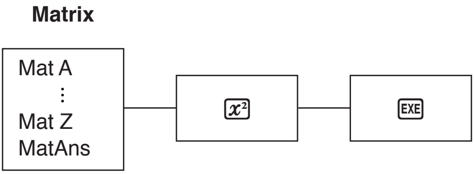
$$A\,A^{-1} = A^{-1}\,A = E = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

- The following shows the formula used to invert Matrix A into inverse matrix A^{-1}.

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

$$A^{-1} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$ Note that $ad - bc \neq 0$.

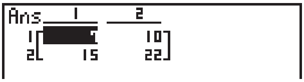
Squaring a Matrix



Example To square the following matrix :

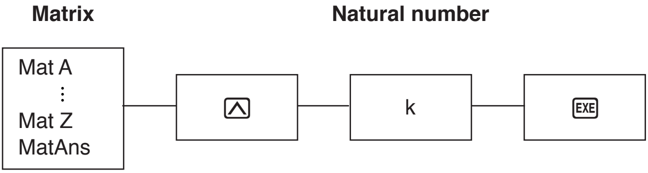
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

F1 (Mat) ALPHA A x² EXE



```
Ans   1      2
 1[    7    10]
 2[   15    22]
```

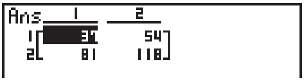
Raising a Matrix to a Power



Example To raise the following matrix to the third power :

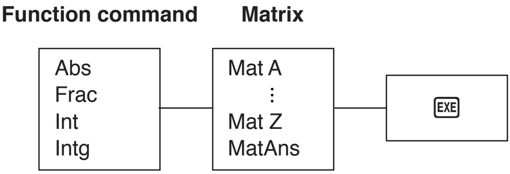
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

F1 (Mat) ALPHA A ^ 3 EXE



```
Ans   1      2
 1[   37    54]
 2[   81   118]
```

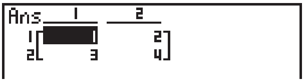
Determining the Absolute Value, Integer Part, Fraction Part, and Maximum Integer of a Matrix



Example **To determine the absolute value of the following matrix :**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & -2 \\ -3 & 4 \end{bmatrix}$$

OPTN F6 (▷) F4 (NUM) F1 (Abs)
OPTN F2 (MAT) F1 (Mat) ALPHA A EXE



```
Ans   1       2
 1 [  1       2 ]
 2 [  3       4 ]
```

- Determinants and inverse matrices are calculated using the elimination method, so errors (such as dropped digits) may be generated.
- Matrix operations are performed individually on each cell, so calculations may require considerable time to complete.
- The calculation precision of displayed results for matrix calculations is ± 1 at the least significant digit.
- If a matrix calculation result is too large to fit into Matrix Answer Memory, an error occurs.
- You can use the following operation to transfer Matrix Answer Memory contents to another matrix (or when Matrix Answer Memory contains a determinant to a variable).

  MatAns → Mat α

  In the above, α is any variable name A through Z. The above does not affect the contents of Matrix Answer Memory.

Chapter 7

Equation Calculations

Your graphic calculator can solve the following three types of equations:

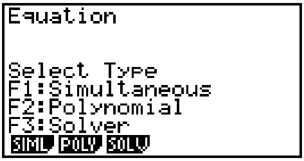
- Linear equations with two to six unknowns
- Quadratic equations
- Cubic equations

7-1 Before Beginning an Equation Calculation

Before beginning an equation calculation you have to first enter the correct mode, and you must also clear the equation memories of any data that might be left over from a previous calculation.

■ Entering an Equation Calculation Mode

In the Main Menu, select the **EQUA** icon to enter the Equation Mode.



```
Equation

Select Type
F1:Simultaneous
F2:Polynomial
F3:Solver
```

- {**SIML**} ... {linear equation with two to six unknowns}
- {**POLY**} ... {quadratic or cubic equation}
- {**SOLV**} ... {solve calculation}

■ Clearing Equation Memories

1. Enter the equation calculation mode (SIML or POLY) you want to use and perform the function key operation required for that mode.
   - In the case of the SIML Mode (F1), use function keys F1 (2) through F5 (6) to specify the number of unknowns.
   - In the case of the POLY Mode (F2), use function keys F1 (2) or F2 (3) to specify the degree of the polynomial.
   - If your pressed F3 (SOLV), advance directly to step 2.

2. Press F2 (DEL).

3. Press F1 (YES) to delete the applicable equation memories, or F6 (NO) to abort the operation without deleting anything.

7-2 Linear Equations with Two to Six Unknowns

You can use the procedures described here to solve linear equations with unknowns that match the following formats:

Two unknowns

$$a_1x + b_1y = c_1$$
$$a_2x + b_2y = c_2$$

⋮

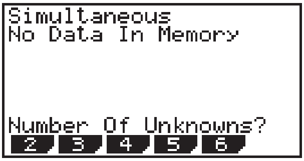
Six unknowns

$$a_1x + b_1y + c_1z + d_1t + e_1u + f_1v = g_1$$
$$a_2x + b_2y + c_2z + d_2t + e_2u + f_2v = g_2$$
$$a_3x + b_3y + c_3z + d_3t + e_3u + f_3v = g_3$$
$$a_4x + b_4y + c_4z + d_4t + e_4u + f_4v = g_4$$
$$a_5x + b_5y + c_5z + d_5t + e_5u + f_5v = g_5$$
$$a_6x + b_6y + c_6z + d_6t + e_6u + f_6v = g_6$$

- You can also solve linear equations with three, four, and five unknowns. In each case, the format is similar to those shown above.

Specifying the Number of Unknowns

While in the Equation Mode, press F1 (SIML) and then specify the number of unknowns.



Simultaneous
No Data In Memory

Number Of Unknowns?

- {**2**}/{**3**}/{**4**}/{**5**}/{**6**} ... linear equation with {2}/{3}/{4}/{5}/{6} unknowns

Solving Linear Equations with Three Unknowns

Example **To solve the following linear equations for x, y, and z:**

$$\begin{aligned} 4x + y - 2z &= -1 \\ x + 6y + 3z &= 1 \\ -5x + 4y + z &= -7 \end{aligned}$$

1. While in the Linear Equation Mode (SIML), press F2 (3), because the linear equations being solved have three unknowns.

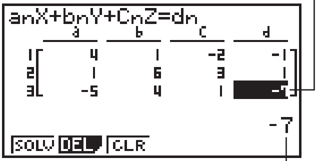
2. Input each coefficient.

4 EXE 1 EXE (–) 2 EXE (–) 1 EXE

1 EXE 6 EXE 3 EXE 1 EXE

(–) 5 EXE 4 EXE 1 EXE (–) 7 EXE

Coefficient input cells



anX+bnY+CnZ=dn

$$\begin{array}{c|cccc} & a & b & c & d \\ \hline 1 & 4 & 1 & -2 & -1 \\ 2 & 1 & 6 & 3 & 1 \\ 3 & -5 & 4 & 1 & -1 \end{array}$$

-7

F1

Value being input into highlighted cell

Each time you press EXE, the input value is registered in the highlighted cell. Each press of EXE inputs values in the following sequence:

coefficient a_1 → coefficient b_1 → coefficient c_1 → coefficient d_1 →

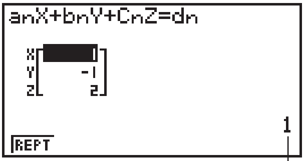
⋮

coefficient a_n → coefficient b_n → coefficient c_n → coefficient d_n (n = 2 to 6)

- You can input fractions and value memory contents as coefficients.

3. After inputting the coefficients, solve the equations.

F1(SOLV)



anX+bnY+CnZ=dn

$$\begin{array}{c|c} X & 1 \\ Y & -1 \\ Z & 2 \end{array}$$

1

F1

Highlighted solution cell value

- Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and 2-digit exponent.
- This unit performs simultaneous linear equations by placing the coefficients inside of a matrix. Because of this, as the coefficient matrix approaches zero, precision in the inverse matrix is reduced and so precision in the results produced also deteriorates. For example, the solution for a linear equation with three unknowns would be calculated as shown below.

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}^{-1} \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}$$

- An error occurs whenever the unit is unable to solve the equations.
- Pressing F1 (REPT) returns to the initial display of the Linear Equation Mode.

Depending on the coefficients that you use, it may take considerable time for the calculation result of simultaneous linear equations to appear on the display. Failure of a result to appear immediately does not mean that the unit is not functioning properly.

■ Changing Coefficients

You can change a coefficient either before or after you register it by pressing EXE.

•To change a coefficient before registering it with EXE

Press the AC key to clear the current value and then input another one.

•To change a coefficient after registering it with EXE

Use the cursor keys to highlight the cell that contains the coefficient that you want to change. Next, input the value that you want to change to.

■ Clearing All the Coefficients

While in the Linear Equation Mode, press the F3 (CLR) function key. This operation clears all the coefficients to zero.

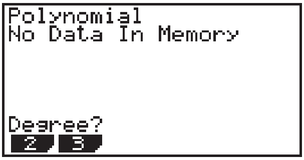
7-3 Quadratic and Cubic Equations

This calculator can also solve quadratic and cubic equations that match the following formats (when $a \neq 0$):

- **Quadratic:** $ax^2 + bx + c = 0$
- **Cubic:** $ax^3 + bx^2 + cx + d = 0$

Specifying the Degree of an Equation

While in the Equation Mode, press F2 (POLY) and then specify the degree of the equation.



Polynomial
No Data In Memory

Degree?

- {**2**}/{**3**} ... {quadratic}/{cubic} equation

Solving a Quadratic or Cubic Equation

Example **To solve the following cubic equation:**

$x^3 - 2x^2 - x + 2 = 0$

1. Press F2 (3) to enter the Cubic Equation Mode.

2. Input each coefficient.

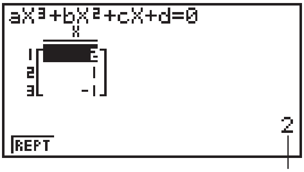
   1 EXE (–) 2 EXE (–) 1 EXE 2 EXE

- Each time you press EXE, the input value is registered in the highlighted cell. Each press of EXE inputs values in the following sequence:

  coefficient a → coefficient b → coefficient c → coefficient d

  Input for coefficient d is required only for cubic equations.
- You can input fractions and value memory contents as coefficients.

3. After inputting the coefficients, press F1 (SOLV) to solve the equations.



aX³+bX²+cX+d=0

Highlighted solution cell value

- Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and 2-digit exponent.
- An error occurs whenever the unit is unable to solve the equations.
- Pressing F1 (REPT) returns to the initial display of the Cubic Equation Mode.

■ Multiple root (1 or 2) solutions or imaginary number solutions

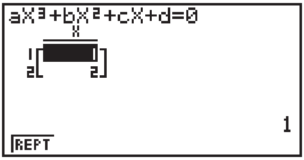
The following examples illustrate how multiple-root solutions and imaginary number solutions are handled.

●To solve a cubic equation that produces a multiple-value solution

Example **To solve the following cubic equation:**

$x^3 - 4x^2 + 5x - 2 = 0$

1 EXE (–) 4 EXE 5 EXE (–) 2 EXE
F1(SOLV)



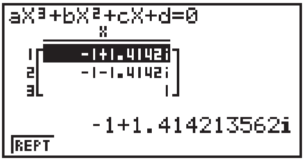
```
aX³+bX²+cX+d=0
         X
 1[         ]
 2[        2]

                    1
```

●To solve a cubic equation that produces an imaginary number solution

Example **To solve the following cubic equation:**

$x^3 + x^2 + x - 3 = 0$

1 EXE 1 EXE 1 EXE (–) 3 EXE
F1(SOLV)



```
aX³+bX²+cX+d=0
         X
 1[ -1+1.4142i]
 2  -1-1.4142i
 3[          1]
      -1+1.414213562i
```

It may take considerable time for the calculation result of cubic equations to appear on the display. Failure of a result to appear immediately does not mean that the unit is not functioning properly.

■ Changing Coefficients

You can change a coefficient either before or after you register it by pressing EXE.

•To change a coefficient before registering it with EXE

Press the AC key to clear the current value and then input another one.

•To change a coefficient after registering it with EXE

Use the cursor keys to highlight the cell that contains the coefficient that you want to change. Next, input the value that you want to change to.

■ Clearing All the Coefficients

While in the Quadratic or Cubic Equation Mode, press the F3 (CLR) function key. This operation clears all the coefficients to zero.

7-4 Solve Calculations

You can determine the value of any variable you are using without going through the trouble of solving an equation.

Input the equation, and a table of variables appears on the display. Use the table to assign values to variables and then execute the calculation to obtain a solution and display the value of the unknown variable.

P.408

- You cannot use the variable table in the Program Mode. When you want to use the Solve calculation function in the Program Mode, you have to use program commands to assign values to variables.

■ Entering the Solve Calculation Mode

While in the Equation Mode, press F3 (SOLV). The Solve input screen appears.

Input the expression. You can input numbers, alpha-characters, and operation symbols. If you do not input an equals sign, the calculator assumes that the expression is to the left of the equals sign and there is a zero to the right. To specify a value other than zero to the right of the equals sign, you must input the equals sign and the value.

●To perform solve calculations

Example **To calculate initial velocity of an object thrown into the air and taking a time of 2 seconds to reach a height of 14 meters, when gravitational acceleration is 9.8 m/S²**

The following formula expresses the relationship between height H, initial velocity V, time T, and gravitational acceleration G of a free falling object.

$$H = VT - \frac{1}{2}GT^2$$

1. Press F2 (DEL) F1 (YES) to clear any previously input equations.

2. Input the equation.

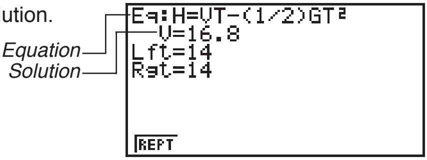
   ALPHA H SHIFT = ALPHA V ALPHA T − (1 ÷ 2) ALPHA G ALPHA T x^2 EXE

3. Input the values.

   1 4 EXE (H=14)
   0 EXE (V=0)
   2 EXE (T=2)
   9 • 8 EXE (G=9.8)

4. Press ⏶ to move the highlighting to V = 0.

5. Press F6 (SOLV) to obtain the solution.



Equation

Solution

```
Eq:H=VT-(1/2)GT²
  V=16.8
Lft=14
Rgt=14

REPT
```

- An error occurs if you input more than one equals sign.
- "Lft" and "Rgt" indicate the left and right sides that are calculated using the approximate value. The closer the difference between these two values is to zero, the greater the accuracy of the result.

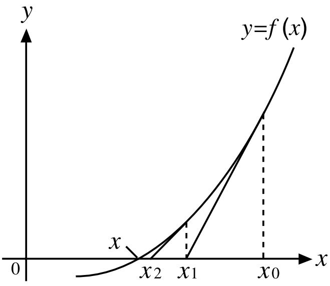
Solve Calculations

The solution of the function is approximated using Newton's method.

•Newton's method

This method is based on the assumption that $f(x)$ can be approximated by a linear expression within a very narrow range.

First, a starting value (predicted value) x_0 is given. Using this starting value as a base, approximate value x_1 is obtained, and then the left side and right side calculation results are compared. Next, approximate value x_1 is used as the initial value to calculate the next approximate value x_2. This procedure is repeated until the difference between the left side and right side calculated values is less than some minute value.



- Solutions obtained using Newton's method may include errors.
- To check results, plug them into the original expression and perform the calculation.

- Solve uses Newton's method to calculate approximations. The following can sometimes occur when this method is used.
  - Solutions may be impossible to obtain for certain initial estimated values. Should this happen, try inputting another value that you assume to be in the vicinity of the solution and perform the calculation again.
  - The calculator may be unable to obtain a solution, even though a solution exists.
- Due to certain idiosyncrasies of Newton's method, solutions for the following types of functions tend to be difficult to calculate.
  - Periodic functions (i.e. $y = \sin x - a$)
  - Functions whose graph produce sharp slopes (i.e. $y = e^x$, $y = {}^1/\,x$)
  - Inverse proportion expressions and other discontinuous functions.

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- Note that the Solve function can also be used in the ALGBR Mode to display results using natural display notation.

7-5 What to Do When an Error Occurs

•Error during coefficient value input

Press the AC key to clear the error and return to the value that was registered for the coefficient before you input the value that generated the error. Try inputting a new value again.

•Error during calculation

Press the AC key to clear the error and display coefficient a. Try inputting values for the coefficients again.

Chapter 8

Graphing

A collection of versatile graphing tools plus a large 127 × 63-dot display makes it easy to draw a variety of function graphs quickly and easily. This calculator is capable of drawing the following types of graphs.

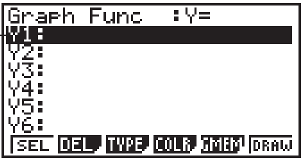
- Rectangular coordinate (Y =) graphs
- Polar coordinate (*r* =) graphs
- Parametric graphs
- X = constant graphs
- Inequality graphs
- Integration graphs (in the RUN mode only)

A selection of graph commands also makes it possible to incorporate graphing into programs.

8-1 Before Trying to Draw a Graph

■ Entering the Graph Mode

On the Main Menu, select the **GRAPH** icon and enter the GRAPH Mode. When you do, the Graph Function menu appears on the display. You can use this menu to store, edit, and recall functions and to draw their graphs.



Memory area

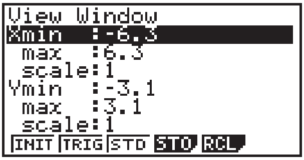
Use ▲ and ▼ to change selection.

- {**SEL**} ... {draw/non-draw status}
- {**DEL**} ... {function delete}
- {**TYPE**} ... {graph type menu}
- {**COLR**} ... {graph color}
- {**GMEM**} ... {graph memory save/recall}
- {**DRAW**} ... {graph draw}

8-2 View Window (V-Window) Settings

Use the View Window to specify the range of the x-and y-axes, and to set the spacing between the increments on each axis. You should always set the View Window parameters you want to use before drawing a graph.

1. Press SHIFT F3 (V·Window) to display the View Window.



```
View Window
Xmin  :-6.3
 max  :6.3
 scale:1
Ymin  :-3.1
 max  :3.1
 scale:1
```

X min .... Minimum x-axis value

X max .... Maximum x-axis value

X scale .... Spacing of x-axis increments

Y min .... Minimum y-axis value

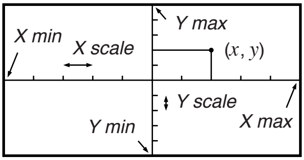
Y max .... Maximum y-axis value

Y scale .... Spacing of y-axis increments

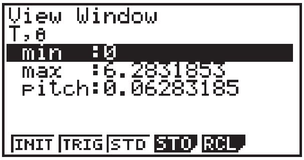
P.115 • {**INIT**}/{**TRIG**}/{**STD**} ... View Window {initial settings}/{initial settings using specified angle unit}/{standardized settings}

P.116 • {**STO**}/{**RCL**} ... View Window setting {store}/{recall}

The nearby illustration shows the meaning of each of these parameters.



2. Input a value for a parameter and press EXE. The calculator automatically selects the next parameter for input.
   - You can also select a parameter using the ▼ and ▲ keys.
   - There are actually nine View Window parameters. The remaining three parameters appear on the display when you move the highlighting down past the Y scale parameter by inputting values and pressing ▼.



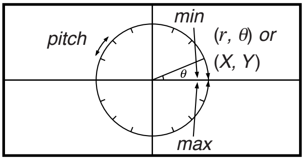
```
View Window
T,θ
 min  :0
 max  :6.2831853
 pitch:0.06283185
```

T, θ min .... T, θ minimum values

T, θ max .... T, θ maximum values

T, θ pitch .... T, θ pitch

The nearby illustration shows the meaning of each of these parameters.



3. To exit the View Window, press EXIT or SHIFT QUIT.
   - Pressing EXE without inputting any value also exits the View Window.

- The following is the input range for View Window parameters.

  –9.9999E+97 to 9.99999E+97
- You can input parameter values up to 14 digits long. Values greater than 10^7 or less than 10^{-2}, are automatically converted to a 7-digit mantissa (including negative sign) plus a 2-digit exponent.
- The only keys that enabled while the View Window is on the display are: 0 to 9, •, EXP, (–), ▲, ▼, ◀, ▶, +, –, ×, ÷, (,), SHIFT π, EXIT, SHIFT QUIT. You can use (–) or – to input negative values.
- The existing value remains unchanged if you input a value outside the allowable range or in the case of illegal input (negative sign only without a value).
- Inputting a View Window range so the min value is greater than the max value, causes the axis to be inverted.
- You can input expressions (such as 2π) as View Window parameters.
- When the View Window setting does not allow display of the axes, the scale for the y-axis is indicated on either the left or right edge of the display, while that for the x-axis is indicated on either the top or bottom edge.
- When View Window values are changed, the graph display is cleared and the newly set axes only are displayed.
- View Window settings may cause irregular scale spacing.
- Setting maximum and minimum values that create too wide of a View Window range can result in a graph made up of disconnected lines (because portions of the graph run off the screen), or in graphs that are inaccurate.
- The point of deflection sometimes exceeds the capabilities of the display with graphs that change drastically as they approach the point of deflection.
- Setting maximum and minimum values that create to narrow of a View Window range can result in an error.

■ Initializing and Standardizing the View Window

•To initialize the View Window

You can use either of the following two methods to initialize the View Window.

Normal initialization

Press SHIFT F3 (V-Window) F1 (INIT) to initialize the View Window to the following settings.

Xmin = –6.3   Ymin = –3.1
Xmax = 6.3   Ymax = 3.1
Xscale = 1   Yscale = 1

Trigonometric initialization

Press SHIFT F3 (V-Window) F2 (TRIG) to initialize the View Window to the following settings.

Deg Mode
Xmin = –540   Ymin = –1.6
Xmax = 540   Ymax = 1.6
Xscale = 90   Yscale = 0.5

Rad Mode
Xmin = –9.4247779
Xmax = 9.42477796
Xscale = 1.57079632

Gra Mode
Xmin = –600
Xmax = 600
Xscale = 100

- The settings for Y min, Y max, Y pitch, T/θ min, T/θ max, and T/θ pitch remain unchanged when you press F2 (TRIG).

•To standardize the View Window

Press SHIFT F3 (V-Window) F3 (STD) to standardize the View Window to the following settings.

Xmin = –10   Ymin = –10
Xmax = 10   Ymax = 10
Xscale = 1   Yscale = 1

View Window Memory

You can store up to six sets of View Window settings in View Window memory for recall when you need them.

•To store View Window settings

Inputting View Window values and then pressing F4 (STO) F1 (V·W1) stores the View Window contents in View Window memory V·W1.

- There are six View Window memories numbered V·W1 to V·W6.
- Storing View Window settings in a memory area that already contains settings replaces the existing settings with the new ones.

•To recall View Window settings

Pressing F5 (RCL) F1 (V·W1) recalls the contents of View Window memory V·W1.

- Recalling View Window settings causes the settings currently on the display to be deleted.

- You can change View Window settings in a program using the following syntax.

  View Window [X min value], [X max value], [X scale value],
  [Y min value], [Y max value], [Y scale value],
  [T, θ min value], [T, θ max value], [T, θ pitch value]

8-3 Graph Function Operations

You can store up to 20 functions in memory. Functions in memory can be edited, recalled, and graphed.

■ Specifying the Graph Type

Before you can store a graph function in memory, you must first specify its graph type.

1. While the Graph Function Menu is on the display, press F3 (TYPE) to display the graph type menu, which contains the following items.

- **{Y=}**/**{r=}**/**{Parm}**/**{X=c}** ... {rectangular coordinate}/{polar coordinate}/{parametric}/{X=constant} graph
- **{Y>}**/**{Y<}**/**{Y≥}**/**{Y≤}** ... {Y>$f(x)$}/{Y<$f(x)$}/{Y≧$f(x)$}/{Y≦$f(x)$} inequality graph

2. Press the function key that corresponds to the graph type you want to specify.

■ Storing Graph Functions

●To store a rectangular coordinate function (Y =)

Example **To store the following expression in memory area Y1 :**
$y = 2x^2 - 5$

F3 (TYPE) F1 (Y =) (Specifies rectangular coordinate expression.)

2 X,θ,T x^2 − 5 (Inputs expression.)

EXE (Stores expression.)

```
Graph Func   :Y=
Y1■2X²-5
```

- You will not be able to store the expression in an area that already contains a parametric function. Select another area to store your expression or delete the existing parametric function first. This also applies when storing r = expressions, X = constant expressions, and ineqalities.

●To store a polar coordinate function (r =)

Example **To store the following expression in memory area r2 :**
$r = 5 \sin 3\theta$

F3 (TYPE) F2 (r =) (Specifies polar coordinate expression.)

5 sin 3 X,θ,T (Inputs expression.)

EXE (Stores expression.)

```
Graph Func   :r=
r2■5sin 3θ
```

•To store a parametric function

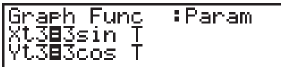
Example **To store the following functions in memory areas Xt3 and Yt3 :**

$x = 3 \sin T$
$y = 3 \cos T$

F3(TYPE) F3(Parm) (Specifies parametric expression.)

3 sin X,θ,T EXE (Inputs and stores x expression.)

3 cos X,θ,T EXE (Inputs and stores y expression.)



```
Graph Func   :Param
Xt3■3sin T
Yt3■3cos T
```

- You will not be able to store the expression in an area that already contains a rectangular coordinate expression, polar coordinate expression, X = constant expression or inequality. Select another area to store your expression or delete the existing expression first.

•To store an X = constant expression

Example **To store the following expression in memory area X4 :**
X = 3

F3(TYPE) F4(X = c) (Specifies X = constant expression.)

3 (Inputs expression.)

EXE (Stores expression.)

```
Graph Func   :X=const
X4■3
```

- Inputting X, Y, T, r, or θ for the constant in the above procedures causes an error.

•To store an inequality

Example **To store the following inequality in memory area Y5 :**
$y > x^2 - 2x - 6$

F3(TYPE) F6(▷) F1(Y>) (Specifies an inequality.)

X,θ,T x^2 − 2 X,θ,T − 6 (Inputs expression.)

EXE (Stores expression.)

```
Graph Func   :Y>
Y5■X²-2X-6
```

Editing Functions in Memory

•To edit a function in memory

Example **To change the expression in memory area Y1 from $y = 2x^2 - 5$ to $y = 2x^2 - 3$**

▶ (Displays cursor.)

▶ ▶ ▶ ▶ [3] (Changes contents.)

[EXE] (Stores new graph function.)

```
Graph Func  :Y=
Y1■2X²-3
```

•To delete a function

1. While the Graph Function Menu is on the display, press ▲ or ▼ to display the cursor and move the highlighting to the area that contains the function you want to delete.

2. Press [F2] (DEL).

3. Press [F1] (YES) to delete the function for [F6] (NO) to abort the procedure without deleting anything.

Parametric functions come in pairs (Xt and Yt).

When editing a parametric function, clear the graph functions and re-input from the beginning.

Drawing a Graph

•To specify the graph color

The default color for graph drawing is blue, but you can change the color to orange or green if you want.

1. While the Graph Function Menu is on the display, press ▲ or ▼ to display the cursor and move the highlighting to the area that contains the function whose graph color you want to change.

2. Press [F4] (COLR) to display a color menu, which contains the following items.
   - {**Blue**}/{**Orng**}/{**Grn**} ... {blue}/{orange}/{green}

3. Press the function key for the color you want to use.

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

Example **To select the following functions for drawing :**

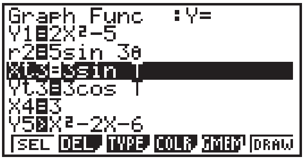
Y1 = $2x^2 - 5$ r2 = 5 sin3θ

Use the following View Window parameters.

Xmin	= –5	**Ymin**	= –5
Xmax	= 5	**Ymax**	= 5
Xscale	= 1	**Yscale**	= 1

▼ ▼

(Select a memory area that contains a function for which you want to specify non-draw.)

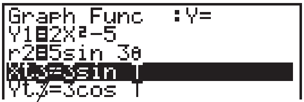


```
Graph Func   :Y=
Y1■2X²-5
r2■5sin 3θ
Xt3■3sin T
Yt3■3cos T
X4■3
Y5■X²-2X-6
```

F1

F1(SEL)

(Specify non-draw.)

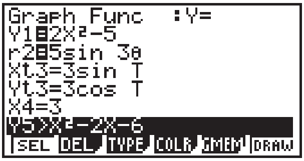


```
Graph Func   :Y=
Y1■2X²-5
r2■5sin 3θ
Xt3=3sin T
Yt3=3cos T
```

Unhighlights

▼ ▼ F1(SEL)

▼ F1(SEL)

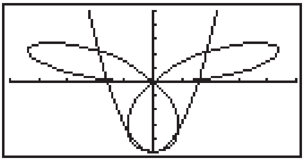


```
Graph Func   :Y=
Y1■2X²-5
r2■5sin 3θ
Xt3=3sin T
Yt3=3cos T
X4=3
Y5>X²-2X-6
```

F6

F6(DRAW) or EXE

(Draws graphs.)



- Pressing SHIFT F6 (G↔T) or AC returns to the Graph Function Menu.

- You can use the set up screen settings to alter the appearance of the graph screen as shown below.

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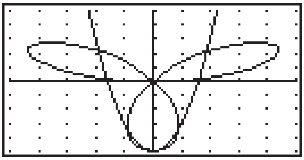
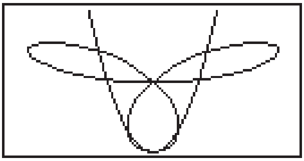
- Grid: On

  This setting causes dots to appear at the grid intersects on the display.



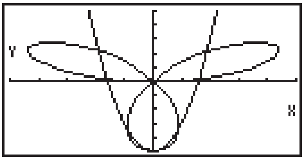
- Axes: Off

  This setting clears the axis lines from the display.



- Label: On

  This setting displays labels for the *x*- and *y*-axes.



- A polar coordinate (*r* =) or parametric graph will appear coarse if the settings you make in the View Window cause the T, *θ* pitch value to be too large, relative to the differential between the T, *θ* min and T, *θ* max settings. If the settings you make cause the T, *θ* pitch value to be too small relative to the differential between the T, *θ* min and T, *θ* max settings, on the other hand, the graph will take a very long time to draw.
- Attempting to draw a graph for an expression in which X is input for an X = constant expression results in an error.

8-4 Graph Memory

Graph memory lets you store up to six sets of graph function data and recall it later when you need it.

A single save operation saves the following data in graph memory.

- All graph functions in the currently displayed Graph Function Menu (up to 20)
- Graph types
- Graph colors
- Draw/non-draw status
- View Window settings (1 set)

•To store graph functions in graph memory

Pressing F5(GMEM) F1(STO) F1(GM1) stores the selected graph function into graph memory GM1.

- There are six graph memories numbered GM1 to GM6.
- Storing a function in a memory area that already contains a function replaces the existing function with the new one.
- If the data exceeds the calculator's remaining memory capacity, an error occurs.

•To recall a graph function

Pressing F5 (GMEM) F2 (RCL) F1 (GM1) recalls the contents of graph memory GM1.

- Recalling data from graph memory causes any data currently on the Graph Function Menu to be deleted.

8-5 Drawing Graphs Manually

After you select the **RUN** icon in the Main Menu and enter the RUN Mode, you can draw graphs manually. First press SHIFT F4 (Sketch) F5 (GRPH) to recall the Graph Command Menu, and then input the graph function.

- {**Y=**}/{**r=**}/{**Parm**}/{**X=c**}/{**G∫dx**} ... {rectangular coordinate}/{polar coordinate}/{parametric}/{X = constant}/{integration} graph
- {**Y>**}/{**Y<**}/{**Y≥**}/{**Y≤**} ... {Y>$f(x)$}/{Y<$f(x)$}/{Y≧$f(x)$}/{Y≦$f(x)$} inequality graph

●To graph using rectangular coordinates (Y =) [Sketch]-[GRPH]-[Y=]

You can graph functions that can be expressed in the format $y = f(x)$.

Example **To graph $y = 2x^2 + 3x - 4$**

Use the following View Window parameters.

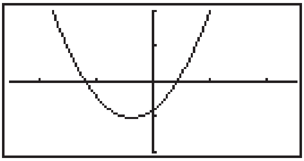
Xmin	**= –5**	**Ymin**	**= –10**
Xmax	**= 5**	**Ymax**	**= 10**
Xscale	**= 2**	**Yscale**	**= 5**

1. In the set up screen, specify "**Y=**" for Func Type and then press EXIT.

2. Input the rectangular coordinate (Y =) expression.

   SHIFT F4 (Sketch) F1 (Cls) EXE
   F5 (GRPH) F1 (Y =) 2 X,θ,T x^2 + 3 X,θ,T − 4

3. Press EXE to draw the graph.



- You can draw graphs of the following built-in scientific functions.

• sin x	• cos x	• tan x	• $\sin^{-1} x$	• $\cos^{-1} x$
• $\tan^{-1} x$	• sinh x	• cosh x	• tanh x	• $\sinh^{-1} x$
• $\cosh^{-1} x$	• $\tanh^{-1} x$	• $\sqrt{x}$	• x^2	• log x
• ln$x$	• 10^x	• e^x	• x^{-1}	• $\sqrt[3]{x}$

View Window settings are made automatically for built-in graphs.

•To graph using polar coordinates (r =) [Sketch]-[GRPH]-[r=]

You can graph functions that can be expressed in the format $r = f(\theta)$.

Example **To graph $r = 2 \sin 3\theta$**

Use the following View Window parameters.

Xmin = –3	**Ymin = –2**	**T, θ min = 0**
Xmax = 3	**Ymax = 2**	**T, θ max = π**
Xscale = 1	**Yscale = 1**	**T, θ pitch = π÷36**

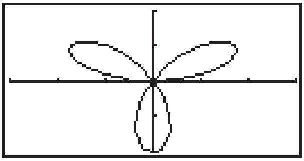
1. In the set up screen, specify "***r*=**" for Func Type.

2. Specify "**Rad**" as the angle unit and then press EXIT.

3. Input the polar coordinate expression (r =).

   SHIFT F4(Sketch) F1(Cls) EXE
   F5(GRPH) F2(r =) 2 sin 3 X,θ,T

4. Press EXE to draw the graph.



- You can draw graphs of the following built-in scientific functions.

• sin θ	• cos θ	• tan θ	• $\sin^{-1} \theta$	• $\cos^{-1} \theta$
• $\tan^{-1} \theta$	• sinh θ	• cosh θ	• tanh θ	• $\sinh^{-1} \theta$
• $\cosh^{-1} \theta$	• $\tanh^{-1} \theta$	• $\sqrt{\theta}$	• θ^2	• log θ
• lnθ	• 10^{θ}	• e^{θ}	• θ^{-1}	• $\sqrt[3]{\theta}$

View Window settings are made automatically for built-in graphs.

•To graph parametric functions **[Sketch]-[GRPH]-[Parm]**

You can graph parametric functions that can be expressed in the following format.

$(X, Y) = (f(T), g(T))$

Example **To graph the following parametric functions:**
x = 7 cos T – 2 cos 3.5T y = 7 sin T – 2 sin 3.5T

Use the following View Window parameters.

Xmin = –20   Ymin = –12   T, θ min = 0
Xmax = 20   Ymax = 12   T, θ max = 4π
Xscale = 5   Yscale = 5   T, θ pitch = π÷36

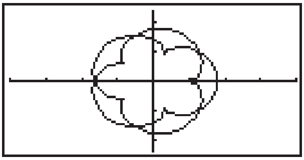
1. In the set up screen, specify "**Parm**" for Func Type.

2. Specify "**Rad**" (radians) as the angle unit and then press EXIT.

3. Input the parametric functions.

   SHIFT F4(Sketch) F1(Cls) EXE
   F5(GRPH) F3(Parm)
   7 cos X,θ,T − 2 cos 3 . 5 X,θ,T ,
   7 sin X,θ,T − 2 sin 3 . 5 X,θ,T)

4. Press EXE to draw the graph.



•To graph X = constant **[Sketch]-[GRPH]-[X=c]**

You can graph functions that can be expressed in the format X = constant.

Example **To graph X = 3**

Use the following View Window parameters.

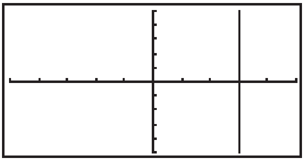
Xmin = –5   Ymin = –5
Xmax = 5   Ymax = 5
Xscale = 1   Yscale = 1

1. In the set up screen, specify "**X=c**" for Func Type and then press EXIT.

2. Input the expression.

   SHIFT F4 (Sketch) F1 (Cls) EXE
   F5 (GRPH) F4 (X = c) 3

3. Press EXE to draw the graph.



●To graph inequalities

[Sketch]-[GRPH]-[Y>]/[Y<]/[Y≥]/[Y≤]

You can graph inequalities that can be expressed in the following four formats.

- $y > f(x)$
- $y < f(x)$
- $y \geqq f(x)$
- $y \leqq f(x)$

Example **To graph the inequality $y > x^2 - 2x - 6$**

Use the following View Window parameters.

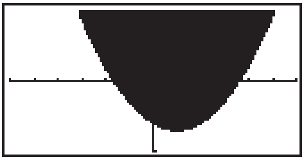
Xmin	**= –6**	**Ymin**	**= –10**
Xmax	**= 6**	**Ymax**	**= 10**
Xscale	**= 1**	**Yscale**	**= 5**

1. In the set up screen, specify "**Y>**" for Func Type and then press EXIT.

2. Input the inequality.

   SHIFT F4 (Sketch) F1 (Cls) EXE
   F5 (GRPH) F6 (▷) F1 (Y>) X,θ,T x^2 − 2 X,θ,T − 6

3. Press EXE to draw the graph.



•To draw an integration graph **[Sketch]-[GRPH]-[G∫dx]**

You can graph an integration calculation performed using the function $y = f(x)$.

Example **To graph the following, with a tolerance of “tol” = 1E - 4:**

$$\int_{-2}^{1} (x + 2)\,(x - 1)\,(x - 3)\,dx$$

Use the following View Window parameters.

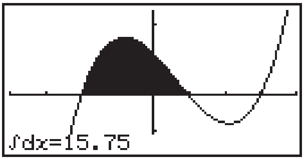
Xmin = –4 **Ymin** = –8
Xmax = 4 **Ymax** = 12
Xscale = 1 **Yscale** = 5

1. In the set up screen, specify “**Y=**” for Func Type and then press EXIT .

2. Input the integration graph expression.

SHIFT F4 (Sketch) F1 (Cls) EXE
F5 (GRPH) F5 (G∫dx) (X,θ,T + 2) (X,θ,T − 1)
(X,θ,T − 3) , (−) 2 , 1 , 1 EXP (−) 4

3. Press EXE to draw the graph.



∫dx=15.75

- Before drawing an integration graph, be sure to always press SHIFT F4 (Sketch) F1 (Cls) to clear the screen.
- You can also incorporate an integration graph command into programs.

8-6 Other Graphing Functions

The functions described in this section tell you how to read the *x*- and *y*-coordinates at a given point, and how to zoom in and zoom out on a graph.

- These functions can be used with rectangular coordinate, polar coordinate, parametric, X = constant, and inequality graphs only.

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■ Connect Type and Plot Type Graphs (Draw Type)

You can use the Draw Type setting of the set up screen to specify one of two graph types.

- Connect

Points are plotted and connected by lines to create a curve.

- Plot

Points are plotted without being connected.

■ Trace

With trace, you can move a flashing pointer along a graph with the cursor keys and obtain readouts of coordinates at each point. The following shows the different types of coordinate readouts produced by trace.

- Rectangular Coordinate Graph

```
X=-3.095238095  Y=5.8752834444
```

- Polar Coordinate Graph

```
r=1.7320508075  θ=0.34906585039
```

- Parametric Function Graph

```
T=0.785398163
X=6.7975065333  Y=4.1843806035
```

- X = Constant Graph

```
X=3             Y=0
```

- Inequality Graph

```
X=-6.3          Y<38.69
```

•To use trace to read coordinates

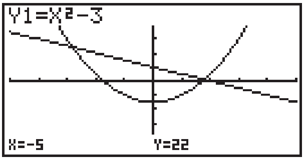
Example **To determine the points of intersection for graphs produced by the following functions:**

Y1 = x^2 – 3 **Y2 = –x + 2**

Use the following View Window parameters.

Xmin = –5 **Ymin = –10**
Xmax = 5 **Ymax = 10**
Xscale = 1 **Yscale = 2**

1. After drawing the graphs, press F1 (Trace) to make the pointer appear at the far left of the graph.



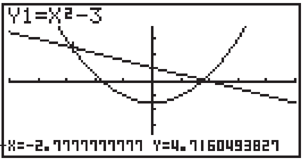
Y1=X²-3

X=-5 Y=22

- The pointer may not be visible on the graph when you press F1 (Trace).

2. Use ▶ to move the pointer to the first intersection.

▶ ~ ▶



Y1=X²-3

x/*y* coordinate values

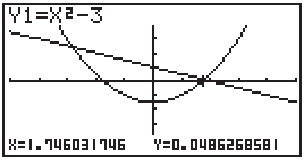
X=-2.7777777777 Y=4.7160493827

- Pressing ◀ and ▶ moves the pointer along the graph. Holding down either key moves the pointer at high speed.

3. Use ▲ and ▼ to move the pointer between the two graphs.

4. Use ▶ to move the pointer to the other intersection.

▶ ~ ▶



Y1=X²-3

X=1.746031746 Y=0.0486268581

- To abort a trace operation, press F1 (Trace).
- Do not press the AC key while performing a trace operation.

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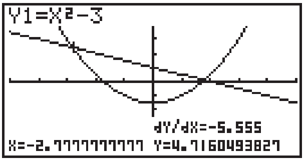
•To display the derivative

If the Derivative item in the set up screen is set to "**On**", the derivative appears on the display along with the coordinate values.



Y1=X²-3

dY/dX=-5.555

X=-2.7777777777 Y=4.7160493827

- The following shows how the display of coordinates and the derivative changes according to the Graph Type setting.

- Rectangular Coordinate Graph

```
                     dY/dX=-5.555
X=-2.7777777777 Y=4.7160493827
```

- Polar Coordinate Graph

```
dr/dθ=4.2426     dY/dX=0.6602
r=1.4142135623   θ=0.26179938779
```

- Parametric Function Graph

```
dX/dT=3              dY/dT=0
T=0                  dY/dX=0
```

- X = Constant Graph

```
                     dY/dX=ERROR
X=3                  Y=0
```

- Inequality Graph

```
                     dY/dX=-12.6
X=-6.3               Y<38.69
```

- The derivative is not displayed when you use trace with a built-in scientific function.

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- Setting the Coord item in the set up screen to “**Off**” turns display of the coordinates for the current pointer location off.

●Scrolling

When the graph you are tracing runs off the display along either the *x*- or *y*-axis, pressing the ▶ or ◀ cursor key causes the screen to scroll in the corresponding direction eight dots.

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- You can scroll only rectangular coordinate and inequality graphs while tracing. You cannot scroll polar coordinate graphs, parametric function graphs, or X = constant graphs.
- The graph on the screen does not scroll when you are tracing while the Dual Screen Mode is set to “**Graph**” or “**G to T**”.

- Trace can be used only immediately after a graph is drawn. It cannot be used after changing the settings of a graph.
- The *x*- and *y*-coordinate values at the bottom of the screen are displayed using a 12-digit mantissa or a 7-digit mantissa with a 2-digit exponent. The derivative is displayed using a 6-digit mantissa.
- You cannot incorporate trace into a program.
- You can use trace on a graph that was drawn as the result of an output command (◢), which is indicated by the “-Disp-” indicator on the screen.

■ Scroll

You can scroll a graph along its *x*- or *y*-axis. Each time you press ▲, ▼, ◀, or ▶, the graph scrolls 12 dots in the corresponding direction.

Graphing in a Specific Range

You can use the following syntax when inputting a graph to specify a start point and end point.

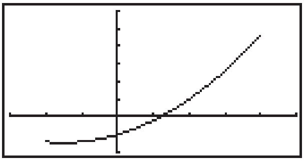
<function> , SHIFT [<start point> , <end point> SHIFT] EXE

Example **To graph $y = x^2 + 3x - 5$ within the range of $-2 \leqq x \leqq 4$**

Use the following View Window parameters.

Xmin	**= –3**	**Ymin**	**= –10**
Xmax	**= 5**	**Ymax**	**= 30**
Xscale	**= 1**	**Yscale**	**= 5**

F3 (TYPE) F1 (Y =)
(Specifies graph type.)
X,θ,T x² + 3 X,θ,T − 5 ,
SHIFT [(−) 2 , 4 SHIFT] EXE
(Stores expression.)
F6 (DRAW) or EXE (Draws graph.)



- You can specify a range for rectangular coordinate, polar coordinate, parametric, and inequality graphs.

Overwrite

Using the following syntax to input a graph causes multiple versions of the graph to be drawn using the specified values. All versions of the graph appear on the display at the same time.

<function with one variable> , SHIFT [<variable name> SHIFT =
<value> , <value> , ... <value> SHIFT] EXE

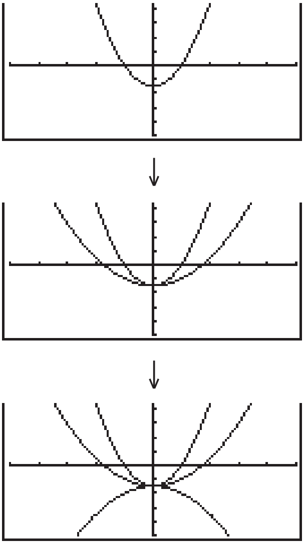
Example **To graph $y = Ax^2 - 3$, substituting 3, 1, and –1 for the value of A**

Use the following View Window parameters.

Xmin	**= –5**	**Ymin**	**= –10**
Xmax	**= 5**	**Ymax**	**= 10**
Xscale	**= 1**	**Yscale**	**= 2**

F3 (TYPE) F1 (Y =) (Specifies graph type.)
ALPHA A X,θ,T x² − 3 , SHIFT [ALPHA A SHIFT =
3 , 1 , (−) 1 SHIFT] EXE (Stores expression.)

F6(DRAW) (Draws graph.)



- The function that is input using the above syntax can have only one variable.
- You cannot use X, Y, r, θ, or T as the variable name.
- You cannot assign a variable to the variable in the function.
- P.7 When the set up screen's Simul Graph item is set to "**On**", the graphs for all the variables are drawn simultaneously.
- You can use overwrite with rectangular coordinate, polar coordinate, parametric, and inequality graphs.

Zoom

The zoom feature lets you enlarge and reduce a graph on the display.

•Before using zoom

Immediately after drawing a graph, press F2 (Zoom) to display the Zoom Menu.

- {**BOX**} ... {graph enlargement using box zoom}
- {**FACT**} ... {displays screen for specification of zoom factors}
- {**IN**}/{**OUT**} ... {enlarges}/{reduces} graph using zoom factors
- P.135 {**AUTO**} ... {automatically sizes the graph so it fills the screen along the y-axis}
- {**ORIG**} ... {original size}
- P.136 {**SQR**} ... {adjusts ranges so x-range equals y-range}
- P.136 {**RND**} ... {rounds coordinates at current pointer location}
- P.137 {**INTG**} ... {converts View Window x-axis and y-axis values to integers}
- P.138 {**PRE**} ... {after a zoom operation, returns View Window parameters to previous settings}

•To use box zoom **[Zoom]-[BOX]**

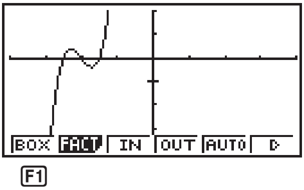
With box zoom, you draw a box on the display to specify a portion of the graph, and then enlarge the contents of the box.

Example **To use box zoom to enlarge a portion of the graph $y = (x + 5)(x + 4)(x + 3)$**

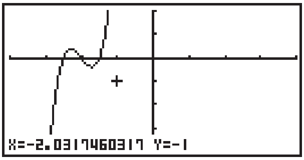
Use the following View Window parameters.

Xmin = –8	**Ymin = –4**
Xmax = 8	**Ymax = 2**
Xscale = 2	**Yscale = 1**

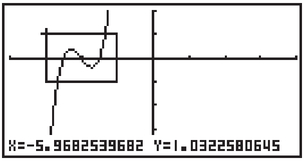
1. After graphing the function, press F2 (Zoom).



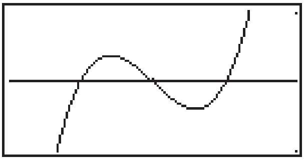
2. Press F1 (BOX), and then use the cursor keys to move the pointer to the location of one of the corners of the box you want to draw on the screen. Press EXE to specify the location of the corner.


X=-2.0317460317 Y=-1

3. Use the cursor keys to move the pointer to the location of the corner that is diagonally across from the first corner.


X=-5.9682539682 Y=1.0322580645

4. Press EXE to specify the location of the second corner. When you do, the part of the graph inside the box is immediately enlarged so it fills the entire screen.



- To return to the original graph, press F2 (Zoom) F6 (▷) F1 (ORIG).

- Nothing happens if you try to locate the second corner at the same location or directly above the first corner.
- You can use box zoom for any type of graph.

•To use factor zoom [Zoom]-[FACT]-[IN]/[OUT]

With factor zoom, you can zoom in or zoom out on the display, with the current pointer location being at the center of the new display.

- Use the cursor keys to move the pointer around the display.

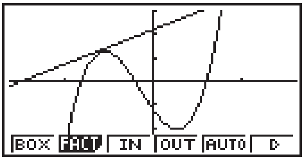
Example **Graph the two functions below, and enlarge them five times in order to determine whether or not they are tangential.**

Y1 = $(x + 4)(x + 1)(x - 3)$ Y2 = $3x + 22$

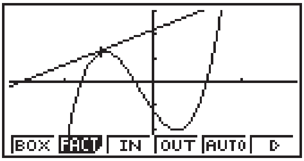
Use the following View Window parameters.

Xmin = –8 **Ymin = –30**
Xmax = 8 **Ymax = 30**
Xscale = 5 **Yscale = 10**

1. After graphing the functions, press F2 (Zoom), and the pointer appears on the screen.



2. Use the cursor keys to move the pointer to the location that you want to be the center of the new display.



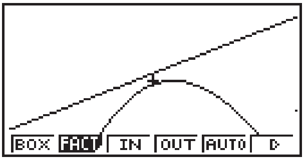
F2

3. Press F2 (FACT) to display the factor specification screen, and input the factor for the x- and y-axes.

F2(FACT)
5 EXE 5 EXE

```
Factor
 Xfact:5
 Yfact:5
```

4. Press EXIT to return to the graphs, and then press F3 (IN) to enlarge them.



This enlarged screen makes it clear that the graphs of the two expressions are not tangential.

Note that the above procedure can also be used to reduce the size of a graph (zoom out). In step 4, press F4 (OUT).

- The above procedure automatically converts the *x*-range and *y*-range View Window values to 1/5 of their original settings. Pressing F6 (▷) F5 (PRE) changes the values back to their original settings.
- You can repeat the factor zoom procedure more than once to further enlarge or reduce the graph.

●To initialize the zoom factor

Press F2 (Zoom) F2 (FACT) F1 (INIT) to initialize the zoom factor to the following settings.

Xfact = 2 Yfact = 2

- You can use the following syntax to incorporate a factor zoom operation into a program.

  Factor <X factor>, <Y factor>
- You can specify only positive value up to 14 digits long for the zoom factors.
- You can use factor zoom for any type of graph.

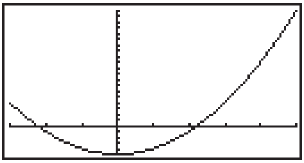
■ Auto View Window Function [Zoom]-[AUTO]

The auto View Window feature automatically adjusts *y*-range View Window values so that the graph fills the screen along the *y*-axis.

Example **To graph $y = x^2 - 5$ with Xmin = –3 and Xmax = 5, and then use auto View Window to adjust the y-range values**

1. After graphing the function, press F2 (Zoom).

2. Press F5 (AUTO).



Graph Range Adjustment Function [Zoom]-[SQR]

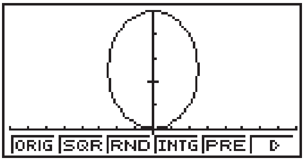
This function makes the View Window x-range value the same as the y-range value. It is helpful when drawing circular graphs.

Example **To graph $r = 5\sin\theta$ and then adjust the graph.**

Use the following View Window parameters.

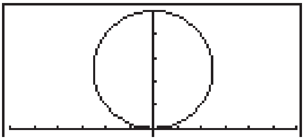
Xmin = –8 **Ymin = –1**
Xmax = 8 **Ymax = 5**
Xscale = 1 **Yscale = 1**

1. After drawing the graph, press F2 (Zoom) F6 (▷).



F2

2. Press F2 (SQR) to make the graph a circle.



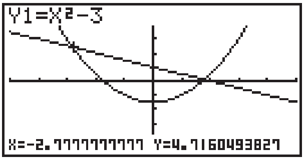
Coordinate Rounding Function [Zoom]-[RND]-[Trace]

This feature rounds the coordinate values at the pointer location to the optimum number of significant digits. Rounding coordinates is useful when using trace and plot.

Example **To round the coordinates at the points of intersection of the two graphs drawn on page 128**

Use the same View Window parameters as in the example on page 128.

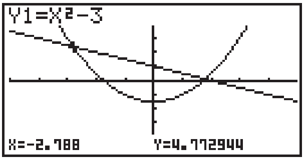
1. After graphing the functions, press F1 (Trace) and move the pointer to the first intersection.



```
Y1=X²-3
X=-2.7777777777 Y=4.7160493827
```

2. Press F2 (Zoom) F6 (▷).

3. Press F3 (RND) and then F1 (Trace). Use ▶ to move the pointer to the other intersection. The rounded coordinate values for the pointer position appear on the screen.



Y1=X²-3

X=-2.788 Y=4.772944

■ Integer Function

[Zoom]-[INTG]

This function makes the dot width equal 1, converts axis values to integers, and redraws the graph.
If one x-axis dot is Δx and one y-axis dot is Δy:

$$\Delta x = \frac{\text{Xmax} - \text{Xmin}}{126} \qquad \Delta y = \frac{\text{Ymax} - \text{Ymin}}{62}$$

Notes on the Auto View Window, Graph Range Adjustment, Coordinate Rounding, and Integer Functions

- These functions can be used with all graphs.
- These functions cannot be incorporated into programs.
- These functions can be used with a graph produced by a multi-statement connected by " :", even if the multi-statement includes non-graph operations.
- When any of these functions is used in a statement that ends with a display result command {◢} to draw a graph, these functions affect the graph up to the display result command {◢} only. Any graphs drawn after the display result command {◢} are drawn according to normal graph overwrite rules.

Returning the View Window to Its Previous Settings

[Zoom]-[PRE]

The following operation returns View Window parameters to their original settings following a zoom operation.

F6 (▷) F5 (PRE)

- You can use PRE with a graph altered by any type of zoom operation.

8-7 Picture Memory

You can save up to six graphic image in picture memory for later recall. You can overdraw the graph on the screen with another graph stored in picture memory.

•To store a graph in picture memory

Pressing OPTN F1(PICT) F1(STO) F1(Pic1) stores the graph drawn on the display in picture memory Pic1.

- There are six picture memories numbered Pic1 to Pic6.
- Storing a graph in a memory area that already contains data replaces the existing data with the new data.

•To recall a stored graph

In the GRAPH Mode, pressing OPTN F1(PICT) F2(RCL) F1(Pic1) recalls the contents of picture memory Pic1.

- Dual Graph screens or any other type of graph that uses a split screen cannot be saved in picture memory.

8-8 Graph Background

P.6

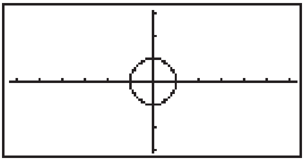
You can use the set up screen to specify the memory contents of any picture memory area (**Pict 1** through **Pict 6**) as the Background item. When you do, the contents of the corresponding memory area is used as the background of the graph screen.

- You can use a background in the RUN, STAT, GRAPH, DYNA, TABLE, RECUR, CONICS Modes.

Example 1 **With the circle graph $X^2 + Y^2 = 1$ as the background, use Dynamic Graph to graph $Y = X^2 + A$ as variable A changes value from –1 to 1 in increments of 1.**

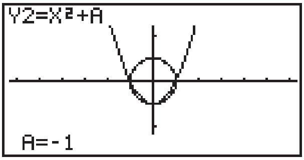
Recall the background graph.

($X^2 + Y^2 = 1$)



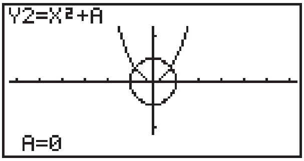
Draw the dynamic graph.

($Y = X^2 - 1$)



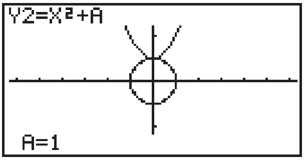
↓↑

($Y = X^2$)



↓↑

($Y = X^2 + 1$)



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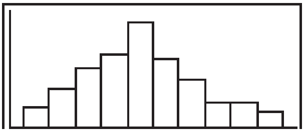
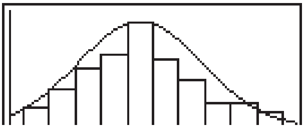
- See “14. Implicit Function Graphs” for details on drawing a circle graph, and “13. Dynamic Graph” for details on using the Dynamic Graph feature.

Example 2 **With a statistical histogram as the background, graph a normal distribution**

Recall the backgound graph.
(Histogram)



Graph the normal distribution.



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- See “18. Statistical Graphs and Calculations” for details on drawing a statistical graphs.

Chapter 9

Graph Solve

You can use any of the following methods to analyze function graphs and approximate results.

- Root extraction
- Determination of the maximum and minimum
- Determination of the y-intercept
- Determination of the intersection of two graphs
- Determination of the coordinates at any point (y for a given x/x for a given y)
- Determination of the integral for any range

9-1 Before Using Graph Solve

After using the **GRAPH Mode** to draw the graph, press SHIFT F5 (G-Solv) to display a function menu that contains the following items.

- {**ROOT**}/{**MAX**}/{**MIN**}/{**Y-ICPT**}/{**ISCT**} ... {root}/{maximum}/{minimum/ {y-intercept}/{intersections of two graphs}
- {**Y-CAL**}/{**X-CAL**}/{$\int dx$} ... {y-coordinate for a given x-coordinate}/{x-coordinate for a given y-coordinate}/{integral for a given range}

9-2 Analyzing a Function Graph

The following two graphs are used for all of the examples in this section, except for the example for determining the points of intersection for two graphs.

Memory location Y1 = $x + 1$ Y2 = $x(x + 2)(x – 2)$

Use the View Window to specify the following parameters.

$$\text{(A)}\begin{bmatrix} \text{Xmin} & = & -5 & \text{Ymin} & = & -5 \\ \text{Xmax} & = & 5 & \text{Ymax} & = & 5 \\ \text{Xscale} & = & 1 & \text{Yscale} & = & 1 \end{bmatrix} \quad \text{(B)}\begin{bmatrix} \text{Xmin} & = & -6.3 & \text{Ymin} & = & -3.1 \\ \text{Xmax} & = & 6.3 & \text{Ymax} & = & 3.1 \\ \text{Xscale} & = & 1 & \text{Yscale} & = & 1 \end{bmatrix}$$

■ Determining Roots

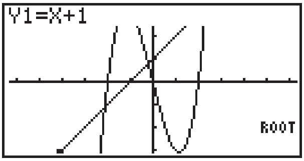
Example **To determine the roots for $y = x(x + 2)(x – 2)$**

View Window: **(B)**

SHIFT F5(G-Solv)

F1(ROOT)

(This puts the unit into standby waiting for selection of a graph.)

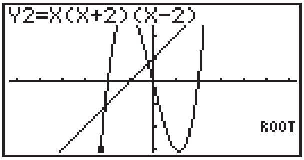


- A “ ■ ” cursor appears on the graph that has the lowest memory area number.

Specify the graph you want to use.

▼

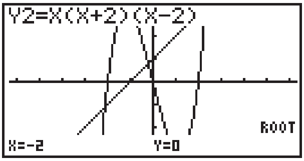
- Use ▲ and ▼ to move the cursor to the graph whose roots you want to find.



Determine the root.

EXE

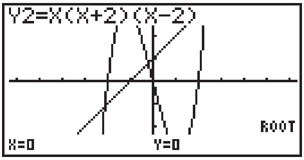
- Roots are found starting from the left.



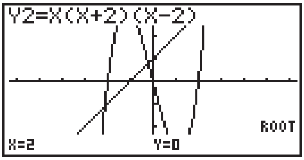
Search for the next root to the right.

▶

- If there is no root to the right, nothing happens when you press ▶.


Y2=X(X+2)(X-2)
X=0 Y=0

▶


Y2=X(X+2)(X-2)
X=2 Y=0

- You can use ◀ to move back to the left.
- If there is only one graph, pressing F1(ROOT) directly displays the root (selection of the graph is not required).
- Note that the above operation can be performed on rectangular coordinate (Y=) and inequality graphs only.

■ Determining Maximums and Minimums

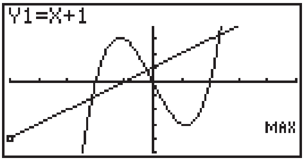
Example **To determine the maximum and minimum for $y = x\ (x + 2)\ (x - 2)$**

View Window: **(A)**

SHIFT F5(G-Solv)

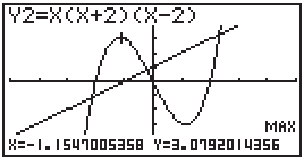
F2(MAX)

(This puts the unit into standby waiting for selection of a graph.)


Y1=X+1

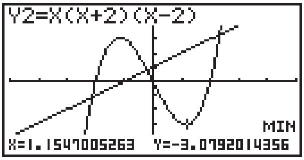
Specify the graph and determine the maximum.

▼ EXE


Y2=X(X+2)(X-2)
X=-1.1547005358 Y=3.0792014356

Specify the graph and determine the minimum.

SHIFT F5(G-Solv)
F3(MIN) ▼ EXE


Y2=X(X+2)(X-2)

X=1.1547005263 Y=-3.0792014356

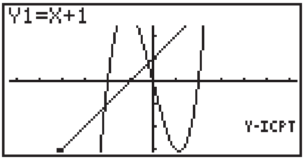
- If there is more than one maximum/minimum, you can use ◀ and ▶ to move between them.
- If there is only one graph, pressing F2 (MAX) / F3 (MIN) directly displays the maximum/minimum (selection of the graph is not required).
- Note that the above operation can be performed on rectangular coordinate (Y=) and inequality graphs only.

Determining *y*-intercepts

Example **To determine the *y*-intercept for *y* = *x* + 1**

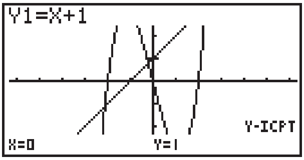
View Window: **(B)**

SHIFT F5(G-Solv)
F4(Y-ICPT)
(This puts the unit into standby waiting for selection of a graph.)


Y1=X+1

Determine the *y*-intercept.

EXE


Y1=X+1

X=0 Y=1

- *y*-intercepts are the points where the graph intersects the *y*-axis.
- If there is only one graph, pressing F4 (Y-ICPT) directly displays the *y*-intercepts (selection of the graph is not required).
- Note that the above operation can be performed on rectangular coordinate (Y=) and inequality graphs only.

Determining Points of Intersection for Two Graphs

Example **To draw the following three graphs and then determine the points of intersection for the Graph Y1 and Graph Y3.**

View Window: **(A)**

Y1 = x **+ 1**

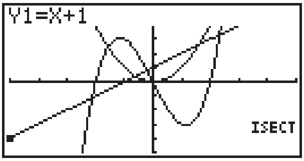
Y2 = x **(**x **+ 2) (**x **– 2)**

Y3 = x^2

SHIFT F5(G-Solv)

F5(ISCT)

(This puts the unit into standby waiting for selection of a graph.)

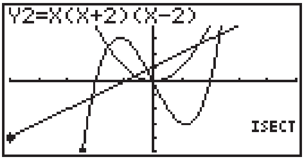


```
Y1=X+1
```

Specify Graph Y1.

EXE

- Pressing EXE changes " ■ " into " ◆ " for specification of the first graph.

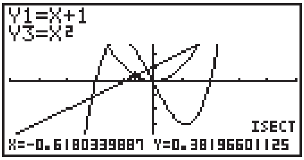


```
Y2=X(X+2)(X-2)
```

Specify the second graph (Graph Y3, here) to determine the points of intersection.

▼ EXE

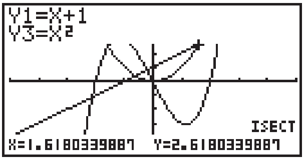
- Use ▲ and ▼ to move " ■ " on the second graph.
- Intersections are found starting from the left.



```
Y1=X+1
Y3=X²
X=-0.6180339887 Y=0.38196601125
```

▶

- The next intersection to the right is found. If there is no intersection to the right, nothing happens when you perform this operation.



```
Y1=X+1
Y3=X²
X=1.6180339887  Y=2.6180339887
```

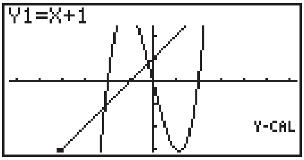
- You can use ◀ to move back to the left.
- If there are only two graphs, pressing F5 (ISCT) directly displays the intersections (selection of the graph is not required).
- Note that the above operation can be performed on rectangular coordinate (Y=) and inequality graphs only.

Determining a Coordinate (x for a given y/y for a given x)

Example **To determine the y-coordinate for x = 0.5 and the x-coordinate for y = 3.2 in the graph $y = x (x + 2) (x – 2)$**

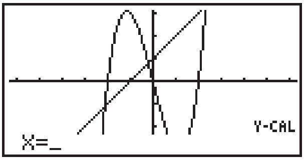
View Window: **(B)**

SHIFT F5(G-Solv) F6(▷) F1(Y-CAL)



Specify a graph.

▼ EXE



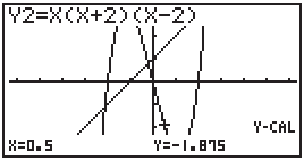
- At this time, the unit waits for input of an x-coordinate value.

Input the x-coordinate value.

0 • 5

Determine the corresponding y-coordinate value.

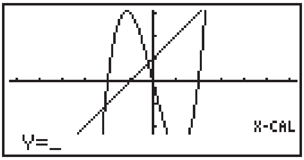
EXE



X=0.5 Y=-1.875

Specify a graph.

SHIFT F5(G-Solv) F6(▷)
F2(X-CAL) ▼ EXE



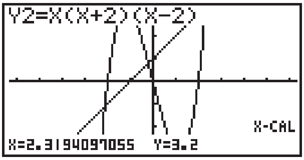
- At this time, the unit waits for input of a y-coordinate value.

Input the y-coordinate value.

3 • 2

Determine the corresponding x-coordinate value.

EXE



X=2.3194097055 Y=3.2

- If there is more than one *x*-coordinate value for a given *y*-coordinate value or more than one *y*-coordinate value for a given *x*-coordinate value, use ▶ and ◀ to move between them.
- The display used for the coordinate values depends on the graph type as shown below.

  - **Polar Coordinate Graph**


r=1.7320508075 θ=0.34906585039

  - **Parametric Graph**


T=0.7853981634
X=6.7975065333 Y=4.1843806035

  - **Inequality Graph**


X=1 Y<-7

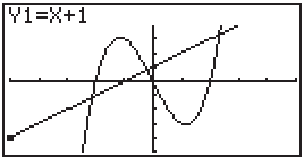
- Note that you can not determine a *y*-coordinate for a given *x*-coordinate with a parametric graph.
- If there is only one graph, pressing F1 (Y-CAL) / F2 (X-CAL) directly displays the *x*-coordinate/*y*-coordinate (selection of the graph is not required).

Determining the Integral for Any Range

Example $\int_{-1.5}^{0} x\,(x + 2)\,(x - 2)\,dx$

View Window: **(A)**

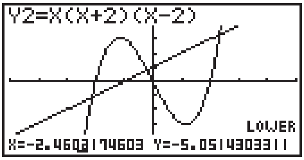
SHIFT F5 (G-Solv) F6 (▷)
F3 (∫*dx*)
(Graph selection standby)


Y1=X+1

Select graph.

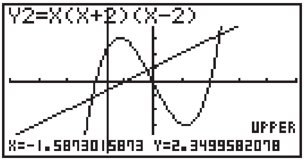
▼ EXE

- The display is prompting input of the lower limit of the integration range.


Y2=X(X+2)(X-2)
LOWER
X=-2.4603174603 Y=-5.0514303311

Move the pointer and input the lower limit.

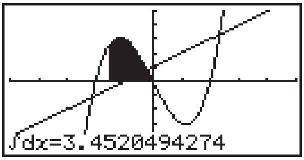
▶~▶ EXE


Y2=X(X+2)(X-2)
UPPER
X=-1.5873015873 Y=2.3499582078

Input the upper limit and determine the integral.

▶~▶(Upper limit; x = 0)

EXE



- The lower limit must be less than the upper limit when specifying the integration range.
- Note that the above operation can be performed on rectangular coordinate (Y=) graphs only.

■ Graph Solve Precautions

- Depending on the View Window parameter settings, there may be some error in solutions produced by Graph Solve.
- If no solution can be found for any of the above operations, the message "Not Found" appears on the display.
- The following conditions can interfere with calculation precision and may make it impossible to obtain a solution.

  — When the solution is a point of tangency to the x-axis.

  — When the solution is a point of tangency between two graphs.

Chapter 10

Sketch Function

The sketch function lets you draw lines and graphs on an existing graph.

- Note that Sketch function operation in the **STAT, GRAPH, TABLE, RECUR** and **CONICS Modes** is different from Sketch function operation in the **RUN** and **PRGM Modes**.

10-1 Before Using the Sketch Function

Press SHIFT F4 (Sketch) to display the sketch menu.

STAT, GRAPH, TABLE, RECUR, CONICS Mode

- P.166 {**Cls**} ... {clears drawn line and point}
- P.155 ~ P.157 {**Tang**}/{**Norm**}/{**Inv**} ... {tangent}/{line normal to a curve}/{inverse graph}

- {Tang}, {Norm}, and {Inv} menus appear only when you display the sketch menu while in the **GRAPH** and **TABLE Modes**.

- P.158 {**PLOT**} ... {plot menu}
- P.160 {**LINE**} ... {line menu}
- P.162 {**Crcl**}/{**Vert**}/{**Hztl**} ... {circle}/{vertical line}/{horizontal line}
- P.163 {**PEN**} ... {freehand drawing}
- P.164 {**Text**} ... {comment text}

RUN, PRGM Mode

- {**GRPH**} ... {graph command menu}
- P.165 {**PIXL**} ... {pixel menu}
- P.166 {**Test**} ... {tests pixel on/off status}

- Other menu items are identical to those in the STAT, GRAPH, TABLE, RECUR, CONICS Mode menu.

10-2 Graphing with the Sketch Function

The sketch function lets you draw lines and plot points on a graph that is already on the screen.

P.112

All the examples in this section that show operations in the STAT, GRAPH, TABLE, RECUR, and CONICS Modes are based on the assumption that the following function has already been graphed in the **GRAPH Mode**.

Memory Area Y1 = $x(x + 2)(x - 2)$

The following are the View Window parameters used when drawing the graph.

Xmin	**= –5**	**Ymin**	**= –5**
Xmax	**= 5**	**Ymax**	**= 5**
Xscale	**= 1**	**Yscale**	**= 1**

■ Tangent

[Sketch]-[Tang]

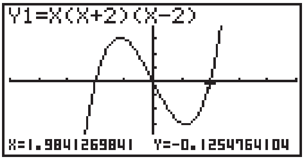
This function lets you draw a line that is tangent to a graph at any point.

•To draw a tangent in the GRAPH or TABLE Mode

Example **To draw a line that is tangent to point (x = 2, y = 0) of $y = x(x + 2)(x - 2)$**

1. After graphing the function, display the sketch menu and press F2 (Tang).

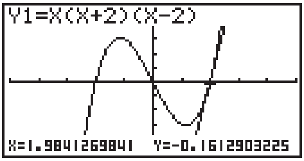
2. Use the cursor keys to move the pointer the position of the point where you want to draw the line.



Y1=X(X+2)(X-2)

X=1.9841269841 Y=-0.1254764104

3. Press EXE to draw the line.



Y1=X(X+2)(X-2)

X=1.9841269841 Y=-0.1612903225

•To draw a tangent in the RUN or PRGM Mode

The following is the command syntax for drawing a tangent in these modes.

Tangent <graph function>, <*x*-coordinate>

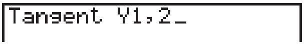
P.30

- Use the variable data (VARS) menu to specify the function to be graphed.

Example **To draw a line that is tangent to point (x = 2, y = 0) of $y = x(x + 2)(x – 2)$**

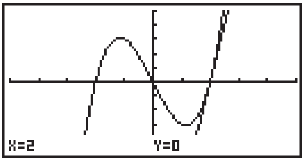
1. In the RUN Mode, display the sketch menu, press F2 (Tang), and then perform the following input.

   VARS F4(GRPH) F1(Y) 1 , 2



```
Tangent Y1,2_
```

2. Press EXE to draw the tangent line.



```
X=2          Y=0
```

■ Line Normal to a Curve [Sketch]-[Norm]

With this function you can draw a line that is normal to the curve at a specific point.

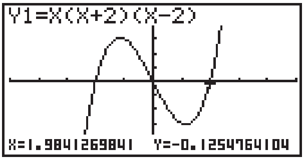
- A line that is normal to the curve at a given point is one that is perpendicular to the tangent line at that point.

•To draw a line normal to a curve in the GRAPH or TABLE Mode

Example **To draw a line that is normal to the curve at point (x = 2, y = 0) of $y = x(x + 2)(x – 2)$**

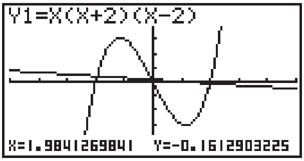
1. After graphing the function, display the sketch menu and press F3 (Norm).

2. Use the cursor keys to move the pointer the position of the point where you want to draw the line.



```
Y1=X(X+2)(X-2)
X=1.9841269841   Y=-0.1254764104
```

3. Press EXE to draw the line.



Y1=X(X+2)(X-2)

X=1.9841269841 Y=-0.1612903225

•To draw a line normal to a curve in the RUN or PRGM Mode

The following is the syntax for drawing a line normal to a curve in these modes.

Normal <graph function>, <*x*-coordinate>

P.30

- Use the variable data (VARS) menu to specify the function to be graphed.

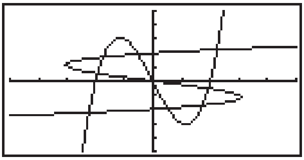
Graphing an Inverse Function **[Sketch]-[Inv]**

This function lets you graph the inverse of the function used to produce your original graph.

•To graph an inverse function in the GRAPH or TABLE Mode

Example **To graph the inverse of $y = x(x + 2)(x - 2)$**

After graphing the function, display the sketch menu and press F4 (Inv).



- When graphing an inverse function when there is more than one graph function stored in memory, select one of the functions and then press EXE.

•To graph an inverse function in the RUN or PRGM Mode

The following is the syntax for graphing an inverse function in these modes.

Inverse <graph function>

P.30

- Use the variable data (VARS) menu to specify the function to be graphed.

- You can only graph the inverse of functions whose graph type is specified as rectangular coordinate type.

Plotting Points

[Sketch]-[PLOT]

When plotting points on a graph, first display the sketch menu and then press F6 (▷) F1 (PLOT) to display the plot menu.

- {**Plot**} ... {plot a point}
- {**Pl·On**} ... {plot point at specific coordinates}
- {**Pl·Off**} ... {delete point at specific coordinates}
- {**Pl·Chg**} ... {switch status of point at specific coordinates}

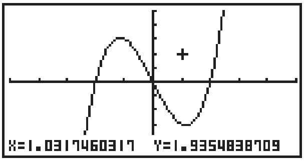
•To plot points in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

[Sketch]-[PLOT]-[Plot]

Example **To plot a point on the graph of $y = x(x + 2)(x - 2)$**

1. After drawing the graph, display the sketch menu and press F6 (▷) F1 (PLOT) F1 (Plot) to display the pointer in the center of the screen.

2. Use the cursor keys to move the pointer the locations of the points you want to plot and press EXE to plot.
   - You can plot as many points as you want.



X=1.031746031 7 Y=1.935483870 9

- The current x- and y-coordinate values are assigned respectively to variables X and Y.

•To plot points in the RUN or PRGM Mode

[Sketch]-[PLOT]-[Plot]

The following is the syntax for plotting points in these modes.

Plot <x-coordinate>, <y-coordinate>

Example **To plot a point at (2, 2)**

Use the following View Window parameters.

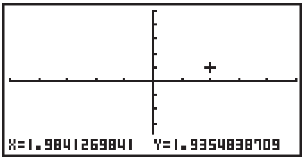
Xmin = –5 **Ymin** = –10
Xmax = 5 **Ymax** = 10
Xscale = 1 **Yscale** = 2

1. After entering the RUN Mode, display the sketch menu and perform the following operation.

   SHIFT F4 (Sketch) F6 (▷)
   F1 (PLOT) F1 (Plot) 2 , 2

```
Plot 2,2_
```

2. Press EXE and the pointer appears on the display. Press EXE again to plot a point.



```
X=1.984126984l  Y=1.9354838709
```

- You can use the cursor keys to move the pointer around the screen.

- If you do not specify coordinates, the pointer is located in the center of the graph screen when it appears on the display.
- If the coordinates you specify are outside the range of the View Window parameters, the pointer will not be on the graph screen when it appears on the display.
- The current *x*- and *y*-coordinate values are assigned respectively to variables X and Y.

Turning Plot Points On and Off

[Sketch]-[PLOT]-[Pl·On]/[Pl·Off]/[Pl·Chg]

Use the following procedures to turn specific plot points on and off.

●To turn plot points on and off in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

• To turn a plot point on

1. After drawing the graph, display the sketch menu and press F6 (▷) F1 (PLOT) F2 (Pl·On) to display the pointer in the center of the screen.

2. Use the cursor keys to move the pointer to the location where you want to plot a point and then press EXE.

• To turn a plot point off

Perform the same procedure as described under “To turn a plot point on” above, except press F3 (Pl·Off) in place of F2 (Pl·On).

• To change the on/off status of a plot point

Perform the same procedure as described under “To turn a plot point on” above, except press F4 (Pl·Chg) in place of F2 (Pl·On).

●To turn plot points on and off in the RUN or PRGM Mode

The following are the syntax for turning plot points on and off in these modes.

- **To turn a plot point on**
  PlotOn <*x*-coordinate>, <*y*-coordinate>

- **To turn a plot point off**
  PlotOff <*x*-coordinate>, <*y*-coordinate>

- **To change the on/off status of a plot point**
  PlotChg <*x*-coordinate>, <*y*-coordinate>

■ Drawing a Line **[Sketch]-[LINE]**

To draw a line on a graph, first display the sketch menu and then press F6 (▷) F2 (LINE) to display the line menu.

- {**Line**} ...{Draw a line between two plotted points}
- {**F·Line**} ... {Draw a line}

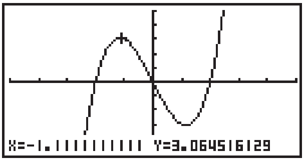
●To connect two plotted points with a line in the STAT, GRAPH, TABLE, RECUR and CONICS Modes **[Sketch]-[LINE]-[Line]**

Example **To draw a line between the two points of inflection on the graph of $y = x(x + 2)(x - 2)$**

Use the same View Window parameters as in the example on page 155.

1. After drawing a graph, display the sketch menu and then press F6 (▷) F1 (PLOT) F1 (Plot) to display the pointer in the center of the screen.

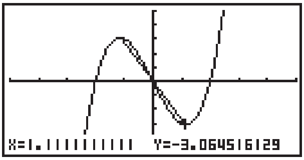
2. Use the cursor keys to move the pointer to one of the points of inflection and press EXE to plot it.



```
X=-1.1111111111 Y=3.064516129
```

3. Use the cursor keys to move the pointer to the other point of inflection.

4. Display the sketch menu and then press F6 (▷) F2 (LINE) F1 (Line) to draw a line to the second dot.

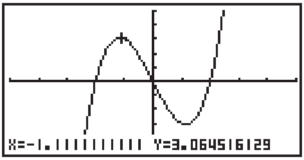


•To draw a line between any two points in the STAT, GRAPH, TABLE, RECUR and CONICS Modes [Sketch]-[LINE]-[F·Line]

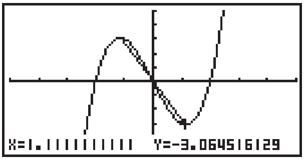
Example **To draw a line between two points of inflection on the graph of $y = x(x + 2)(x - 2)$**

1. After drawing a graph, display the sketch menu and then press F6 (▷) F2 (LINE) F2 (F·Line) to display the pointer in the center of the screen.

2. Use the cursor keys to move the pointer to one of the points of inflection and press EXE.



3. Use the cursor keys to move the pointer to the other point of inflection and press EXE to draw the line.



•To draw a line in the RUN or PRGM Mode

The following is the syntax for drawing lines in these modes.

F-Line <*x*-coordinate 1>, <*y*-coordinate 1>, <*x*-coordinate 2>, <*y*-coordinate 2>

Drawing a Circle

[Sketch]-[Crcl]

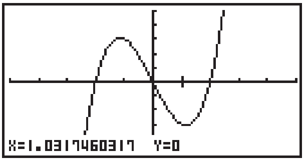
You can use the following procedures to draw a circle on a graph.

•To draw a circle in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

Example **To draw a circle with a radius of R = 1 centered at point (1, 0) on the graph of $y = x(x + 2)(x - 2)$**

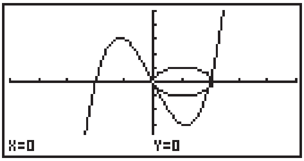
1. After drawing a graph, display the sketch menu and then press F6 (▷) F3 (Crcl) to display the pointer in the center of the screen.

2. Use the cursor keys to move the pointer to the location where you want the center point of the circle to be and press EXE to plot it.



X=1.0317460317 Y=0

3. Use the cursor keys to move the pointer to a point on the circumference of the circle (here to point x = 0) and then press EXE to draw the circle.



X=0 Y=0

•To draw a circle in the RUN or PRGM Mode

The following is the syntax for drawing circles in these modes.

Circle <center point x-coordinate>, <center point y-coordinate>, <radius R value>

- Certain View Window parameters can make a circle appear as an ellipse.

■ Drawing Vertical and Horizontal Lines **[Sketch]-[Vert]/[Hztl]**

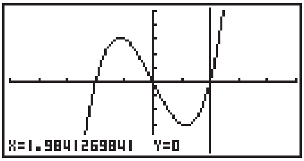
The procedures presented here draw vertical and horizontal lines that pass through a specific coordinate.

●To draw vertical and horizontal lines in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

Example **To draw a vertical line on the graph of $y = x(x + 2)(x - 2)$**

1. After drawing a graph, display the sketch menu and then press F6 (▷) F4 (Vert) to display the pointer along with a vertical line in the center of the screen.

2. Use the ◀ and ▶ cursor keys to move the line left and right, and press EXE to draw the line at the current location.



X=1.9841269841 Y=0

To draw a horizontal line, simply press F5 (Hztl) in place of F4 (Vert), and use the ▲ and ▼ cursor keys to move the horizontal line on the display.

●To draw vertical and horizontal lines in the RUN or PRGM Mode

The following is the syntax for drawing vertical and horizontal lines in these modes.

- **To draw a vertical line**

  Vertical <x-coordinate>

- **To draw a horizontal line**

  Horizontal <y-coordinate>

■ Freehand Drawing **[Sketch]-[PEN]**

This function lets you make freehand drawings on a graph, just as if you were using a pen.

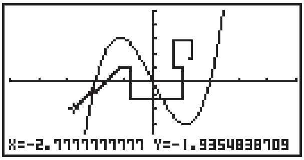
- Freehand drawing is available only in the **STAT, GRAPH, TABLE, RECUR** and **CONICS Modes**.

Example **To draw on the graph of $y = x(x + 2)(x - 2)$**

1. After drawing a graph, display the sketch menu and then press F6 (▷) F6 (▷) F1 (PEN) to display the pointer in the center of the screen.

2. Use the cursor keys to move the pointer to the location where you want to start drawing and press EXE to plot it.

3. Use the cursor keys to move the pointer, drawing a line as it moves. Press EXE to stop the draw operation of the pointer.



X=-2.7777777777 Y=-1.9354838709

- Press AC to quit the freehand draw operation.

■ Comment Text [Sketch]-[Text]

Use the following procedure to insert text for comments and labels into a graph.

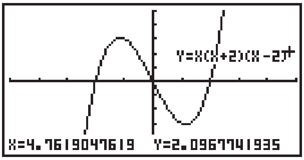
●To insert text in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

Example **To insert the graph function as comment text into the graph of $y = x(x + 2)(x - 2)$**

1. After drawing a graph, display the sketch menu and then press F6 (▷) F6 (▷) F2 (Text) to display the pointer in the center of the screen.

2. Use the cursor keys to move the pointer to the location where you want to insert the comment text, and then input the text.

▶ ~ ▶ ▲ ~ ▲
ALPHA Y SHIFT = X,θ,T
(X,θ,T + 2) (X,θ,T − 2)



Y=X(X+2)(X-2)

X=4.7619047619 Y=2.0967741935

•To insert text in the RUN or PRGM Mode

The following is the syntax for inserting text in these modes.

Text <line number>, <column number>, "<text>"

- The line number can be specified within the range of 1 to 63, while the column number can be specified in the range of 1 to 127.

- The following are the characters that can be used inside of comment text in the STAT, GRAPH, TABLE, RECUR, or CONICS Mode.

  A~Z, r, θ, space, 0~9, ., +, –, ×, ÷, (–), EXP, π, Ans, ┛, (,), [,], {, }, comma, →, x^2, ^, log, In, $\sqrt{\ }$, $^{x}\sqrt{\ }$, 10^x, e^x, $^{3}\sqrt{\ }$, x^{-1}, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$
- A newline operation cannot be performed when inserting comment text. To input multiple lines, you have to perform the above comment text insert operation more than once.

■ Turning Pixels On and Off **[Sketch]-[PIXL]**

The following procedure lets you turn each individual screen pixel on and off. You can specify any pixel from the upper left-hand corner (1, 1) to the lower right-hand corner (63, 127) of the screen.

Line range: 1 to 63
Column range: 1 to 127

- Note that you can turn pixels on and off only in the RUN and PRGM Modes.

When turning pixels on and off, first display the sketch menu and then press F6 (▷) F6 (▷) F3 (PIXL) to display the pixel menu.

- {**On**} ... {turns specified pixel on}
- {**Off**} ... {turns specified pixel off}
- {**Chg**} ... {switches status of specified pixel}

•To turn pixels on and off **[Sketch]-[PIXL]-[On]/[Off]/[Chg]**

• To turn a pixel on

PxlOn <line number>, <column number>

• To turn a pixel off

PxlOff <line number>, <column number>

• To change the on/off status of a pixel

PxlChg <line number>, <column number>

•To check the on/off status of a pixel [Sketch]-[Test]

While the sketch menu is on the screen, press F6 (▷) F6 (▷) F4 (Test) and then input the command shown below to check the status of the specified pixel. 1 is returned when the pixel is on, and 0 is returned when the pixel is off.

PxlTest <line number>, <column number>

- Specify a line in the range of 1 to 63 and a column in the range of 1 to 127.
- Trying to perform one of the above operations without specifying a line and column number results in an error.
- Pixel operations are valid only within the allowable line and column ranges.

■ Clearing Drawn Lines and Points [Sketch]-[Cls]

The following operation clears all drawn lines and points from the screen.

•To clear lines and points in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

Lines and points drawn using sketch menu functions are temporary. Display the sketch menu and press F1 (Cls) to clear drawn lines and points, leaving only the original graph.

•To clear drawn lines and points in the RUN or PRGM Mode

The following is the syntax for clearing drawn lines and points, as well as the graph itself.

Cls EXE

Chapter 11

Dual Graph

Dual Graph lets you split the display between two different screens, which you can then use to draw different graphs at the same time. Dual Graph gives you valuable graph analysis capabilities.

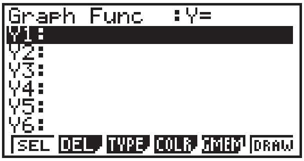
- You should be familiar with the contents of “8-3 Graph Function Operations” before reading this chapter.

11-1 Before Using Dual Graph

P.7

1. From the Main Menu, enter the **GRAPH** Mode. Next, display the set up screen and specify "**Graph**" for Dual Screen.

2. Press EXIT.



```
Graph Func  :Y=
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:
```

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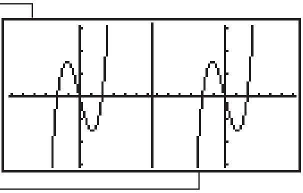
- For further details about the function key menu at the bottom of the display, see "8-1 Before Trying to Draw a Graph".
- 8,192 bytes of memory are used whenever you set the Dual Screen setting to "Graph".

About Dual Graph Screen Types

The screen on the left side of the display is called the *active screen*, and the graph on the left side of the display is called the *active graph*. Conversely, the right side is the *inactive screen*, which contains the *inactive graph*. Any function that you execute while using Dual Graph is always applied to the active graph. To execute a function on the right-side inactive graph, you must first make it active by moving it into the active screen.

Active Screen

Actual graph drawing is done here.



Inactive Screen

Use the inactive screen to make copies of active screen graphs, and for the result of Zoom operations.

- Indicators appear to the right of the formulas in the function memory list to tell where graphs are drawn with Dual Graph.

```
Graph Func  :Y=
Y1=X(X+2)(X-2)          R
Y2=2X²-3                B
```

Indicates inactive graph (on right side of display)

Indicates graph drawn on both sides of display

Performing a draw operation with the function marked "R" in the above example screen causes the graph to be drawn on the right (inactive) side on the display. The function marked "B" is drawn on both sides of the graph.

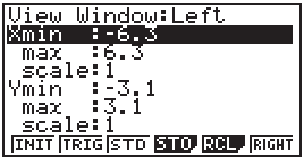
Pressing F1 (SEL) while one of the function's is highlighted would causes its "R" or "B" indicator to be cleared. A function without an indicator is drawn as the active graph (on the left side of the display).

11-2 Specifying the Left and Right View Window Parameters

You can specify different View Window parameter for the left and right sides of the graph display.

●To specify View Window parameters

Press SHIFT F3 (V-Window) to display the View Window parameter setting screen for the active (left side) graph.



View Window:Left
Xmin :-6.3
max :6.3
scale:1
Ymin :-3.1
max :3.1
scale:1

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- {**INIT**}/{**TRIG**}/{**STD**} ... View Window {normal initialization}/{trigonometric initialization}/{standardization}

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- {**STO**}/{**RCL**} ... View Window setting {store}/{recall}
- {**RIGHT**}/{**LEFT**} ... {active (left)}/{inactive (right)} screen View Window setting swap

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- Use the procedures described under "View Window (V-Window) Settings" to input parameter values.

- Use the following key operations to change to different screens while inputting View Window parameters for the left and right side screens.

  While the View Window parameter setting screen for the active graph is shown:

- F6 (RIGHT) .... displays the inactive graph View Window parameter setting screen

  While the View Window parameter setting screen for the inactive graph is shown:

- F6 (LEFT) ...... displays the active graph View Window parameter setting screen

11-3 Drawing a Graph in the Active Screen

You can draw graphs only in the active screen. You can then copy or move the graph to the inactive screen.

•Drawing a graph in the active screen

Example **To draw the graph of $y = x (x + 1) (x - 1)$**

Use the following View Window parameters:

Xmin = –2 **Ymin = –2**
Xmax = 2 **Ymax = 2**
Xscale = 0.5 **Yscale = 1**

Input the function.

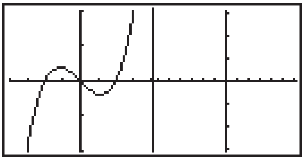
X,θ,T (X,θ,T + 1) (X,θ,T − 1)

Store the function.

EXE

Draw the graph.

F6 (DRAW) or EXE



11-4 Displaying a Graph in the Inactive Screen

There are two methods you can use to display a graph in the inactive screen. You can copy a graph from the active screen to the inactive screen, or you can move the graph from the active screen to the inactive screen. In both cases, you must first draw the graph in the left-side active screen.

Before Displaying a Graph in the Inactive Screen

After drawing a graph in the active screen, press OPTN, and the Dual Graph function menu appears at the bottom of the display.

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- {**COPY**} ... {copies active graph to inactive screen}
- {**SWAP**} ... {switches active screen and inactive screen}
- {**PICT**} ... {picture function}

Copying the Active Graph to the Inactive Screen

Example **To draw the graph for $y = x (x + 1) (x - 1)$ on the active screen and the inactive screen**

Use the following View Window parameters:

Active (Left) Screen
View Window parameters

Xmin = –2 **Ymin = –2**
Xmax = 2 **Ymax = 2**
Xscale = 0.5 **Yscale = 1**

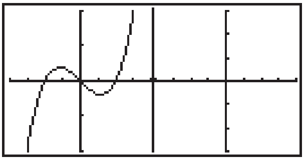
Inactive (Right) Screen
View Window parameters

Xmin = –4 **Ymin = –3**
Xmax = 4 **Ymax = 3**
Xscale = 1 **Yscale = 1**

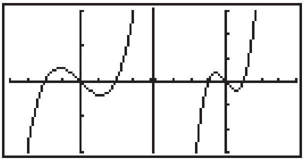
Assume that the function being graphed is stored in memory area Y1.

```
Graph Func  :Y=
Y1=X(X+1)(X-1)
```

Draw the graph in the active screen.
F6(DRAW)



Copy the graph to the inactive (right) screen.
OPTN F1(COPY)



- The graph is reproduced using the inactive screen View Window parameters.

Switching the Contents of the Active and Inactive Screens

Switch the screens.

OPTN F2(SWAP)

- Note that using F2 (SWAP) to switch the screens also switches their View Window parameters.

Drawing Different Graphs on the Active Screen and Inactive Screen

Example **To draw the graphs of the following functions on the screens noted:**

Active Screen: $y = x\,(x + 1)\,(x - 1)$

Inactive Screen: $y = 2x^2 - 3$

Use the View Window parameters shown below.

Active (Left) Screen View Window parameters		Inactive (Right) Screen View Window parameters	
Xmin = –4	**Ymin = –5**	**Xmin = –2**	**Ymin = –2**
Xmax = 4	**Ymax = 5**	**Xmax = 2**	**Ymax = 2**
Xscale = 1	**Yscale = 1**	**Xscale = 0.5**	**Yscale = 1**

Assume that the functions being graphed are stored in memory areas Y1 and Y2.

Select the function for the graph that you want to end up in the inactive (right) screen.

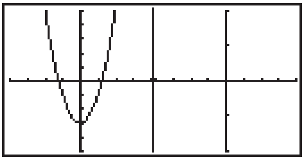
```
Graph Func  :Y=
Y1=X(X+1)(X-1)
Y2■2X²-3
```

F1(SEL)

```
Graph Func  :Y=
Y1=X(X+1)(X-1)
Y2■2X²-3
```

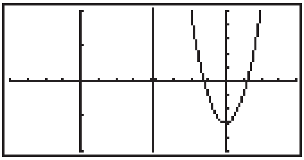
Draw the graph in the active screen.

F6(DRAW)



Swap the screens so the graph is on the inactive (right) screen.

OPTN F2(SWAP)



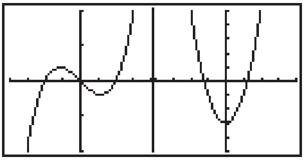
Select the function for the graph that you want in the now-empty active (left) screen.

AC F1(SEL)

Graph Func :Y=
Y1=X(X+1)(X-1)
Y2=$2X^2-3$ R

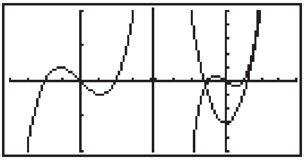
Draw the graph.

F6(DRAW)



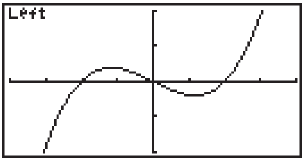
- At this point, you could perform a copy operation and superimpose the active graph over the inactive graph.

OPTN F1(COPY)

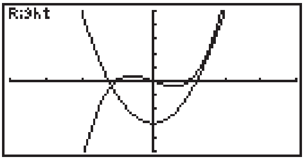


- Pressing SHIFT F6 (G↔T) lets you switch between display of the active and inactive graphs, using the entire display for each.

SHIFT F6(G↔T)



SHIFT F6(G↔T)



SHIFT F6(G↔T)

Graph Func :Y=
Y1=X(X+1)(X-1) B
Y2=$2X^2-3$ R

Other Graph Functions with Dual Graph

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After drawing a graph using Dual Graph, you can use the trace, zoom, sketch and scroll functions. Note, however, that these functions are available only for the active (left) graph. For details on using these functions, see “8-6 Other Graphing Functions”.

- To perform any of the above operations on the inactive graph, first move the inactive graph to the active screen.
- The graph screen will not scroll while a trace operation is being performed on the active graph.

The following shows some example operations using the zoom function.

Example 1 **To use box zoom to enlarge the graph of $y = x\ (x + 1)\ (x - 1)$**

Use the following View Window parameters for the active graph.

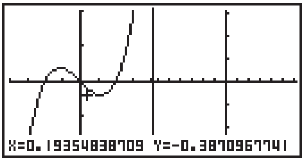
Xmin = –2	**Ymin = –2**
Xmax = 2	**Ymax = 2**
Xscale = 0.5	**Yscale = 1**

Assume that the function is already stored in memory area Y1.

```
Graph Func  :Y=
Y1=X(X+1)(X-1)
```

Press F6 (DRAW) or EXE to draw the graph.

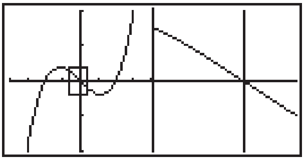
SHIFT F2 (Zoom) F1 (BOX)



```
X=0.19354838709 Y=-0.3870967741
```

- Use the cursor keys to move the pointer to one of the corners of the box and then press EXE.

- Use the cursor keys to move to the opposite corner of the box and then press EXE to enlarge the graph.



- The zoom operation changes the View Window parameters of the inactive screen, so the graph in the inactive screen is cleared.

Chapter 12

Graph-to-Table

With this function, the screen shows both a graph and a table. You can move a pointer around the graph and store its current coordinates inside the table whenever you want. This function is very useful for summarizing graph analysis results.

- Be sure to read “Chapter 8 Graphing” and “Chapter 9 Graph Solve” before trying to perform any of the operations described in this chapter.

12-1 Before Using Graph-to-Table

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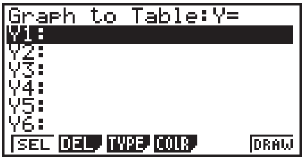
1. In the Main Menu, select the **GRAPH** icon and enter the GRAPH Mode. Next, use the set up screen to set the Dual Screen item to “**G to T**”.

2. Press EXIT and the Graph-to-Table menu appears.



Graph to Table:Y=
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:

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- For the meaning of the items in the function menu at the bottom of the screen, see “8-1 Before Trying to Draw a Graph”.

- Whenever the set up screen’s Dual Screen item is set to “G to T”, you can only store rectangular coordinate (Y=), polar coordinate (r=), and parametric function graphs in memory.
- You cannot use Graph-to-Table to display split graph/table screens using X=constant or inequality graphs of functions stored in the GRAPH or TABLE Mode.

12-2 Using Graph-to-Table

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•To store graph pointer coordinates in a table

- If the Derivative item in the set up screen is set to "**On**", the derivative at the location of the trace pointer is also stored in the table.

Example **To store the points of intersection and the coordinates for the following graphs where X = 0:**

Y1 = x^2 – 3 **Y2 = –x + 2**

Use the following View Window parameters.

Xmin = –5 **Ymin = –10**

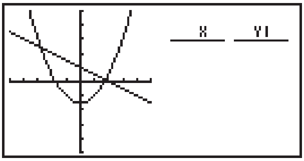
Xmax = 5 **Ymax = 10**

Xscale = 1 **Yscale = 2**

1. Input the two functions.

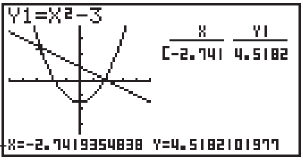
```
Graph to Table:Y=
Y1■X²-3
Y2=-X+2
```

2. Press F6 (DRAW) (or EXE) to draw the graph in the left half of the screen.



3. Press F1 (Trace) and then use ▶ to move the pointer to the first intersection.

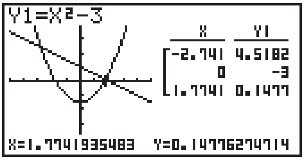
4. Press EXE to store the coordinates of the pointer location in the table on the right side of the screen.



```
Y1=X²-3
        X       Y1
    -2.741   4.5182
X=-2.7419354838 Y=4.5182101977
```

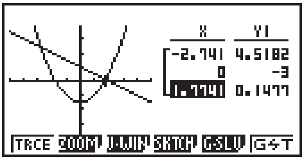
x/*y*-coordinate value

5. Use ▶ to move the pointer to the point where X = 0 and then press EXE.
Next, move the pointer to the next intersection and press EXE again.



```
Y1=X²-3
        X       Y1
    -2.741   4.5182
         0       -3
    1.7741   0.1477
X=1.7741935483  Y=0.14776274714
```

6. Pressing AC causes the highlighting to appear in the table. You can then use the cursor keys to move the highlighting around the table and check its values. Press AC again to return the pointer to the graph screen.



X	Y1
-2.741	4.5182
0	-3
1.7741	0.1477

•To save numeric table values in a list file

You can save columns of values into list files. Up to six values can be stored in a list file.

- The highlighting can be located in any row of the column whose data you want to save in the list.

Example **To save the x-coordinate data of the previous example in List 1.**

1. Starting from the screen that appears in step 6 of the previous example, press OPTN. The following function menu appears.

- {**CHNG**} ... {changes the active screen (between left and right)}
- {**LMEM**} ... {saves table column to list file}
- {**PICT**} ... {saves graph data to graph memory}

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2. Press F2 (LMEM).

3. Press F1 (List1) to store the data in the x-coordinate column into List 1.

- Table data uses the same memory as TABLE menu table data.
- Always be sure to store table data into a list.
- Any of the following operations causes table data to be deleted.
  - — Editing expression data
  - — Changing set up screen or View Window settings
  - — Changing to a different mode
- If you save data into a list that already contains data, the previous data is replaced with the new data.
- For details on recalling numeric data saved in a list file, see “17. List Function”.

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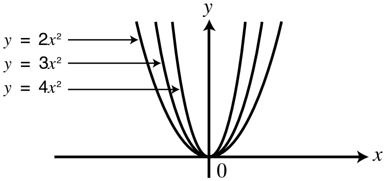
Graph-to-Table Precautions

- The only coordinates that can be saved in the table are those where the pointer can move to using trace and graph solve.
- The only graph functions that can be used with a graph produced using the Graph-to-Table are: trace, scroll, zoom, and graph solve (excluding integration calculations).
- Graph functions cannot be used while the highlighting is blinking in the table. To clear the highlighting and make the graph side the active screen, press OPTN F1 (CHNG).
- OPTN key operation is disabled whenever a graph and table are both on the screen and there is no numeric data in the table, and when the screen is not split (i.e. when either the graph or table only is on the display).
- An error occurs if a graph for which a range is specified or an overwrite graph is included among the graph expressions.

Chapter 13

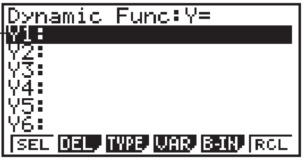
Dynamic Graph

The Dynamic Graph Mode of this calculator shows you real-time representations of changes in a graph as coefficients and terms are changed. It lets you see what happens to a graph when such changes are made. For example, you can see the graph change as illustrated here as the value of coefficient A changes in the formula $y = \mathrm{A}x^2$.



13-1 Before Using Dynamic Graph

In the Main Menu, select the **DYNA** icon and enter the DYNA Mode. When you do the dynamic function list appears on the screen.



Selected memory area

Press ▼ and ▲ to move.

- {**SEL**} ... {dynamic Graph draw/non-draw status}
- {**DEL**} ... {function delete}
- {**TYPE**} ... {function type specification}
- {**VAR**} ... {coefficient menu}
- {**B·IN**} ... {menu of built-in functions*}
- {**RCL**} ... {recall and execution of Dynamic Graph conditions and screen data}

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* The built-in function menu contains the following seven functions.

- $Y=AX+B$
- $Y=A(X+B)^2+C$
- $Y=AX^2+BX+C$
- $Y=AX$^3+BX^2+CX+D
- $Y=A\sin(BX+C)$
- $Y=A\cos(BX+C)$
- $Y=A\tan(BX+C)$

13-2 Storing, Editing, and Selecting Dynamic Graph Functions

In addition to the seven built-in functions, you can input 20 of your own Dynamic Functions. Once a function is stored in memory, it can be edited and selected when needed for graphing.

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All of the procedures you need to use for storing, editing, and selecting Dynamic Graph functions are identical to those you use in the **GRAPH Mode**. For details, see “8-3 Graph Function Operations”.

- Dynamic Graphs can be one of the following three types only: rectangular coordinate (Y=), polar coordinate (r=), and parametric.
- You cannot use Dynamic Graph with X=constant or inequality graphs of functions stored in the GRAPH or TABLE Mode.
- If you try to use Dynamic Graph with a function that does not contain a variable, a “No Variable” error occurs. If this happens, press AC to clear the error.
- Dynamic Graph always uses blue to draw graphs. This cannot be changed.

13-3 Drawing a Dynamic Graph

The following is the general procedure you should use to draw a Dynamic Graph.

1. Select or input a function.

2. Define the dynamic coefficient.
   - This is a coefficient whose value changes in order to produce the different graphs.
   - If the dynamic coefficient is already defined from a previous operation, you can skip this step.

3. Assign values to each of the coefficients of the function.

4. Specify the range of the dynamic coefficient.
   - If the range of the dynamic coefficient is already defined from a previous operation, you can skip this step.

5. Specify the speed of the draw operation.
   - If the speed is already defined from a previous operation, you can skip this step.

6. Draw the Dynamic Graph.

●To set Dynamic Graph conditions

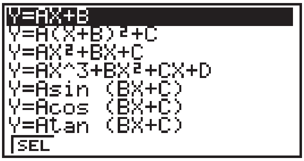
Example **To use Dynamic Graph to graph y = A (x–1)^2 –1 as the value of A changes from 2 to 5 in increments of 1**

Use the following View Window parameters.

Xmin = – 6.3 **Ymin** = – 3.1
Xmax = 6.3 **Ymax** = 3.1
Xscale = 1 **Yscale** = 1

1. Input the function you want to graph. Here we will edit a built-in function to input our function.

F5(B·IN)



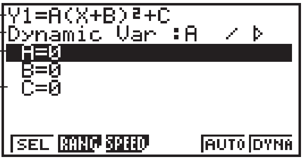
```
Y=AX+B
Y=A(X+B)²+C
Y=AX²+BX+C
Y=AX^3+BX²+CX+D
Y=Asin (BX+C)
Y=Acos (BX+C)
Y=Atan (BX+C)
```

▼ F1(SEL)

```
Dynamic Func:Y=
Y1=A(X+B)²+C
```

2. Display the coefficient menu.

[F4](VAR) or [EXE]



Function being graphed
Coefficient whose value will change
Coefficients in function

```
Y1=A(X+B)²+C
Dynamic Var :A
 A=0
 B=0
 C=0
```

- {**SEL**} ... {selects dynamic coefficient}
- {**RANG**} ... {dynamic coefficient range settings}
- {**SPEED**} ... {dynamic Graph drawing speed}
- {**AUTO**} ... {automatic setting of end and pitch values to match coefficient values}
- {**DYNA**} ... {dynamic Graph draw operation}

- The calculator automatically makes the first variable it finds the dynamic coefficient. To select a different coefficient, use ▼ and ▲ to move the highlighting to the coefficient you want to use, and the press [F1] (SEL).
- The letters representing each coefficient are variables, and so the values that appears on the screen are those currently assigned to each variable. If a complex number is assigned to a variable, only the integer part appears.
- All variables contained in the currently selected function appear on the display in alphabetical order.
- If there is more than one function that can be drawn using Dynamic Graph, the message “**Too Many Functions**” appears on the display.
- If the value of the dynamic variable is zero and you press [F5] (AUTO), the dynamic variable automatically changes to 1 and Dynamic Graphing is performed.

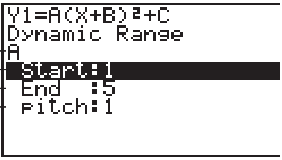
3. Specify the value of each coefficient.

[2] [EXE] [(–)] [1] [EXE] [(–)] [1] [EXE]

- If there is more than one coefficient, use ▲ and ▼ to move the highlighting to each coefficient and input its value.
- Values you input for coefficients are also assigned to the corresponding variable.

4. Recall the dynamic coefficient range setting menu.

[F2](RANG)



Dynamic coefficient
Start value
End value
Increment

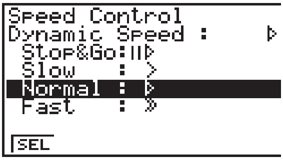
```
Y1=A(X+B)²+C
Dynamic Range
A
 Start:1
 End  :5
 Pitch:1
```

- The range you set remains in effect until you change it.

5. Change the range settings.

   2 EXE EXIT

- If you want to change the Dynamic Graph speed, press F3 (SPEED).



```
Speed Control
Dynamic Speed :    ▷
 Stop&Go:II▷
 Slow   : >
 Normal : ▷
 Fast   : »

SEL
```

F1

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You can set the Dynamic Graph speed to any one of the following settings.

Stop & Go:	Each step of the Dynamic Graph draw operation is performed each time you press EXE.
Slow:	1/2 Normal
Normal:	Default speed
Fast:	Double Normal

1. Use ▲ and ▼ to move the highlighting to the speed you want to use.

2. Press F1 (SEL) to set the highlighted speed.

●To start the Dynamic Graph draw operation

There are four different variations for Dynamic Graphing.

■ 10-time Continuous Drawing

Select "**Stop**" as the draw type (Dynamic Type) to perform 10-time continuous drawing. With this drawing style, 10 versions of the graph are drawn and then the draw operation stops automatically.

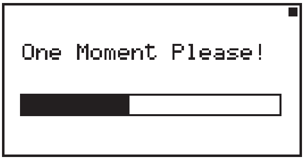
Example **To use 10-time continuous drawing to draw the same graph that you drew in the previous example (page 184)**

P.7

1. Display the coefficient value specification menu. Next, display the set up screen and specify "**Stop**" for Dynamic Type and then press EXIT.

2. Start drawing of the Dynamic Graph.

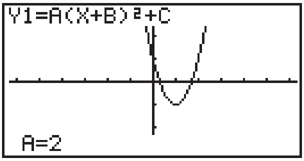
   F6 (DYNA)



```
One Moment Please!
```

↓

①

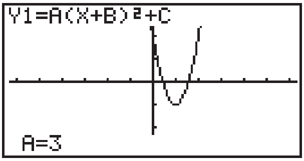


$Y1=A(X+B)^2+C$

A=2

→
←

②

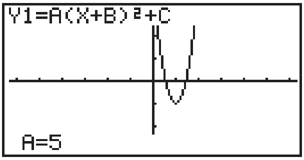


$Y1=A(X+B)^2+C$

A=3

↓↑

④

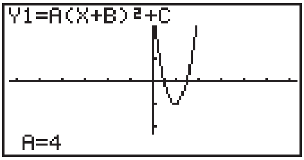


$Y1=A(X+B)^2+C$

A=5

→
←

③



$Y1=A(X+B)^2+C$

A=4

The above sequence continues to repeat from ① through ④.
Graph is drawn 10 times.

- While the message "**One Moment Please!**" is shown on the display, you can press AC to interrupt drawing of the graph and return to the coefficient range setting display.
- Pressing AC while the Dynamic Graph is being drawn changes to the drawing speed setting display. The draw operation is suspended at this time, and you can view the graph by pressing SHIFT F6 (G↔T).
- If you do not want the function and coefficient values shown on the display with the graph, use the graph function set up display to switch Graph Func "**Off**".
- Pressing F5 (AUTO) draws up to 11 versions of the Dynamic Graph, starting from the start (Start) value of the dynamic coefficient.

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■ Continuous Drawing

When the Dynamic Graph draw type (Dynamic Type) is set to "**Cont**" (continuous), drawing of the Dynamic Graph continues until you press AC.

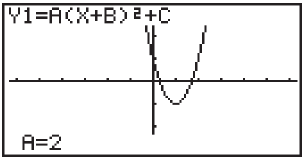
Example **To continuously draw the same graph that you input in the previous example (page 184)**

P.7

1. Display the coefficient value specification menu. Next, display the set up screen and specify "**Cont**" for Dynamic Type and then press EXIT.

2. Start drawing of the Dynamic Graph.

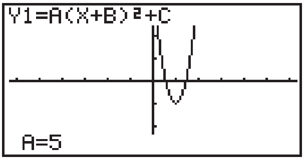
F6(DYNA)



$Y1=A(X+B)^2+C$

A=2

…→
←…



$Y1=A(X+B)^2+C$

A=5

- Pressing AC while the Dynamic Graph is being drawn changes to the drawing speed setting display. The draw operation is suspended at this time, and you can view the graph by pressing SHIFT F6 (G↔T).
- Selecting "Cont" and then executing a Dynamic Graph operation causes the graphing operation to repeat until you press AC. Be sure that you do not forget to stop the Dynamic Graph operation after you are finished. Allowing it to continue will run down the batteries.

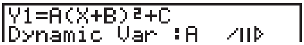
■ Stop & Go Drawing

By selecting "**STOP & GO** ‖▷" as the graph drawing speed, you can draw graphs one by one. A graph is drawn each time you press EXE.

Example **To use Stop & Go to draw the same graph that you drew in the previous example (page 184)**

1. Display the coefficient value specification display and press F3 (SPEED).

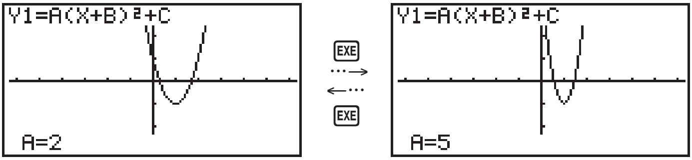
2. Use ⏶ and ⏷ to select "**STOP & GO** (‖▷)" and press F1 (SEL) EXIT.



Y1=A(X+B)²+C
Dynamic Var :A   ⁄‖▷

3. Start drawing of the Dynamic Graph.

F6 (DYNA)



Y1=A(X+B)²+C
A=2

Y1=A(X+B)²+C
A=5

- Pressing AC while the Dynamic Graph is being drawn changes to the drawing speed setting display. The draw operation is suspended at this time, and you can view the graph by pressing SHIFT F6 (G↔T).

■ Overwriting

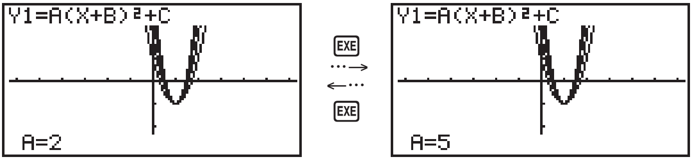
By turning "**On**" the locus (Locus) setting of the Dynamic Graph, graphs are sequentially drawn on the same display. The newest graph drawn is easily identifiable because its color is different from graphs that were previously on the display.

Example **To switch the locus setting on and draw the same graph that you drew in the previous example (page 184)**

1. Display the coefficient value specification menu. Next, display the set up screen and specify "**On**" for Locus and then press EXIT.

2. Start drawing of the Dynamic Graph.

F6 (DYNA)



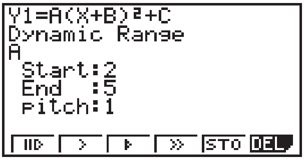
- Pressing AC while the Dynamic Graph is being drawn changes to the drawing speed setting display. The draw operation is suspended at this time, and you can view the graph by pressing SHIFT F6 (G↔T).

- Depending on the complexity of the graphs being drawn, it may take some time for them to appear on the display.
- Trace and zoom features cannot be used on a Dynamic Graph screen.

•To adjust the Dynamic Graph speed

You can use the following procedure to adjust the Dynamic Graph speed while the draw operation is taking place.

1. While a Dynamic Graph draw operation is being performed, press AC to change to the speed adjustment menu.



```
Y1=A(X+B)²+C
Dynamic Range
A
 Start:2
 End  :5
 Pitch:1
```

- {II▷} ... {Each step of the Dynamic Graph draw operation is performed each time you press EXE.}
- {>}/{▷}/{≫} ... {slow (1/2 speed)}/{normal (default speed)}/{fast (double speed)}
- {**STO**} ... {stores graph conditions and screen data in Dynamic Graph memory}
- {**DEL**} ... {deletes Dynamic Graph screen data}

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2. Press the function key (F1 to F4) that corresponds to the speed you want to change to.

- To clear the speed adjustment menu without changing anything, press EXE.
- Press SHIFT F6 (G↔T) to return to the graph screen.

13-4 Using Dynamic Graph Memory

You can store Dynamic Graph conditions and screen data in Dynamic Graph memory for later recall when you need it. This lets you save time, because you can recall the data and immediately begin a Dynamic Graph draw operation. Note that you can store one set of data in memory at any one time.

The following is all of the data that makes up a set.

- Graph functions (up to 20)
- Dynamic Graph conditions
- Set up screen settings
- View Window contents
- Dynamic Graph screen

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•To save data in Dynamic Graph memory

1. While a Dynamic Graph draw operation is being performed, press AC to change to the speed adjustment menu.

2. Press F5 (STO) to store the data.
   - If there is already data stored in Dynamic Graph memory, the above operation replaces it with the new data.

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•To recall data from Dynamic Graph memory

1. Display the Dynamic Graph function list.

2. Press F6 (RCL) to recall all the data stored in Dynamic Graph memory.
   - Data recalled from Dynamic Graph memory replaces the calculator's current graph functions, draw conditions, and screen data. The previous data is lost when it is replaced.

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•To delete Dynamic Graph screen data

1. Press AC F6 (DEL).

2. Press F1 (YES) to delete the Dynamic Graph screen data, or F6 (NO) to abort the operation without deleting anything.

13-5 Dynamic Graph Application Examples

Example **To use Dynamic Graph to graph the parabolas produced by balls thrown in the air at an initial velocity of 20m/second, at angles of 30, 45, and 60 degrees. (Angle: Deg)**

Use the following View Window parameters.

Xmin = –1 **Ymin** = –1

Xmax = 42 **Ymax** = 16

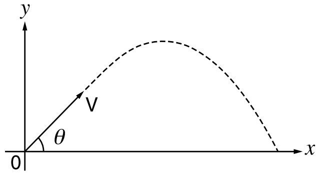
Xscale = 5 **Yscale** = 2

With the initial velocity defined as V and the angle defined as θ, the parabolas can be obtained using the following expressions.

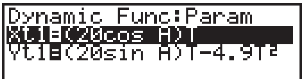
$X = V\cos\theta T$

$Y = V\sin\theta T - (1/2)gT^2$

g = 9.8 meters per second



1. Input the functions, making sure to specify them a "**Param**" (parametric) type.



```
Dynamic Func:Param
Xt1=(20cos A)T
Yt1=(20sin A)T-4.9T²
```

2. Display the coefficient menu and specify the dynamic coefficient.

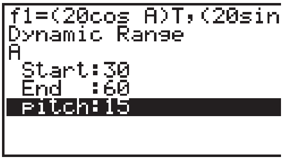
F4 (VAR) 3 0 EXE

```
f1=(20cos A)T,(20sin
Dynamic Var :A
 A=30
```

3. Display the coefficient range menu and specify the range values.

F2 (RANG)

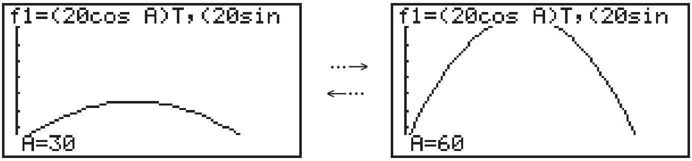
3 0 EXE 6 0 EXE 1 5 EXE



```
f1=(20cos A)T,(20sin
Dynamic Range
A
 Start:30
 End  :60
 pitch:15
```

4. Start the Dynamic Graph draw operation.

EXIT F6 (DYNA)



```
f1=(20cos A)T,(20sin
 A=30
```

```
f1=(20cos A)T,(20sin
 A=60
```

Chapter 14

Implicit Function Graphs

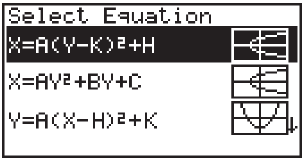
You can graph any one of the following types of implicit functions using the calculator’s built-in functions.

- Parabolic graph
- Circle graph
- Elliptical graph
- Hyperbolic graph

14-1 Before Graphing an Implicit Function

■ Entering the CONICS Mode

1. In the Main Menu, select the **CONICS** icon and enter the CONICS Mode. When you do, the following built in function menu appears on the screen.



Select Equation

$X=A(Y-K)^2+H$

$X=AY^2+BY+C$

$Y=A(X-H)^2+K$

2. Use ▲ and ▼ to highlight the built-in function you want, and then press EXE.

The following nine functions are built in.

Graph Type	Function
Parabola	$X = A (Y - K)^2 + H$ $X = AY^2 + BY + C$ $Y = A (X - H)^2 + K$ $Y = AX^2 + BX + C$
Circle	$(X - H)^2 + (Y - K)^2 = R^2$ $AX^2 + AY^2 + BX + CY + D = 0$
Ellipse	$\frac{(X - H)^2}{A^2} + \frac{(Y - K)^2}{B^2} = 1$
Hyperbola	$\frac{(X - H)^2}{A^2} - \frac{(Y - K)^2}{B^2} = 1$ $\frac{(Y - K)^2}{A^2} - \frac{(X - H)^2}{B^2} = 1$

14-2 Graphing an Implicit Function

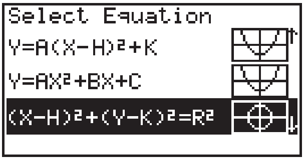
Example 1 **To graph the circle $(X - 1)^2 + (Y - 1)^2 = 2^2$**

Use the following View Window parameters.

Xmin = –6.3 **Ymin = –3.1**
Xmax = 6.3 **Ymax = 3.1**
Xscale = 1 **Yscale = 1**

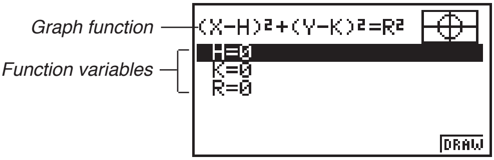
1. Select the function whose graph you want to draw.

▼ ▼ ▼ ▼



```
Select Equation
Y=A(X-H)²+K
Y=AX²+BX+C
(X-H)²+(Y-K)²=R²
```

2. Press EXE and the variable input screen appears.



```
(X-H)²+(Y-K)²=R²
 H=0
 K=0
 R=0
```

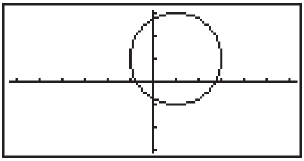
- The values that appear are the values currently assigned to each variable, which are general variables used by the calculator. If the values include an imaginary part, only the real part appears on the display.

3. Assign values to each variable.

1 EXE 1 EXE 2 EXE

- You can also use ▲ and ▼ to highlight a variable and then input a value.

4. Press F6 (DRAW) to draw the graph.



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- Certain View Window parameters can make a circle graph come out looking like an ellipse. When this happens, you can use the graph correction function (SQR) to make corrections and produce a perfect circle.

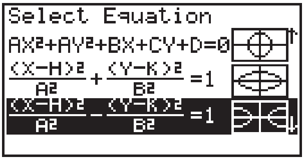
Example 2 To graph the hyperbola $\frac{(X-3)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$

Use the following View Window parameters.

Xmin = –8 **Ymin = –10**
Xmax = 12 **Ymax = 10**
Xscale = 1 **Yscale = 1**

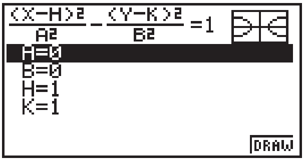
1. Select the function whose graph you want to draw.

▼▼▼▼▼▼▼



Select Equation
AX²+AY²+BX+CY+D=0
$\frac{(X-H)^2}{A^2} + \frac{(Y-K)^2}{B^2} = 1$
$\frac{(X-H)^2}{A^2} - \frac{(Y-K)^2}{B^2} = 1$

2. Press EXE and the variable input screen appears.

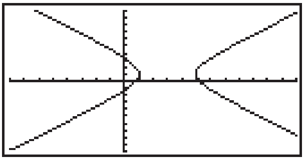


$\frac{(X-H)^2}{A^2} - \frac{(Y-K)^2}{B^2} = 1$
A=0
B=0
H=1
K=1

3. Assign values to each variable.

2 EXE 2 EXE 3 EXE 1 EXE

4. Press F6 (DRAW) to draw the graph.



Implicit Function Graphing Precautions

- Assigning the following types of values to variables contained in built-in function produces an error.

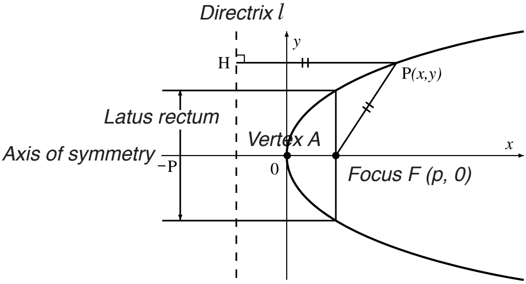
(1) Parabola graph
A = 0

(2) Circle graph
R = 0 for $(X - H)^2 + (Y - K)^2 = R^2$
A = 0 for $AX^2 + AY^2 + BX + CY + D = 0$

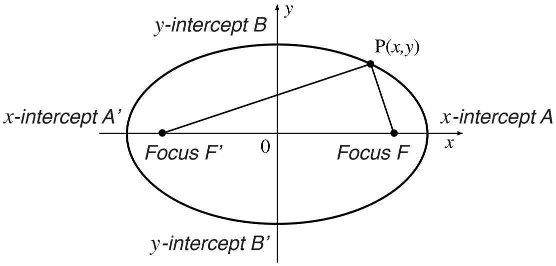
(3) Ellipse/hyperbola graph
A = 0 or B = 0

- Implicit function graphs can be drawn in blue only.
- You cannot overwrite implicit function graphs.
- The calculator automatically clears the screen before drawing a new implicit function graph.
- You can use trace, scroll, zoom, or sketch after graphing an implicit function. However, an implicit function graph cannot be scrolled while using trace.
- You cannot incorporate graphing of an implicit function into a program.

- A parabola is the locus of points equidistant from fixed line l and fixed point F not on the line. Fixed point F is the "focus," fixed line l is the "directrix," the horizontal line that passes through the focus directrix is the "axis of symmetry," the length of a straight line that intersects the parabola, passes through the locus, and is parallel to fixed line l is the "latus rectum," and point A where the parabola intersects the axis of symmetry is the "vertex."

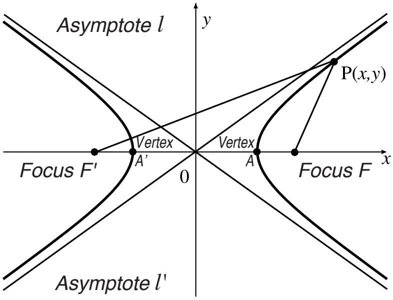


- An ellipse is the locus of points the sum of the distances of each of which from two fixed points F and F' is constant. Points F and F' are the "foci," points A, A', B, and B' where the ellipse intersects the x- and y-axes are the "vertexes," the x-coordinate values of vertexes A and A' are called x-intercepts, and the y-coordinate values of vertexes B and B' are called y-intercepts.



- A hyperbola is the locus of points related to two given points F and F’ such that the difference in distances of each point from the two given points is constant.

  Points F and F’ are the “foci,” points A and A’ where the hyperbola intersects the x-axis are the “vertexes,” the x-coordinate values of vertexes A and A’ are called x-intercepts, the y-coordinate values of vertexes A and A’ are called y-intercepts, and straight lines l and l' , which get closer to the hyperbola as they move away from the foci are “asymptotes.”



14-3 Implicit Function Graph Analysis

You can determine approximations of the following analytical results using implicit function graphs.

- Focus/vertex calculation
- Latus rectum calculation
- Center/radius calculation
- *x*-/*y*-intercept calculation
- Directrix/axis of symmetry drawing and analysis
- Asymptote drawing and analysis

After graphing an implicit function, press F5 (G-Solv) to display the Graph Analysis Menu.

Parabolic Graph Analysis

- {**FOCS**} ... {determines the focus}
- {**SYM**}/{**DIR**} ... draws the {axis of symmetry}/{directrix}
- {**VTX**}/{**LEN**} ... determines the {vertex}/{latus rectum}

Circle Graph Analysis

- {**CNTR**}/{**RADS**} ... determines the {center}/{radius}

Ellipse Graph Analysis

- {**FOCS**}/{**X-IN**}/{**Y-IN**} ... determines the {focus}/{*x*-intercept}/{*y*-intercept}

Hyperbolic Graph Analysis

- {**FOCS**}/{**X-IN**}/{**Y-IN**}/{**VTX**} ... determines the {focus}/{*x*-intercept}/{*y*-intercept}/{vertex}
- {**ASYM**} ... {draws the asymptote}

The following examples show how to use the above menus with various types of implicit function graphs.

•To calculate the focus and vertex

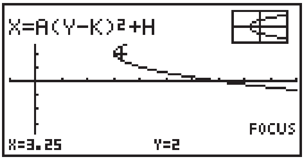
[G-Solv]-[FOCS]/[VTX]

Example **To determine the focus and vertex for the parabola $X = (Y - 2)^2 + 3$**

Use the following View Window parameters.

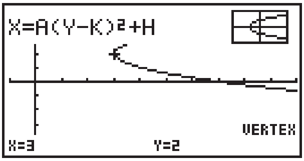
Xmin = –1	**Ymin = –5**
Xmax = 10	**Ymax = 5**
Xscale = 1	**Yscale = 1**

F5 (G-Solv)
F1 (FOCS)
(Calculates the focus.)



```
X=A(Y-K)²+H
X=3.25          Y=2
```

F5 (G-Solv)
F4 (VTX)
(Calculates the vertex.)



```
X=A(Y-K)²+H
X=3             Y=2
```

- When calculating two foci for an ellipse or hyperbolic graph, press ▶ to calculate the second focus. Pressing ◀ returns to the first focus.
- When calculating two vertexes for a hyperbolic graph, press ▶ to calculate the second vertex. Pressing ◀ returns to the first vertex.

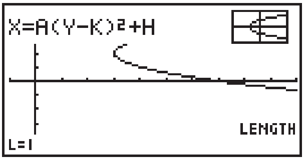
•To calculate the latus rectum [G-Solv]-[LEN]

Example **To determine the latus rectum for the parabola X = (Y – 2)^2 + 3**

Use the following View Window parameters.

Xmin = –1 **Ymin = –5**
Xmax = 10 **Ymax = 5**
Xscale = 1 **Yscale = 1**

F5 (G-Solv)
F5 (LEN)
(Calculates the latus rectum.)



```
X=A(Y-K)²+H
L=1
```

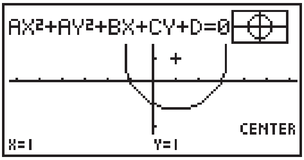
•To calculate the center and radius [G-Solv]-[CNTR]/[RADS]

Example **To determine the center and radius for the circle X^2 + Y^2 – 2X – 2Y – 3 = 0**

Use the following View Window parameters.

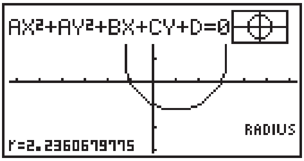
Xmin = –6.3 **Ymin = –3.1**
Xmax = 6.3 **Ymax = 3.1**
Xscale = 1 **Yscale = 1**

F5 (G-Solv)
F1 (CNTR)
(Calculates the center.)



X=1 Y=1

F5 (G-Solv)
F2 (RADS)
(Calculates the radius.)



r=2.2360679775

●To calculate the *x*- and *y*-intercepts **[G-Solv]-[X-IN]/[Y-IN]**

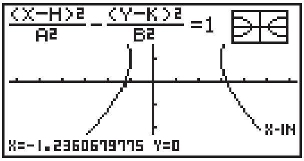
Example **To determine the *x*- and *y*-intercepts for the hyperbola**

$$\frac{(X-1)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

Use the following View Window parameters.

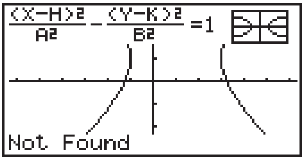
Xmin	**= –6.3**	**Ymin**	**= –3.1**
Xmax	**= 6.3**	**Ymax**	**= 3.1**
Xscale	**= 1**	**Yscale**	**= 1**

F5 (G-Solv)
F2 (X-IN)
(Calculates the *x*-intercept.)



X=-1.2360679775 Y=0

F5 (G-Solv)
F3 (Y-IN)
(Calculates the *y*-intercept.)



Not Found

- Press ▶ to calculate the second set of *x*-/*y*-intercepts. Pressing ◀ returns to the first set of intercepts.

•To draw and analyze the axis of symmetry and directrix

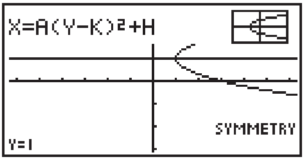
[G-Solv]-[SYM]/[DIR]

Example **To draw the axis of symmetry and directrix for the parabola $X = 2(Y - 1)^2 + 1$**

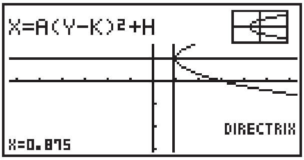
Use the following View Window parameters.

Xmin = –6.3 **Ymin = –3.1**
Xmax = 6.3 **Ymax = 3.1**
Xscale = 1 **Yscale = 1**

F5 (G-Solv)
F2 (SYM)
(Draws the axis of symmetry.)



F5 (G-Solv)
F3 (DIR)
(Draws the directrix.)



•To draw and analyze the asymptotes

[G-Solv]-[ASYM]

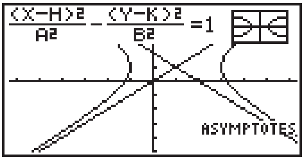
Example **To draw the asymptotes for the hyperbola**

$$\frac{(X-1)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

Use the following View Window parameters.

Xmin = –6.3 **Ymin = –5**
Xmax = 6.3 **Ymax = 5**
Xscale = 1 **Yscale = 1**

F5 (G-Solv)
F5 (ASYM)
(Draws the asymptotes.)



- Certain View Window parameters can produce errors in values produced as graph analysis result.
- The message ”**Not Found**” appears on the display when graph analysis is unable to produce a result.
- The following can result in inaccurate analysis results or may even make it impossible to obtain a solution at all.
  - When the solution is tangent to the x-axis.
  - When the solution is a point of tangency between two graphs.

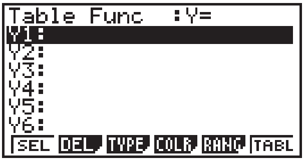
Chapter 15

Table & Graph

With Table & Graph, you can generate tables of discreet data from functions and recursion formulas, and then use the values for graphing. Because of this, Table & Graph makes it easy to grasp the nature of numeric tables and recursion formulas.

15-1 Before Using Table & Graph

First select the **TABLE** icon on the Main Menu and then enter the TABLE Mode. When you do, the table function list appears on the display.



- {**SEL**} ... {numeric table generation/non-generation status}
- {**DEL**} ... {function delete}
- {**TYPE**} ... {function type specification}
- {**COLR**} ... {graph color specification}
- {**RANG**} ... {table range specification screen}
- {**TABL**} ... {start numeric table generation}

- Note that the {RANG} item does not appear when a list name is specified for the Variable item in the set up screen.

15-2 Storing a Function and Generating a Numeric Table

•To store a function

Example **To store the function $y = 3x^2 - 2$ in memory area Y1**

Use ▲ and ▼ to move the highlighting in the TABLE Mode function list to the memory area where you want to store the function. Next, input the function and press EXE to store it.

■ Variable Specifications

There are two methods you can use to specify value for the variable x when generating a numeric table.

- **Table range method**

  With this method, you specify the conditions for the change in value of the variable.

- **List**

  With this method, you substitute the values contained in a previously created list for the value of the variable.

•To generate a table using a table range

Example **To generate a table as the value of variable x changes from –3 to 3, in increments of 1**

F5(RANG)

(–) 3 EXE 3 EXE 1 EXE

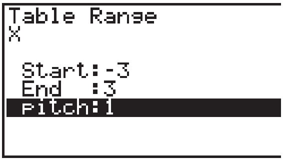


Table Range
X
Start:-3
End :3
pitch:1

The numeric table range defines the conditions under which the value of variable x changes during function calculation.

Start	Variable x start value
End	Variable x end value
pitch	Variable x value change

After specifying the table range, press EXIT to return to the function list.

•To generate a table using a list

1. In the TABLE Mode, display the set up screen.

2. Highlight Variable and then press F2 (LIST) to display the list menu.

3. Select the list you want to use.
   - To select List 6, for example, press F6 (List6). This causes the setting of the Variable item of the set up screen to change to List 6.

4. After specifying the list you want to use, press EXIT to return to the previous screen.
   - Note that the {RANG} item of the TABLE Mode function list does not appear when a list name is specified for the Variable item of the set up screen.

■ Generating a Table

Example **To generate a table of values for the functions stored in memory areas Y1 and Y3 of the TABLE Mode function list**

Use ▲ and ▼ to move the highlighting to the function you want to select for table generation and press F1 (SEL) to select it.

The "=" sign of selected functions is highlighted on the screen. To deselect a function, move the cursor to it and press F1 (SEL) again.

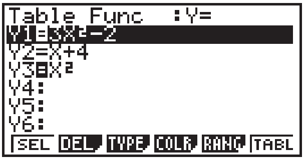
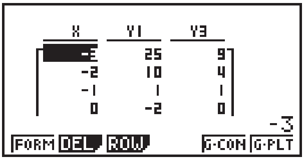


Table Func :Y=
Y1=3X²−2
Y2=X+4
Y3=X²
Y4:
Y5:
Y6:

F6

Press F6 (TABL) or EXE to generate a numeric table using the functions you selected. The value of variable x changes according to the range or the contents of the list you specified.



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-3

Each cell can contain up to six digits, including negative sign.

You can use cursor keys to move the highlighting around the table for the following purposes.

- To display the selected cell's value at the bottom of the screen, using the calculator's current number of decimal place, number of significant digit, and exponential display range settings.
- To scroll the display and view parts of the table that do not fit in the display.
- To display at the top of the screen the scientific function that produced the value in the selected cell (in columns Y1, Y2, etc.)
- To change x variable values by replacing values in column X.

Press F1 (FORM) to return to the TABLE Mode function list.

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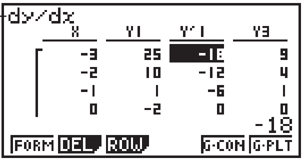
●To generate a differential numeric table

Changing the setting of set up screen's Derivative item to "**On**" causes a numeric table that includes the derivative to be displayed whenever you generate a numeric table.

Locating the cursor at a differential coefficient displays "dy/dx" in the top line to indicate differential.



dy/dx

X	Y1	Y'1	Y3
-3	25	-18	9
-2	10	-12	4
-1	1	-6	1
0	-2	0	0

-18

- An error occurs if a graph for which a range is specified or an overwrite graph is included among the graph expressions.

■ Specifying the function type

You can specify a function as being one of three types.

- Rectangular coordinate (Y=)
- Polar coordinate (r=)
- Parametric (Parm)

1. To display the menu of function types, press F3 (TYPE) while the function list is on the screen.

2. Press the function key that corresponds to the function type you want to specify.
   - When you generate a numeric table, a table is generated only for the function type you specify here.

15-3 Editing and Deleting Functions

•To edit a function

Example **To change the function in memory area Y1 from $y = 3x^2 - 2$ to $y = 3x^2 - 5$**

Use ▲ and ▼ to move the highlighting to the function you want to edit.

```
Table Func   :Y=
Y1=3X²-2
```

Use ◀ and ▶ to move the cursor to the location of the change.

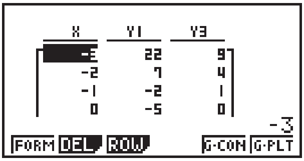
▶ ▶ ▶ ▶ ▶ 5

```
Table Func   :Y=
Y1=3X²-5_
```

EXE

```
Table Func   :Y=
Y1■3X²-5
Y2=X+4
```

F6 (TABL)



```
      X     Y1    Y3
     -3     22     9
     -2      7     4
     -1     -2     1
      0     -5     0
                  -3
```

- The Function Link Feature automatically reflects any changes you make to functions in the TABLE Mode list, in the GRAPH Mode and DYNA Mode lists.

•To delete a function

1. Use ▲ and ▼ to move the highlighting to the function you want to delete and then press F2 (DEL).

2. Press F1 (YES) to delete the function or F6 (NO) to abort the operation without deleting anything.

15-4 Editing Tables and Drawing Graphs

You can use the table menu to perform any of the following operations once you generate a table.

- Change the values of variable *x*
- Edit (delete, insert, and append) rows
- Delete a table
- Draw a connect type graph
- Draw a plot type graph

While the Table & Graph menu is on the display, press F6 (TABL) to display the table menu.

- {**FORM**} ... {display function list}
- {**DEL**} ... {delete table}
- {**ROW**} ... {display menu of row operations}
- {**G·CON**}/{**G·PLT**} ... {connected type}/{draw plot type} graph draw

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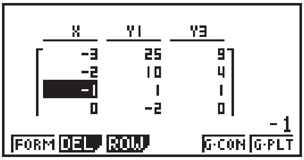
●To change variable values in a table

Example **To change the value in Column *x*, Row 3 of the table generated on page 208 from – 1 to – 2.5**

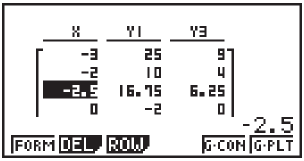
▼ ▼



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-1

(–) 2 . 5 EXE



X	Y1	Y3
-3	25	9
-2	10	4
-2.5	16.75	6.25
0	-2	0

-2.5

- When you change a variable value in Column *x*, all values in the columns to the right are recalculated and displayed.
- If you try to replace a value with an illegal operation (such as division by zero), an error occurs and the original value remains unchanged.
- You cannot directly change any values in the other (non-*x*) columns of the table.

Row Operations

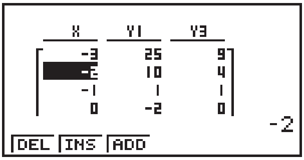
The following menu appears whenever you press F3 (ROW) while the table menu is on the display.

- {**DEL**} ... {delete row}
- {**INS**} ... {insert row}
- {**ADD**} ... {add row}

•To delete a row

Example **To delete Row 2 of the table generated on page 208**

F3 (ROW) ▼

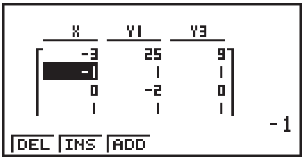


X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-2

F1

F1 (DEL)



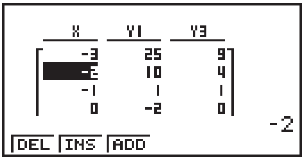
X	Y1	Y3
-3	25	9
-1	1	1
0	-2	0
1	1	1

-1

•To insert a row

Example **To insert a new row between Rows 1 and 2 in the table generated on page 208**

F3 (ROW) ▼

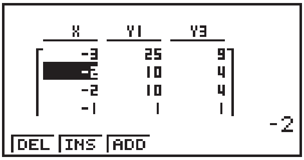


X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-2

F2

F2 (INS)



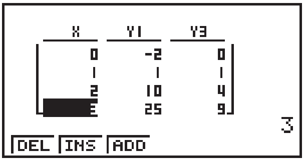
X	Y1	Y3
-3	25	9
-2	10	4
-2	10	4
-1	1	1

-2

•To add a row

Example **To add a new row below Row 7 in the table generated on page 208**

F3 (ROW) ▼ ▼ ▼ ▼ ▼ ▼

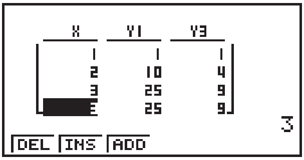


X	Y1	Y3
0	-2	0
1	1	1
2	10	4
3	25	9

3

F3

F3 (ADD)



X	Y1	Y3
1	1	1
2	10	4
3	25	9
3	25	9

3

Deleting a Table

1. Display the table you want to delete and then press F2 (DEL).

2. Press F1 (YES) to delete the table or F6 (NO) to abort the operation without deleting anything.

Graphing a Function

Before drawing a function graph, you must first specify the following.

- Graph color (blue, orange, green)
- Draw/non-draw status of the function

•To specify the graph color

The default color for a graph is blue. Use the following procedure to change the graph color to orange or green.

1. Display the function list and then use ▲ and ▼ to highlight the function whose graph color you want to change.

2. Press F4 (COLR).

3. Press the function key that corresponds to the color you want to specify.
   - {**Blue**}/{**Orng**}/{**Grn**} .. {blue}/{orange}/{green}

•To specify the draw/non-draw status of a formula

There are two options for the draw/non-draw status of a function graph.

- For the selected function only
- Overlay the graphs for all functions

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To specify the draw/non-draw status, use same procedure as that for specifying table generation/non-generation status.

•To graph only a selected function

Example **To graph $y = 3x^2 - 2$, which is stored in memory area Y1, as a connect type graph.**

Use the following View Window parameters.

Xmin = 0 **Ymin = –2**
Xmax = 6 **Ymax = 106**
Xscale = 1 **Yscale = 2**

▽ F1 (SEL)

(Specifies graph non-draw.)

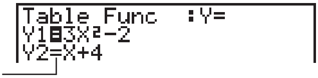
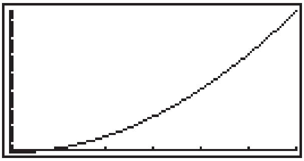


Table Func :Y=
Y1■$3X^2-2$
Y2=X+4

No highlighting

F6 (TABL) F5 (G·CON)

(Specifies connect type graph.)



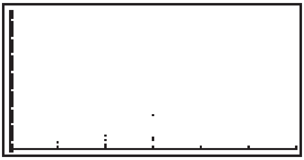
•To graph all of the functions

Example **To use the values in the numeric table generated using the Table Range and the View Window parameters from the previous example to graph all functions stored in memory as plot type graphs.**

Table Func :Y=
Y1■$3X^2-2$
Y2■X+4

F6 (TABL) F6 (G·PLT)

(Specifies plot type graph.)



- After you graph a function, you can press SHIFT F6 (G↔T) or AC to return to the function's numeric table.
- After graphing a function, you can use the trace, zoom, sketch functions. For details, see "8-6 Other Graphing Functions".

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•To graph a function using Dual Screen

Selecting "**T+G**" for the Dual Screen item of the set up screen makes it possible to display both the graph and its numeric table of values.

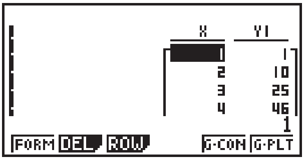
Example **To graph $y = 3x^2 - 2$ in memory area Y1, displaying both the graph and its table**

Use the same View Window parameters as in the example on page 214.

Display the set up screen and specify "T+G" for Dual Screen. Press EXIT.

F6(TABL)

(Shows the table.)



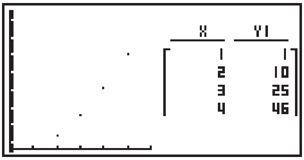
X	Y1
1	1
2	10
3	25
4	46

1

F6

F6(G·PLT)

(Draws plot type graph.)



X	Y1
1	1
2	10
3	25
4	46

- Pressing SHIFT F6 (G↔T) causes the graph on the left side of the Dual Screen to fill the entire display. Note that you cannot use the sketch function while a graph is displayed using SHIFT F6 (G↔T).

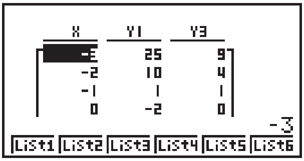
15-5 Copying a Table Column to a List

A simple operation lets you copy the contents of a numeric table column into a list.

•To copy a table to a list

Example **To copy the contents of Column *x* into List 1**

OPTN F1(LIST) F2(LMEM)



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

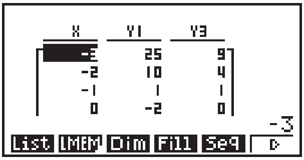
-3

F1

- You can select any row of the column you want to copy.

Press the function key that corresponds the list you want to copy to.

F1(List1)



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-3

Chapter 16

Recursion Table and Graph

You can input two formulas for any of the three following types of recursion, which you can then use to generate a table and draw graphs.

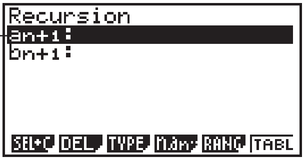
- General term of sequence $\{a_n\}$, made up of a_n and n
- Formulas for linear recursion between two terms, made up of a_{n+1}, a_n, and n
- Formulas for linear recursion between three terms, made up of a_{n+2}, a_{n+1}, a_n, and n

16-1 Before Using the Recursion Table and Graph Function

•To enter the RECUR Mode

On the Main Menu, select the **RECUR** icon and enter the RECUR Mode. This causes the Recursion Menu to appear.

Selected storage area
Press ⏶ and ⏷ to move.



Recursion
a_{n+1}:
b_{n+1}:

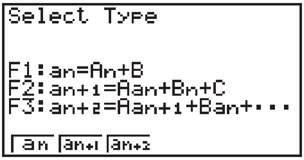
- All recursion formulas that are stored in memory appear in the Recursion Menu.

- {**SEL+C**} ... {menus for control of table generation and graph color}
- {**DEL**} ... {recursion formula delete}
- {**TYPE**} ... {recursion formula type specification}
- {n, a_n ···} ... {menu for input of variable n and general terms a_n and b_n}
- {**RANG**} ... {screen for setting of table range}
- {**TABL**} ... {recursion formula table generation}

•To specify the recursion formula type

Before inputting a recursion formula, you must first specify its type.

1. In the Recursion Menu, press F3 (TYPE).



Select Type

F1:a_n=An+B
F2:a_{n+1}=Aa_n+Bn+C
F3:a_{n+2}=Aa_{n+1}+Ba_n+···

- In this display, "a_n = An + B" is the general term (a_n = A × n + B) of {a_n}.

2. Press the function key for the recursion formula type you want to set.
   - {a_n}/{a_{n+1}}/{a_{n+2}} ... {general term of sequence {a_n}}/{linear recursion between two terms}/{linear recursion between three terms}

16-2 Inputting a Recursion Formula and Generating a Table

Example 1 **To input $a_{n+1} = 2a_n + 1$ and generate a table of values as the value of n change from 1 to 6**

Make $a_1 = 1$.

1. Specify the recursion formula type as linear recursion between two terms and then input the formula.

   2 F4 (n, a_n···) F2 (a_n) + 1

Recursion
an+1=2an+1_

2. Press EXE F5 (RANG) to display the table range setting screen, which contains the following items.
   - {a_0}/{a_1} ... setting of value for {a_0(b_0)}/{a_1(b_1)}

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The table range settings specify the conditions that control the value of variable n in the recursion formula, and the initial term of the numeric value table. You should also specify a starting point for the pointer when drawing a convergence/divergence graph (WEB graph) for a formula for linear recursion between two terms.

Start	Starting value of variable n
End	Ending value of variable n
a_0, b_0	Value of 0th term a_0/b_0 (a_1, b_1 .... Value of 1st term a_1/b_1)
a_nStr, b_nStr	Pointer starting point for convergence/divergence graph (WEB graph)

- The value of variable n increments by 1.

3. Specify the range of the table.

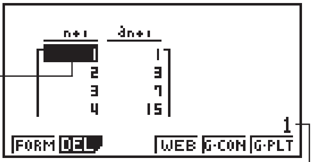
   F2 (a_1)

   1 EXE 6 EXE 1 EXE

Table Range n+1
Start:1
End :6
a1 :1

4. Display the table of the recursion formula. At this time, a menu of table functions appears at the bottom of the screen.

   EXIT F6 (TABL)



n+1	an+1
1	1
2	3
3	7
4	15

1

Currently selected cell (up to six digits)

Value in currently highlighted cell

- Displayed cell values show positive integers up to six digits, and negative integers up to five digits (one digit used for negative sign). Exponential display can use up to three significant digits.
- You can see the entire value assigned to a cell by using the cursor keys to move the highlighting to the cell whose value you want to view.

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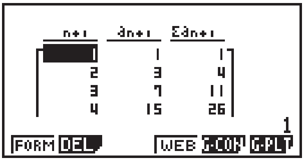
- You can also display the sums of the terms (Σa_n or Σb_n) by turning on Σ Display.



n+1	a_{n+1}	Σa_{n+1}
1	1	1
2	3	4
3	7	11
4	15	26

1

Example 2 **To input $a_{n+2} = a_{n+1} + a_n$ (Fibonacci series) and generate a table of values as the value of n change from 1 to 6**

Make $a_1 = 1$ and $a_2 = 1$.

1. Specify the recursion formula type as linear recursion between three terms and then input the formula.

[F3](TYPE) [F3](a_{n+2}) [F4]($n, a_n\cdots$)
[F3](a_{n+1}) [+] [F2](a_n)

Recursion
$a_{n+2}=a_{n+1}+a_n$_

2. Press [EXE] and then press [F5] (RANG) to display the table range setting screen, which contains the following items.

- {a_0}/{a_1} ... setting of value for {a_0 (b_0) and a_1 (b_1)}/{a_1 (b_1) and a_2 (b_2)}

The table range settings specify the conditions that control the value of variable n in the recursion formula, and the initial term of the numeric value table.

Start .... Starting value of variable n
End .... Ending value of variable n
a_0, a_1, a_2 .... Values of 0th term a_0/b_0, 1st term a_1/b_1, and 2nd term a_2/b_2.

- The value of variable n increments by 1.

3. Specify the range of the table.

[F2](a_1)
[1] [EXE] [6] [EXE] [1] [EXE] [1] [EXE]

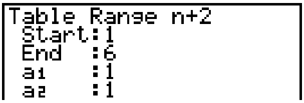
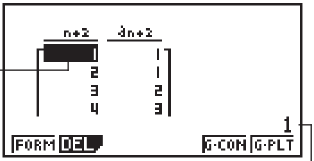


Table Range n+2
Start:1
End :6
a_1 :1
a_2 :1

4. Display the table of the recursion formula. At this time, a menu of table functions appears at the bottom of the screen.

EXIT F6(TABL)



n+2	a_{n+2}
1	1
2	1
3	2
4	3

1

Currently selected cell (up to six digits)

Value in currently highlighted cell

- There can be only one recursion table stored in memory at one time.
- Except for linear expression n, any of the following can be input for general term $\{a_n\}$ to generate a table: exponential expressions (such as $a_n = 2^n - 1$), fractional expressions (such as $a_n = (n + 1)/n$), irrational expressions (such as $a_n = \sqrt{n} - \sqrt{n-1}$), trigonometric expressions (such as a_n = sin $2n\pi$).

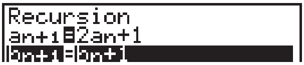
- Note the following points when specifying a table range.
  - If a negative value is specified as a start or end value, the calculator drops the negative sign. If a decimal value or fraction is specified, the unit uses only the integer part of the value.
  - If the value of a_0/b_0 (or a_1/b_1) is greater than the start value, the calculator makes the starting value of variable x the same as the value of a_0/b_0 (or a_1/b_1) before generating the table.
  - If the start value is greater than the end value, the calculator swaps the two values before generating the table.
  - If the start value is the same as the end value, the calculator generates a table using the start value of variable x only.
  - If the start value is very large, it may take a long time to generate a table for linear recursion between two terms and linear recursion between three terms.
- Changing the angle unit setting while a table generated from a trigonometric expression is on the display does not cause the displayed values to change. To cause the values in the table to be updated using the new setting, display the table, press F1 (FORM), change the angle unit setting, and then press F6 (TABL).

•To specify the generation/non-generation status of a formula

Example **To specify generation of a table for recursion formula $a_{n+1} = 2a_n + 1$ while there are two formulas stored**

▼ F1(SEL+C)

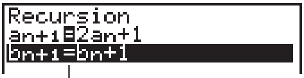
(Selects recursion formula to which non-generation status is to be assigned.)



Recursion
an+1■2an+1
bn+1=bn+1

F1(SEL)

(Specifies non-generation status.)

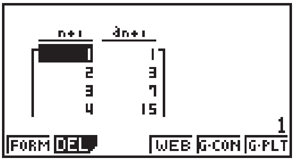


Recursion
an+1■2an+1
bn+1=bn+1

Unhighlights this formula

EXIT F6(TABL)

(Generates table.)



n+1	an+1
1	1
2	3
3	7
4	15

1

- To change the status of a recursion formula from non-generation to generation, select the formula and press F1 (SEL+C), F1 (SEL).

•To change the contents of a recursion formula

Changing the contents of a recursion formula causes the values in the table to be updated using the current table range settings.

Example **To change $a_{n+1} = 2a_n + 1$ to $a_{n+1} = 2a_n - 3$**

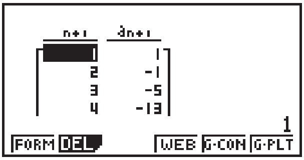
▶ (Displays the cursor.)

▶ ▶ − 3 EXE

(Changes the formula contents.)

Recursion
an+1■2an−3

F6(TABL)



n+1	an+1
1	1
2	-1
3	-5
4	-13

1

•To delete a recursion formula

1. Use ▲ and ▼ to highlight the formula you want to delete. Press F2 (DEL).
2. Press F1 (YES) to delete the formula or F6 (NO) to abort the operation without deleting anything.

16-3 Editing Tables and Drawing Graphs

You get a choice of four options for editing tables and drawing graphs.

- Deletion of a recursion formula table
- Drawing of a connect type graph
- Drawing of a plot type graph
- Drawing of a graph and analysis of convergence/divergence (WEB)

You can access these options from the function menu that appears at the bottom of the screen whenever a table is displayed.

- {**FORM**} ... {returns to Recursion Menu}
- {**DEL**} ... {table delete}
- {**WEB**} ... {convergence/divergence (WEB) graph draw} **P.225**
- {**G·CON**}/{**G·PLT**} ... {connected type}/{draw plot type} recursion graph draw **P.128**

- The {WEB} item is available only when a table generated using a formula for linear recursion between two terms (a_{n+1} =, b_{n+1} =) is on the display.

●To delete a recursion table

1. Display the recursion table you want to delete and then press F2 (DEL).

2. Press F1 (YES) to delete the table or F6 (NO) to abort the operation without deleting anything.

■ Before Drawing a Graph for a Recursion Formula

You must first specify the following.

- Graph color (blue, orange, green)
- Draw/non-draw status of for the recursion formula
- The type of data to be plotted

To specify the graph color and the draw/non-draw status, display the Recursion Menu and then press F1 (SEL+C) to display the following menu items.

- {**SEL**} ... {draw/non-draw status}
- {**BLUE**}/{**ORNG**}/{**GRN**} ... {blue}/{orange}/{green}

•To specify the color of the graph

The default color for a graph is blue. Use the following procedure to change the graph color to orange or green.

1. Display the Recursion Menu and then use ▲ and ▼ to highlight the formula whose graph color you want to change.
2. Press F1 (SEL+C).
3. Press the function key that corresponds to the color you want to specify.

•To specify the draw/non-draw status of a formula

There are two options for the draw/non-draw status of a recursion formula graph.

- Draw the graph for the selected recursion formula only
- Overlay the graphs for both recursion formulas

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To specify the draw/non-draw status, use same procedure as that for specifying generation/non-generation status.

•To specify the type of data to be plotted (Σ Display: On)

You can specify one of two types of data for plotting.

- a_n on the vertical axis, n on the horizontal axis
- Σa_n on the vertical axis, n on the horizontal axis

In the function menu that appears while a table is on the display, press F5 (G·CON) or F6 (G·PLT) to display the plot data menu.

- **{a_n}/{Σa_n}** ... {a_n}/{Σa_n} on vertical axis, n on horizontal axis

Example 1 **Draw a graph of $a_{n+1} = 2a_n + 1$ with a_n on the vertical axis and n on the horizontal axis, and with the points connected.**

Set the following parameters in the View Window.

Xmin = 0 **Ymin = 0**

Xmax = 6 **Ymax = 65**

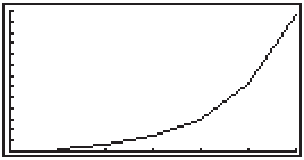
Xscale = 1 **Yscale = 5**

F6 (TABL) F5 (G·CON)

(Selects connected type.)

F1 (a_n)

(Draws graph with a_n on the vertical axis.)



Example 2 **Draw a graph of $a_{n+1} = 2a_n + 1$ with Σa_n on the vertical axis and n on the horizontal axis, and with the points unconnected.**

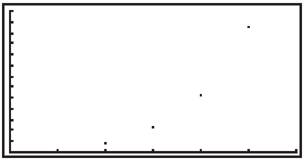
Use the same View Window parameters as those provided in Example 1.

F6 (TABL) F6 (G·PLT)

(Selects plot type.)

F6 (Σa_n)

(Draws graph with Σa_n on the vertical axis.)



- To input a different recursion formula after a graph is drawn, press SHIFT QUIT. This displays the Recursion Menu where you can input a new formula.

■ Drawing a Convergence/Divergence Graph (WEB graph)

With this feature, you can draw a graph of $a_{n+1} = f(a_n)$ where a_{n+1} and a_n are the terms of linear recursion between two terms, substituted respectively for y and x in the function $y = f(x)$. The resulting graph can then be viewed to determine whether or not the graph is convergent or divergent.

Example 1 **To determine whether or not the recursion formula $a_{n+1} = -3a_n^2 + 3a_n$ is convergent or divergent.**

Use the following table range.

Start = 0 **End = 6**

a_0 = 0.01 **a_n Str = 0.01**

b_0 = 0.11 **b_n Str = 0.11**

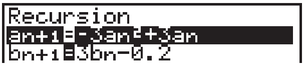
Use the following View Window parameters.

Xmin = 0 **Ymin = 0**

Xmax = 1 **Ymax = 1**

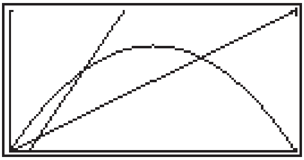
Xscale = 1 **Yscale = 1**

This example assumes that the following two recursion formulas are already stored in memory.

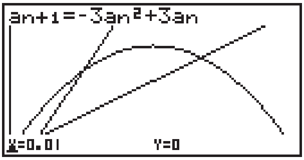


Recursion
an+1=-3an²+3an
bn+1=3bn-0.2

1. Press F6 (TABL) F4 (WEB) to draw the graph.



2. Press EXE, and the pointer appears at the pointer start point (a_nStr = 0.01).

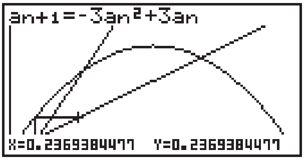


```
an+1=-3an²+3an
X=0.01              Y=0
```

- The Y value for the pointer start point is always 0.

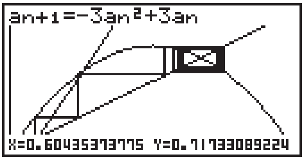
3. Each press of EXE draws web-like lines on the display.

EXE



```
an+1=-3an²+3an
X=0.2369384477   Y=0.2369384477
```

EXE



```
an+1=-3an²+3an
X=0.60435373775 Y=0.71733089224
```

This graph indicates that recursion formula $a_{n+1} = -3a_n^2 + 3a_n$ is convergent.

Example 2 **To determine whether or not the recursion formula $b_{n+1} = 3b_n + 0.2$ is convergent or divergent.**

Use the following table range.

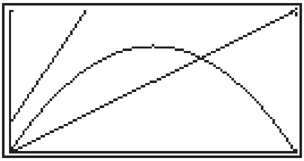
Start = 0 **End = 6**

b_0 = 0.02 **b_n Str = 0.02**

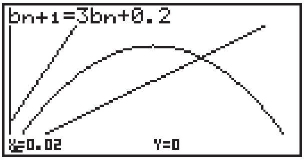
Use the View Window parameters from Example 1.

```
Recursion
an+1=-3an²+3an
bn+1=3bn+0.2
```

1. Press F6 (TABL) F4 (WEB) to draw the graph.



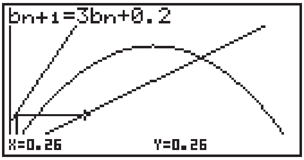
2. Press EXE and then either ▲ or ▼ to make the pointer appear at the pointer start point (b_nStr = 0.02).


bn+1=3bn+0.2
X=0.02 Y=0

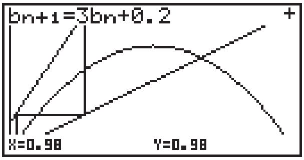
- The Y value for the pointer start point is always 0.

3. Each press of EXE draws web-like lines on the display.

EXE ⋮ ↓


bn+1=3bn+0.2
X=0.26 Y=0.26

EXE ⋮ ↓


bn+1=3bn+0.2
X=0.98 Y=0.98

This graph indicates that recursion formula $b_{n+1} = 3b_n + 0.2$ is divergent.

- Inputting b_n or n for the expression a_{n+1}, or Inputting a_n or n for the expression b_{n+1} for linear recursion between two terms causes an error.

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Drawing a Recursion Formula Graph Using Dual Screen

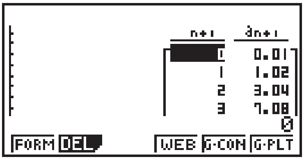
Selecting “**T+G**” for the Dual Screen item of the set up screen makes it possible to display both the graph and its numerical table of values.

Example **To draw the graph of $a_{n+1} = 2a_n + 1$ from Example 1, displaying both the graph and its table**

Display the set up screen and specify “T+G” for Dual Screen. Press EXIT.

F6 (TABL)

(Shows the table.)

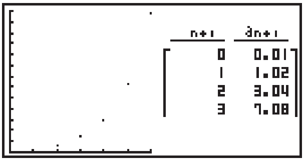


n+1	an+1
0	0.01
1	1.02
2	3.04
3	7.08

0

F6 (G·PLT)

(Draws plot type graph.)



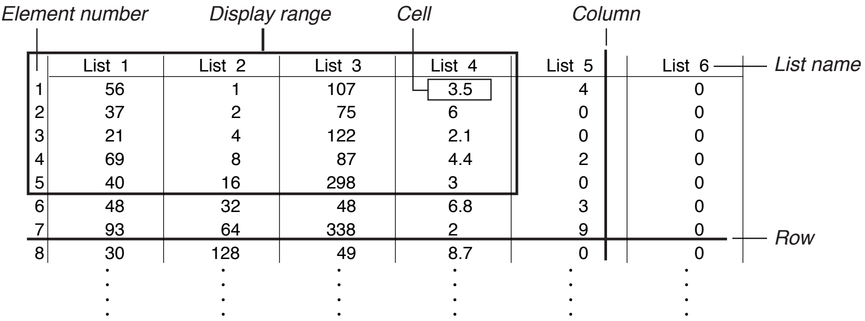
n+1	an+1
0	0.01
1	1.02
2	3.04
3	7.08

- Pressing SHIFT F6 (G↔T) causes the graph on the left side of the Dual Screen to fill the entire display. Note that you cannot use the sketch function while a graph is displayed using SHIFT F6 (G↔T).

Chapter 17

List Function

A list is a kind of container that you can use to store multiple data items.
This calculator lets you store up to six lists in a single file, and you can store up to six files in memory. Stored lists can be used in arithmetic, statistical, and matrix calculations, and for graphing.



	List 1	List 2	List 3	List 4	List 5	List 6
1	56	1	107	3.5	4	0
2	37	2	75	6	0	0
3	21	4	122	2.1	0	0
4	69	8	87	4.4	2	0
5	40	16	298	3	0	0
6	48	32	48	6.8	3	0
7	93	64	338	2	9	0
8	30	128	49	8.7	0	0
	:	:	:	:	:	:

List Data Linking

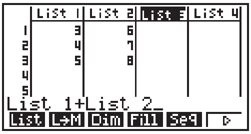
Operation

Graph

List operation

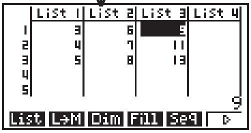
Example:
List 1 + List 2
{1, 2, 3} + {4, 5, 6}
List 1 + 3

List internal operations



```
  List 1 List 2 List 3 List 4
1      3      6
2      4      7
3      5      8
4
5
List 1+List 2_
List L→M Dim Fill Seq ▷
```

EXE



```
  List 1 List 2 List 3 List 4
1      3      6      9
2      4      7     11
3      5      8     13
4
5
                         9
List L→M Dim Fill Seq ▷
```

List graphing

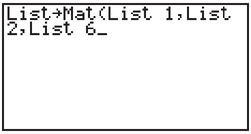
Y1=List 1X

From a graph to a list

Table data generated by GRAPH TO TABLE to a list

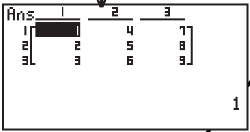
LIST

Memory transfer



```
List→Mat(List 1,List
2,List 6_
```

EXE

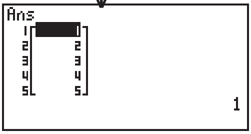


```
Ans  1   2   3
 1[  1   4   7]
 2[  2   5   8]
 3[  3   6   9]
                 1
```

Memory transfer

```
Mat→List(Mat A,1
```

EXE

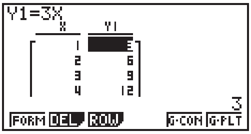


```
Ans
 1[  1]
 2[  2]
 3[  3]
 4[  4]
 5[  5]
         1
```

Example: To send column 1 of Mat A to a list

Generating a table by defining a list as the variable.

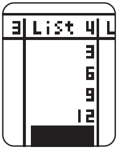
Copying the column of a specific table to a specific list.



```
Y1=3X
     X     Y1
     1      3
     2      6
     3      9
     4     12
                 3
FORM DEL ROW   G·CON G·PLT
```

OPTN
F1 (LIST)
F2 (LMEM)
F4 (List4)

Inside list



```
3 List 4 L
       3
       6
       9
      12
```

Matrix

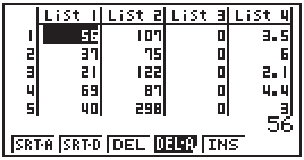
Table

17-1 List Operations

Select the **LIST** icon in the Main Menu and enter the LIST Mode to input data into a list and to manipulate list data.

•To input values one-by-one

Use the cursor keys to move the highlighting to the list name or cell you want to select. Note that ▼ does not move the highlighting to a cell that does not contain a value.



	List 1	List 2	List 3	List 4
1	56	107	0	3.5
2	37	75	0	6
3	21	122	0	2.1
4	69	87	0	4.4
5	40	298	0	3

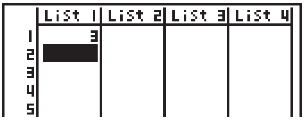
56

The screen automatically scrolls when the highlighting is located at either edge of the screen.

The following example procedure is performed starting with the highlighting located at Cell 1 of List 1.

1. Input a value and press EXE to store it in the list.

3 EXE

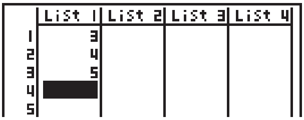


	List 1	List 2	List 3	List 4
1	3			
2				
3				
4				
5				

2. The highlighting automatically moves down to the next cell for input.

   - Note that you can also input the result of an expression in a cell. The following operation shows how to input the value 4 in the second cell and then input the result of 2 + 3 in the next cell.

4 EXE 2 + 3 EXE



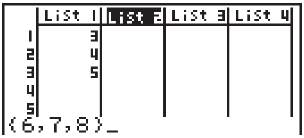
	List 1	List 2	List 3	List 4
1	3			
2	4			
3	5			
4				
5				

•To batch input a series of values

1. Use the cursor keys to move the highlighting to another list.

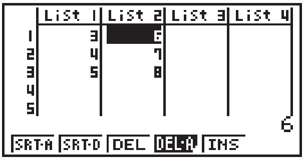
2. Press SHIFT {, and then input the values you want, pressing , between each one. Press SHIFT } after inputting the final value.

SHIFT { 6 , 7 , 8 SHIFT }



3. Press EXE to store all of the values in your list.

EXE



- Remember that a comma separates values, so you should not input a comma after the final value of the set you are inputting.

  Right: {34, 53, 78}

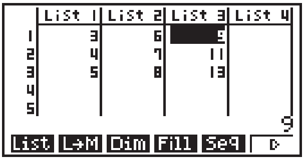
  Wrong: {34, 53, 78,}

You can also use list names inside of a mathematical expression to input values into another cell. The following example shows how to add the values in each row in List 1 and List 2, and input the result into List 3.

1. Use the cursor keys to move the highlighting to the name of the list where you want the calculation results to be input.

2. Press OPTN and input the expression.

OPTN F1(LIST) F1(List) 1 +
F1(List) 2 EXE



17-2 Editing and Rearranging Lists

Editing List Values

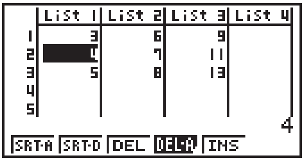
•To change a cell value

Use ◀ or ▶ to move the highlighting to the cell whose value you want to change. Input the new value and press EXE to replace the old data with the new one.

•To delete a cell

1. Use the cursor keys to move the highlighting to the cell you want to delete.

◀◀▼

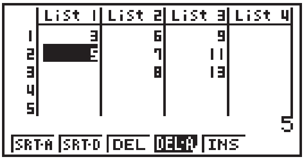


	List 1	List 2	List 3	List 4
1	3	6	9	
2	4	7	11	
3	5	8	13	
4				
5				

4

F3

2. Press F3 (DEL) to delete the selected cell and cause everything below it to be shifted up.



	List 1	List 2	List 3	List 4
1	3	6	9	
2	5	7	11	
3		8	13	
4				
5				

5

- Note that the above cell delete operation does not affect cells in other lists. If the data in the list whose cell you delete is somehow related to the data in neighboring lists, deleting a cell can cause related values to become misaligned.

•To delete all cells in a list

Use the following procedure to delete all the data in a list.

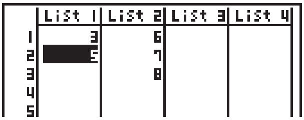
1. Use the cursor key to move the highlighting to any cell of the list whose data you want to delete.

2. Press F4 (DEL-A). The function menu changes to confirm whether you really want to delete all the cells in the list.

3. Press F1 (YES) to delete all the cells in the selected list or F6 (NO) to abort the delete operation without deleting anything.

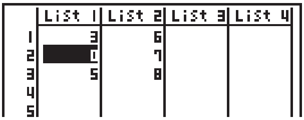
•To insert a new cell

1. Use the cursor keys to move the highlighting to the location where you want to insert the new cell.



	List 1	List 2	List 3	List 4
1	3	6		
2	5	7		
3		8		
4				
5				

2. Press F5 (INS) to insert a new cell, which contains a value of 0, causing everything below it to be shifted down.



	List 1	List 2	List 3	List 4
1	3	6		
2	0	7		
3	5	8		
4				
5				

- Note that the above cell insert operation does not affect cells in other lists. If the data in the list where you insert a cell is somehow related to the data in neighboring lists, inserting a cell can cause related values to become misaligned.

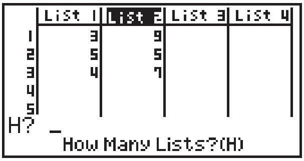
■ Sorting List Values

You can sort lists into either ascending or descending order. The highlighting can be located in any cell of the list.

•To sort a single list

Ascending order

1. While the lists are on the screen, press F1 (SRT-A).



	List 1	List 2	List 3	List 4
1	3	9		
2	5	5		
3	4	7		
4				
5				

```
H? _
   How Many Lists?(H)
```

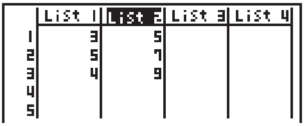
2. The prompt “How Many Lists? (H)” appears to ask how many lists you want to sort. Here we will input 1 to indicate we want to sort only one list.

1 EXE

```
L? _
     Select List(L)
```

3. In response to the “Select List (L)” prompt, input the number of the list you want to sort. Here we will input 2 to specify sorting of List 2.

2 EXE



	List 1	List 2	List 3	List 4
1	3	5		
2	5	7		
3	4	9		
4				
5				

Descending order

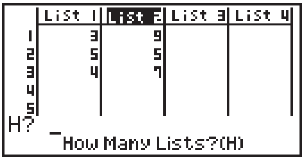
Use the same procedure as that for the ascending order sort. The only difference is that you should press F2 (SRT-D) in place of F1 (SRT-A).

•To sort multiple lists

You can link multiple lists together for a sort so that all of their cells are rearranged in accordance with the sorting of a base list. The base list is sorted into either ascending order or descending order, while the cells of the linked lists are arranged so that the relative relationship of all the rows is maintained.

Ascending order

1. While the lists are on the screen, press F1 (SRT-A).



	List 1	List 2	List 3	List 4
1	3	9		
2	5	5		
3	4	7		
4				
5				

H? _
How Many Lists?(H)

2. The prompt “How Many Lists? (H)” appears to ask how many lists you want to sort. Here we will sort one base list linked to one other list, so we should input 2.

2 EXE

B? _
Select Base List(B)

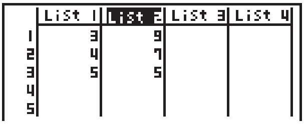
3. In response to the “Select Base List (B)” prompt, input the number of the list you want to sort into ascending order. Here we will specify List 1.

1 EXE

L? _
Select Second List(L)

4. In response to the “Select Second List (L)” prompt, input the number of the list you want to link to the base list. Here we will specify List 2.

2 EXE



	List 1	List 2	List 3	List 4
1	3	9		
2	4	7		
3	5	5		
4				
5				

Descending order

Use the same procedure as that for the ascending order sort. The only difference is that you should press F2 (SRT-D) in place of F1 (SRT-A).

- You can sort up to six lists at one time.
- If you specify a list more than once for a single sort operation, an error occurs.

  An error also occurs if lists specified for sorting do not have the same number of values (rows).

17-3 Manipulating List Data

List data can be used in arithmetic and function calculations. In addition, various list data manipulation functions makes manipulation of list data quick and easy.

You can use list data manipulation functions in the **RUN**, **STAT**, **MAT**, **LIST**, **TABLE**, **EQUA** and **PRGM Modes**.

■ Accessing the List Data Manipulation Function Menu

All of the following examples are performed after entering the **RUN Mode**.

Press OPTN and then F1 (LIST) to display the list data manipulation menu, which contains the following items.

- **{List}/{L→M}/{Dim}/{Fill}/{Seq}/{Min}/{Max}/{Mean}/{Med}/{Sum}/{Prod}/{Cuml}/{%}/{⊿}**

Note that all closing parentheses at the end of the following operations can be omitted.

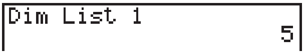
●To count the number of values **[OPTN]-[LIST]-[Dim]**

OPTN F1(LIST) F3(Dim) F1(List) <list number 1-6> EXE

- The number of cells that contain data in a list is called its "dimension."

Example **To enter the RUN Mode and count the number of values in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F3(Dim)
F1(List) 1 EXE



```
Dim List 1
                  5
```

●To create a list or matrix by specifying the number of data
[OPTN]-[LIST]-[Dim]

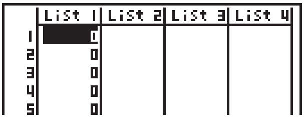
Use the following procedure to specify the number of data in the assignment statement and create a list.

<number of data *n*> → OPTN F1(LIST) F3(Dim) F1(List)
<list number 1-6> EXE

$n = 1 \sim 255$

Example **To create five data items (each of which contains 0) in List 1**

AC 5 → OPTN F1(LIST) F3(Dim)
F1(List) 1 EXE



```
   List 1 List 2 List 3 List 4
 1      0
 2      0
 3      0
 4      0
 5      0
```

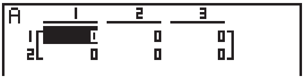
Use the following procedure to specify the number of data rows and columns, and the matrix name in the assignment statement and create a matrix.

SHIFT { <number of row *m*> , <number of column *n*> SHIFT } →
OPTN F1(LIST) F3(Dim) EXIT F2(MAT) F1(Mat) ALPHA <matrix name> EXE

m, *n* = 1 ~ 255, matrix name; A ~ Z

Example **To create a 2-row × 3-column matrix (each cell of which contains 0) in Matrix A**

AC SHIFT { 2 , 3 SHIFT } →
OPTN F1(LIST) F3(Dim) EXIT
F2(MAT) F1(Mat) ALPHA A EXE



```
A     1     2     3
1 [   0     0     0 ]
2 [   0     0     0 ]
```

●To replace all cell values with the same value [OPTN]-[LIST]-[Fill]

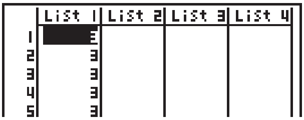
OPTN F1 (LIST) F4 (Fill) <value> , F1 (List) <list number 1-6>) EXE

Example **To replace all values in List 1 with 3**

AC OPTN F1(LIST) F4(Fill)
3 , F1(List) 1) EXE

```
Fill(3,List 1)
                Done
```

The following shows the new contents of List 1.



```
   List 1 List 2 List 3 List 4
 1      3
 2      3
 3      3
 4      3
 5      3
```

●To generate a sequence of numbers [OPTN]-[LIST]-[Seq]

OPTN F1 (LIST) F5 (Seq) <expression> , <variable name> , <start value> , <end value> , <pitch>) EXE

- The result of this operation is stored in ListAns Memory.

Example **To input the number sequence 1^2, 6^2, 11^2 into a list**

Use the following settings.

Variable: *x* Ending value: 11

Starting value: 1 Pitch: 5

AC OPTN F1(LIST) F5(Seq) X,θ,T
x^2 , X,θ,T , 1 , 1 1 , 5) EXE


```
Ans
 1[  1]
 2  36
 3L 121]
```

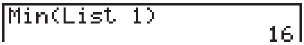
Specifying an ending value of 12, 13, 14, or 15 produces the same result as shown above, because all of them are less than the value produced by the next increment (16).

●To find the minimum value in a list [OPTN]-[LIST]-[Min]

OPTN F1(LIST) F6(▷) F1(Min) F6(▷) F6(▷) F1(List) <list number 1-6>
) EXE

Example **To find the minimum value in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F6(▷) F1(Min)
F6(▷) F6(▷) F1(List) 1) EXE


```
Min(List 1)
             16
```

●To find the maximum value in a list [OPTN]-[LIST]-[Max]

Use the same procedure as when finding the minimum value (Min), except press F2 (Max) in place of F1 (Min).

●To find which of two lists contains the smallest value

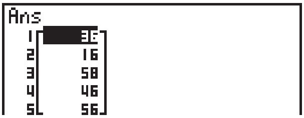
[OPTN]-[LIST]-[Min]

OPTN F1(LIST) F6(▷) F1(Min) F6(▷) F6(▷) F1 (List) <list number 1-6>
, F1 (List) <list number 1-6>) EXE

- The two lists must contain the same number of values. If they don't, an error occurs.
- The result of this operation is stored in ListAns Memory.

Example **To find whether List 1 (75, 16, 98, 46, 56) or List 2 (36, 89, 58, 72, 67) contains the smallest value**

OPTN F1(LIST) F6(▷) F1(Min)
F6(▷) F6(▷) F1(List) 1 ,
F1(List) 2) EXE


```
Ans
 1[ 36]
 2  16
 3  58
 4  46
 5L 56]
```

•To find which of two lists contains the greatest value

[OPTN]-[LIST]-[Max]

Use the same procedure as that for the smallest value, except press F2 (Max) in place of F1 (Min).

- The two lists must contain the same number of values. If they don't, an error occurs.

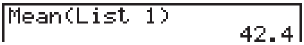
•To calculate the mean of list values

[OPTN]-[LIST]-[Mean]

OPTN F1(LIST) F6(▷) F3(Mean) F6(▷) F6(▷) F1(List) <list number 1-6>) EXE

Example **To calculate the mean of values in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F6(▷) F3(Mean)
F6(▷) F6(▷) F1(List) 1) EXE



```
Mean(List 1)
            42.4
```

•To calculate the mean of values of specified frequency

[OPTN]-[LIST]-[Mean]

This procedure uses two lists: one that contains values and one that contains the number of occurrences of each value. The frequency of the data in Cell 1 of the first list is indicated by the value in Cell 1 of the second list, etc.

- The two lists must contain the same number of values. If they don't, an error occurs.

OPTN F1(LIST) F6(▷) F3(Mean) F6(▷) F6(▷) F1(List)<list number 1-6 (data)> , F1(List)<list number 1-6 (frequency)>) EXE

Example **To calculate the mean of values in List 1 (36, 16, 58, 46, 56), whose frequency is indicated by List 2 (75, 89, 98, 72, 67)**

AC OPTN F1(LIST) F6(▷) F3(Mean)
F6(▷) F6(▷) F1(List) 1 ,
F1(List) 2) EXE

```
Mean(List 1,List 2)
        42.07481297
```

•To calculate the median of values in a list

[OPTN]-[LIST]-[Med]

OPTN F1(LIST) F6(▷) F4(Med) F6(▷) F6(▷) F1(List)<list number 1-6>) EXE

Example **To calculate the median of values in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F6(▷) F4(Med)
F6(▷) F6(▷) F1(List) 1) EXE

```
Median(List 1)
              46
```

•To calculate the median of values of specified frequency

[OPTN]-[LIST]-[Med]

This procedure uses two lists: one that contains values and one that contains the number of occurrences of each value. The frequency of the data in Cell 1 of the first list is indicated by the value in Cell 1 of the second list, etc.

- The two lists must contain the same number of values. If they don't, an error occurs.

OPTN F1(LIST) F6(▷) F4(Med) F6(▷) F6(▷) F1(List) <list number 1-6 (data)> , F1(List) <list number 1-6 (frequency)>) EXE

Example **To calculate the median of values in List 1 (36, 16, 58, 46, 56), whose frequency is indicated by List 2 (75, 89, 98, 72, 67)**

AC OPTN F1(LIST) F6(▷) F4(Med)
F6(▷) F6(▷) F1(List) 1 ,
F1(List) 2) EXE

```
Median(List 1,List 2)
                   46
```

•To calculate the sum of values in a list

[OPTN]-[LIST]-[Sum]

OPTN F1(LIST) F6(▷) F6(▷) F1(Sum) F6(▷) F1(List)<list number 1-6>
EXE

Example **To calculate the sum of values in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) F6(▷) F6(▷)
F1(Sum) F6(▷) F1(List) 1 EXE

```
Sum List 1
                  212
```

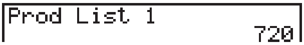
•To calculate the sum of products

[OPTN]-[LIST]-[Prod]

OPTN F1(LIST) F6(▷) F6(▷) F2(Prod) F6(▷) F1(List)<list number 1-6> EXE

Example **To calculate the sum of products for the values in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1(LIST) F6(▷) F6(▷)
F2(Prod) F6(▷) F1(List) 1 EXE



```
Prod List 1
                  720
```

•To calculate the cumulative frequency of each value

[OPTN]-[LIST]-[Cuml]

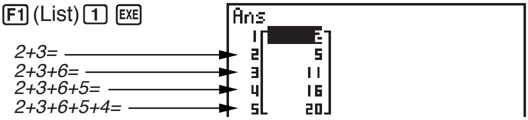
OPTN F1(LIST) F6(▷) F6(▷) F3(Cuml) F6(▷) F1(List) <list number 1-6>
EXE

- The result of this operation is stored in ListAns Memory.

Example **To calculate the cumulative frequency of each value in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1 (LIST) F6 (▷) F6 (▷)

F3 (Cuml) F6 (▷) F1 (List) 1 EXE



```
Ans
 1[  2]
 2   5
 3  11
 4  16
 5[ 20]
```

●To calculate the percentage represented by each value

[OPTN]-[LIST]-[%]

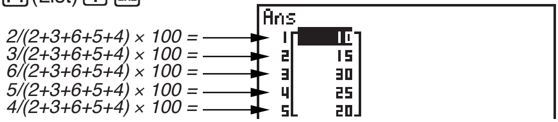
OPTN F1 (LIST) F6 (▷) F6 (▷) F4 (%) F6 (▷) F1 (List)<list number 1-6> EXE

- The above operation calculates what percentage of the list total is represented by each value.
- The result of this operation is stored in ListAns Memory.

Example **To calculate the percentage represented by each value in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1 (LIST) F6 (▷) F6 (▷)

F4 (%) F6 (▷) F1 (List) 1 EXE



```
Ans
 1[ 10]
 2  15
 3  30
 4  25
 5[ 20]
```

●To calculate the differences between neighboring data inside a list

[OPTN]-[LIST]-[⊿]

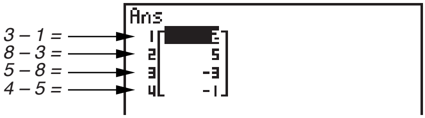
OPTN F1 (LIST) F6 (▷) F6 (▷) F5 (⊿) F6 (▷)<list number 1-6> EXE

- The result of this operation is stored in ListAns memory.

Example **To calculate the difference between the values in List 1 (1, 3, 8, 5, 4)**

AC OPTN F1 (LIST) F6 (▷)

F6 (▷) F5 (⊿) 1 EXE



```
Ans
 1[  2]
 2   5
 3  -3
 4[ -1]
```

- You can specify the location of the new list (List 1 through List 6) with a statement like: ⊿ List 1 → List 2. You cannot specify another memory or ListAns as the destination of the ⊿ List operation. An error also occurs if you specify a ⊿ List as the destination of the results of another ⊿ List operation.
- The number of cells in the new list is one less than the number of cells in the original list.
- Note that an error occurs if you execute ⊿ List for a list that has no data or only one data item.

●To transfer list contents to Matrix Answer Memory

[OPTN]-[LIST]-[L→M]

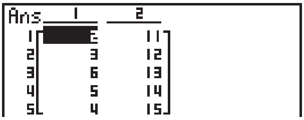
OPTN F1(LIST) F2(L→M) F1(List) <list number 1-6> , F1(List) <list number 1-6>) EXE

- You can input the following as many times as necessary to specify more than one list in the above operation.

, <list number 1-6>

Example **To transfer the contents of List 1 (2, 3, 6, 5, 4) and List 2 (11, 12, 13, 14, 15) to Matrix Answer Memory**

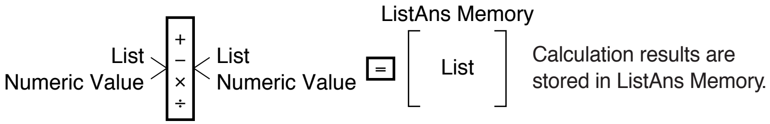
AC OPTN F1(LIST) F2(L→M)
F1(List) 1 , F1(List) 2) EXE



Ans	1	2
1	2	11
2	3	12
3	6	13
4	5	14
5	4	15

17-4 Arithmetic Calculations Using Lists

You can perform arithmetic calculations using two lists or one list and a numeric value.



Error Messages

- A calculation involving two lists performs the operation between corresponding cells. Because of this, an error occurs if the two lists do not have the same number of values (which means they have different “dimensions”).
- An error occurs whenever an operation involving any two cells generates a mathematical error.

Inputting a List into a Calculation

There are two methods you can use to input a list into a calculation.

•To input a specific list by name

Example **To input List 6**

1. Press OPTN to display the first Operation Menu.
   - This is the function key menu that appears in the **RUN Mode** when you press OPTN.

2. Press F1 (LIST) to display the List Data Manipulation Menu.

3. Press F1 (List) to display the “List” command and input the number of the list you want to specify.

•To directly input a list of values

You can also directly input a list of values using {, }, and ,.

Example 1 **To input the list: 56, 82, 64**

SHIFT { 5 6 , 8 2 ,
6 4 SHIFT }

{56,82,64}_

Example 2 **To multiply List 3 $\left(= \begin{bmatrix} 41 \\ 65 \\ 22 \end{bmatrix} \right)$ by the list $\begin{bmatrix} 6 \\ 0 \\ 4 \end{bmatrix}$**

OPTN F1(LIST) F1(List) 3 × SHIFT { 6 , 0 , 4 SHIFT } EXE

The resulting list $\begin{bmatrix} 246 \\ 0 \\ 88 \end{bmatrix}$ is stored in ListAns Memory.

•To assign the contents of one list to another list

Use → to assign the contents of one list to another list.

Example 1 **To assign the contents of List 3 to List 1**

OPTN F1(LIST) F1(List) 3 → F1(List) 1 EXE

In place of F1 (List) 3 operation in the above procedure, you could input SHIFT { 4 1 , 6 5 , 2 2 SHIFT }.

Example 2 **To assign the list in ListAns Memory to List 1**

OPTN F1(LIST) F1(List) SHIFT Ans → F1(List) 1 EXE

•To input a single list cell value into a calculation

You can extract the value in a specific cell of a list and use it in a calculation. Specify the cell number by enclosing it between square brackets using the [and] keys.

Example **To calculate the sine of the value stored in Cell 3 of List 2**

sin OPTN F1(LIST) F1(List) 2 SHIFT [3 SHIFT] EXE

•To input a value into a specific cell

You can input a value into a specific cell inside a list. When you do, the value that was previously stored in the cell is replaced with the new value you input.

Example **To input the value 25 into Cell 2 of List 3**

2 5 → OPTN F1(LIST) F1(List) 3 SHIFT [2 SHIFT] EXE

Recalling List Contents

Example **To recall the contents of List 1**

OPTN F1 (LIST) F1 (List) 1 EXE

- The above operation displays the contents of the list you specify and also stores them in ListAns Memory. You can then use the ListAns Memory contents in a calculation.

•To use list contents in ListAns Memory in a calculation

Example **To multiply the list contents in ListAns Memory by 36**

OPTN F1 (LIST) F1 (List) SHIFT Ans × 3 6 EXE

- The operation OPTN F1 (LIST) F1 (List) SHIFT Ans recalls ListAns Memory contents.
- This operation replaces current ListAns Memory contents with the result of the above calculation.

Graphing a Function Using a List

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When using the graphing functions of this calculator, you can input a function such as Y1 = List1 X. If List 1 contains the values 1, 2, 3, this function will produces three graphs: Y = X, Y = 2X, Y = 3X.
There are certain limitations on using lists with graphing functions.

Inputting Scientific Calculations into a List

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You can use the numeric table generation functions in the Table & Graph Menu to input values that result from certain scientific function calculations into a list. To do this, first generate a table and then use the list copy function to copy the values from the table to the list.

Performing Scientific Function Calculations Using a List

Lists can be used just as numeric values are in scientific function calculations. When the calculation produces a list as a result, the list is stored in ListAns Memory.

Example 1 **To use List 3 $\begin{bmatrix} 41 \\ 65 \\ 22 \end{bmatrix}$ to perform sin (List 3)**

Use radians as the angle unit.

sin OPTN F1 (LIST) F1 (List) 3 EXE

The resulting list $\begin{bmatrix} -0.158 \\ 0.8268 \\ -8E-3 \end{bmatrix}$ is stored in ListAns Memory.

In place of the F1 (List) 3 operation in the above procedure, you could input SHIFT { 4 1 , 6 5 , 2 2 SHIFT }.

Example 2 **To use List 1** $\begin{bmatrix} \mathbf{1} \\ \mathbf{2} \\ \mathbf{3} \end{bmatrix}$ **and List 2** $\begin{bmatrix} \mathbf{4} \\ \mathbf{5} \\ \mathbf{6} \end{bmatrix}$ **to perform List 1**$^{\textbf{List 2}}$

List1 ^ List2 EXE

This creates a list with the results of 1^4, 2^5, 3^6.

The resulting list $\begin{bmatrix} 1 \\ 32 \\ 729 \end{bmatrix}$ is stored in ListAns Memory.

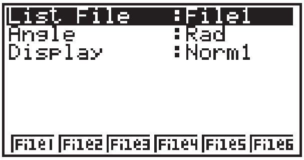
17-5 Switching Between List Files

You can store up to six lists (List 1 to List 6) in each file (File 1 to File 6). A simple operation lets you switch between list files.

•To switch between list files

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

Press SHIFT SETUP to display the LIST Mode set up screen.



List File :File1
Angle :Rad
Display :Norm1

Press the function key to select the file you want.

Example **To select File 3**

F3(File3)

EXIT

List File :File3

All subsequent list operations are applied to the lists contained in the file you select (List File3 in the above example).

Chapter 18

Statistical Graphs and Calculations

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

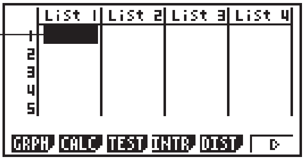
Important!

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

18-1 Before Performing Statistical Calculations

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

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



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

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

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

18-2 Paired-Variable Statistical Calculation Examples

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

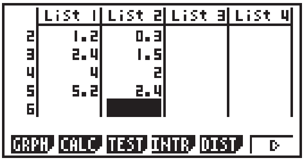
Example **To input the following two data groups and perform statistical calculations**

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

■ Inputting Data into Lists

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

0 • 5 EXE 1 • 2 EXE
2 • 4 EXE 4 EXE 5 • 2 EXE
▶
(−) 2 • 1 EXE 0 • 3 EXE
1 • 5 EXE 2 EXE 2 • 4 EXE



	List 1	List 2	List 3	List 4
2	1.2	0.3		
3	2.4	1.5		
4	4	2		
5	5.2	2.4		
6				

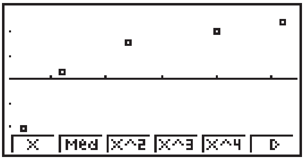
Once data is input, you can use it for graphing and statistical calculations.

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

■ Plotting a Scatter Diagram

Use the data input above to plot a scatter diagram.

F1(GRPH) F1(GPH1)



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

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

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

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

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

SHIFT SETUP F2 (Man)

EXIT (Returns to previous menu.)

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

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

■ Changing Graph Parameters

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

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

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

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

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- {**SEL**} ... {simultaneous graph (GPH1, GPH2, GPH3) selection}
- {**SET**} ... {graph settings (graph type, list assignments)}

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

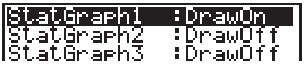
- You can press any function key (F1, F2, F3) to draw a graph regardless of the current location of the highlighting in the statistical data list.

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

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

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

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



```
StatGraph1   :DrawOn
StatGraph2   :DrawOff
StatGraph3   :DrawOff
```

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

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

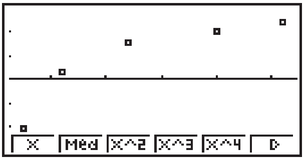
- {**On**}/{**Off**} ... setting {On (draw)}/{Off (non-draw)}
- {**DRAW**} ... {draws all On graphs}

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

•To draw a graph

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

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



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

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

- **Graph Type**

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

- **List**

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

- **Frequency**

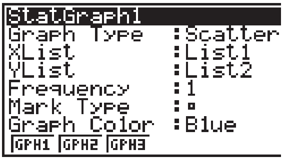
Normally, each data item or data pair in the statistical data list is represented on a graph as a point. When you are working with a large number of data items however, this can cause problems because of the number of plot points on the graph. When this happens, you can specify a frequency list that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

- **Mark Type**

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

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

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



```
StatGraph1
Graph Type   :Scatter
XList        :List1
YList        :List2
Frequency    :1
Mark Type    :▫
Graph Color  :Blue
```

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

•StatGraph (statistical graph specification)

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

•Graph Type (graph type specification)

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

•XList (*x*-axis data list)

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

•YList (*y*-axis data list)

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

•Frequency (number of data items)

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

•Mark Type (plot mark type)

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

•Graph Color (graph color specification)

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

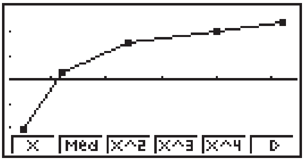
•Outliers (outliers specification)

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

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

■ Drawing an *xy* Line Graph

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

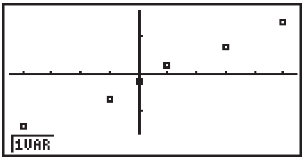


Press EXIT or SHIFT QUIT to return to the statistical data list.

P.254
(Graph Type)
(NPP)

■ Drawing a Normal Probability Plot

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



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

■ Selecting the Regression Type

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

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

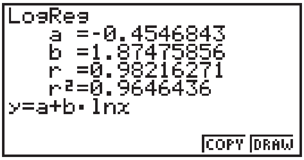
Displaying Statistical Calculation Results

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

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

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

F6(▷)F1(Log)



```
LogReg
   a =-0.4546843
   b =1.87475856
   r =0.98216271
   r²=0.9646436
y=a+b·lnx
```

Graphing Statistical Calculation Results

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

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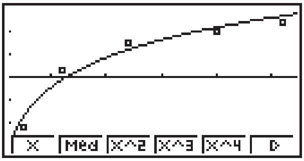
- {**COPY**} ... {stores the displayed regression formula as a graph function}
- {**DRAW**} ... {graphs the displayed regression formula}

Example **To graph a logarithmic regression**

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



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

18-3 Calculating and Graphing Single-Variable Statistical Data

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

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

■ Drawing a Histogram (Bar Graph)

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

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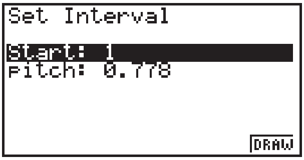
Data should already be input in the statistical data list (see "Inputting Data into Lists"). Draw the graph using the procedure described under "Changing Graph Parameters".

P.254
(Graph Type)
(Hist)

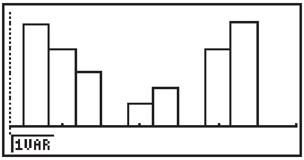


Set Interval

Start: 1
Pitch: 0.778

F6

⇒
F6 (DRAW)



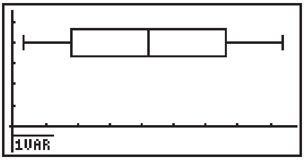
The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and pitch values.

■ Med-box Graph (Med-Box)

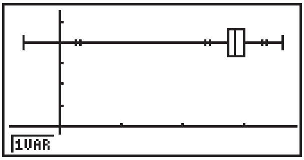
P.254
(Graph Type)
(Box)

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

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



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



P.254
(Graph Type)
(Box)

■ Mean-box Graph

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

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

Note :

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

P.254
(Graph Type)
(N·Dis)

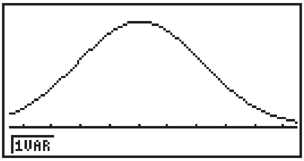
■ Normal Distribution Curve

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

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

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

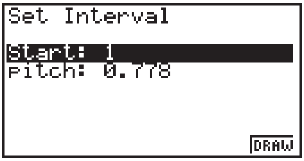
From the statistical data list, press F1 (GRPH) to display the graph menu, press F6 (SET), and then change the graph type of the graph you want to use (GPH1, GPH2, GPH3) to normal distribution.



P.254
(Graph Type)
(Brkn)

■ Line Graph

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

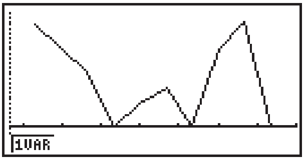


```
Set Interval

Start: 1
pitch: 0.778
```

F6

⇒
F6 (DRAW)



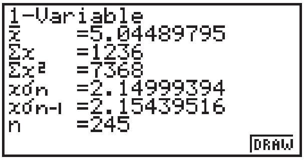
The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and pitch values.

■ Displaying Single-Variable Statistical Results

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

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

Pressing F1 (1VAR) displays the following screen.



```
1-Variable
x̄      =5.04489795
Σx     =1236
Σx²    =7368
xσn    =2.14999394
xσn-1  =2.15439516
n      =245
```

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

The following describes the meaning of each of the parameters.

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

Σx .... sum of data

Σx^2 .... sum of squares

$x\sigma_n$ .... population standard deviation

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

n .... number of data items

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

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

18-4 Calculating and Graphing Paired-Variable Statistical Data

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

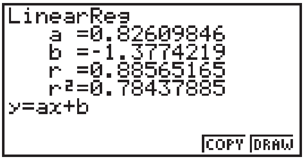
■ Linear Regression Graph

P.254

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

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

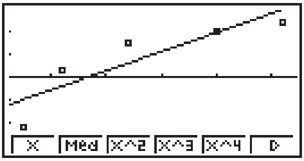
(Graph Type) SHIFT QUIT F1(GRPH) F6(SET) ▼
(Scatter) F1(Scat)
(GPH1) SHIFT QUIT F1(GRPH) F1(GPH1)
(X) F1(X)



```
LinearReg
   a =0.82609846
   b =-1.3774219
   r =0.88565165
   r²=0.78437885
y=ax+b
```

F6

F6(DRAW)



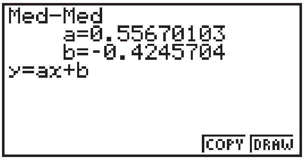
a ...... regression coefficient (slope)
b ...... regression constant term (intercept)
r .... correlation coefficient
r^2 ...... coefficient of determination

■ Med-Med Graph

P.254

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

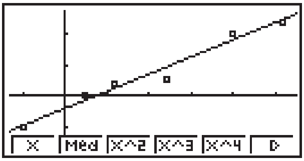
F2(Med)



```
Med-Med
     a=0.55670103
     b=-0.4245704
y=ax+b
```

F6

F6(DRAW)



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

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

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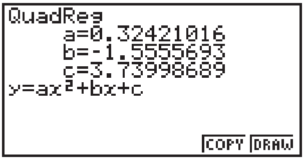
■ Quadratic/Cubic/Quartic Regression Graph

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

Ex. Quadratic regression

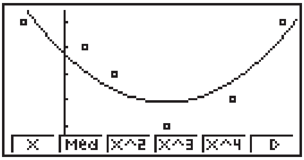
F3(X^2)



```
QuadReg
    a=0.32421016
    b=-1.5555693
    c=3.73998689
y=ax²+bx+c
```

F6

F6(DRAW)



Quadratic regression

a ...... regression second coefficient

b ...... regression first coefficient

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

Cubic regression

a ...... regression third coefficient

b ...... regression second coefficient

c ...... regression first coefficient

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

Quartic regression

a ...... regression fourth coefficient

b ...... regression third coefficient

c ...... regression second coefficient

d ...... regression first coefficient

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

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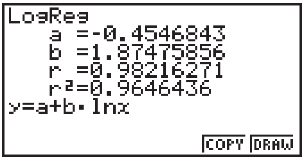
■ Logarithmic Regression Graph

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

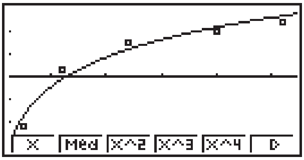
F6(▷)F1(Log)



```
LogReg
   a =-0.4546843
   b =1.87475856
   r =0.98216271
   r²=0.9646436
y=a+b·lnx
```

F6

F6(DRAW)



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

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

r ...... correlation coefficient

r^2 ..... coefficient of determination

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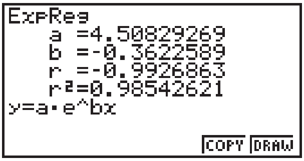
■ Exponential Regression Graph

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

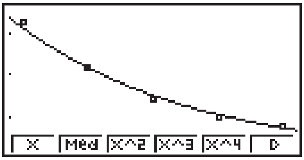
F6(▷)F2(Exp)



```
ExpReg
   a =4.50829269
   b =-0.3622589
   r =-0.9926863
   r²=0.98542621
y=a·e^bx
```

F6

F6(DRAW)



a ...... regression coefficient

b ...... regression constant term

r ...... correlation coefficient

r^2 ..... coefficient of determination

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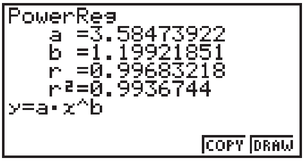
■ Power Regression Graph

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

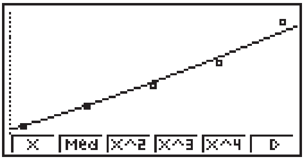
F6 (▷) F3 (Pwr)



```
PowerReg
   a =3.58473922
   b =1.19921851
   r =0.99683218
   r²=0.9936744
y=a·x^b
```

F6

F6 (DRAW)



a ...... regression coefficient

b ...... regression power

r ...... correlation coefficient

r^2 ..... coefficient of determination

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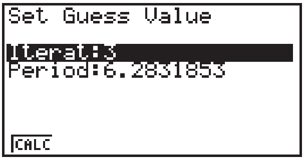
■ Sine Regression Graph

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

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

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

F6 (▷) F5 (Sin)



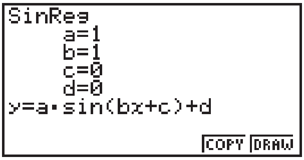
```
Set Guess Value

Iterat:3
Period:6.2831853
```

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

Period ...... domain

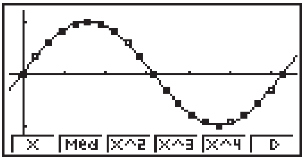
F1 (CALC)



```
SinReg
     a=1
     b=1
     c=0
     d=0
y=a·sin(bx+c)+d
```

F6

F6(DRAW)



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

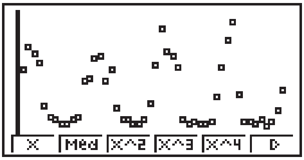
Example **To perform sine regression using the gas usage data shown below**

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

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

Input the above data and plot a scatter diagram.

F1(GRPH) F1(GPH1)

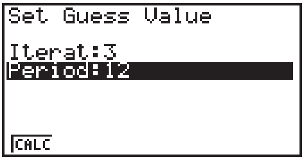


Since this example involves monthly billing, we will assume a period of 12.

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

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

F6(▷) F5(Sin) ▼ 1 2 EXE



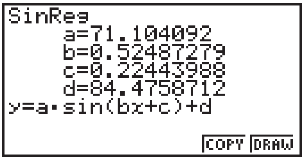
Set Guess Value

Iterat:3
Period:12

CALC

Execute the calculation and produce sine regression analysis results.

F1(CALC)

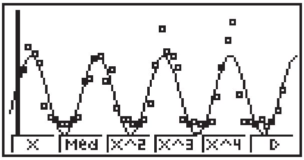


```
SinReg
    a=71.104092
    b=0.52487279
    c=0.22443988
    d=84.4758712
y=a·sin(bx+c)+d
```

F6

Display a sine regression graph based on the analysis results.

F6(DRAW)



Residual Calculation

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

P.6

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

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

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

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

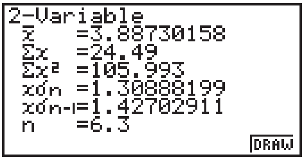
Any data already existing in the selected list is cleared. The residual of each plot is stored in the same precedence as the data used as the model.

Displaying Paired-Variable Statistical Results

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

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

Pressing F4 (2VAR) displays the following screen.



```
2-Variable
 x̄    =3.88730158
 Σx   =24.49
 Σx²  =105.993
 xσn  =1.30888199
 xσn-1=1.42702911
 n    =6.3
```

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

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

■ Copying a Regression Graph Formula to the Graph Mode

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

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

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

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

```
Graph Func
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:
    To Store :[EXE]
```

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

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

Multiple Graphs

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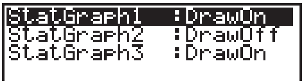
You can draw more than one graph on the same display by using the procedure under “Changing Graph Parameters” to set the graph draw (On)/non-draw (Off) status of two or all three of the graphs to draw “**On**”, and then pressing F6 (DRAW). After drawing the graphs, you can select which graph formula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



```
StatGraph1  :DrawOn
StatGraph2  :DrawOff
StatGraph3  :DrawOn
```

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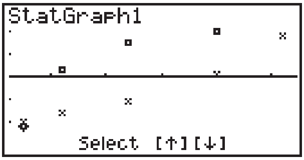
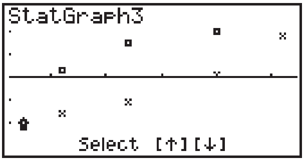
F6(DRAW)
F1(X)



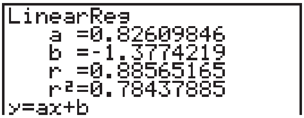
- The text at the top of the screen indicates the currently selected graph (StatGraph1 = Graph 1, StatGraph2 = Graph 2, StatGraph3 = Graph 3).

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

▼



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



```
LinearReg
   a =0.82609846
   b =-1.3774219
   r =0.88565165
   r²=0.78437885
y=ax+b
```

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

18-5 Performing Statistical Calculations

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

•To specify statistical calculation data lists

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

```
1Var XList  :List1
1Var Freq   :1
2Var XList  :List1
2Var YList  :List2
2Var Freq   :1

List1 List2 List3 List4 List5 List6
```

The following is the meaning for each item.

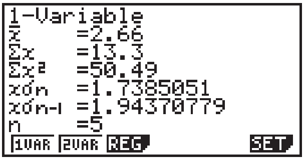
1Var XList	specifies list where single-variable statistic *x* values (XList) are located
1Var Freq	specifies list where single-variable frequency values (Frequency) are located
2Var XList	specifies list where paired-variable statistic *x* values (XList) are located
2Var YList	specifies list where paired-variable statistic *y* values (YList) are located
2Var Freq	specifies list where paired-variable frequency values (Frequency) are located

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

■ Single-Variable Statistical Calculations

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

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



```
1-Variable
x̄      =2.66
Σx     =13.3
Σx²    =50.49
xσn    =1.7385051
xσn-1  =1.94370779
n      =5
1VAR 2VAR REG          SET
```

P.259

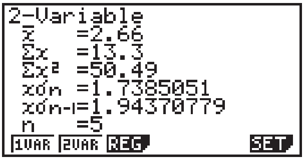
Now you can use the cursor keys to view the characteristics of the variables.

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

■ Paired-Variable Statistical Calculations

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

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



```
2-Variable
 x̄     =2.66
 Σx    =13.3
 Σx²   =50.49
 xσn   =1.7385051
 xσn-1=1.94370779
 n     =5
```

P.266

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

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

■ Regression Calculation

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

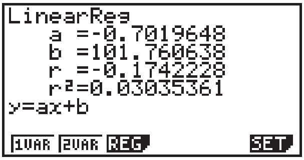
You can directly determine the same expression from the data input screen.

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

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

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

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



```
LinearReg
   a =-0.7019648
   b =101.760638
   r =-0.1742228
   r²=0.03035361
y=ax+b
```

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

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

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

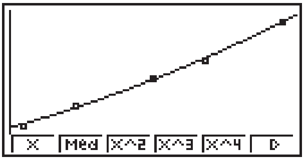
- Note that you cannot obtain estimated value for a Med-Med, quadratic regression, cubic regression, quartic regression, or sine regression graph.

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

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

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

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



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

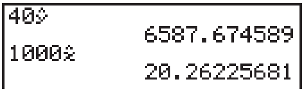
4. Press the keys as follows.

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

```
40ŷ
                6587.674589
```

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

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



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

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

*

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

Probability Distribution Calculation and Graphing

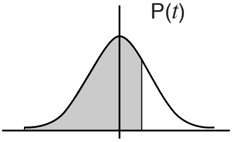
You can calculate and graph probability distributions for single-variable statistics.

•Probability distribution calculations

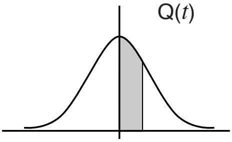
Use the **RUN Mode** to perform probability distribution calculations. Press OPTN in the RUN Mode to display the option number and then press F6 (▷) F3 (PROB) F6 (▷) to display a function menu, which contains the following items.

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

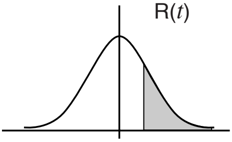
- Probability P(t), Q(t), and R(t), and normalized variate $t(x)$ are calculated using the following formulas.



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



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



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

$t(x)$

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

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

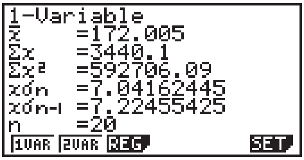
Class no.	Height (cm)	Frequency
1	158.5	1
2	160.5	1
3	163.3	2
4	167.5	2
5	170.2	3
6	173.3	4
7	175.5	2
8	178.6	2
9	180.4	2
10	186.7	1

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

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

   F2 (CALC) F6 (SET)

   ▼ F3 (List2) EXIT F1 (1VAR)



```
1-Variable
x̄     =172.005
Σx    =3440.1
Σx²   =592706.09
xσn   =7.04162445
xσn-1 =7.22455425
n     =20
```

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

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

F4 (*t*() 1 6 0 • 5) EXE

(Normalized variate *t* for 160.5cm) Result: –1.633855948

(≒ –1.634)

F4 (*t*() 1 7 5 • 5) EXE

(Normalized variate *t* for 175.5cm) Result: 0.4963343361

(≒ 0.496)

F1 (P() 0 • 4 9 6) −

F1 (P() (–) 1 • 6 3 4) EXE

(Percentage of total) Result: 0.638921

(63.9% of total)

F3 (R() 0 • 4 9 6) EXE

(Percentile) Result: 0.30995

(31.0 percentile)

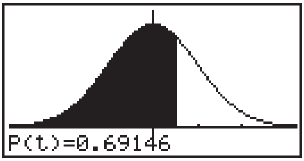
Probability Graphing

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

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

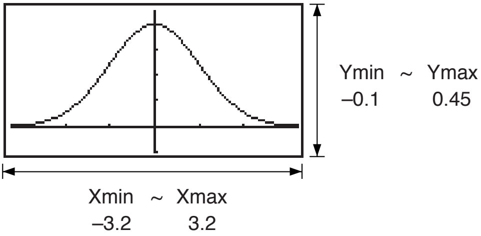
Perform the following operation in the **RUN Mode**.

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



P(t)=0.69146

The following shows the View Window settings for the graph.



18-6 Tests

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

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

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

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

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

The ***t* Test** uses the sample size and obtained data to test the hypothesis that the sample is taken from a particular population. The hypothesis that is the opposite of the hypothesis being proven is called the *null hypothesis*, while the hypothesis being proved is called the *alternative hypothesis*. The t-test is normally applied to test the null hypothesis. Then a determination is made whether the null hypothesis or alternative hypothesis will be adopted.

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

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

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

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

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

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

2-Sample F Test tests the hypothesis that there will be no change in the result for a population when a result of a sample is composed of multiple factors and one or more of the factors is removed. It could be used, for example, to test the carcinogenic effects of multiple suspected factors such as tobacco use, alcohol, vitamin deficiency, high coffee intake, inactivity, poor living habits, etc.

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

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

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

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

About data type specification

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

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

■ Z Test

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

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

•1-Sample Z Test

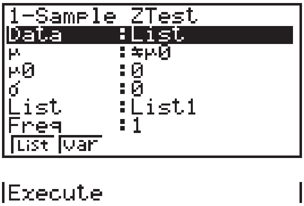
This test is used when the sample standard deviation for a population is known to test the hypothesis that the population mean value is equal to the sample mean value. The **1-Sample Z Test** is applied to standard normal distribution.

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

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

Perform the following key operation from the statistical data list.

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



```
1-Sample ZTest
Data    :List
μ       :≠μ0
μ0      :0
σ       :0
List    :List1
Freq    :1
LIST VAR

Execute
```

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

Data	data type
μ	population mean value test conditions ("$\neq \mu_0$" specifies two-tail test, "$< \mu_0$" specifies lower one-tail test, "$> \mu_0$" specifies upper one-tail test.)
μ_0	assumed population mean
σ	population standard deviation ($\sigma > 0$)
List	list whose contents you want to use as data (List 1 to 6)
Freq	frequency (1 or List 1 to 6)
Execute	executes a calculation or draws a graph

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

```
x̄          :0
n          :0
```

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

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

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

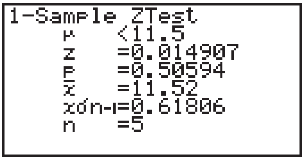
F1(List) ▼ F2(<) ▼

1 1 • 5 EXE

3 EXE

F1(List1) ▼ F1(1) ▼

F1(CALC)



```
1-Sample ZTest
    μ   <11.5
    z   =0.014907
    p   =0.50594
    x̄   =11.52
    xσn-1=0.61806
    n   =5
```

μ<11.5	assumed population mean and direction of test
z	Z score
p	p-value
$\bar{x}$	sample mean
$x\sigma_{n-1}$	sample standard deviation
n	sample size

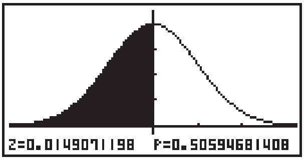
F6(DRAW) can be used in place of F1(CALC) in the final Execute line to draw a graph.

Perform the following key operation from the statistical result screen.

EXIT (To data input screen)

▼▼▼▼▼▼ (To Execute line)

F6 (DRAW)



z=0.0149071198 p=0.50594681408

•2-Sample Z Test

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

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

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

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

σ_1 : population standard deviation of sample 1

σ_2 : population standard deviation of sample 2

n_1 : sample 1 size

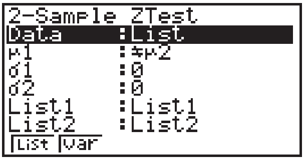
n_2 : sample 2 size

Perform the following key operation from the statistical data list.

F3 (TEST)

F1 (Z)

F2 (2-S)



2-Sample ZTest

Data :List

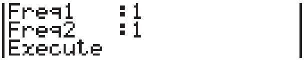
μ1 :≠μ2

σ1 :0

σ2 :0

List1 :List1

List2 :List2



Freq1 :1

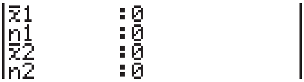
Freq2 :1

Execute

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

Data	data type
μ_1	population mean value test conditions ("≠ μ_2" specifies two-tail test, "< μ_2" specifies one-tail test where sample 1 is smaller than sample 2, "> μ_2" specifies one-tail test where sample 1 is greater than sample 2.)
σ_1	population standard deviation of sample 1 ($\sigma_1 > 0$)
σ_2	population standard deviation of sample 2 ($\sigma_2 > 0$)
List1	list whose contents you want to use as sample 1 data
List2	list whose contents you want to use as sample 2 data
Freq1	frequency of sample 1 (positive integer)
Freq2	frequency of sample 2 (positive integer)
Execute	executes a calculation or draws a graph

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



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

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

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

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

F1(List) ▼

F2(<) ▼

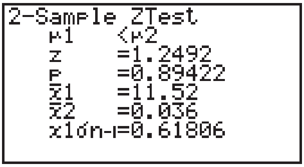
1 5 • 5 EXE

1 3 • 5 EXE

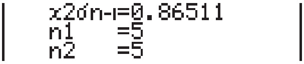
F1(List1) ▼ F2(List2) ▼

F1(1) ▼ F1(1) ▼

F1(CALC)



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



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

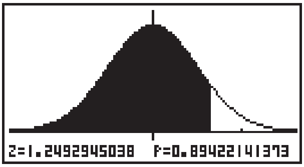
$\mu_1<\mu_2$	direction of test
z	Z score
p	p-value
$\bar{x}_1$	sample 1 mean
$\bar{x}_2$	sample 2 mean
$x_1\sigma_{n-1}$	sample 1 standard deviation
$x_2\sigma_{n-1}$	sample 2 standard deviation
n_1	sample 1 size
n_2	sample 2 size

Perform the following key operation to display a graph.

EXIT

▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼

F6(DRAW)



•1-Prop Z Test

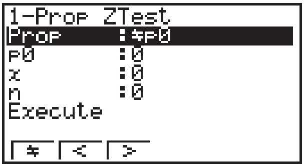
This test is used to test whether data that satisfies certain criteria reaches a specific proportion. It tests the hypothesis when sample size and the number of data satisfying the criteria are specified. The **1-Prop Z Test** is applied to standard normal distribution.

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

p_0 : expected sample proportion
n : sample size

Perform the following key operation from the statistical data list.

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



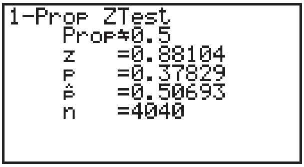
```
1-Prop ZTest
Prop      :≠p0
p0        :0
x         :0
n         :0
Execute
```

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

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

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

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



```
1-Prop ZTest
    Prop≠0.5
    z    =0.88104
    p    =0.37829
    p̂    =0.50693
    n    =4040
```

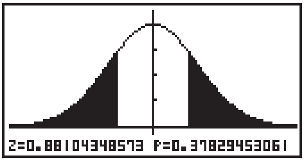
Prop≠0.5	direction of test
z	Z score
p	p-value
$\hat{p}$	estimated sample proportion
n	sample size

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

EXIT

▼▼▼▼

F6(DRAW)



```
Z=0.88104348573  P=0.37829453061
```

•2-Prop *Z* Test

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

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

x_1 : sample 1 data value

x_2 : sample 2 data value

n_1 : sample 1 size

n_2 : sample 2 size

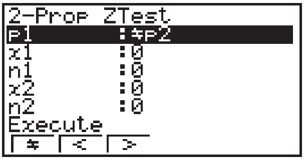
$\hat{p}$: estimated sample proportion

Perform the following key operation from the statistical data list.

F3(TEST)

F1(Z)

F4(2-P)



```
2-Prop ZTest
p1       :≠p2
x1       :0
n1       :0
x2       :0
n2       :0
Execute
```

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

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

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

F3(>) ▼

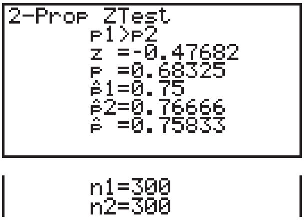
2 2 5 EXE

3 0 0 EXE

2 3 0 EXE

3 0 0 EXE

F1(CALC)



```
2-Prop ZTest
      p1>p2
      z =-0.47682
      p =0.68325
      p̂1=0.75
      p̂2=0.76666
      p̂ =0.75833

      n1=300
      n2=300
```

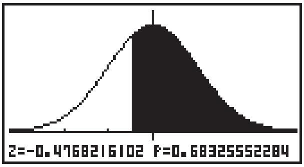
$p_1 > p_2$	direction of test
z	Z score
p	p-value
$\hat{p}_1$	estimated proportion of population 1
$\hat{p}_2$	estimated proportion of population 2
$\hat{p}$	estimated sample proportion
n_1	sample 1 size
n_2	sample 2 size

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

EXIT

▼ ▼ ▼ ▼ ▼

F6(DRAW)



```
Z=-0.4768216102 P=0.68325552284
```

■ *t* Test

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

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

•1-Sample *t* Test

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

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

$\bar{x}$: sample mean

μ_0 : assumed population mean

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

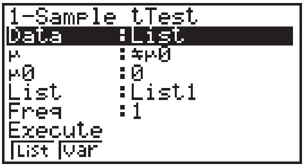
n : sample size

Perform the following key operation from the statistical data list.

F3(TEST)

F2(*t*)

F1(1-S)

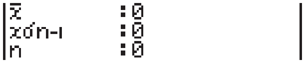


```
1-Sample tTest
Data     :List
μ        :≠μ0
μ0       :0
List     :List1
Freq     :1
Execute
```

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

Data	data type
μ	population mean value test conditions ("$\neq \mu_0$" specifies two-tail test, "$< \mu_0$" specifies lower one-tail test, "$> \mu_0$" specifies upper one-tail test.)
μ_0	assumed population mean
List	list whose contents you want to use as data
Freq	frequency
Execute	executes a calculation or draws a graph

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



```
x̄        :0
xσn-1    :0
n        :0
```

$\bar{x}$	sample mean
$x\sigma_{n-1}$	sample standard deviation ($x\sigma_{n-1} > 0$)
n	sample size (positive integer)

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

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

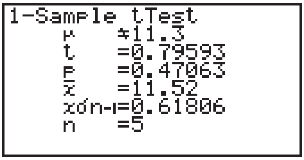
F1(List) ▼

F1($\neq$) ▼

1 1 · 3 EXE

F1(List1) ▼ F1(1) ▼

F1(CALC)



```
1-Sample tTest
    μ   ≠11.3
    t   =0.79593
    p   =0.47063
    x̄   =11.52
    xσn-1=0.61806
    n   =5
```

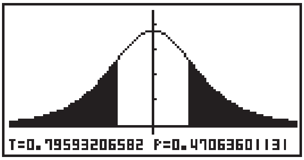
$\mu \neq 11.3$	assumed population mean and direction of test
t	t-value
p	p-value
$\bar{x}$	sample mean
$x\sigma_{n-1}$	sample standard deviation
n	sample size

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

EXIT

▼ ▼ ▼ ▼ ▼

F6(DRAW)



```
T=0.79593206582 P=0.47063601131
```

•2-Sample *t* Test

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

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

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

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

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

The following applies when pooling is in effect.

$$df = n_1 + n_2 - 2$$

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

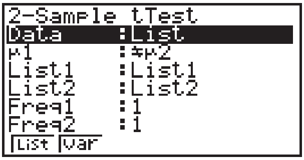
The following applies when pooling is not in effect.

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

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

Perform the following key operation from the statistical data list.

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



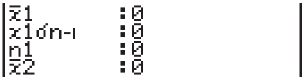
```
2-Sample tTest
Data    :List
μ1      :≠μ2
List1   :List1
List2   :List2
Freq1   :1
Freq2   :1
```

```
Pooled  :Off
Execute
```

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

Data	data type
μ_1	sample mean value test conditions ("≠ μ_2" specifies two-tail test, "< μ_2" specifies one-tail test where sample 1 is smaller than sample 2, "> μ_2" specifies one-tail test where sample 1 is greater than sample 2.)
List1	list whose contents you want to use as sample 1 data
List2	list whose contents you want to use as sample 2 data
Freq1	frequency of sample 1 (positive integer)
Freq2	frequency of sample 2 (positive integer)
Pooled	pooling On or Off
Execute	executes a calculation or draws a graph

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



```
x̄1       :0
x1σn-1   :0
n1       :0
x̄2       :0
```

```
x2σn-1   :0
n2       :0
```

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

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

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

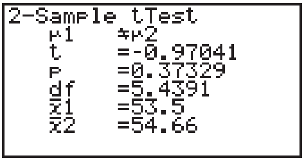
F1(List) ▼ F1(≠) ▼

F1(List1) ▼ F2(List2) ▼

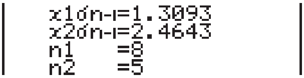
F1(1) ▼ F1(1)

▼ F2(Off) ▼

F1(CALC)



```
2-Sample tTest
   μ1    ≠μ2
   t     =-0.97041
   p     =0.37329
   df    =5.4391
   x̄1    =53.5
   x̄2    =54.66
```



```
   x1σn-1=1.3093
   x2σn-1=2.4643
   n1    =8
   n2    =5
```

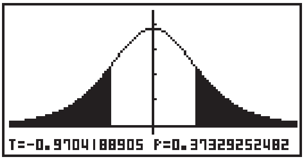
$\mu_1 \neq \mu_2$	direction of test
t	t-value
p	p-value
df	degrees of freedom
$\bar{x}_1$	sample 1 mean
$\bar{x}_2$	sample 2 mean
$x_1\sigma_{n-1}$	sample 1 standard deviation
$x_2\sigma_{n-1}$	sample 2 standard deviation
n_1	sample 1 size
n_2	sample 2 size

Perform the following key operation to display a graph.

EXIT

▼▼▼▼▼▼▼

F6(DRAW)



```
T=-0.9704188905 P=0.37329252482
```

The following item is also shown when Pooled = On.

```
xpσn-1=1.8163
```

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

•LinearReg *t* Test

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

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

a : intercept

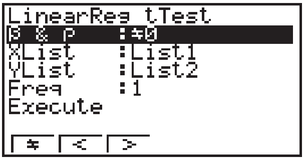
b : slope of the line

Perform the following key operation from the statistical data list.

F3(TEST)

F2(t)

F3(REG)



```
LinearReg tTest
β & ρ   :≠0
XList   :List1
YList   :List2
Freq    :1
Execute
```

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

β & ρ	p-value test conditions ("≠ 0" specifies two-tail test, "< 0" specifies lower one-tail test, "> 0" specifies upper one-tail test.)
XList	list for x-axis data
YList	list for y-axis data
Freq	frequency
Execute	executes a calculation

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

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

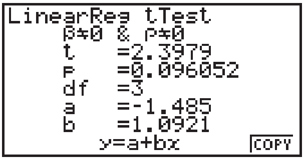
F1(≠)▼

F1(List1)▼

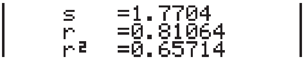
F2(List2)▼

F1(1)▼

F1(CALC)



```
LinearReg tTest
    β≠0 & ρ≠0
    t   =2.3979
    p   =0.096052
    df  =3
    a   =-1.485
    b   =1.0921
      y=a+bx      COPY
```



```
    s   =1.7704
    r   =0.81064
    r²  =0.65714
```

$\beta \neq 0$ & $\rho \neq 0$	direction of test
t	t-value
p	p-value
df	degrees of freedom
a	constant term
b	coefficient
s	standard error
r	correlation coefficient
r^2	coefficient of determination

P.267

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

F6(COPY)

```
Graph Func
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:
   To Store :[EXE]
```

Other Tests

•χ^2 Test

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

expected counts

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

n : all data values

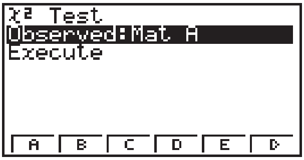
$$\chi^2 = \sum_{i=1}^{k} \sum_{j=1}^{\ell} \frac{(x_{ij} - F_{ij})^2}{F_{ij}}$$

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

Perform the following key operation from the statistical data list.

F3(TEST)

F3(CHI)


χ² Test
Observed:Mat A
Execute

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

Observed .... name of matrix (A to Z) that contains observed counts (all cells positive integers)

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

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

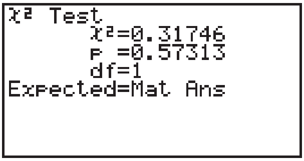
Example **To perform a χ^2 Test on a specific matrix cell**

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

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

F1(Mat A)▼

F1(CALC)


χ² Test
χ²=0.31746
p =0.57313
df=1
Expected=Mat Ans

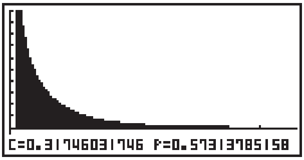
χ^2	χ^2 value
p	p-value
df	degrees of freedom
Expected	expected counts (Result is always stored in MatAns.)

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

EXIT

▼

F6(DRAW)



```
C=0.31746031746 P=0.57313785158
```

•2-Sample *F* Test

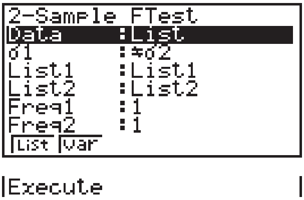
2-Sample *F* Test tests the hypothesis that when a sample result is composed of multiple factors, the population result will be unchanged when one or some of the factors are removed. The F Test is applied to F distribution.

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

Perform the following key operation from the statistical data list.

F3(TEST)

F4(F)

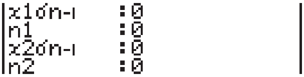


```
2-Sample FTest
Data    :List
σ1      :≠σ2
List1   :List1
List2   :List2
Freq1   :1
Freq2   :1
Execute
```

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

Data	data type
σ_1	population standard deviation test conditions ("≠ σ_2" specifies two-tail test, "< σ_2" specifies one-tail test where sample 1 is smaller than sample 2, "> σ_2" specifies one-tail test where sample 1 is greater than sample 2.)
List1	list whose contents you want to use as sample 1 data
List2	list whose contents you want to use as sample 2 data
Freq1	frequency of sample 1
Freq2	frequency of sample 2
Execute	executes a calculation or draws a graph

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



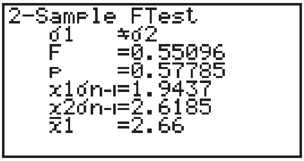
```
x1σn-1    :0
n1        :0
x2σn-1    :0
n2        :0
```

$x_1\sigma_{n\text{-}1}$	sample 1 standard deviation ($x_1\sigma_{n\text{-}1} > 0$)
n_1	sample 1 size (positive integer)
$x_2\sigma_{n\text{-}1}$	sample 2 standard deviation ($x_2\sigma_{n\text{-}1} > 0$)
n_2	sample 2 size (positive integer)

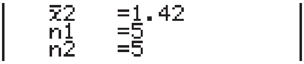
Example **To perform a 2-Sample F Test when two lists of data are input**

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

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



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

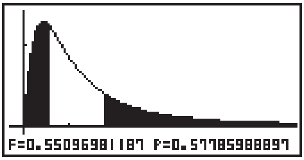


```
   x̄2    =1.42
   n1    =5
   n2    =5
```

$\sigma_1 \neq \sigma_2$	direction of test
F	F value
p	p-value
$x_1\sigma_{n\text{-}1}$	sample 1 standard deviation
$x_2\sigma_{n\text{-}1}$	sample 2 standard deviation
$\bar{x}_1$	sample 1 mean
$\bar{x}_2$	sample 2 mean
n_1	sample 1 size
n_2	sample 2 size

Perform the following key operation to display a graph.

EXIT
▼ ▼ ▼ ▼ ▼ ▼
F6(DRAW)



•Analysis of Variance (ANOVA)

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

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

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

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

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

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

$$Fdf = k - 1$$

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

k : number of populations

$\bar{x}_i$: mean of each list

$x_i\sigma_{n-1}$: standard deviation of each list

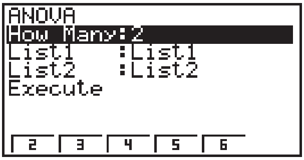
n_i : size of each list

$\bar{x}$: mean of all lists

Perform the following key operation from the statistical data list.

F3(TEST)

F5(ANOV)



ANOVA
How Many:2
List1 :List1
List2 :List2
Execute

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

How Many ...... number of samples

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

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

Execute .... executes a calculation

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

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

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

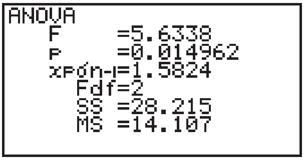
F2(3)▼

F1(List1)▼

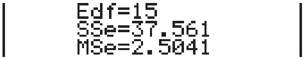
F2(List2)▼

F3(List3)▼

F1(CALC)



```
ANOVA
   F     =5.6338
   p     =0.014962
   xpσn-1=1.5824
     Fdf=2
     SS =28.215
     MS =14.107
```



```
     Edf=15
     SSe=37.561
     MSe=2.5041
```

F .... *F* value

p .... p-value

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

Fdf .... numerator degrees of freedom

SS .... factor sum of squares

MS .... factor mean squares

Edf .... denominator degrees of freedom

SSe .... error sum of squares

MSe .... error mean squares

18-7 Confidence Interval

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

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

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

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

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

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

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

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

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

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

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

About data type specification

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

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

Z Confidence Interval

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

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

•1-Sample Z Interval

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

The following is the confidence interval.

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

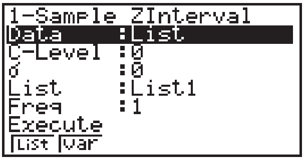
$$Right = \bar{x} + Z\left(\frac{\alpha}{2}\right)\frac{\sigma}{\sqrt{n}}$$

However, α is not the confidence level itself.

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

Perform the following key operation from the statistical data list.

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



```
1-Sample ZInterval
Data     :List
C-Level  :0
σ        :0
List     :List1
Freq     :1
Execute
```

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

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

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

```
x̄        :0
n        :0
```

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

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

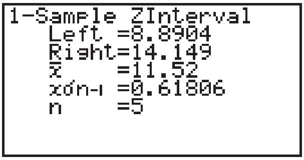
For this example, we will obtain the Z Interval for the data {11.2, 10.9, 12.5, 11.3, 11.7}, when C-Level = 0.95 (95% confidence level) and σ = 3.

F1 (List) ▼

0 . 9 5 EXE

3 EXE

F1 (List1) ▼ F1 (1) ▼ F1 (CALC)



```
1-Sample ZInterval
   Left =8.8904
   Right=14.149
   x̄    =11.52
   xσn-1 =0.61806
   n    =5
```

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

•2-Sample Z Interval

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

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

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

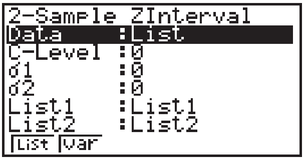
$\bar{x}_1$: sample 1 mean
$\bar{x}_2$: sample 2 mean
σ_1 : population standard deviation of sample 1
σ_2 : population standard deviation of sample 2
n_1 : sample 1 size
n_2 : sample 2 size

Perform the following key operation from the statistical data list.

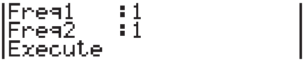
F4 (INTR)

F1 (Z)

F2 (2-S)



```
2-Sample ZInterval
Data     :List
C-Level  :0
σ1       :0
σ2       :0
List1    :List1
List2    :List2
```



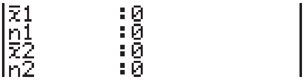
```
Freq1    :1
Freq2    :1
Execute
```

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

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

σ_1	population standard deviation of sample 1 ($\sigma_1 > 0$)
σ_2	population standard deviation of sample 2 ($\sigma_2 > 0$)
List1	list whose contents you want to use as sample 1 data
List2	list whose contents you want to use as sample 2 data
Freq1	frequency of sample 1
Freq2	frequency of sample 2
Execute	executes a calculation

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



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

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

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

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

F1(List) ▼

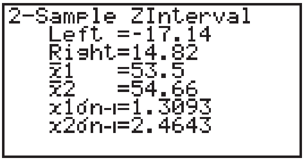
0 • 9 5 EXE

1 5 • 5 EXE

1 3 • 5 EXE

F1(List1) ▼ F2(List2) ▼ F1(1) ▼

F1(1) ▼ F1(CALC)



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

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

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

•1-Prop Z Interval

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

The following is the confidence interval.

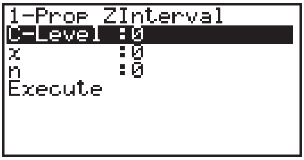
$$Left = \frac{x}{n} - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{1}{n}\left(\frac{x}{n}\left(1-\frac{x}{n}\right)\right)}$$

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

n : sample size
x : data

Perform the following key operation from the statistical data list.

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



```
1-Prop ZInterval
C-Level :0
x       :0
n       :0
Execute
```

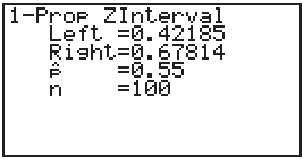
Data is specified using parameter specification. The following shows the meaning of each item.

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

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

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

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



```
1-Prop ZInterval
   Left =0.42185
   Right=0.67814
   p̂    =0.55
   n    =100
```

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

•2-Prop Z Interval

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

The following is the confidence interval.

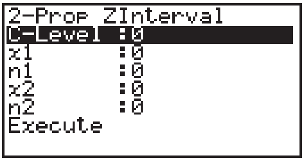
$$Left = \frac{x_1}{n_1} - \frac{x_2}{n_2} - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{\frac{x_1}{n_1}\left(1-\frac{x_1}{n_1}\right)}{n_1} + \frac{\frac{x_2}{n_2}\left(1-\frac{x_2}{n_2}\right)}{n_2}}$$

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

n_1, n_2 : sample size
x_1, x_2 : data

Perform the following key operation from the statistical data list.

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



```
2-Prop ZInterval
C-Level :0
x1      :0
n1      :0
x2      :0
n2      :0
Execute
```

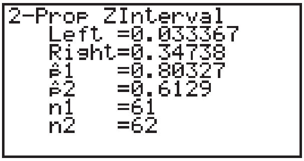
Data is specified using parameter specification. The following shows the meaning of each item.

C-Level	confidence level (0 ≦ C-Level < 1)
x_1	sample 1 data value (x_1 ≧ 0)
n_1	sample 1 size (positive integer)
x_2	sample 2 data value (x_2 ≧ 0)
n_2	sample 2 size (positive integer)
Execute	Executes a calculation

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

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

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



```
2-Prop ZInterval
   Left =0.033367
   Right=0.34738
   p̂1   =0.80327
   p̂2   =0.6129
   n1   =61
   n2   =62
```

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

$\hat{p}_1$	expected p-value 1
$\hat{p}_2$	expected p-value 2
n_1	sample 1 size
n_2	sample 2 size

■ *t* Confidence Interval

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

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

•1-Sample *t* Interval

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

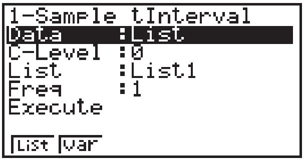
The following is the confidence interval.

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

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

Perform the following key operation from the statistical data list.

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

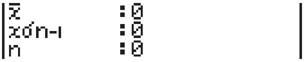


```
1-Sample tInterval
Data    :List
C-Level :0
List    :List1
Freq    :1
Execute
```

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

Data	data type
C-Level	confidence level (0 ≦ C-Level < 1)
List	list whose contents you want to use as sample data
Freq	sample frequency
Execute	execute a calculation

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



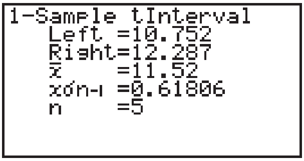
```
x̄       :0
xσn-1   :0
n       :0
```

$\bar{x}$	sample mean
$x\sigma_{n-1}$	sample standard deviation ($x\sigma_{n-1} \geqq 0$)
n	sample size (positive integer)

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

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

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



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

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

●2-Sample *t* Interval

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

The following confidence interval applies when pooling is in effect.

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

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

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

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

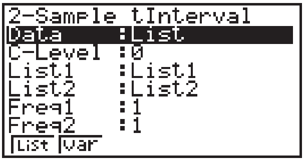
$$Right = (\bar{x}_1 - \bar{x}_2) + t_{df}\left(\frac{\alpha}{2}\right)\sqrt{\left(\frac{x_1\sigma_{n-1}{}^2}{n_1}+\frac{x_2\sigma_{n-1}{}^2}{n_2}\right)}$$

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

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

Perform the following key operation from the statistical data list.

F4(INTR)
F2(t)
F2(2-S)



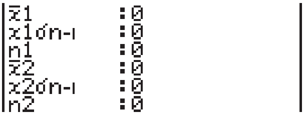
2-Sample tInterval
Data :List
C-Level :0
List1 :List1
List2 :List2
Freq1 :1
Freq2 :1

Pooled :Off
Execute

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

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

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



$\bar{x}1$:0
$x1\sigma_{n-1}$:0
n1 :0
$\bar{x}2$:0
$x2\sigma_{n-1}$:0
n2 :0

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

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

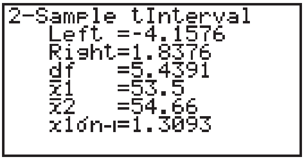
For this example, we will obtain the 2-Sample t Interval for data 1 = {55, 54, 51, 55, 53, 53, 54, 53} and data 2 = {55.5, 52.3, 51.8, 57.2, 56.5} without pooling when C-Level = 0.95.

F1(List) ▼

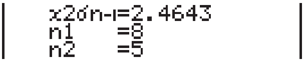
0 . 9 5 EXE

F1(List1) ▼ F2(List2) ▼ F1(1) ▼

F1(1) ▼ F2(Off) ▼ F1(CALC)



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



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

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

The following item is also shown when Pooled = On.

```
   xpσn-1=1.8163
```

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

18-8 Distribution

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

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

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

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

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

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

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

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

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

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

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

About data type specification

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

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

Normal Distribution

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

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

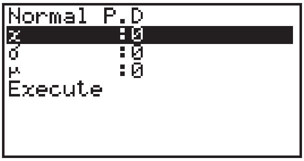
•Normal probability density

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

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

Perform the following key operation from the statistical data list.

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



```
Normal P.D
x          :0
σ          :0
μ          :0
Execute
```

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

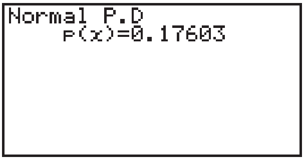
x	data
σ	population standard deviation ($\sigma > 0$)
μ	population mean
Execute	executes a calculation or draws a graph

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

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

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

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



```
Normal P.D
     p(x)=0.17603
```

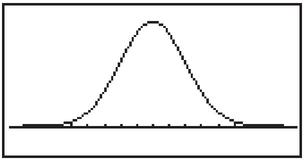
$p(x)$ .... normal probability density

Perform the following key operation to display a graph.

EXIT

▼ ▼ ▼

F6 (DRAW)



•Normal distribution probability

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

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

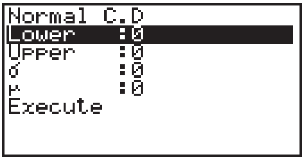
a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

F5 (DIST)

F1 (NORM)

F2 (Ncd)



```
Normal C.D
Lower    :0
Upper    :0
σ        :0
μ        :0
Execute
```

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

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

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

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

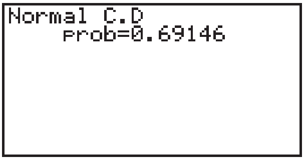
(–) 1 EXP 9 9 EXE

3 6 EXE

2 EXE

3 5 EXE

F1 (CALC)



```
Normal C.D
    prob=0.69146
```

prob .... normal distribution probability

- This calculator performs the above calculation using the following:

  $\infty = 1E99, -\infty = -1E99$

•Inverse cumulative normal distribution

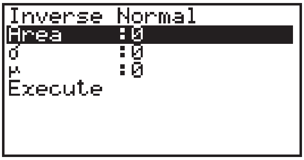
Inverse cumulative normal distribution calculates a value that represents the location within a normal distribution for a specific cumulative probability.

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

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

Perform the following key operation from the statistical data list.

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



```
Inverse Normal
Area      :0
σ         :0
μ         :0
Execute
```

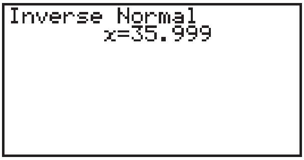
Data is specified using parameter specification. The following shows the meaning of each item.

Area	probability value ($0 \leqq$ Area $\leqq 1$)
σ	population standard deviation ($\sigma > 0$)
μ	population mean
Execute	executes a calculation

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

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

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



```
Inverse Normal
     x=35.999
```

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

Student-*t* Distribution

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

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

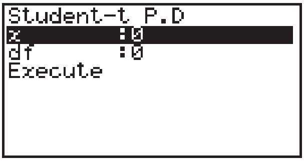
•Student-*t* probability density

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

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

Perform the following key operation from the statistical data list.

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



```
Student-t P.D
x         :0
df        :0
Execute
```

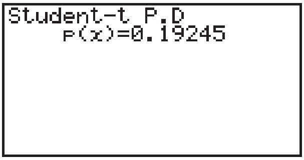
Data is specified using parameter specification. The following shows the meaning of each item.

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

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

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

1 EXE
2 EXE
F1 (CALC)



```
Student-t P.D
     p(x)=0.19245
```

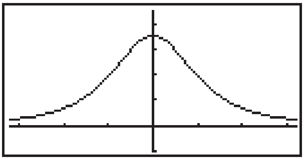
p(*x*) .... Student-*t* probability density

Perform the following key operation to display a graph.

EXIT

▼ ▼

F6 (DRAW)



●Student-*t* distribution probability

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

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

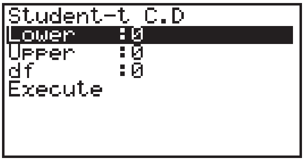
a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

F5 (DIST)

F2 (*t*)

F2 (tcd)



```
Student-t C.D
Lower    :0
Upper    :0
df       :0
Execute
```

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

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

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

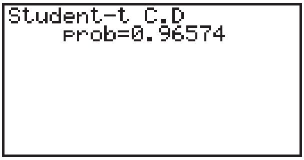
For this example, we will calculate Student-*t* distribution probability when lower boundary = –2, upper boundary = 3, and degrees of freedom = 18.

(–) 2 EXE

3 EXE

1 8 EXE

F1 (CALC)



```
Student-t C.D
     prob=0.96574
```

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

Chi-square Distribution

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

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

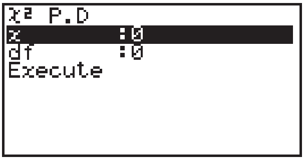
•χ^2 probability density

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

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

Perform the following key operation from the statistical data list.

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



```
χ² P.D
x        :0
df       :0
Execute
```

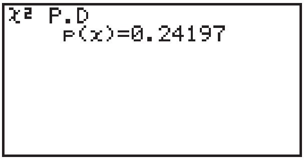
Data is specified using parameter specification. The following shows the meaning of each item.

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

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

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

1 EXE
3 EXE
F1 (CALC)



```
χ² P.D
    p(x)=0.24197
```

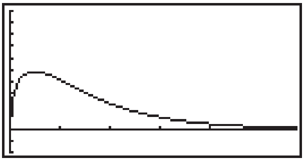
$p(x)$ .... χ^2 probability density

Perform the following key operation to display a graph.

EXIT

▼ ▼

F6 (DRAW)



•χ^2 distribution probability

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

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

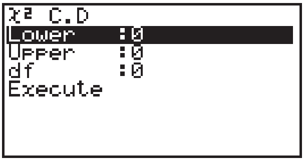
a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

F5 (DIST)

F3 (CHI)

F2 (Ccd)



```
χ² C.D
Lower    :0
Upper    :0
df       :0
Execute
```

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

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

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

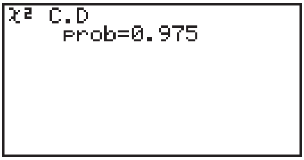
For this example, we will calculate χ^2 distribution probability when lower boundary = 0, upper boundary = 19.023, and degrees of freedom = 9.

0 EXE

1 9 • 0 2 3 EXE

9 EXE

F1 (CALC)



```
χ² C.D
   prob=0.975
```

prob .... χ^2 distribution probability

■ *F* Distribution

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

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

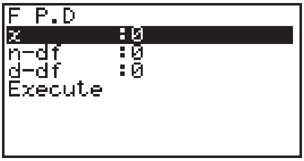
●*F* probability density

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

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

Perform the following key operation from the statistical data list.

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



```
F P.D
x          :0
n-df       :0
d-df       :0
Execute
```

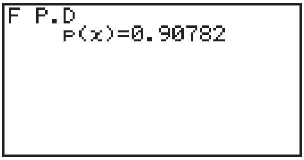
Data is specified using parameter specification. The following shows the meaning of each item.

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

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

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

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

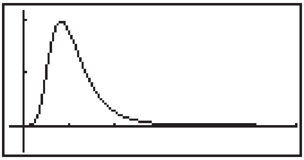


```
F P.D
    p(x)=0.90782
```

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

Perform the following key operation to display a graph.

EXIT
▼ ▼ ▼
F6 (DRAW)



•*F* distribution probability

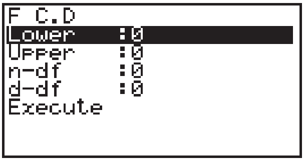
F distribution probability calculates the probability of *F* distribution data falling between two specific values.

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

a : lower boundary
b : upper boundary

Perform the following key operation from the statistical data list.

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



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

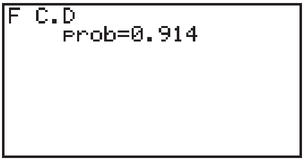
Data is specified using parameter specification. The following shows the meaning of each item.

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

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

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

0 EXE
1 . 9 8 2 4 EXE
1 9 EXE
1 6 EXE
F1(CALC)



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

prob	*F* distribution probability

Binomial Distribution

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

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

•Binomial probability

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

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

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

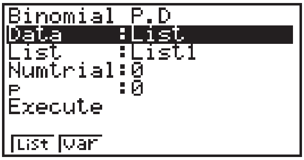
n : number of trials

Perform the following key operation from the statistical data list.

F5 (DIST)

F5 (BINM)

F1 (Bpd)



```
Binomial P.D
Data    :List
List    :List1
Numtrial:0
p       :0
Execute
```

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

Data	data type
List	list whose contents you want to use as sample data
Numtrial	number of trials (positive integer)
p	success probability ($0 \leqq p \leqq 1$)
Execute	executes a calculation

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

```
x       :0
```

x	integer from 0 to n

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

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

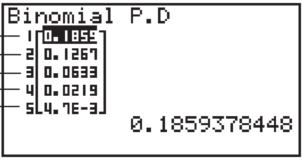
F1 (List) ▼

F1 (List1) ▼

1 5 EXE

0 . 6 EXE

F1 (CALC)



```
Binomial P.D
 1[0.1859]
 2[0.1267]
 3[0.0633]
 4[0.0219]
 5[4.7E-3]
        0.1859378448
```

•Binomial cumulative density

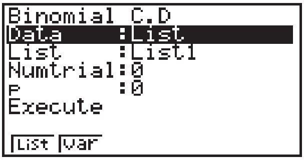
Binomial cumulative density calculates the probability of binomial distribution data falling between two specific values.

Perform the following key operation from the statistical data list.

F5 (DIST)

F5 (BINM)

F2 (Bcd)



```
Binomial C.D
Data     :List
List     :List1
Numtrial:0
p        :0
Execute
```

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

Data	data type
List	list whose contents you want to use as sample data
Numtrial	number of trials (positive integer)
p	success probability ($0 \leqq p \leqq 1$)
Execute	executes a calculation

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

```
x        :0
```

x	integer from 0 to n

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

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

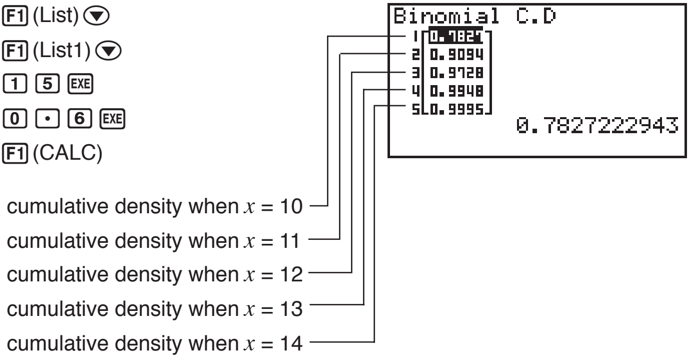
F1 (List) ▼

F1 (List1) ▼

1 5 EXE

0 • 6 EXE

F1 (CALC)



```
Binomial C.D
 1 [0.7827]
 2 [0.9094]
 3 [0.9728]
 4 [0.9948]
 5 [0.9995]
         0.7827222943
```

cumulative density when x = 10

cumulative density when x = 11

cumulative density when x = 12

cumulative density when x = 13

cumulative density when x = 14

Poisson Distribution

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

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

•Poisson probability

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

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

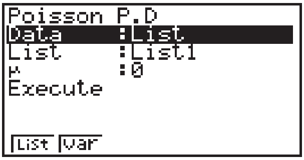
Perform the following key operation from the statistical data list.

F5 (DIST)

F6 (▷)

F1 (POISN)

F1 (Ppd)



```
Poisson P.D
Data    :List
List    :List1
μ       :0
Execute

LIST VAR
```

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

Data .... data type

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

μ .... population mean ($\mu > 0$)

Execute .... executes a calculation

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

```
x       :0
```

x .... value

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

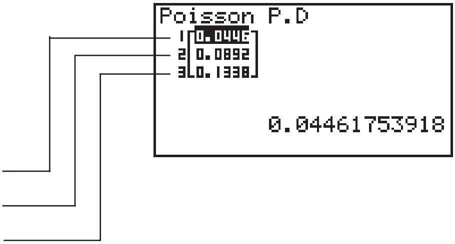
For this example, we will calculate Poisson probability for data = {2, 3, 4} when μ = 6.

F1 (List) ▼

F1 (List1) ▼

6 EXE

F1 (CALC)



```
Poisson P.D
 1 0.0446
 2 0.0892
 3 0.1338

     0.04461753918
```

probability when x = 2

probability when x = 3

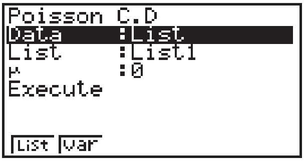
probability when x = 4

•Poisson cumulative density

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

Perform the following key operation from the statistical data list.

F5 (DIST)
F6 (▷)
F1 (POISN)
F2 (Pcd)


Poisson C.D
Data :List
List :List1
μ :0
Execute

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

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

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

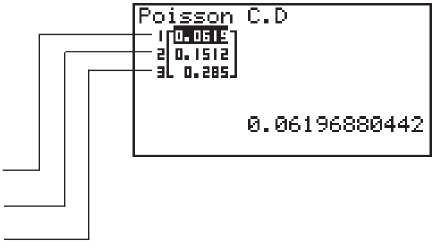

x :0

x .... value

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

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

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


Poisson C.D
1 0.0619
2 0.1512
3 0.285
0.06196880442

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

■ Geometric Distribution

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

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

•Geometric probability

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

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

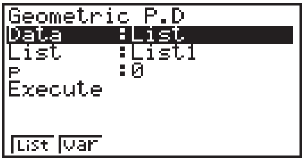
Perform the following key operation from the statistical data list.

F5 (DIST)

F6 (▷)

F2 (GEO)

F1 (Gpd)



```
Geometric P.D
Data      :List
List      :List1
p         :0
Execute
```

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

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

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

```
x         :0
```

x .... value

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

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

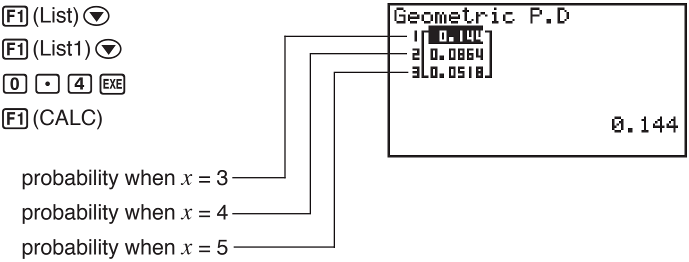
For this example, we will calculate geometric probability for data = {3, 4, 5} when p = 0.4.

F1 (List) ▼

F1 (List1) ▼

0 • 4 EXE

F1 (CALC)



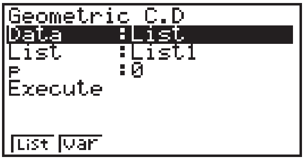
```
Geometric P.D
1 0.144
2 0.0864
3 0.0518
                0.144
```

•Geometric cumulative density

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

Perform the following key operation from the statistical data list.

F5 (DIST)
F6 (▷)
F2 (GEO)
F2 (Gcd)



```
Geometric C.D
Data      :List
List      :List1
p         :0
Execute
```

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

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

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

```
x         :0
```

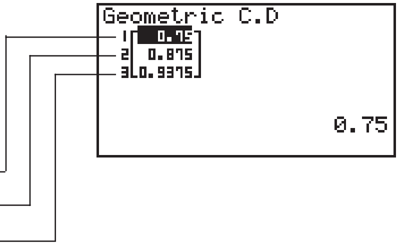
x .... value

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

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

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

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



```
Geometric C.D
1 [ 0.75  ]
2   0.875
3 [0.9375 ]
                0.75
```

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

Chapter 19

Financial Calculations

19-1 Before Performing Financial Calculations

The Financial Mode provides you with the tools to perform the following types of financial calculations.

- Simple interest
- Compound interest
- Investment appraisal (Cash Flow)
- Amortization
- Interest rate conversion (annual percentage rate and effective interest rate)
- Cost, selling price, margin
- Day/date calculations

●Graphing in the Financial Mode

After performing a financial calculation, you can use F6 (GRPH) to graph the results as shown below.

- Pressing SHIFT F1 (TRCE) while a graph is on the display activates Trace, which can be used to look up other financial values. In the case of simple interest, for example, pressing ▶ displays PV, SI, and SFV. Pressing ◀ displays the same values in reverse sequence.
- Zoom, Scroll, Sketch, and G-Solve cannot be used in the Financial Mode.
- In the Financial Mode, horizontal lines are blue and vertical lines are red. These colors are fixed and cannot be changed.
- The present value is positive when it represents receipt of money, and a negative value when it represents a payment.
- Note that calculation results produced in this mode should be regarded as reference values only.
- Whenever performing an actual financial transaction, be sure to check any calculation results obtained using this calculator with against the figures calculated by your financial institution.

●Set up screen settings

Note the following points regarding set up screen settings whenever using the Financial Mode.

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- The following graph set up screen settings are all turned off for graphing in the Financial Mode: Axes, Grid, Dual Screen.

P.6

- Drawing a financial graph while the Label item is turned on, displays the label CASH for the vertical axis (deposits, withdrawals), and TIME for the horizontal axis (frequency).
- The number of display digits applied in the Financial Mode is different from the number of digits used in other modes. The calculators automatically reverts to Norm 1 whenever you enter the Financial Mode, which cancels a Sci (number of significant digits) or Eng (engineering notation) setting made in another mode.

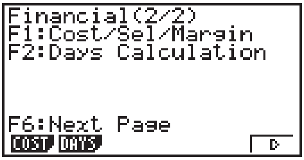
Entering the Financial Mode

On the Main Menu, select the **TVM** icon to enter the Financial Mode. When you do, the Financial 1 screen appears on the display.

Financial 1 screen

Financial(1/2)
F1:Simple Interest
F2:Compound Interest
F3:Cash Flow
F4:Amortization
F5:Conversion
F6:Next Page

Financial 2 screen



Financial(2/2)
F1:Cost/Sel/Margin
F2:Days Calculation

F6:Next Page

- {**SMPL**}/{**CMPD**}/{**CASH**}/{**AMT**}/{**CNVT**}/{**COST**}/{**DAYS**} ... {simple interest}/{compound interest}/{cash flow}/{amortization}/{conversion}/{cost, selling price, margin}/{day/date} calculation

19-2 Simple Interest Calculations

This calculator uses the following formulas to calculate simple interest.

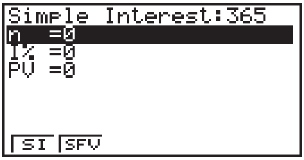
365-day Mode $SI' = \frac{n}{365} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

360-day Mode $SI' = \frac{n}{360} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

$$SI = -SI'$$
$$SFV = -(PV + SI')$$

SI : simple interest
n : number of simple interest periods
PV : present value
$I\%$: periodic interest rate
SFV : simple future value

Press F1 (SMPL) from the Financial 1 screen to display the following input screen for simple interest calculation.



```
Simple Interest:365
n  =0
I% =0
PV =0
```

n ....number of simple interest periods (days)
I% .... annual interest rate
PV .... present value

- {*SI*}/{*SFV*} ... calculates {simple interest}/{simple future value}

Example **What would the interest amount and principal plus interest be for a loan of $1,500 borrowed for 90 days at an annual rate of 7.25%?**

Use the 360-day mode and two decimal places.

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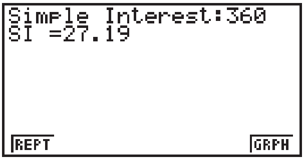
P.6

In the set up screen, specify "**360**" for Date Mode and "**Fix2**" for Display and then press EXIT.

Perform the following key operation from the input screen.

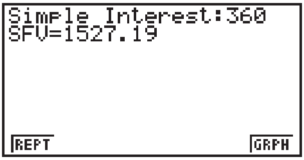
9 0 EXE
7 • 2 5 EXE
(−) 1 5 0 0 EXE
F1(*SI*)



```
Simple Interest:360
SI =27.19
```

Now you can perform the following key operation to return to the input screen and then display the principal plus interest.

F1(REPT) (Returns to the input screen)
F2(*SFV*)



Simple Interest:360
SFV=1527.19

You can also press F6(GRPH) to draw a cash flow graph.

F6(GRPH)

The left side is *PV*, while the right side is *SI* and *SFV*. The upper part of the graph is positive (+), while the bottom part is negative (–).

- V-Window values vary in accordance with simple interest conditions.

Press EXIT (or SHIFT F6 (G↔T)) to return to the input screen.

Press EXIT again to return to the Financial 1 screen.

19-3 Compound Interest Calculations

This calculator uses the following standard formulas to calculate compound interest.

•Formula I

$$PV + PMT \bullet \frac{(1+i \bullet S)[(1+i)^n - 1]}{i(1+i)^n} + FV \frac{1}{(1+i)^n} = 0 \qquad \left(i = \frac{I\%}{100}\right)$$

Here:

$$PV = -(PMT \bullet \alpha + FV \bullet \beta)$$

$$FV = -\frac{PMT \bullet \alpha + PV}{\beta}$$

$$PMT = -\frac{PV + FV \bullet \beta}{\alpha}$$

$$n = \frac{\log\left\{\dfrac{(1+iS)\,PMT - FVi}{(1+iS)\,PMT + PVi}\right\}}{\log(1+i)}$$

$$\alpha = \frac{(1+i \bullet S)[(1+i)^n - 1]}{i(1+i)^n}$$

$$\beta = \frac{1}{(1+i)^n}$$

PV : present value
FV : future value
PMT : payment
n : number of compound periods
$I\%$: annual interest rate

i is calculated using Newton's Method.

S = 0 assumed for beginning of term
S = 1 assumed for end of term

$F(i)$ = Formula I

$$F(i)' = \frac{PMT}{i}\left[-\frac{(1+iS)[1-(1+i)^{-n}]}{i} + (1+iS)[n(1+i)^{-n-1}] + S[1-(1+i)^{-n}]\right]$$
$$+ FV - n(1+i)^{-n-1}$$

•Formula II ($I\%$ = 0)

$$PV + PMT \times n + FV = 0$$

Here:

$$PV = -(PMT \bullet n + FV)$$

$$FV = -(PMT \bullet n + PV)$$

$$PMT = -\frac{PV + FV}{n}$$

$$n = -\frac{PV + FV}{PMT}$$

- A deposit is indicated by a plus sign (+), while a withdrawal is indicated by a minus sign (–).

●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*%') when the number of installments per year (*P*/*Y*) is different from the number of compound interest calculation periods (*C*/*Y*). This conversion is required for installment savings accounts, loan repayments, etc.

$$I\%' = \left\{ (1 + \frac{I\%}{100 \times [C/Y]})^{\frac{[C/Y]}{[P/Y]}} - 1 \right\} \times 100$$

P/*Y* : installment periods per year
C/*Y* : compounding periods per year

When calculating *n*, *PV*, *PMT*, *FV*

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.

$$i = I\%' \div 100$$

When calculating *I*%

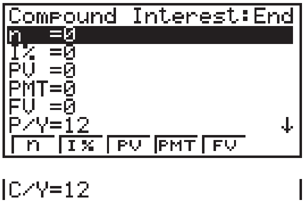
After *I*% is obtained, the following calculation is performed to convert to *I*%'.

$$I\%' = \left\{ (1 + \frac{I\%}{100})^{\frac{[P/Y]}{[C/Y]}} - 1 \right\} \times [C/Y] \times 100$$

P/*Y* : installment periods per year
C/*Y* : compounding periods per year

The value of *I*%' is returned as the result of the *I*% calculation.

Press F2 (CMPD) in the Financial 1 screen to display the input screen for compound interest calculation.



```
Compound Interest:End
n  =0
I% =0
PV =0
PMT=0
FV =0
P/Y=12
C/Y=12
```

n	number of compound periods
I%	annual interest rate
PV	present value (loan amount in case of loan; balance in case of savings)

PMT	payment for each installment (payment in case of loan; deposit in case of savings)
FV	future value (unpaid balance in case of loan; principal plus interest in case of savings)
P/*Y*..................	installment periods per year
C/*Y*	compounding periods per year

Inputting Values

A period (*n*) is expressed as a positive value. Either the present value (*PV*) or future value (*FV*) is positive, while the other (*PV* or *FV*) is negative.

Precision

This calculator performs interest calculations using Newton's Method, which produces approximate values whose precision can be affected by various calculation conditions. Because of this, interest calculation results produced by this calculator should be used keeping the above limitation in mind or the results should be verified.

■ Compound Interest Examples

This section shows how compound interest calculations can be used in a variety of applications.

•Savings (standard compound interest)

Input Condition: Future value is greater than present value.

Formula Representation of Input Condition: $PMT = 0$

$|PV| < |FV|$

Example **Calculate the interest rate required to increase a principal of $10,000 to $12,000 in three years, when compounding is performed semiannually.**

Perform the following key operation from the input screen.

3 × 1 2 EXE (Input $n = 3 \times 12$.)

▼

(–) 1 0 0 0 0 EXE ($PV = –10,000$)

0 EXE

1 2 0 0 0 EXE ($FV = 12,000$)

1 EXE

2 EXE (Semiannual compounding)

F2 (*I*%)

Compound Interest:End
I% =0.5070905363

Now you can press F6 to draw a cash flow graph.

F6 (GRPH)

The left side is *PV*, while the right side is *FV*. The upper part of the graph is positive (+), while the bottom part is negative (–).

•Installment savings

Input Condition: Future value is greater than the total of payments.

Formula Representation of Input Condition:

PMT and *FV* have different signs (positive, negative) when $PV = 0$.

$-FV < n \times PMT$ when $FV > 0$

$-FV > n \times PMT$ when $FV < 0$

Example **Calculate the interest rate required to have a $2,500 balance in an installment savings account in two years when $100 is deposited each month and interest is compounded semiannually.**

Perform the following key operation from the input screen.

2 × 1 2 EXE (Input $n = 2 \times 12$.)

▼

0 EXE ($PV = 0$)

(–) 1 0 0 EXE ($PMT = -100$)

2 5 0 0 EXE ($FV = 2{,}500$)

1 2 EXE (Monthly installment)

2 EXE (Compounding every six months)

F2 (*I*%)

Compound Interest:End
I% =4.273664396

•Loans

Input Condition: Total of payments is greater than loan amount.

Formula Representation of Input Condition:

PMT and *PV* have different signs (positive, negative) when $FV = 0$.

$-PV > n \times PMT$ when $PV > 0$

$-PV < n \times PMT$ when $PV < 0$

Example **Calculate the interest rate required to repay a $2,300 balance on a loan in two years paying back $100 per month, when interest is compounded monthly.**

Perform the following key operation from the input screen.


Compound Interest:End
I% =4.119793667

2 × 1 2 EXE (Input n = 2 × 12.)

▼

2 3 0 0 EXE (PV = 2,300)

(−) 1 0 0 EXE (PMT = –100)

0 EXE (FV = 0)

1 2 EXE (Monthly installment)

(Monthly compounding)

F2 (I%)

The value you input for P/Y (the number of installment periods per year) is also automatically input for C/Y (the number of compounding periods per year). You can input another value for C/Y if you want.

•Loan when final installment is greater than other installments

Input Condition: Total of equal amount payments is greater than the difference between the loan amount and final payment amount.

Formula Representation of Input Condition:

PV, PMT, FV do not equal zero.

$PV + FV > -n \times PMT$ when $FV > PV$

$PV + FV < -n \times PMT$ when $FV < PV$

Example **Calculate the interest rate required to repay a $2,500 balance on a loan in two years (24 installments) paying back $100 per month and a final $200 installment, when interest is compounded monthly.**

Perform the following key operation from the input screen.


Compound Interest:End
I% =3.542452842

2 × 1 2 EXE (Input n = 2 × 12.)

▼

2 5 0 0 EXE (PV = 2,500)

(−) 1 0 0 EXE (PMT = –100)

(−) 2 0 0 EXE (FV = –200)

1 2 EXE (Monthly installment)

(Monthly compounding)

F2 (I%)

■ Savings

•Future value

Example **Calculate the future value after 7.6 years for a principal of $500 and an interest rate of 6%, compounded annually.**

Perform the following key operation from the input screen.

7 . 6 EXE (n = 7.6 years)
6 EXE (I = 6%)
(–) 5 0 0 EXE (PV = –500)
0 EXE (PMT = 0)
0 EXE (FV = 0)
1 EXE
1 EXE (Annual compounding)
F5 (FV)

```
Compound Interest:End
FV =778.5644694
```

•Principal

Example **Calculate the principal required at 5.5%, compounded monthly, to produce a total of $20,000 in a year.**

Perform the following key operation from the input screen.

1 × 1 2 EXE (Input n = 1 × 12.)
5 . 5 EXE (I = 5.5%)
▼
0 EXE (PMT = 0)
2 0 0 0 0 EXE (FV = 20,000)
1 EXE
1 2 EXE (Monthly compounding)
F3 (PV)

```
Compound Interest:End
PV =-10352.62559
```

•Compound interest rate

Example **Calculate the interest required, compounded monthly, to produce a total of $10,000 in 10 years on an initial investment of $6,000.**

P.7

In the set up screen, specify "**Begin**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

1 0 × 1 2 EXE (Input n = 10 × 12.)

▼

(–) 6 0 0 0 EXE (PV = –6,000)

0 EXE (PMT = 0)

1 0 0 0 0 EXE (FV = 10,000)

1 EXE

1 2 EXE (Monthly compounding)

F2 (I%)

Compound Interest:Bgn
I% =0.425763533

•Compound interest period

Example **Calculate the amount of time required to increase an initial investment of $5,000 to a total of $10,000 at an annual rate of 4%, compounded monthly.**

P.7

In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

▼

4 EXE (I% = 4)

(–) 5 0 0 0 EXE (PV = –5,000)

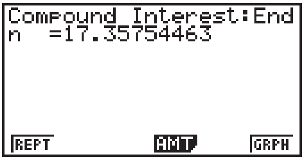
0 EXE (PMT = 0)

1 0 0 0 0 EXE (FV = 10,000)

1 EXE

1 2 EXE (Monthly compounding)

F1 (n)



Compound Interest:End
n =17.35754463

•Installment savings

Example **Calculate (to two decimal places) the principal plus interest for $250 monthly installments for five years at 6% annual interest, compounded monthly.**

Calculate amounts for when installments are made at the beginning of each month and at the end of each month.

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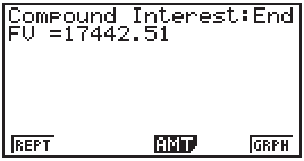
P.6

In the set up screen, specify "**End**" for Payment and "**Fix2**" for Display, and then press EXIT.

Perform the following key operation from the input screen.



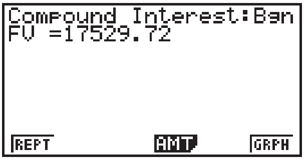
```
Compound Interest:End
FV =17442.51
```

5 × 1 2 EXE (Input n = 5 × 12.)
6 EXE (I = 6.0%)
0 EXE (PV = 0)
(−) 2 5 0 EXE
▼
1 2 EXE (Monthly installments)
(Monthly compounding)
F5 (FV)

P.7

Specifying “**Begin**” for Payment in the set up screen changes to calculation of installments at the beginning of each month.

F5 (FV)



```
Compound Interest:Bgn
FV =17529.72
```

•Installment amount

Example **Calculate the amount required for each installment to accumulate a total of $10,000 in 5 years at an annual interest rate of 6%, compounded semiannually.**

P.7
P.6

In the set up screen, specify “**End**” for Payment, “**Norm1**” for Display, and then press EXIT .

Perform the following key operation from the input screen.

```
Compound Interest:End
PMT=-143.5995006
```

5 × 1 2 EXE (Input n = 5 × 12.)
6 EXE (I = 6.0%)
0 EXE (PV = 0)
▼
1 0 0 0 0 EXE (FV = 10,000)
1 2 EXE (Monthly installments)
2 EXE (Semiannual compounding)
F4 (PMT)

•Number of installments

Example **Calculate the number of monthly $84 installments required to accumulate a total of $6,000 at an annual interest rate of 6%, compounded annually.**

P.7

In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

▼
6 EXE
0 EXE ($PV = 0$)
(-) 8 4 EXE ($PMT = -84$)
6 0 0 0 EXE ($FV = 6{,}000$)
1 2 EXE (Monthly installments)
1 EXE (Annual compounding)
F1 (n)

```
Compound Interest:End
n  =61.45017475
```

•Interest rate

Example **Calculate the annual interest rate required to accumulate a total of $10,000 in 10 years with $60 monthly installments.**

P.7

In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

1 0 × 1 2 EXE (Input $n = 10 \times 12$.)
▼
0 EXE ($PV = 0$)
(-) 6 0 EXE ($PMT = -60$)
1 0 0 0 0 EXE ($FV = 10{,}000$)
1 2 EXE (Monthly installments)
1 EXE (Annual compounding)
F2 (I%)

```
Compound Interest:End
I% =6.495824535
```

•Principal plus interest with initial deposit

Example **Calculate the principal plus interest after one year for an installment savings account with an interest rate of 4.5%, compounded monthly, opened with an initial deposit of $1,000, with $500 installments added each month.**

P.7

In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

1 × 1 2 EXE (Input n = 1 × 12.)

4 • 5 EXE

(–) 1 0 0 0 EXE (PV = –1,000)

(–) 5 0 0 EXE (PMT = –500)

▼

1 2 EXE (Monthly installments)

(Monthly compounding)

F5 (FV)


Compound Interest:End
FV =7171.24983

•Borrowing power

Example **Calculate how much can be borrowed on a 15-year loan at a 7.5% annual interest rate, compounded monthly, if a payment of $450 per month can be made.**

P.7

In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

1 5 × 1 2 EXE (Input n = 15 × 12.)

7 • 5 EXE

▼

(–) 4 5 0 EXE (PMT = –450)

0 EXE (FV = 0)

1 2 EXE (Monthly installments)

(Monthly compounding)

F3 (PV)


Compound Interest:End
PV =48543.04208

•Loan installments

Example **Calculate the size of the monthly installment for a 25-year $300,000 home loan made at 6.2%, compounded semiannually.**

P.7

In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

2 5 × 1 2 EXE (Input n = 25 × 12.)

6 • 2 EXE

3 0 0 0 0 0 EXE (PV = 300,000)

▼

0 EXE (FV = 0)

1 2 EXE (Monthly installments)

2 EXE (Semiannual compounding)

F4 (PMT)


Compound Interest:End
PMT=-1955.228277

•Number of installments

Example **Calculate the number of years it will take to repay a $60,000 loan borrowed at 5.5%, compounded monthly, with monthly installments of $840.**

P.7

In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

▼
5 • 5 EXE
6 0 0 0 0 EXE (PV = 60,000)
(−) 8 4 0 EXE (PMT = –840)
0 EXE (FV = 0)
1 2 EXE (Monthly installments)
(Monthly compounding)
F1 (n)

```
Compound Interest:End
n   =86.72384474
```

•Effective interest rate

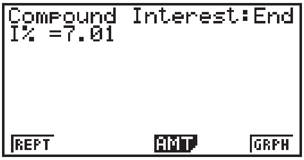
Example **Calculate (to two decimal places) the effective interest rate compounded monthly, on a 25-year $65,000 loan repaid with $460 monthly installments.**

P.7
P.6

In the set up screen, specify "**End**" for Payment, "**Fix2**" for Display, and then press EXIT.

Perform the following key operation from the input screen.

2 5 × 1 2 EXE (Input n = 25 × 12.)
▼
6 5 0 0 0 EXE (PV = 65,000)
(−) 4 6 0 EXE (PMT = –460)
0 EXE (FV = 0)
1 2 EXE (Monthly installments)
(Monthly compounding)
F2 (I%)



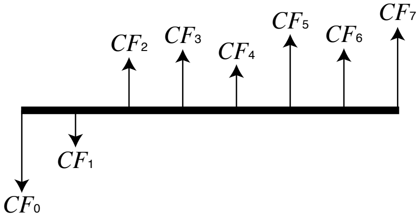
```
Compound Interest:End
I% =7.01
```

19-4 Investment Appraisal

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.

- Net present value (*NPV*)
- Net future value (*NFV*)
- Internal rate of return (*IRR*)
- Pay back period (*PBP*)

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.

Investment appraisal can be used to clearly determine whether an investment is realizing profits that were originally targeted.

•*NPV*

$$NPV = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \dots + \frac{CF_n}{(1+i)^n} \qquad \left(i = \frac{I\%}{100}\right)$$

n: natural number up to 254

•*NFV*

$$NFV = NPV \times (1+i)^{\mathrm{N}}$$

•*IRR*

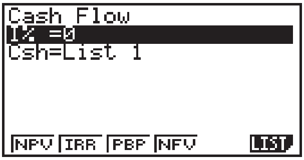
$$0 = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \dots + \frac{CF_n}{(1+i)^n}$$

In this formula, $NPV = 0$, and the value of *IRR* is equivalent to $i \times 100$. 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*

Initial value of N when $NPV \geqq 0$.

Press F3 (CASH) from the initial screen 1 to display the following input screen for investment appraisal.



Cash Flow
I% =0
Csh=List 1

I% .... interest rate

Csh .... list for cash flow

- {**NPV**}/{**IRR**}/{**PBP**}/{**NFV**} ... {net present value}/{internal rate of return}/ {pay back period}/{net future value}
- {**LIST**} ... {specifies a list for cash flow}

Example **An investment of $86,000 in machinery projects the annual revenues shown in the table below (all revenues realized at the end of the fiscal year). What is the net profit or loss of this investment if the useful service life of the machine is six years, the resale value after six years is $14,000, and the capital cost is 11%?**

Year	Revenues
1	–5,000
2	42,000
3	31,000
4	24,000
5	23,000
6	12,000 + 14,000

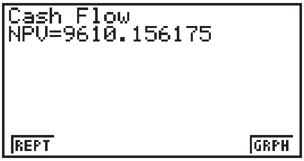
On the Main Menu, select the **LIST** icon to enter the LIST Mode and perform the following key operation.

▶(List 2)
(−) 8 6 0 0 0 EXE
(−) 5 0 0 0 EXE
4 2 0 0 0 EXE
3 1 0 0 0 EXE
2 4 0 0 0 EXE
2 3 0 0 0 EXE
1 2 0 0 0 + 1 4 0 0 0 EXE

Return to the Main Menu by pressing MENU. Select the **TVM** icon to enter the Financial Mode, and then press F3 (CASH).

Perform the following key operation from the input screen.

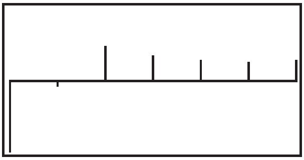
1 1 EXE (*I*% = 11)
F6 (List) F2 (List2)
F1 (*NPV*)



Cash Flow
NPV=9610.156175

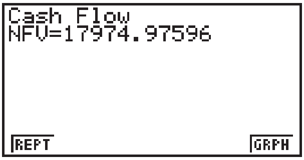
Now you can press F6 (GRPH) to draw a cash flow graph.

F6 (GRPH)



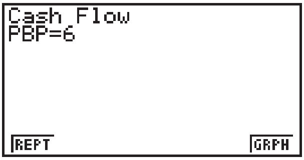
Pressing SHIFT F1 (TRCE) activates trace, which can be used to look up the following values.

SHIFT F6 (G↔T)
F4 (*NFV*)



Cash Flow
NFV=17974.97596

F1 (REPT)
F3 (*PBP*)



Cash Flow
PBP=6

Example **An investment of $10,000 in machinery projects the annual revenues shown in the table below (all revenues realized at the end of the fiscal year). What is the internal rate of return of this investment if the useful service life of the machinery is five years and the resale value after five years is $7,000?**

Year	Revenues
1	2,000
2	2,400
3	2,200
4	2,000
5	1,800 + 3,000

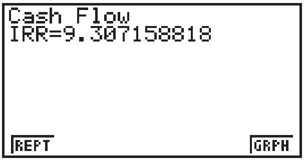
On the Main Menu, select the **LIST** icon to enter the LIST Mode and perform the following key operation.

▶ ▶(List 3)
(−) 1 0 0 0 0 EXE
2 0 0 0 EXE
2 4 0 0 EXE
2 2 0 0 EXE
2 0 0 0 EXE
1 8 0 0 + 3 0 0 0 EXE

Return to the Main Menu by pressing MENU. Select the **TVM** icon to enter the Financial Mode, and then press F3 (CASH).

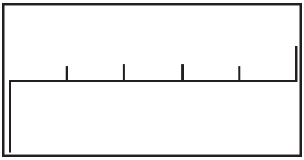
Perform the following key operation from the input screen.

▼
F6(List) F3(List 3)
F2(*IRR*)


Cash Flow
IRR=9.307158818

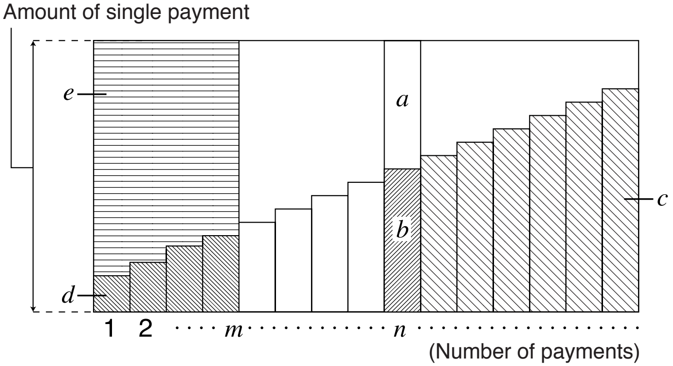
Now you can press F6 to draw a cash flow graph.

F6(GRPH)



19-5 Amortization of a Loan

This calculator can be used to calculate the principal and interest portion of a monthly installment, the remaining principal, and amount of principal and interest repaid up to any point.



a: Interest portion of installment PM1 (*INT*)

b: Principal portion of installment PM1 (*PRN*)

c: Balance of principal after installment PM2 (*BAL*)

d: Total principal from installment PM1 to payment of installment PM2 (ΣPRN)

e: Total interest from installment PM1 to payment of installment PM2 (ΣINT)

* $a + b$ = one repayment (*PMT*)

$$a : INT_{\text{PM1}} = |\, BAL_{\text{PM1}-1} \times i \,| \times (PMT \text{ sign})$$

$$b : PRN_{\text{PM1}} = PMT + BAL_{\text{PM1}-1} \times i$$

$$c : BAL_{\text{PM2}} = BAL_{\text{PM2}-1} + PRN_{\text{PM2}}$$

$$d : \sum_{\text{PM1}}^{\text{PM2}} PRN = PRN_{\text{PM1}} + PRN_{\text{PM1+1}} + \dots + PRN_{\text{PM2}}$$

$$e : \sum_{\text{PM1}}^{\text{PM2}} INT = INT_{\text{PM1}} + INT_{\text{PM1+1}} + \dots + INT_{\text{PM2}}$$

$BAL_0 = PV$ ($INT_1 = 0$ and $PRN_1 = PMT$ at beginning of installment term)

•Converting between the nominal interest rate and effective interest rate

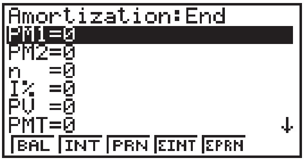
The nominal interest rate (*I*% value input by user) is converted to an effective interest rate (*I*%') for installment loans where the number of installments per year is different from the number of compound interest calculation periods.

$$I\%' = \left\{ \left(1 + \frac{I\%}{100 \times [C/Y]}\right)^{\frac{[C/Y]}{[P/Y]}} - 1 \right\} \times 100$$

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.

$$i = I\%' \div 100$$

Press F4 (*AMT*) from the initial screen 1 to display the following input screen for amortization.


```
Amortization:End
PM1=0
PM2=0
n  =0
I% =0
PV =0
PMT=0                ↓
```


```
FV =0
P/Y=12
C/Y=12
```

PM1	first installment of installments 1 through n
PM2	second installment of installments 1 through n
n	installments
I%	interest rate
PV	principal
PMT	payment for each installment
FV	future value
P/Y	installments per year
C/Y	compoundings per year

- {*BAL*} ... {balance of principal after installment PM2}
- {*INT*}/{*PRN*} ... {interest}/{principal} portion of installment PM1
- {Σ*INT*}/{Σ*PRN*} ... {total principal}/{total interest} from installment PM1 to payment of installment PM2

Example **Calculate the monthly installment due on a $140,000 15-year home mortgage at an annual rate of 6.5%, compounded semiannually.**

Also calculate *PRN* and *INT* for the second year (24th installment), *BAL* for installment 49, and Σ*INT*, Σ*PRN* for installments 24 through 49.

Display the TVM Menu and then press F2.

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In the set up screen, specify "**End**" for Payment and then press EXIT.

Perform the following key operation from the input screen.

1 5 × 1 2 EXE (Input n = 15 × 12.)

6 • 5 EXE

1 4 0 0 0 0 EXE (PV = 140,000)

▼

0 EXE (FV = 0)

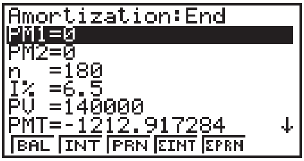
1 2 EXE (Monthly installments)

2 EXE (Semiannual compounding)

F4 (PMT)

```
Compound Interest:End
PMT=-1212.917284
```

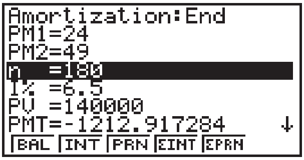
Pressing F4 (AMT) displays the amortization input screen.



```
Amortization:End
PM1=0
PM2=0
n  =180
I% =6.5
PV =140000
PMT=-1212.917284   ↓
```

Input 24 for PM1 and 49 for PM2.

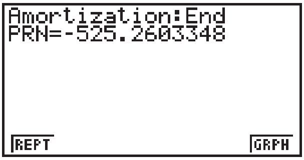
2 4 EXE 4 9 EXE



```
Amortization:End
PM1=24
PM2=49
n  =180
I% =6.5
PV =140000
PMT=-1212.917284   ↓
```

Calculate PRN.

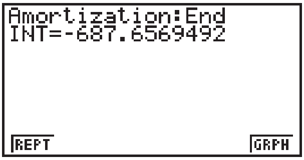
F3 (PRN)



```
Amortization:End
PRN=-525.2603348
```

F1 (REPT)

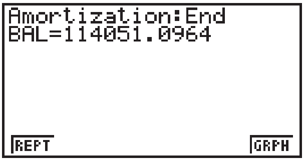
F2 (INT)



```
Amortization:End
INT=-687.6569492
```

F1 (REPT)

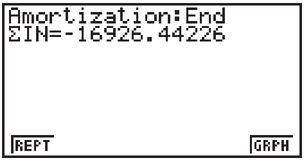
F1 (BAL)



```
Amortization:End
BAL=114051.0964
```

Calculate Σ*INT* from installment 24 to 49.

F1 (REPT)
F4 (Σ*INT*)



```
Amortization:End
ΣIN=-16926.44226
```

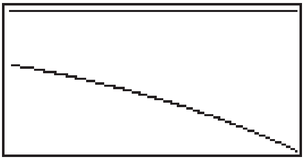
Calculate Σ*PRN*.

F1 (REPT)
F5 (Σ*PRN*)

```
Amortization:End
ΣPR=-14609.40712
```

Now you can press F6 to draw a cash flow graph.

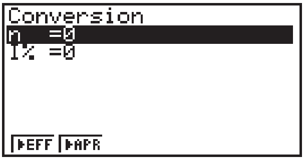
F6 (GRPH)



- Trace can be activated following the calculation. Pressing ▶ displays *INT* and *PRN* when n = 1. Each subsequent press of ▶ displays *INT* and *PRN* for n = 2, n = 3, and so on.

19-6 Conversion between Percentage Interest Rate and Effective Interest Rate

Press F5 (CNVT) in the Financial 1 screen to display the following input screen for interest rate conversion.


Conversion
n =0
I% =0

n .... number of compoundings
I% .... interest rate

- {▶**EFF**}/{▶**APR**} ... {annual percentage rate to effective interest rate}/{effective interest rate to annual percentage rate} conversion

■ Converting the Annual Percentage Rate (*APR*) to the Effective Interest Rate (*EFF*)

$$EFF = \left[\left(1 + \frac{APR/100}{n}\right)^{n} - 1\right] \times 100$$

Example **Calculate (to two decimal places) the effective interest rate for an account paying an interest rate of 12%, compounded quarterly.**

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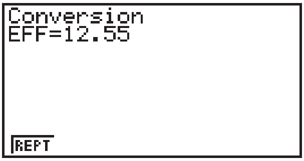
In the set up screen, specify "**Fix2**" for Display and then press EXIT.

Perform the following key operation from the input screen.

4 EXE (n = 4)
1 2 EXE (I% = 12%)
F1 (▶*EFF*)


Conversion
EFF=12.55

- The obtained value is assigned to I%.

■ Converting the Effective Interest Rate (*EFF*) to the Annual Percentage Rate (*APR*)

$$APR = \left[\left(1 + \frac{EFF}{100}\right)^{\frac{1}{n}} - 1\right] \times n \times 100$$

Example **Calculate the annual percentage rate for an account paying an effective interest rate of 12.55%, compounded quarterly.**

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In the set up screen, specify “**Norm1**” for Display and then press EXIT.

Perform the following key operation from the input screen.

4 EXE (n = 4)

1 2 • 5 5 EXE (I% = 12.55%)

F2 (▶APR)

```
Conversion
APR=11.99919376
```

- The obtained value is assigned to I%.

19-7 Cost, Selling Price, Margin Calculations

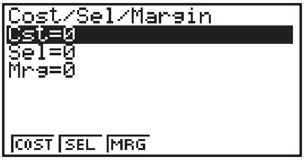
Cost, selling price, or margin can be calculated by inputting the other two values.

$$CST = SEL\left(1 - \frac{MAR}{100}\right)$$

$$SEL = \frac{CST}{1 - \frac{MAR}{100}}$$

$$MAR(\%) = \left(1 - \frac{CST}{SEL}\right) \times 100$$

Press F1 (COST) from the initial screen 2 to display the following input screen.



Cost/Sel/Margin
Cst=0
Sel=0
Mrg=0

Cst	cost
Sel	selling price
Mrg	margin

- {**COST**}/{**SEL**}/{**MRG**} ... calculates {cost}/{selling price}/{margin}

■ Cost

Example **Calculate the cost for a selling price of $2,000 and a margin of 15%.**

Perform the following key operation from the input screen.

▼
2 0 0 0 EXE (Sel = 2,000)
1 5 EXE (Mrg = 15)
F1 (COST)

Cost/Sel/Margin
Cst=1700

■ Selling Price

Example **Calculate the selling price for a cost of $1,200 and a margin of 45%.**

Perform the following key operation from the input screen.

1 2 0 0 EXE (Cst = 1,200)

▼

4 5 EXE (Mrg = 45)

F2 (SEL)

```
Cost/Sel/Margin
Sel=2181.818182
```

■ Margin

Example **Calculate the margin for a selling price of $2,500 and a cost of $1,250.**

Perform the following key operation from the input screen.

1 2 5 0 EXE (Cst = 1,250)

2 5 0 0 EXE (Sel = 2,500)

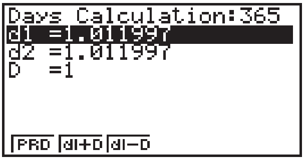
F3 (MRG)

```
Cost/Sel/Margin
Mrg=50
```

19-8 Day/Date Calculations

You can calculate the number of days between two dates, or you can determine what date comes a specific number of days before or after another date.

Press F2 (DAYS) from the initial screen 2 to display the following input screen for day/date calculation.


Days Calculation:365
d1 =1.011997
d2 =1.011997
D =1

d1 .... date 1

d2 .... date 2

D .... number of days

- {**PRD**} ... {calculates number of dates between two dates (d2 – d1)}
- {**d1+D**}/{**d1–D**} ... Calculates {future date/previous date}

> - The set up screen can be used to specify either a 365-day or 360-day year for financial calculations. Day/date calculations are also performed in accordance with the current setting for number of days in the year, but the following calculations cannot be performed when the 360-day year is set. Attempting to do so causes an error.
>
>   (Date) + (Number of Days)
>
>   (Date) – (Number of Days)
> - The allowable calculation range is January 1, 1901 to December 31, 2099.

The format for inputting a date is: <month> • <day><year>

Two digits must always be input for the day, so a leading zero must be input for days 1 through 9.

Example **January 2, 1990**

1 • 0 2 1 9 9 0

December 31, 2099

1 2 • 3 1 2 0 9 9

Example **Calculate the number of days from August 8, 1967 to July 15, 1970, using a 365-day year.**

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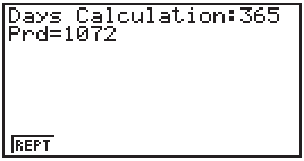
In the set up screen, specify "**365**" for Date Mode and then press EXIT.

Perform the following key operation from the input screen.


```
Days Calculation:365
Prd=1072
```

8 • 0 8 1 9 6 7 EXE

(d1 = August 8, 1967)

7 • 1 5 1 9 7 0 EXE

(d2 = July 15,1970)

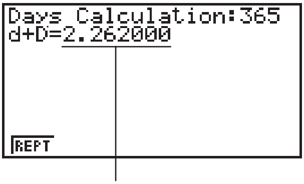
F1 (PRD)

Prd .... number of days

Example **Determine the date that is 1,000 days after June 1, 1997.**

Note that the attempting to perform the following calculation while the 360-day year is in effect causes an error.

Perform the following key operation from the input screen.


```
Days Calculation:365
d+D=2.262000
```

February 26, 2000

6 • 0 1 1 9 9 7 EXE

(d1 = June 1, 1997)

▼ (d2 = Any date)

1 0 0 0 EXE

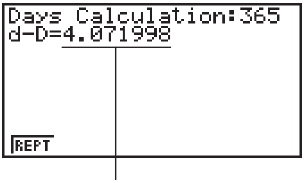
F2 (d1+D)

d+D .... future date calculation

Example **To determine the date that is 1,000 days before January 1, 2001, usig a 365-day year.**

Note that the attempting to perform the following calculation while the 360-day year is in effect causes an error.

Perform the following key operation from the input screen.


```
Days Calculation:365
d-D=4.071998
```

April 7, 1998

1 • 0 1 2 0 0 1 EXE

(d1 = January 1, 2001)

▼ (d2 = Any date)

1 0 0 0 EXE

F3 (d1–D)

d–D .... previous date calculation

Chapter 20

Algebraic Expressions

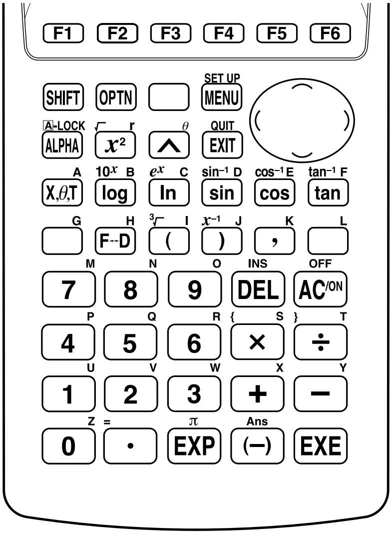
The ALGBR Mode (Algebraic Mode) provides tools for expansion of algebraic expressions, factoring, etc. In this mode, differential and integration calculation results are displayed as mathematical expressions instead of decimal values.

20-1 Before Using the Algebraic Mode

In the Main Menu, select the **ALGBR** icon to enter the ALGBR Mode and display its initial screen, which contains the following items.

- {**expn**} ... {expansion}
- {**fctor**} ... {factorization}
- {**diff**} ... {differential}
- {**∫(**} ... {integration}
- {**SOLV**} ... {Solve function}
- {**tExp**} ... {expression transformation using the addition theorem}
- {**tColl**} ... {product-to-sum transformation using the addition theorem}
- {**comb**} ... {combination}
- {**PTS▶**} ... {function for line passing through specific points}
- {**CPLX**} ... {complex function transformation}
- {**appr**} ... {convert to numeric value}
- {**collc**} ... {collection}
- {**tanL**} ... {tangent expression}

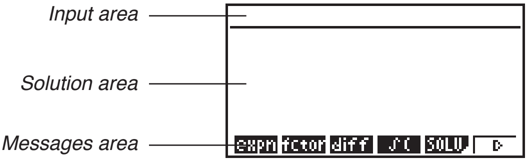
The following table shows the keys that can be used in the ALGBR Mode.



- The F↔D key performs its screen shot send function only. It does not perform its fraction-decimal conversion function.

20-2 Inputting and Executing Calculations

The ALGBR Mode display is divided into three areas: an input area, a solution area, and a message area (used for display of menus and error messages).

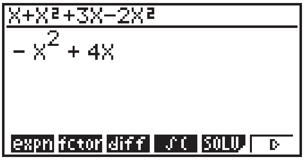


Example $X + X^2 + 3X - 2X^2$

X,θ,T + X,θ,T x^2 + 3 X,θ,T − 2 X,θ,T x^2

X+X²+3X−2X²

EXE



X+X²+3X−2X²

$-X^2 + 4X$

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- Solutions are displayed in natural display notation.
- Solutions produced in the ALGBR Mode are also stored in Ans memory and can be recalled by pressing SHIFT Ans.
- You can input up to 255 bytes of data for each ALGBR Mode calculation.
- If a solution does not fit within the solution area, use ▲, ▼, ◀, and ▶ to scroll the screen.
- Inputting more data while there is data in the input area and solution area causes the previous data to be cleared from two areas automatically.
- If you clear the display by pressing AC, you can recall the previous operation by pressing ◀ or ▶ (Replay Function).
- The Angle item of the set up screen can be set to either **"Deg"** or **"Rad"** for ALGBR Mode operations.
- The Display item of the set up screen can be set to **"Fix"**, **"Sci"**, or **"Norm"** for ALGBR Mode operations. Note, however, that this setting is applied for the **approx** command only.
- A displayed solution can be stored in function memory by pressing OPTN F6 (FMEM) F1 (STO). Next, press a function F1 (f_1) to F6 (f_6) to select a specific function memory.

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20-3 ALGBR Mode Commands

In the ALGBR Mode, results are calculated in accordance with commands and expressions you input. This section describes each of the commands available in the ALGBR Mode.

■ Conventions Used in this Section

The following conventions are used in the command descriptions of this section.

Item	Description
<expression>	This item indicates a mathematical expression input by you. The actual expression you should input depends on the type of operation you are performing. One example of an expression is: X+1.
<variable>	This item indicates a variable input by you. The actual variable you should input depends on the type of operation you are performing. One example of a variable is: A.
[ ]	Anything enclosed within square brackets is optional, which means you can skip it if you want. Note the following: expand (<expression>[)] The above example means that the final closed parenthesis to the right of <expression> does not need to be input for the command to execute properly.

■ Commands

•Expansion —— (expn)

This command expands an expression.

Syntax: expand (<expression>[)]

Example **To expand the expression $(X + 2)^2$**

F1 (expn) (X,θ,T + 2) x^2 EXE **$X^2 + 4X + 4$**

•Factorization —— (fctor)

This command factorizes an expression.

Syntax: factor (<expression>[)]

Example **To factorize the expression X^2 - 4X + 4**

F2 (fctor) X,θ,T x^2 − 4 X,θ,T
+ 4 EXE $(X – 2)^2$

- You can also factorize a value into its prime factors.

Example **To factorize 64 into its prime factors**

F2 (fctor) 6 4 EXE 2^6

●Addition Theorems —— (tExp)

This command uses trigonometric addition theorems to transform an expression.

Syntax: tExpand (<expression>[)]

Example **To transform sin(A+B) using addition theorems**

F6 (▷) F1 (tExp)
sin (ALPHA A + ALPHA B EXE **cos(B) · sin(A) + sin(B) · cos(A)**

●Product-to-Sum Transformation —— (tColl)

This command uses addition theorems to perform product-to-sum transformation.

Syntax: tCollect (<expression>[)]

Example **To perform product-to-sum transformation on sin(A)cos(B) using addition theorems**

F6 (▷) F2 (tColl)
sin ALPHA A cos ALPHA B EXE

$$\frac{\sin(A + B)}{2} + \frac{\sin(A - B)}{2}$$

•Integration —— (∫( )

This command can be used to determine the primitive function or calculate the definite integral for an expression.

Syntax 1: ∫ (<expression>, <variable> [, <integration constant>] [)]
Syntax 2: ∫ (<expression>[, <variable>, <integration constant>] [)]
Syntax 3: ∫ (<expression>, <variable> , <start>, <end> [)]

<integration constant>........... Integration constant
<start> .... Start point of the integration interval
<end> .... End point of the integration interval

- A default variable of X is used when specification of a variable is skipped in Syntax 2.
- Syntax 3 calculates the definite interval in accordance with the specified integration interval.
- Multiple integral calculations can also be performed.

Example **To integrate the expression X^2 for variable X**

F4(∫( ) X,θ,T x^2 , X,θ,T EXE

$$\frac{X^3}{3}$$

- A default value of 0 is automatically assumed for the integration constant. Inputting a symbol name such as C for the integration constant produces a result in a form that is the same as the indefinite integral.

•Differential —— (diff)

This command can be used to determine the derivative or calculate the value of the derivative for an expression.

Syntax 1: diff (<expression>, <variable>, <*n*th>[, <differential coefficient>] [)]
Syntax 2: diff (<expression>, <variable>[, <*n*th>, <differential coefficient>] [)]
Syntax 3: diff (<expression>[, <variable>, <*n*th>, <differential coefficient>] [)]

<*n*th> .... Specifies differential of *n*th order. *n* must be a positive integer.
<differential coefficient>
.... Any value specified as the differential coefficient is substituted in the function for calculation of the result.

- Syntax 1 determines the derivative in accordance with a specified expression, variable and order. Specifying a differential coefficient calculates a result in accordance with the input value.
- A default order of 1 is used when specification of the order is skipped in Syntax 2.
- A default variable of X is used when specification of a variable is skipped in Syntax 3.

Example **To differentiate the expression X^6 for variable X**

F3(diff) X,θ,T ^ 6 EXE **$6X^5$**

•Tangent Expression —— (tanL)

This command calculates the tangent expression of another expression.

Syntax: tanLine (<expression>, <variable>, <contact point>[)]

<contact point>
.... The contact point is specified using the <variable> name.

Example **To calculate the tangent expression when X = 2 for the expression X^3**

F6(▷) F6(▷) F3(tanL)
X,θ,T ^ 3 , X,θ,T , 2 EXE **12X – 16**

•Solve —— (solve)

This command calculate solutions for an expression. Solutions are displayed as mathematical expressions.

Syntax: solve (<expression> [=<expression>] [, <variable>] [)]

The second expression can be preceded by any of the following operators: = (equals), < (less than), > (greater than), ≤ (less than or equal to), or ≥ (greater than or equal to).

- A default variable of X is used when specification of a variable is skipped.

Example **To solve AX+B = 0 for X**

F5 (SOLV) F1 (solve) ALPHA A
X,θ,T + ALPHA B , X,θ,T EXE

$$\left\{ X = \frac{-B}{A} \right\}$$

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- Other solve functions are available that produce numeric calculation results .

●Convert to Numeric Value —— (appr)

This command converts an expression to a numeric value.

Syntax: approx <expression>

Example **To convert the expression $\sqrt{2}$ to a numeric value**

F6 (▷) F6 (▷) F1 (appr)
SHIFT √ 2 EXE

1.414213562

- Any command to the left of **approx** causes an error.

Example **1+ approx ($\sqrt{2}$) (Causes an error.)**

- Inputting another ALGBR Mode command or the **signum(** function into the **approx** command causes an error.

Example **approx approx $\sqrt{2}$ (Causes an error.)**

■ Difference Between "approx" and Standard Calculations

approx differs from standard calculations (calculations that do not use natural display notation) in the number of display digits and handling of variables. With standard calculations, calculation results are displayed without using exponential notation.

Example 9 ^ 2 0 EXE **12157665459056928801**

When part of the expression includes a variable, the variable is processed as a variable regardless of whether or not it has been assigned a value.

Example 5 × ALPHA A + 3 EXE **5A + 3**

With **approx**, calculation results are displayed using exponential notation. As with the RUN Mode, the mantissa can have up to 10 digits and the exponent up to two digits. The number of digits that can be input for **approx** depends on the setting of the set up screen's Display item.

Example F6 (▷) F6 (▷) F1 (appr) 9 ^ 2 0 EXE **(Display: Norm1)**

1.215766546E + 19

When part of the expression includes a variable, the calculation is performed by substituting the value for the variable. The following shows the calculation when A = 0.

Example F6 (▷) F6 (▷) F1 (appr) 5 × ALPHA A + 3 EXE

3

•Collection —— (collc)

This command arranges the terms of an expression, focusing on a particular variable.

Syntax: collect (<expression>[, <variable>] [)]

- A default variable of X is used when specification of a variable is skipped.

Example **To arrange the terms of the expression X^2 + AX + BX, focusing on the variable X**

F6 (▷) F6 (▷) F2 (collc) X,θ,T x^2 +
ALPHA A X,θ,T + ALPHA B X,θ,T EXE

$X^2 + (A + B)X$

•Combine —— (comb)

This command produces a fraction made up of a fully expanded numerator over a fully expanded denominator.

Syntax: combine (<expression>[)]

Example **To combine the expressions (X+1) / (X+2) + X × (X+3)**

F6 (▷) F3 (comb) (X,θ,T + 1)
÷ (X,θ,T + 2) + X,θ,T ×
(X,θ,T + 3) EXE

$$\frac{X^3 + 5X^2 + 7X + 1}{X + 2}$$

•Sequence —— (sequ)

This command creates the function that describes the relationship between the variable and the value of the expression, if the value of the expression is entered when the variable is assigned the first specified <value>, the second specified <value>, and so on.

- The function is a linear algebra expression.

Syntax 1: sequence ({<value>, <value>, ...} [,<variable>] [)]

- A default variable of X is used when specification of a variable is skipped.

Example **To obtain the expression when 1 through 4 is {23, 30, 37, 45}**

F6 (▷) F4 (PTS▶) F1 (sequ)
SHIFT { 2 3 , 3 0 , 3 7 ,
4 5 SHIFT } , ALPHA N EXE

$$\frac{N^3}{6} - N^2 + \frac{53N}{6} + 15$$

- If List 1 = {23, 30, 37, 45}, the same result can be obtained by inputting the following: sequence(List 1, N).

Syntax 2: sequence ({<value>, <value>, ...},{<value>, <value>, ...} [,<variable>] [)]

The values input with this syntax are handled as lists, with the first value of the first list paired with the first value of the second list, the second value with the second value, and so on. This syntax creates a function using this relationship.

Example **To obtain an expression for variable values {2, 4, 6, 8} and expression values {23, 30, 37, 44}**

F6 (▷) F4 (PTS▶) F1 (sequ)
SHIFT { 2 , 4 , 6 , 8
SHIFT } , SHIFT { 2 3 , 3 0
, 3 7 , 4 4 SHIFT } ,
ALPHA N EXE

$$\frac{7N}{2} + 16$$

- If List 1 = {2, 4, 6, 8} and List 2 = {23, 30, 37, 44}, the same result can be obtained by inputting the following: sequence(List 1, List 2, N).

•Sum of Sequence —— (smSq)

This command obtains a function that expresses the sum up to the *n*th term of a sequence of numbers.

- The function is a linear algebra expression.

Syntax: sumSeq ({<value>, <value>, ...} [,<variable>] [)]

- A default variable of X is used when specification of a variable is skipped.

Example **To obtain an expression that expresses the sum up to the *n*th term when terms 1 through 4 are the following sequence of values: {23, 30, 37, 45}**

F6 (▷) F4 (PTS▶) F2 (smSq)

SHIFT { 2 3 , 3 0 , 3 7

, 4 5 SHIFT } , ALPHA N EXE

$$\frac{N^4}{24}-\frac{N^3}{4}+\frac{95N^2}{24}+\frac{77N}{4}$$

- If List 1 = {23, 30, 37, 45}, the same result can be obtained by inputting the following: sumSeq(List 1, N).

•Complex Exponential-to-Trigonometric Transformation —— (expTo)

This command transforms an exponential function whose exponent includes an imaginary number to a trigonometric function.

Syntax: expToTrig (<expression>[)]

Example **To transform the following function to a trigonometric function: e^{iX}**

F6 (▷) F5 (CPLX) F1 (expTo)

SHIFT e^x (F3 (i) X,θ,T) EXE

cos(X) + i · sin(X)

•Complex Trigonometric-to-Exponential Transformation —— (trgTo)

This command transforms a trigonometric function whose argument is an imaginary number to an exponential function.

Syntax: trigToExp (<expression>[)]

Example **To transform the following function to an exponential function: cos iX**

F6 (▷) F5 (CPLX) F2 (trgTo)

COS (F3 (i) X,θ,T) EXE

$$\frac{e^{X}+\frac{1}{e^{X}}}{2}$$

20-4 Signum Function

The signum function described in this section is available in the ALGBR Mode.

Syntax: signum (<expression>[)]

- A solution can be obtained only when <expression> is a numeric value.

Definition:

$$signum(A) \begin{cases} 1 \text{ (real number, } A > 0) \\ \text{Undefined } (A = 0) \\ -1 \text{ (real number, } A < 0) \\ \frac{A}{|A|} \; (A = \text{imaginary number}) \end{cases}$$

Example **To solve signum (3.1)**

OPTN F5(sign) 3 • 1 EXE **1**

Example **To solve signum (–4)**

OPTN F5(sign) (–) 4 EXE **– 1**

20-5 Natural Display Notation

Most calculators use their own symbols, such as ABS for absolute values and ^ for powers, in place of standard mathematical notation. Expressions in the ALGBR Mode are displayed using "natural display notation," which uses standard mathematical notation as shown below.

Absolute Values	$\lvert A \rvert$
Powers	X^4
Fractions	$\frac{5}{3}$
Square Roots	$2\sqrt{2}$
Roots	$\sqrt[3]{X}$
Integration	$\int_{A}^{B} \sin(\cos(X))dx$
Differentials	$\frac{d^n}{dx^n}(X^3)$

20-6 ALGBR Mode Error Messages

A number of error messages are unique to the ALGBR Mode. The following lists the error messages and explains the meaning of each one.

- Error messages unique to the ALGBR Mode appear in the message area of the display.

● Undefined

No solution exists for the operation being performed.

Example **1/0**

● Overflow ERROR

The result of the operation being performed exceeds the range of the calculator.

Example **99999^99999**

● Domain ERROR

Input value is outside the domain of the operation being performed.

Example **(–4)!**

● Non-Real ERROR

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Only real numbers have been input and the result is a complex number while the set up screen's Answer Type item is specified as **"Real"**.

Example **(–1)^(1/2)**

● No Solution

No solution can be obtained using the Solve Function.

Example **solve(X^2 = –1, X), when Answer Type = "Real"**

● Ma ERROR

Attempt to use **approx** with an expression that generates an error unique to the ALGBR Mode.

Example **approx(1/0)**

● Other Errors

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Stk, Syn, Mem, Arg, and Dim errors have the same meanings as they do in the RUN Mode. See "Overflow and Errors" for details.

20-7 ALGBR Mode Precautions

- When an input expression cannot be processed any further, the expression displayed as the result of an operation will be identical to the input expression.
- It may take a considerable amount of time for a result to appear. This does not indicate malfunction.
- Note that there may be a variety of different formats that can be used to express a result. Because of this, even if the format of a result may displayed by the calculator does not match the format that you need for your purposes, it does not necessarily mean that the result is wrong.

Regardless of whether intervals are continuous or discontinuous, this calculator performs definite integral calculations by first obtaining an indefinit integral. Based on this result, it then obtains a definite integral.

$$\left[\begin{array}{l} f(x) \\ F(x)\text{: primitive function of } f(x) \end{array}\right.$$

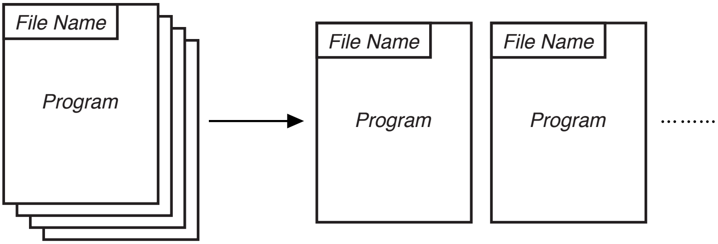
$$\int_a^b f(x)dx = F(b) - F(a)$$

Chapter 21

Programming

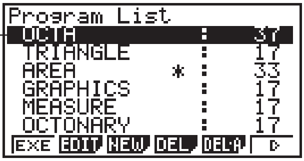
21-1 Before Programming

The programming function helps to make complex, often-repeated calculations quick and easy. Commands and calculations are executed sequentially, just like the manual calculation multistatements. Multiple programs can be stored under file names for easy recall and editing.



Select the **PRGM** icon in the Main Menu and enter the PRGM Mode. When you do, a program list appears on the display.

Selected memory area
(use ⏶ and ⏷ to move)



```
Program List
 UCTA          :    37
 TRIANGLE      :    17
 AREA        * :    33
 GRAPHICS      :    17
 MEASURE       :    17
 OCTONARY      :    17
EXE EDIT NEW DEL DEL·A ▷
```

- {**EXE**}/{**EDIT**} ... program {execute}/{edit}
- {**NEW**} ... {new program}
- {**DEL**}/{**DEL·A**} ... {specific program}/{all program} delete
- {**SRC**}/{**REN**} ... file name {search}/{change}

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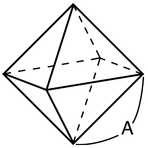
- If there are not programs stored in memory when you enter the PRGM Mode, the message "**No Programs**" appears on the display and only the NEW item (F3) is shown in the function menu.

  The values to the right of the program list indicate the number of bytes used up by each program.

21-2 Programming Examples

Example 1 **To calculate the surface area and volume of three regular octahedrons of the dimensions shown in the table below**

Store the calculation formula under the file name OCTA.



Length of One Side (A)	Surface Area (S)	Volume (V)
7 cm	cm^2	cm^3
10 cm	cm^2	cm^3
15 cm	cm^2	cm^3

The following are the formulas used for calculating surface area S and volume V of a regular octahedron for which the length of one side is known.

$$S = 2\sqrt{3}\,A^2, \quad V = \frac{\sqrt{2}}{3}A^3$$

When inputting a new formula, you first register the file name and then input the actual program.

●To register a file name

Example **To register the file name OCTA**

- Note that a file name can be up to eight characters long.

1. Display the program list menu and press F3 (NEW) to display a menu, which contains the following items.
   - {**RUN**}/{**BASE**} ... {general calculation}/{number base} program input
   - {**🔑**} ... {password registration}
   - {**SYBL**} ... {symbol menu}

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2. Input the name of the file.

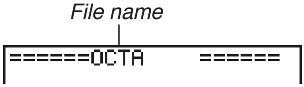
O C T A

Program Name
[OCTA▮   ]

- The cursor changes form to indicate alpha character input.
- The following are the characters you can use in a file name:
  A through Z, *r*, *θ*, spaces, [,], {, }, ’, ”, ~, 0 through 9, ., +, –, ×, ÷
- Note, however, that X,θ,T and ⊡ cannot be input for the name of a program that contains binary, octal, decimal, or hexadecimal calculations.

- Use F1 (RUN) to input a program for general calculations (a program to be executed in the COMP Mode). For programs that involve number system specifications, use F2 (BASE). Note that programs input after pressing F2 (BASE) are indicated by B to the right of the file name.
- Pressing F6 (SYBL) displays a menu of symbols (’, ”, ~) that can be input.
- You can delete a character while inputting a file name by moving the cursor to the character you want to delete and pressing DEL.

3. Press EXE to register the file name and change to the program input screen.



```
======OCTA     ======
```

- Registering a file name uses 17 bytes of memory.
- The file name input screen remains on the display if you press EXE without inputting a file name.
- To exit the file name input screen and return to the program list without registering a file name, press EXIT.
- When you register the name of a program that contains binary, octal, decimal, or hexadecimal calculations, the indicator B is appended to the right of the file name.

●To input a program

The following items are included in the function menu of the program input screen, which is used for program input.

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- {**TOP**}/{**BTM**} ... {top}/{bottom} of program

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- {**SRC**} ... {search}
- {**MENU**} ... {mode menu}
- {**SYBL**} ... {symbol menu}

●To change modes in a program

- Pressing F4 (MENU) while the program input screen is on the display causes a mode change menu to appear. You can use this menu to input mode changes into your programs.
- {**STAT**}/{**MAT**}/{**LIST**}/{**GRPH**}/{**DYNA**}/{**TABL**}/{**RECR**}

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For details on each of these modes, see “To select an icon”, as well as the sections of this manual that describe what you can do in each mode.

- The following menu appears whenever you press F4 (MENU) while inputting a program that involves number base specifications.
- {**d ~ o**}/{**LOG**}

- Pressing F6 (SYBL) displays a menu of symbols (’, ”, ~, ∗, /, #) that can be input into a program.

- Pressing SHIFT SET UP displays a menu of commands that can be used to change set up screen settings inside a program.

- {**ANGL**}/{**COOR**}/{**GRID**}/{**AXES**}/{**LABL**}/{**DISP**}/{**P/L**}/{**DRAW**}/{**DERV**}/{**BACK**}/{**FUNC**}/{**SIML**}/{**S-WIN**}/{**LIST**}/{**LOCS**}/{**T-VAR**}/{**ΣDSP**}/{**RESID**}

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For details on each of these commands, see “Set Up Screen Function Key Menus”.

The following function key menu appears if you press SHIFT SET UP while inputting a program that contains binary, octal, decimal, or hexadecimal calculation.

- {**Dec**}/{**Hex**}/{**Bin**}/{**Oct**}

Actual program contents are identical to manual calculations. The following shows how the calculation of the surface area and volume of a regular octahedron would be calculated using a manual calculation.

Surface Area S .. 2 × SHIFT √ 3 × <value of A> x² EXE
Volume V .... SHIFT √ 2 ÷ 3 × <value of A> ∧ 3 EXE

You could also perform this calculation by assigning the value for the length of one side to variable A.

Length of One Side A
.... <value of A> → ALPHA A EXE
Surface Area S .. 2 × SHIFT √ 3 × ALPHA A x² EXE
Volume V .... SHIFT √ 2 ÷ 3 × ALPHA A ∧ 3 EXE

If you simply input the manual calculations shown above however, the calculator would execute them from beginning to end, without stopping. The following commands make it possible to interrupt a calculation for input of values and display of intermediate results.

? : This command pauses program execution and displays a question mark as a prompt for input of a value to assign to a variable. The syntax for this command is: ? → <variable name>.

◢ : This command pauses program execution and displays the last calculation result obtained or text. It is similar to pressing EXE in a manual calculation.

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- For full details on using these and other commands, see “Useful Program Commands”.

The following shows examples of how to actually use the ? and ◢ commands.

SHIFT PRGM F4(?) → ALPHA A F6(▷) F5(:)

2 × SHIFT √ 3 × ALPHA A x^2

F6(▷) F5(◢)

SHIFT √ 2 ÷ 3 × ALPHA A ^ 3

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3_
```

SHIFT QUIT or EXIT EXIT

```
Program List
 OCTA          :   37
```

•To run a program

1. While the program list is on the display, use ⏶ and ⏷ to highlight the name of the program you want to run.

2. Press F1 (EXE) or EXE to run the program.

Let's try running the program we input above.

Length of One Side (A)	Surface Area (S)	Volume (V)
7 cm	169.7409791 cm^2	161.6917506 cm^3
10 cm	346.4101615 cm^2	471.4045208 cm^3
15 cm	779.4228634 cm^2	1590.990258 cm^3

```
Program List
 OCTA          :   37
```

F1 (EXE) or EXE

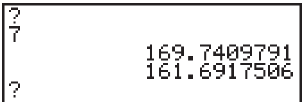
```
?
```

7 EXE
(Value of A)

```
?
7
             169.7409791
                 - Disp -
```

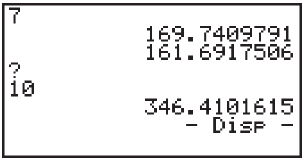
Intermediate result produced by ◢

EXE EXE



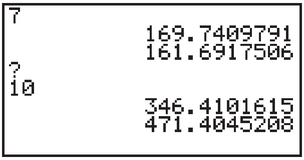
```
?
7
             169.7409791
             161.6917506
?
```

1 0 EXE



```
7
             169.7409791
             161.6917506
?
10
             346.4101615
                 - Disp -
```

EXE



```
7
             169.7409791
             161.6917506
?
10
             346.4101615
             471.4045208
```

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- Pressing EXE while the program’s final result is on the display re-executes the program.
- You can also run a program while in the **RUN Mode** by inputting: Prog ”<file name>” EXE.
- An error occurs if the program specified by Prog ”<file name>” cannot be found.

21-3 Debugging a Program

A problem in a program that keeps the program from running correctly is called a "bug," and the process of eliminating such problems is called "debugging." Either of the following symptoms indicates that your program contains bugs and that debugging is required.

- Error messages appearing when the program is run
- Results that are not within your expectations

•To eliminate bugs that cause error messages

An error message, like the one shown below, appears whenever something illegal occurs during program execution.

```
Ma ERROR
```

P.450 When such a message appears, press ◀ or ▶ to display the location where the error was generated, along with the cursor. Check the "Error Message Table" for steps you should take to correct the situation.

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- Note that pressing ◀ or ▶ will not display the location of the error if the program is password protected.

•To eliminate bugs that cause bad results

P.379 If your program produces results that are not what you normally expect, check the contents of the program and make necessary changes. See "Editing File Names and Program Contents" for details on how to change program contents.

21-4 Calculating the Number of Bytes Used by a Program

This unit comes with 60 kbytes of memory. A byte is a unit of memory that can be used for storage of data.

There are two types of commands: 1-byte commands and 2-byte commands.

- Examples of 1-byte commands: sin, cos, tan, log, (,), A, B, C, 1, 2, etc.
- Examples of 2-byte commands: Lbl 1, Goto 2, etc.

While the cursor is located inside of a program, each press of ◀ or ▶ causes the cursor to move one byte.

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- You can check how much memory has been used and how much remains at any time by selecting the **SYS Mode** and entering the memory status screen. See “Memory Status” for details.

21-5 Secret Function

When inputting a program, you can protect it with a password that limits access to the program contents to those who know the password. Password protected programs can be executed by anyone without inputting the password.

•To register a password

Example **To create a program file under the name AREA and protect it with the password CASIO**

1. While the program list is on the display, press F3 (NEW) and input the file name of the new program file.

   F3(NEW)

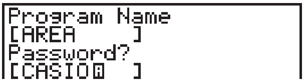
   A R E A

```
Program Name
[AREA    ]
```

2. Press F5 (🔑) and then input the password.

   F5(🔑)

   C A S I O



```
Program Name
[AREA     ]
Password?
[CASIO    ]
```

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- The password input procedure is identical to that used for file name input.

3. Press EXE to register the file name and password. Now you can input the contents of the program file.
   - Registration of a password uses 16 bytes of memory.
   - Pressing EXE without inputting a password registers the file name only, without a password.

4. After inputting the program, press SHIFT QUIT to exit the program file and return to the program list. Files that are password protected are indicated by an asterisk to the right of the file name.

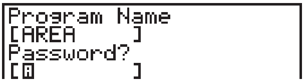
```
Program List
 OCTA          :    37
 AREA        * :    33
```

•To recall a program

Example **To recall the file named AREA which is protected by the password CASIO**

1. In the program list, use ▲ and ▼ to move the highlighting to the name of the program you want to recall.

2. Press F2 (EDIT).



```
Program Name
[AREA     ]
Password?
[         ]
```

3. Input the password and press EXE to recall the program.
   - The message “**Mismatch**” appears if you input the wrong password.

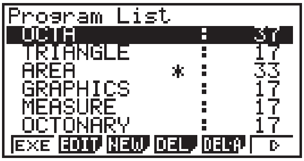
21-6 Searching for a File

There are three different methods for searching for a specific file name.

•To find a file using scroll search

Example **To use scroll search to recall the program named OCTA**

1. While the program list is on the display, use ⏶ and ⏷ to scroll through the list of program names until you find the one you want.



```
Program List
 OCTA          :    37
 TRIANGLE      :    17
 AREA        * :    33
 GRAPHICS      :    17
 MEASURE       :    17
 OCTONARY      :    17
```

F2

2. When the highlighting is located at the name of the file you want, press F2 (EDIT) to recall it.

```
======OCTA    ======
2→A:2×√3×A²◢
√2/3×A^3
```

•To find a file using file name search

Example **To use file name search to recall the program named OCTA**

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1. While the program list is on the display, press F3 (NEW) and input the name of the file you want to find.
   - If the file you are looking for is password protected, you should also input the password.

F3(NEW)

O C T A

```
Program Name
[OCTA█    ]
```

2. Press EXE to recall the program.
   - If there is no program whose file name matches the one you input, a new file is created using the input name.

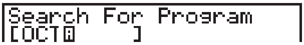
•To find a file using initial character search

Example **To use initial character search to recall the program named OCTA**

1. While the program list is on the display, press F6 (▷) F1 (SRC) and input the initial characters of the file you want to find.

F6(▷)F1(SRC)

O C T



```
Search For Program
[OCT█     ]
```

2. Press EXE to search.

```
Program List
 OCTA           :   37
 OCTONARY       :   17
```

- All files whose file names start with the characters you input are recalled.
- If there is no program whose file name starts with the characters you input, the message “**Not Found**” appears on the display. If this happens, press EXIT to clear the error message.

3. Use ▲ and ▼ to highlight the file name of the program you want to recall and then press F2 (EDIT) to recall it.

21-7 Searching for Data Inside a Program

Example **To search for the letter "A" inside the program named OCTA**

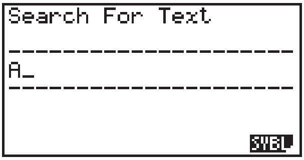
1. Recall the program.

2. Press F3 (SRC) and input the data you want to search for.

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

F3(SRC)

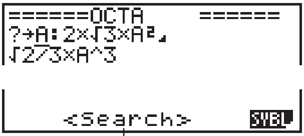
ALPHA A



```
Search For Text
---------------------
A_
---------------------
                SYBL
```

- You cannot specify the newline symbol (↵) or display command (◢) for the search data.

3. Press EXE to begin the search. The contents of the program appears on the screen with the cursor located at the first instance of the data you specified.



```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3

      <Search>  SYBL
```

Indicates search operation is in progress

4. Press EXE to find the next instance of the data.

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

- If there is no match inside the program for the data you specified, the contents of the program appear with the cursor located at the point from which you started your search.
- Once the contents of the program are on the screen, you can use the cursor keys to move the cursor to another location before searching for the next instance of the data. Only the part of the program starting from the current cursor location is searched when you press EXE.
- Once the search finds an instance of your data, inputting characters or moving the cursor causes the search operation to be cancelled (clearing the Search indicator from the display).
- If you make a mistake while inputting characters to search for, press AC to clear your input and re-input from the beginning.

21-8 Editing File Names and Program Contents

●To edit a file name

Example **To change the name of a file from TRIANGLE to ANGLE**

1. While the program list is on the display, use ▲ and ▼ to move the highlighting to the file whose name you want to edit and then press F6 (▷) F2 (REN).

```
Rename
[■RIANGLE]
```

2. Make any changes you want.

   DEL DEL DEL

```
Rename
[■NGLE    ]
```

3. Press EXE to register the new name and return to the program list.
   - If the modifications you make result in a file name that is identical to the name of a program already stored in memory, the message "**Already Exists**" appears. When this happens, you can perform either of the following two operations to correct the situation.
   - Press ▶ or ◀ to clear the error and return to the file name input screen.
   - Press AC to clear the new file name and input a new one.

●To edit program contents

1. Find the file name of the program you want in the program list.

2. Recall the program.
   - The procedures you use for editing program contents are identical to those used for editing manual calculations. For details, see "Editing Calculations".
   - The following function keys are also useful when editing program contents.

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F1 (TOP) .... Moves the cursor to the top of the program

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

F2 (BTM) .... Moves the cursor to the bottom of the program

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3_
```

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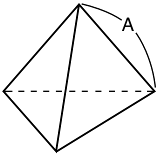
Example 2 **To use the OCTA program to create a program that calculates the surface area and volume of regular tetrahedrons when the length of one side is known**

Use TETRA as the file name.



Length of One Side (A)	Surface Area (S)	Volume (V)
7 cm	cm^2	cm^3
10 cm	cm^2	cm^3
15 cm	cm^2	cm^3

The following are the formulas used for calculating surface area S and volume V of a regular tetrahedron for which the length of one side is known.

$$S = \sqrt{3}\,A^2, \quad V = \frac{\sqrt{2}}{12}A^3$$

Use the following key operations when inputting the program.

Length of One Side A .. SHIFT PRGM F4 (?) → ALPHA A F6 (▷) F5 (:)
Surface Area S .... SHIFT √ 3 × ALPHA A x^2 F6 (▷) F5 (◢)
Volume V .... SHIFT √ 2 ÷ 1 2 × ALPHA A ⋀ 3

Compare this with the program for calculating the surface area and volume of a regular octahedron.

Length of One Side A .. SHIFT PRGM F4 (?) → ALPHA A F6 (▷) F5 (:)
Surface Area S .... 2 × SHIFT √ 3 × ALPHA A x^2 F6 (▷) F5 (◢)
Volume V .... SHIFT √ 2 ÷ 3 × ALPHA A ⋀ 3

As you can see, you can produce the TETRA program by making the following changes in the OCTA program.

- Deleting 2 × (underlined using a wavy line above)
- Changing 3 to 1 2 (underlined using a solid line above)

Let's edit OCTA to produce the TETRA program.

1. Edit the program name.

```
Program List
 OCTA
```

F6 (▷) F2 (REN) T E T R A

```
Rename
[TETRA▯   ]
```

EXE

```
Program List
 TETRA
```

2. Edit the program contents.

F2 (EDIT)

```
======TETRA    ======
2→A:2×√3×A²◢
√2/3×A^3
```

▶ ▶ ▶ ▶ DEL DEL

```
======TETRA    ======
?→A:√3×A²◢
√2/3×A^3
```

▼ ◀ SHIFT INS 1 2

```
======TETRA    ======
?→A:√3×A²◢
√2/123×A^3
```

DEL

```
======TETRA    ======
?→A:√3×A²◢
√2/12×A^3
```

SHIFT QUIT

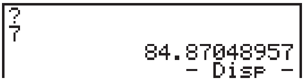
Let's try running the program.

Length of One Side (A)	Surface Area (S)	Volume (V)
7 cm	84.87048957 cm^2	40.42293766 cm^3
10 cm	173.2050808 cm^2	117.8511302 cm^3
15 cm	389.7114317 cm^2	397.7475644 cm^3

F1 (EXE) or EXE

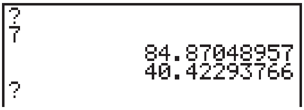
```
?
```

7 EXE
(Value of A)



```
?
7
          84.87048957
           - Disp -
```

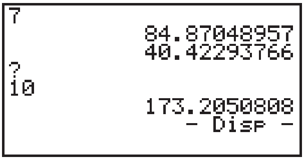
EXE EXE



```
?
7
          84.87048957
          40.42293766

?
```

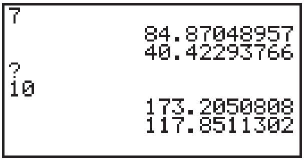
1 0 EXE



```
7
          84.87048957
          40.42293766

?
10
          173.2050808
           - Disp -
```

EXE



```
7
          84.87048957
          40.42293766

?
10
          173.2050808
          117.8511302
```

⋮ ⋮

21-9 Deleting a Program

There are two methods for deletion of a file name and its program.

●To delete a specific program

1. While the program list is on the display, use ▲ and ▼ to move the highlighting to the name of the program you want to delete.

2. Press F4 (DEL).

3. Press F1 (YES) to delete the selected program or F6 (NO) to abort the operation without deleting anything.

●To delete all programs

1. While the program list is on the display, press F5 (DEL·A).

2. Press F1 (YES) to delete all the programs in the list or F6 (NO) to abort the operation without deleting anything.
   - You can also delete all programs using the **SYS Mode**. See “Clearing Memory Contents” for details.

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21-10 Useful Program Commands

In addition to calculation commands, this calculator also includes a variety of relational and jump commands that can be used to create programs that make repeat calculations quick and easy.

Program Menu

Press SHIFT PRGM to display the program menu.

- **{COM}/{CTL}/{JUMP}/{CLR}/{DISP}/{REL}/{I/O}**
- {**?**} ... {input command}
- { ◢ } ... {output command}
- { **:** } ... {multi-statement command}

■ COM (program command menu)

Selecting {COM} from the program menu displays the following function menu items.

- **{If}/{Then}/{Else}/{I-End}/{For}/{To}/{Step}/{Next}/{Whle}/{WEnd}/{Do}/{Lp-W}** ... {If}/{Then}/{Else}/{IfEnd}/{For}/{To}/{Step}/{Next}/{While}/{WhileEnd}/{Do}/ {LpWhile} command

■ CTL (program control command menu)

Selecting {CTL} from the program menu displays the following function menu items.

- **{Prog}/{Rtrn}/{Brk}/{Stop}** ... {Prog}/{Return}/{Break}/{Stop} command

■ JUMP (jump command menu)

Selecting {JUMP} from the program menu displays the following function menu items.

- **{Lbl}/{Goto}** ... {Lbl}/{Goto} command
- {⇒} ... {jump command}
- **{Isz}/{Dsz}** ... {jump and increment}/{jump and decrement}

■ CLR (clear command menu)

Selecting {CLR} from the program menu displays the following function menu items.

- **{Text}/{Grph}/{List}** ... clears {text}/{graph}/{list}

■ DISP (display command menu)

Selecting {DISP} from the program menu displays the following function menu items.

- {**Stat**}/{**Grph**}/{**Dyna**} ... {statistical graph}/{graph}/{Dynamic Graph} draw

- {**F-Tbl**} ... {Table & Graph command menu}

The following are the items that appear in the above menu.

- {**Tabl**}/{**G-Con**}/{**G-Plt**} ... {DispF-Tbl}/{DrawFTG-Con}/{DrawFTG-Plt} command

- {**R-Tbl**} ... {recursion calculation and recursion fomula}

The following are the items that appear in the above menu.

- {**Tabl**}/{**Web**}/{**an-Cn**}/{**Σa-Cn**}/{**an-Pl**}/{**Σa-Pl**} ... {DispR-Tbl}/{DrawWeb}/{DrawR-Con}/{DrawRΣ-Con}/{DrawR-Plt}/{DrawRΣ-Plt} command

■ REL (conditional jump relational operator commands)

Selecting {REL} from the program menu displays the following function menu items.

- {**=**}/{**≠**}/{**>**}/{**<**}/{**≥**}/{**≤**} ... {=}/{≠}/{>}/{<}/{≥}/{≤} relational operators

■ I/O (input/output commands)

Selecting {I/O} from the program menu displays the following function menu items.

- {**Lcte**}/{**Gtky**}/{**Send**}/{**Recv**} ... {Locate}/{Getkey}/{Send(}/{Receive(} command

- The appearance of the function menu differs slightly for a program that contains binary, octal, decimal, or hexadecimal calculation, but the functions in the menu are the same.

21-11 Command Reference

Command Index

The following are conventions that are used in this section when describing the various commands.

Boldface Text	Actual commands and other items that always must be input are shown in boldface.
{Curly Brackets}	Curly brackets are used to enclose a number of items, one of which must be selected when using a command. Do not input the curly brackets when inputting a command.
[Square Brackets]	Square brackets are used to enclose items that are optional. Do not input the square brackets when inputting a command.
Numeric Expressions	Numeric expressions (such as 10, 10 + 20, A) indicate constants, calculations, numeric constants, etc.
Alpha Characters	Alpha characters indicate literal strings (such as AB).

■ Basic Operation Commands

? (Input Command)

Function: Prompts for input of values for assignment to variables during program execution.

Syntax: ? → <variable name>

Example: ? → A ↵

Description:

1. This command momentarily interrupts program execution and prompts for input of a value or expression for assignment to a variable. When the input command is executed, "?" to appears on the display and the calculator stands by for input.

2. Input in response to the input command must be a value or an expression, and the expression cannot be a multi-statement.

◢ (Output Command)

Function: Displays and intermediate result during program execution.

Description:

1. This command momentarily interrupts program execution and displays alpha character text or the result of the calculation immediately before it.

2. The output command should be used at locations where you would normally press the EXE key during a manual calculation.

: (Multi-statement Command)

Function: Connects two statements for sequential execution without stopping.

Description:

1. Unlike the output command (◢), statements connected with the multi-statement command are executed non-stop.

2. The multi-statement command can be used to link two calculation expressions or two commands.

3. You can also use a carriage return indicated by ↵ in place of the multi-statement command.

↵ (Carriage Return)

Function: Connects two statements for sequential execution without stopping.

Description:

1. Operation of the carriage return is identical to that of the multi-statement command.

2. Using a carriage return in place of the multi-statement command makes the displayed program easier to read.

■ Program Commands (COM)

If~Then

Function: The Then-statement is executed only when the If-condition is true (non-zero).

Syntax:

$$\text{If} \quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}} \left\{\begin{matrix} \text{↵} \\ : \\ \text{◢} \end{matrix}\right\} \text{Then <statement>} \left[\left\{\begin{matrix} \text{↵} \\ : \\ \text{◢} \end{matrix}\right\} \text{<statement>}\right]$$

Parameters: condition, numeric expression

Description:

1. The Then-statement is executed only when the If-condition is true (non-zero).

2. If the condition is false (0), the Then-statement is not executed.

3. An If-condition must always be accompanied by a Then-statement. Omitting the Then-statement results in an error.

Example: If A = 0 ↵
Then ”A = 0”

If~Then~IfEnd

Function: The Then-statement is executed only when the If-condition is true (non-zero). The IfEnd-statement is always executed: after the Then-statement is executed or directly after the If-condition when the If-condition is false (0).

Syntax:

$$\text{If}\quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}}\ \left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{Then <statement>}$$

$$\left[\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\right]\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{IfEnd}$$

Parameters: condition, numeric expression

Description:

This command is almost identical to If~Then. The only difference is that the IfEnd-statement is always executed, regardless of whether the If-condition is true (non-zero) or false (0).

Example: If A = 0 ↵
Then ”A = 0” ↵
IfEnd ↵
”END”

If~Then~Else

Function: The Then-statement is executed only when the If-condition is true (non-zero). The Else-statement is executed when the If-condition is false (0).

Syntax:

$$\text{If}\quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}}\ \left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{Then <statement>}\left[\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\right]$$

$$\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{Else <statement>}\left[\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\right]$$

Parameters: condition, numeric expression

Description:

1. The Then-statement is executed when the If-conditions is true (non-zero).

2. The Else-statement is executed when the If-conditions is false (zero).

Example: If A = 0 ↵
Then ”TRUE” ↵
Else ”FALSE”

If~Then~Else~IfEnd

Function: The Then-statement is executed only when the If-condition is true (non-zero). The Else-statement is executed when the If-condition is false (0). The IfEnd-statement is always executed following either the Then-statement or Else-statement.

Syntax:

$$\text{If}\quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}}\ \left\{\begin{matrix}↵\\ :\\ ◢\end{matrix}\right\}\ \text{Then <statement>}\left[\left\{\begin{matrix}↵\\ :\\ ◢\end{matrix}\right\}\ \text{<statement>}\right]$$

$$\left\{\begin{matrix}↵\\ :\\ ◢\end{matrix}\right\}\text{Else <statement>}\left[\left\{\begin{matrix}↵\\ :\\ ◢\end{matrix}\right\}\ \text{I<statement>}\right]\left\{\begin{matrix}↵\\ :\\ ◢\end{matrix}\right\}\text{IfEnd}$$

Parameters: condition, numeric expression

Description:

This command is almost identical to If~Then~Else. The only difference is that the IfEnd-statement is always executed, regardless of whether the If-condition is true (non-zero) or false (0).

Example:

```
? → A ↵
If A = 0 ↵
Then ”TRUE”↵
Else ”FALSE”↵
IfEnd↵
”END”
```

For~To~Next

Function: This command repeats everything between the For-statement and the Next-statement. The starting value is assigned to the control variable with the first execution, and the value of the control variable is incremented by one with each execution. Execution continues until the value of the control variable exceeds the ending value.

Syntax:

$$\text{For <starting value>} \rightarrow \text{<control variable name> To <ending value>}\ \left\{\begin{matrix}↵\\ :\\ ◢\end{matrix}\right\}$$

$$\left[\text{<statement>}\left\{\begin{matrix}↵\\ :\\ ◢\end{matrix}\right\}\right]\quad \text{Next}$$

Parameters:

- control variable name: A to Z
- starting value: value or expression that produces a value (i.e. sin x, A, etc.)
- ending value: value or expression that produces a value (i.e. sin x, A, etc.)

Description:

1. When the starting value of the control variable is greater than the ending value, execution continues from the statement following Next, without executing the statements between For and Next.

2. A For-statement must always have a corresponding Next-statement, and the Next-statement must always come after its corresponding For-statement.

3. The Next-statement defines the end of the loop created by For~Next, and so it must always be included. Failure to do so results in an error.

Example: For 1 → A To 10↵
A × 3 → B↵
B ◢
Next

For~To~Step~Next

Function: This command repeats everything between the For-statement and the Next-statement. The starting value is assigned to the control variable with the first execution, and the value of the control variable is changed according to the step value with each execution. Execution continues until the value of the control variable exceeds the ending value.

Syntax:

For <starting value> → <control variable name> To <ending value> Step <step value> { ↵ : ◢ }

Next

Parameters:

- control variable name: A to Z
- starting value: value or expression that produces a value (i.e. sin x, A, etc.)
- ending value: value or expression that produces a value (i.e. sin x, A, etc.)
- step value: numeric value (omitting this value sets the step to 1)

Description:

1. This command is basically identical to For~To~Next. The only difference is that you can specify the step.

2. Omitting the step value automatically sets the step to 1.

3. Making the starting value less than the ending value and specifying a positive step value causes the control variable to be incremented with each execution. Making the starting value greater than the ending value and specifying a negative step value causes the control variable to be decremented with each execution.

Example:

```
For 1 → A To 10 Step 0.1↵
A × 3 → B ↵
B ◢
Next
```

Do~LpWhile

Function: This command repeats specific commands as long as its condition is true (non-zero).

Syntax:

$$\text{Do} \begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \sim \text{LpWhile <expression>}$$

Parameters: expression

Description:

1. This command repeats the commands contained in the loop as long as its condition is true (non-zero). When the condition becomes false (0), execution proceeds from the statement following the LpWhile-statement.

2. Since the condition comes after the LpWhile-statement, the condition is tested (checked) after all of the commands inside the loop are executed.

Example:

```
Do↵
? → A↵
A × 2 → B↵
B ◢
LpWhile B >10
```

While~WhileEnd

Function: This command repeats specific commands as long as its condition is true (non-zero).

Syntax:

$$\text{While <expression>} \begin{Bmatrix} \text{↵} \\ : \\ \text{◢} \end{Bmatrix} \sim \text{WhileEnd}$$

Parameters: expression

Description:

1. This command repeats the commands contained in the loop as long as its condition is true (non-zero). When the condition becomes false (0), execution proceeds from the statement following the WhileEnd-statement.

2. Since the condition comes after the While-statement, the condition is tested (checked) before the commands inside the loop are executed.

Example:

```
10 → A↵
While A > 0↵
A – 1 → A↵
"GOOD"↵
WhileEnd
```

■ Program Control Commands (CTL)

Break

Function: This command breaks execution of a loop and continues from the next command following the loop.

Syntax: Break ↵

Description:

1. This command breaks execution of a loop and continues from the next command following the loop.

2. This command can be used to break execution of a For-statement, Do-statement, and While-statement.

Example:

```
While A>0↵
If A > 2↵
Then Break↵
IfEnd↵
WhileEnd↵
A ◢   ←———— Executed after Break
```

Prog

Function: This command specifies execution of another program as a subroutine. In the RUN Mode, this command executes a new program.

Syntax: Prog "file name" ↵

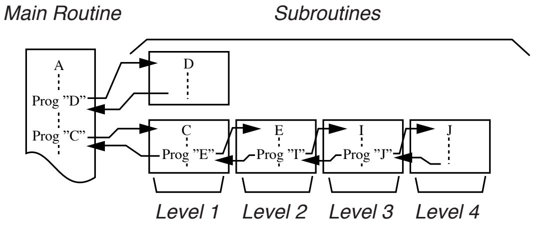
Example: Prog "ABC" ↵

Description:

1. Even when this command is located inside of a loop, its execution immediately breaks the loop and launches the subroutine.

2. This command can be used as many times as necessary inside of a main routine to call up independent subroutines to perform specific tasks.

3. A subroutine can be used in multiple locations in the same main routine, or it can be called up by any number of main routines.



4. Calling up a subroutine causes it to be executed from the beginning. After execution of the subroutine is complete, execution returns to the main routine, continuing from the statement following the Prog command.

5. A Goto~Lbl command inside of a subroutine is valid inside of that subroutine only. It cannot be used to jump to a label outside of the subroutine.

6. If a subroutine with the file name specified by the Prog command does not exist, an error occurs.

7. In the **RUN Mode**, inputting the Prog command and pressing EXE launches the program specified by the command.

Return

Function: This command returns from a subroutine.

Syntax: Return ↵

Description:

Execution of the Return command inside a main routine causes execution of the program to stop.

Example:

```
Prog "A"        Prog "B"
1 → A↵          For A → B To 10↵
Prog "B"↵       B + 1 → C↵
C ◢             Next↵
                Return
```

Executing the program in File A displays the result of the operation (11).

Stop

Function: This command terminates execution of a program.

Syntax: Stop ↵

Description:

1. This command terminates program execution.

2. Execution of this command inside of a loop terminates program execution without an error being generated.

Example:

```
For 2 → I To 10↵
If I = 5↵
Then ”STOP” : Stop↵
IfEnd↵
Next
```

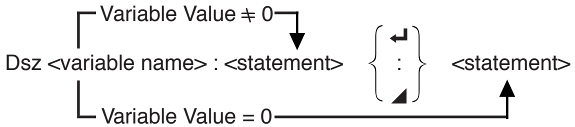
This program counts from 2 to 10. When the count reaches 5, however, it terminates execution and displays the message “STOP.”

■ Jump Commands (JUMP)

Dsz

Function: This command is a count jump that decrements the value of a control variable by 1, and then jumps if the current value of the variable is zero.

Syntax:



Parameters:

Variable Name: A to Z, r, θ

[Example] Dsz B : Decrements the value assigned to variable B by 1.

Description:

This command decrements the value of a control variable by 1, and then tests (checks) it. If the current value is non-zero, execution continues with the next statement. If the current value is zero, execution jumps to the statement following the multi-statement command (:), display command (◢), or carriage return (↵).

Example:

```
10 → A : 0 → C :
Lbl 1 : ? → B : B+C → C :
Dsz A : Goto 1 : C ÷ 10
```

This program prompts for input of 10 values, and then calculates the average of the input values.

Goto~Lbl

Function: This command performs an unconditional jump to a specified location.

Syntax: Goto <value or variable> ~ Lbl <value or variable>

Parameters: Value (from 0 to 9), variable (A to Z, r, θ)

Description:

1. This command consists of two parts: Goto n (where n is a value from 0 to 9) and Lbl n (where n is the value specified for Goto). This command causes program execution to jump to the Lbl-statement whose value matches that specified by the Goto-statement.

2. This command can be used to loop back to the beginning of a program or to jump to any location within the program.

3. This command can be used in combination with conditional jumps and count jumps.

4. If there is no Lbl-statement whose value matches that specified by the Goto-statement, an error occurs.

Example:

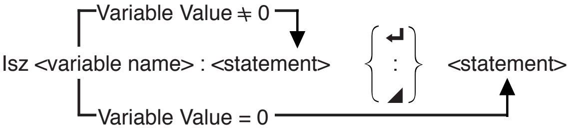
```
? → A : ? → B : Lbl 1 :
? → X : A × X + B ◢
Goto 1
```

This program calculates y = AX + B for as many values for each variable that you want to input. To quit execution of this program, press AC.

Isz

Function: This command is a count jump that increments the value of a control variable by 1, and then jumps if the current value of the variable is zero.

Syntax:



Parameters:

Variable Name: A to Z, r, θ

[Example] Isz A : Increments the value assigned to variable A by 1.

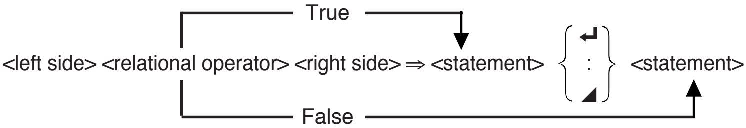
Description:

This command increments the value of a control variable by 1, and then tests (checks) it. If the current value is non-zero, execution continues with the next statement. If the current value is zero, execution jumps to the statement following the multi-statement command (:), display command (◢), or carriage return (↵).

⇒ (Jump Code)

Function: This code is used to set up conditions for a conditional jump. The jump is executed whenever the conditions are false.

Syntax:



Parameters:

left side/right side: variable (A to Z, r, θ), numeric constant, variable expression (such as: A × 2)

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relational operator: =, ≠, >, <, ≥, ≤

Description:

1. The conditional jump compares the contents of two variables or the results of two expressions, and a decision is made whether or not to execute the jump based on the results of the comparison.
2. If the comparison returns a true result, execution continues with the statement following the ⇒ command. If the comparison returns a false result, execution jumps to the statements following the multi-statement command (:), display command (◢), or carriage return (↵).

Example: Lbl 1 : ? → A :
A ≧ 0 ⇒ √ A ◢
Goto 1

With this program, inputting a value of zero or greater calculates and displays the square root of the input value. Inputting a value less than zero returns to the input prompt without calculating anything.

■ Clear Commands (CLR)

ClrGraph

Function: This command clears the graph screen.

Syntax: ClrGraph↵

Description: This command clears the graph screen during program execution.

ClrList

Function: This command clears list data.

Syntax: ClrList↵

Description: This command clears the contents of the currently selected list (List 1 to List 6) during program execution.

ClrText

Function: This command clears the text screen.

Syntax: ClrText↵

Description: This command clears text from the screen during program execution.

■ Display Commands (DISP)

DispF-Tbl, DispR-Tbl

Function: These commands display numeric tables.

Syntax:

DispF-Tbl ↵
DispR-Tbl ↵

Description:

1. These commands generate numeric tables during program execution in accordance with conditions defined within the program.

2. DispF-Tbl generates a function table, while DispR-Tbl generates a recursion table.

DrawDyna

Function: This command executes a Dynamic Graph draw operation.

Syntax: DrawDyna ↵

Description: This command performs a Dynamic Graph draw operation during program execution in accordance with the drawing conditions defined within the program.

DrawFTG-Con, DrawFTG-Plt

Function: These commands graph functions.

Syntax:

DrawFTG-Con ↵
DrawFTG-Plt ↵

Description:

1. These commands graph functions in accordance with conditions defined within the program.

2. DrawFTG-Con produces a connect type graph, while DrawFTG-Plt produces a plot type graph.

DrawGraph

Function: This command draws a graph.

Syntax: DrawGraph ↵

Description: This command draws a graph in accordance with the drawing conditions defined within the program.

DrawR-Con, DrawR-Plt

Function: These commands graph recursion expressions, with a_n(b_n) as the vertical axis and n as the horizontal axis.

Syntax:

DrawR-Con ↵

DrawR-Plt ↵

Description:

1. These commands graph recursion expressions, with a_n(b_n) as the vertical axis and n as the horizontal axis, in accordance with conditions defined within the program.

2. DrawR-Con produces a connect type graph, while DrawR-Plt produces a plot type graph.

DrawRΣ-Con, DrawRΣ-Plt

Function: These commands graph recursion expressions, with Σa_n(Σb_n) as the vertical axis and n as the horizontal axis.

Syntax:

DrawRΣ-Con ↵

DrawRΣ-Plt ↵

Description:

1. These commands graph recursion expressions, with Σa_n(Σb_n) as the vertical axis and n as the horizontal axis, in accordance with conditions defined within the program.

2. DrawRΣ-Con produces a connect type graph, while DrawRΣ-Plt produces a plot type graph.

DrawStat

Function: This draws a statistical graph.

Syntax:

DrawStat ↵

Description:

This command draws a statistical graph in accordance with conditions defined within the program.

DrawWeb

Function: This command graphs convergence/divergence of a recursion expression (WEB graph).

Syntax: DrawWeb [name of recursion expression], [number of lines] ↵

Example: DrawWeb a_{n+1} (b_{n+1}), 5 ↵

Description:

1. This command graphs convergence/divergence of a recursion expression (WEB graph).

2. Omitting the number of lines specification automatically specifies the default value 30.

■ Input/Output Commands (I/O)

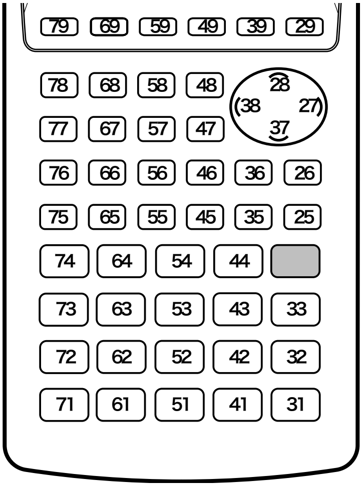
Getkey

Function: This command returns the code that corresponds to the last key pressed.

Syntax: Getkey ↵

Description:

1. This command returns the code that corresponds to the last key pressed.



2. A value of zero is returned if no key was pressed previous to executing this command.

3. This command can be used inside of a loop.

Locate

Function: This command displays alpha-numeric characters at a specific location on the text screen.

Syntax:

Locate <column number>, <line number>, <value>
Locate <column number>, <line number>, <variable name>
Locate <column number>, <line number>, ”<string>”

[Example] Locate 1, 1, ”AB”↵

Parameters:

- line number: number from 1 to 7
- column number: number from 1 to 21
- value: numeric value
- variable name: A to Z
- string: character string

Description:

1. This command displays values (including variable contents) or text at a specific location on the text screen.
2. The row is designated by a value from 1 to 7, which the column is designed by a value from 1 to 21.

Example: Cls↵
Locate 7, 1, ”CASIO CFX”
This program displays the text “CASIO CFX” in the center of the screen.

- In some cases, the ClrText command should be executed before running the above program.

Receive (

Function: This command receives data from an external device.

Syntax: Receive (<data>)

Description:

1. This command receives data from an external device.

2. The following types of data can be received by this command.
   - Individual values assigned to variables
   - Matrix data (all values - individual values cannot be specified)
   - List data (all values - individual values cannot be specified)
   - Picture data

Send (

Function: This command sends data to an external device.

Syntax: Send (<data>)

Description:

1. This command sends data to an external device.

2. The following types of data can be sent by this command.
   - Individual values assigned to variables
   - Matrix data (all values - individual values cannot be specified)
   - List data (all values - individual values cannot be specified)

■ Conditional Jump Relational Operators (REL)

=, ≠, >, <, ≥, ≤

Function: These relational operators are used in combination with the conditional jump command.

Syntax:

<left side> <relational operator> <right side> ⇒ <statement> $\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}$ <statement>

Parameters:

left side/right side: variable (A to Z, r, θ), numeric constant, variable expression (such as: A × 2)

relational operator: =, ≠, >, <, ≥, ≤

Description:

1. The following six relational operators can be used in the conditional jump command

   <left side> = <right side> : true when <left side> equals <right side>

   <left side> ≠ <right side> : true when <left side> does not equal <right side>

   <left side> > <right side> : true when <left side> is greater than <right side>

   <left side> < <right side> : true when <left side> is less than <right side>

   <left side> ≥ <right side> : true when <left side> is greater than or equal to <right side>

   <left side> ≤ <right side> : true when <left side> is less than or equal to <right side>

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2. See "⇒ (Jump Code)" for details on using the conditional jump.

21-12 Text Display

You can include text in a program by simply enclosing it between double quotation marks. Such text appears on the display during program execution, which means you can add labels to input prompts and results.

Program	**Display**
? → X	?
”X =” ? → X	X = ?

- If the text is followed by a calculation formula, be sure to insert a display command (◢) between the text and calculation.
- Inputting more than 21 characters causes the text to move down to the next line. The screen scrolls automatically if the text causes the screen to become full.

21-13 Using Calculator Functions in Programs

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Using Matrix Row Operations in a Program

These commands let you manipulate the rows of a matrix in a program.

- For this type of program, be sure to use the **MAT Mode** to input the matrix, and then switch to the **PRGM Mode** to input the program.

•To swap the contents of two rows (Swap)

Example 1 **To swap the values of Row 2 and Row 3 in the following matrix:**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

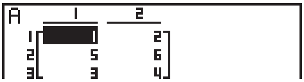
The following is the syntax to use for this program.

Swap A, 2, 3

Matrix name

Executing this program produces the following result.

(MAT Mode)



A	1	2
1	1	2
2	5	6
3	3	4

•To calculate a scalar product (∗Row)

Example 2 **To calculate the scalar product of Row 2 of the matrix in Example 1, multiplying by 4**

The following is the syntax to use for this program.

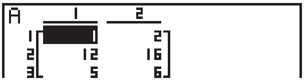
∗Row 4, A, 2

Matrix name

Multiplier

Executing this program produces the following result.

(MAT Mode)



A	1	2
1	1	2
2	12	16
3	5	6

•To calculate a scalar product and add the results to another row (∗Row+)

Example 3 **To calculate the scalar product of Row 2 of the matrix in Example 1, multiplying by 4, and add the result to row 3**

The following is the syntax to use for this program.

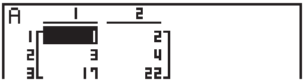
∗Row+ 4, A, 2, 3

Matrix name

Multiplier

Executing this program produces the following result.

(MAT Mode)



```
A     1      2
1 [         2 ]
2       3   4
3 [    17  22 ]
```

•To add two rows (Row+)

Example 4 **To add Row 2 to Row 3 of the matrix in Example 1**

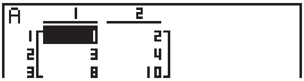
The following is the syntax to use for this program.

Row+ A, 2, 3

Matrix name

Executing this program produces the following result.

(MAT Mode)



```
A     1      2
1 [         2 ]
2       3   4
3 [     8  10 ]
```

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■ Using Graph Functions in a Program

You can incorporate graph functions into a program to draw complex graphs and to overlay graphs on top of each other. The following shows various types of syntax you need to use when programming with graph functions.

- View Window

  View Window –5, 5, 1, –5, 5, 1↵

- Graph function input

  Y = Type↵ ..... Specifies graph type.

  ”X^2 – 3” → Y1↵

- Graph draw operation

  DrawGraph↵

Example Program

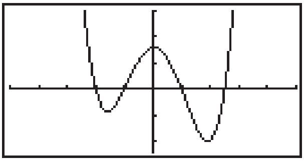
①ClrGraph↵ ① SHIFT PRGM F6 F1 F2

②View Window –10, 10, 2, –120, 150, 50↵ ② SHIFT F3 F1 EXIT

③Y = Type↵
"X ^ 4–X ^ 3–24X^2 + 4X + 80" → Y1④↵
⑤G SelOn 1↵
⑥Orange G1↵
⑦DrawGraph

③ F4 F4 F3 F1
④ VARS F4 F1 EXIT EXIT
⑤ F4 F4 F1 F1 EXIT
⑥ F4 F2
⑦ SHIFT PRGM F6 F2 F2

Executing this program produces the result shown here.



Using Dynamic Graph Functions in a Program

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Using Dynamic Graph functions in a program makes it possible to perform repeat Dynamic Graph operations. The following shows how to specify the Dynamic Graph range inside a program.

- **Dynamic Graph range**

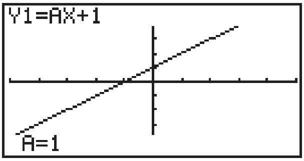
1 → D Start↵
5 → D End↵
1 → D pitch↵

Example Program

ClrGraph↵
View Window –5, 5, 1, –5, 5, 1↵
Y = Type↵
"AX + 1" → Y1①↵
②D SelOn 1↵
③D Var A↵
1 → ④D Start↵
5 → ⑤D End↵
1 → ⑥D pitch↵
⑦DrawDyna

① VARS F4 F1 EXIT EXIT
② F4 F5 F1
③ F3
④ VARS F5 F1
⑤ F2
⑥ F3
⑦ SHIFT PRGM F6 F2 F3

Executing this program produces the result shown here.



⋮ ↑
↓ ⋮

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■ Using Table & Graph Functions in a Program

Table & Graph functions in a program can generate numeric tables and perform graphing operations. The following shows various types of syntax you need to use when programming with Table & Graph functions.

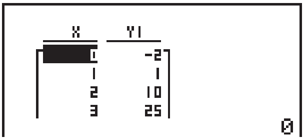
- Table range setting
  - 1 → F Start↵
  - 5 → F End↵
  - 1 → F pitch↵
- Numeric table generation
  - DispF-Tbl↵
- Graph draw operation
  - Connect type: DrawFTG-Con↵
  - Plot type: DrawFTG-Plt↵

Example Program

ClrGraph↵	
ClrText↵	
View Window 0, 6, 1, –2, 106, 2↵	
Y = Type↵	
"3X² – 2" → Y1↵	
①T SelOn 1↵	① F4 F6 F1 F1
0 → ②F Start↵	② VARS F6 F1 F1
6 → ③F End↵	③ F2
1 → ④F pitch↵	④ F3
⑤DispF-Tbl◢	⑤ SHIFT PRGM F6 F2 F4 F1
⑥DrawFTG-Con	⑥ SHIFT PRGM F6 F2 F4 F2

Executing this program produces the results shown here.

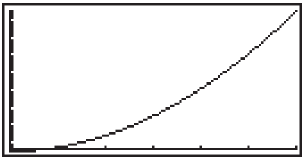
Numeric Table



X	Y1
0	-2
1	1
2	10
3	25

0

Graph



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■ Using Recursion Table & Graph Functions in a Program

Incorporating Recursion Table & Graph functions in a program lets you generate numeric tables and perform graphing operations. The following shows various types of syntax you need to use when programming with Recursion Table & Graph functions.

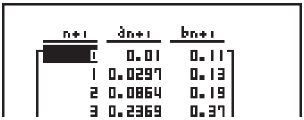
- Recursion formula input
  - a_{n+1} Type↵ .... Specifies recursion type.
  - ”3a_n + 2” → a_{n+1}↵
  - ”4b_n + 6” → b_{n+1}↵
- Table range setting
  - 1 → R Start↵
  - 5 → R End↵
  - 1 → a_0↵
  - 2 → b_0↵
  - 1 → a_n Start↵
  - 3 → b_n Start↵
- Numeric table generation
  - DispR-Tbl↵
- Graph draw operation
  - Connect type: DrawR-Con↵, DrawRΣ-Con↵
  - Plot type: DrawR-Plt↵, DrawRΣ-Plt↵
- Statistical convergence/divergence graph (WEB graph)
  - DrawWeb a_{n+1}, 10↵

Example Program

ClrGraph↵	
View Window 0, 1, 1, 0, 1, 1↵	
① a_{n+1} Type↵	① F4 F6 F2 F3 F2 EXIT
”–3②a_n^2 + 3a_n” → a_{n+1}↵	② F4 F2
”3b_n – 0.2” → b_{n+1}↵	
0 → ③R Start↵	③ VARS F6 F2 F2 F1
6 → R End↵	
0.01 → a_0↵	
0.11 → b_0↵	
0.01 → a_n Start↵	
0.11 → b_n Start↵	
④ DispR-Tbl◢	④ SHIFT PRGM F6 F2 F5 F1
⑤ DrawWeb ⑥a_{n+1}, 30	⑤ SHIFT PRGM F6 F2 F5 F2 EXIT EXIT EXIT ⑥ F4 F6 F2 F4 F3

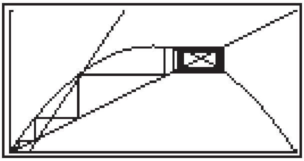
Executing this program produces the results shown here.

Numeric Table



n+1	an+1	bn+1
0	0.01	0.11
1	0.0297	0.13
2	0.0864	0.19
3	0.2369	0.37

Recursion graph



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Using List Sort Functions in a Program

These functions let you sort the data in lists into ascending or descending order.

- Ascending order

$\overset{①}{\text{SortA}}$ ($\overset{②}{\text{List}}$ 1, List 2, List 3)

Lists to be sorted (up to six can be specified)

① F4 F3 F1 EXIT ② OPTN F1 F1

- Descending order

SortD (List 1, List 2, List 3)

Lists to be sorted (up to six can be specified)

Using Solve Calculation Function in a Program

You can incorporate a solve calculation function into a program.

The following is the syntax for using the Solve function in a program.

Solve($f(x)$, n, a, b)

Upper limit
Lower limit
Initial estimated value

Example Program

① Solve($2X^2$ + 7X – 9, 1, 0, 1) ① OPTN F4 F1

- In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
- Input of the closing parenthesis, lower limit a and upper limit b can be omitted.
- Solutions obtained using Solve may include errors.
- Note that you cannot use a Solve, differential, quadratic differential, integration, maximum/minimum value or Σ calculation expression inside of a Solve calculation term.

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■ Using Statistical Calculations and Graphs in a Program

Including statistical calculations and graphing operations into program lets you calculate and graph statistical data.

•To set conditions and draw a statistical graph

Following "StatGraph", you must specify the following graph conditions:

- Graph draw/non-draw status (DrawOn/DrawOff)
- Graph Type
- x-axis data location (list name)
- y-axis data location (list name)
- Frequency data location (list name)
- Mark Type
- Graph Color

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The graph conditions that are required depends on the graph type. See "Changing Graph Parameters".

- The following is a typical graph condition specification for a scatter diagram or xyLine graph.

  S-Gph1 DrawOn, Scatter, List1, List2, 1, Square, Blue ↵

  In the case of an xy line graph, replace "Scatter" in the above specification with "xyLine".

- The following is a typical graph condition specification for a normal probability plot.

  S-Gph1 DrawOn, NPPlot, List1, Square, Blue ↵

- The following is a typical graph condition specification for a single-variable graph.

  S-Gph1 DrawOn, Hist, List1, List2, Blue ↵

  The same format can be used for the following types of graphs, by simply replacing "Hist" in the above specification with the applicable graph type.

P.254

Histogram:	Hist
Median Box:	MedBox
Mean Box:	MeanBox
Normal Distribution:	N-Dist
Broken Line:	Broken

- The following is a typical graph condition specification for a regression graph.

  S-Gph1 DrawOn, Linear, List1, List2, List3, Blue ↵

  The same format can be used for the following types of graphs, by simply replacing "Linear" in the above specification with the applicable graph type.

P.254

Linear Regression: .... Linear
Med-Med: .... Med-Med
Quadratic Regression: ... Quad
Cubic Regression: .... Cubic
Quartic Regression: .... Quart
Logarithmic Regression: .. Log
Exponential Regression: Exp
Power Regression: .... Power

- The following is a typical graph condition specification for a sine regression graph.

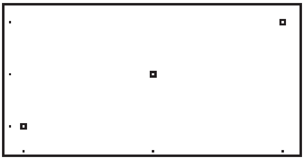
  S-Gph1 DrawOn, Sinusoidal, List1, List2, Blue ↵

Example Program

```
ClrGraph↵
①
S-Wind Auto↵
          ②
{1, 2, 3} → List  1↵
          ③
{1, 2, 3} → List  2↵
④      ⑤          ⑥                     ⑦         ⑧
S-Gph1 DrawOn, Scatter, List1, List2, 1, Square, Blue ↵
⑨
DrawStat
```

① SHIFT SET UP F6 F6 F3 F1
② OPTN F1 F1
③ F1 EXIT EXIT
④ F4 F1 F2 F1 EXIT
⑤ F1 F1 EXIT
⑥ F2 F4 EXIT
⑦ EXIT F4 F1
⑧ EXIT F5 F1
⑨ SHIFT PRGM F6 F2 F1

Executing this program produces the scatter diagram shown here.



■ Performing Statistical Calculations

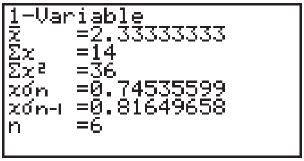
- Single-variable statistical calculation

① 1-Variable List 1, List 2

Frequency data (Frequency)

x-axis data (XList)

① F4 F1 F6 F1



```
1-Variable
x̄     =2.33333333
Σx    =14
Σx²   =36
xσn   =0.74535599
xσn-1 =0.81649658
n     =6
```

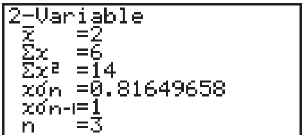
- Paired-variable statistical calculation

2-Variable List 1, List 2, List 3

Frequency data (Frequency)

y-axis data (YList)

x-axis data (XList)



```
2-Variable
 x̄    =2
 Σx   =6
 Σx²  =14
 xσn  =0.81649658
 xσn-1=1
 n    =3
```

- Regression statistical calculation

① LinearReg List 1, List 2, List 3

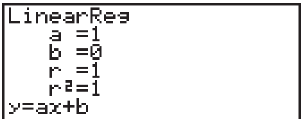
*Calculation type**

Frequency data (Frequency)

y-axis data (YList)

x-axis data (XList)

① F4 F1 F6 F6 F1



```
LinearReg
   a =1
   b =0
   r =1
   r²=1
y=ax+b
```

* Any one of the following can be specified as the calculation type.

LinearReg	linear regression
Med-MedLine .	Med-Med calculation
QuadReg	quadratic regression
CubicReg	cubic regression
QuartReg	quartic regression
LogReg	logarithmic regression
ExpReg	exponential regression
PowerReg	power regression

- Sine regression statistical calculation

SinReg List 1, List 2

y-axis data (YList)

x-axis data (XList)

Chapter 22

Data Communications

This chapter tells you everything you need to know to transfer programs between the CASIO Power Graphic unit and another CASIO Power Graphic unit, connected with an optionally available SB-62 cable. To transfer data between a unit and a personal computer, you will need to purchase the separately available CASIO FA-122 Interface Unit.

This chapter also contains information on how to use the optional SB-62 cable to connect to a CASIO Label Printer to transfer screen data for printing.

22-1 Connecting Two Units

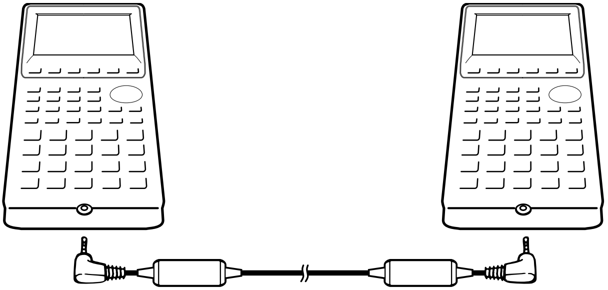
The following procedure describes how to connect two units with an optional SB-62 connecting cable for transfer of programs between them.

•To connect two units

1. Check to make sure that the power of both units is off.

2. Remove the covers from the connectors of the two units.
   - Be sure you keep the connector covers in a safe place so you can replace them after you finish your data communications.

3. Connect the two units using the SB-62 cable.



SB-62 cable

- Keep the connectors covered when you are not using them.

22-2 Connecting the Unit with a Personal Computer

To transfer data between the unit and a personal computer, you must connect them through a separately available CASIO FA-122 Interface Unit.

For details on operation, the types of computer that can be connected, and hardware limitations, see the user's manual that comes with the FA-122.

Some types of data may not be able to be exchanged with a personal computer.

•To connect the unit with a personal computer

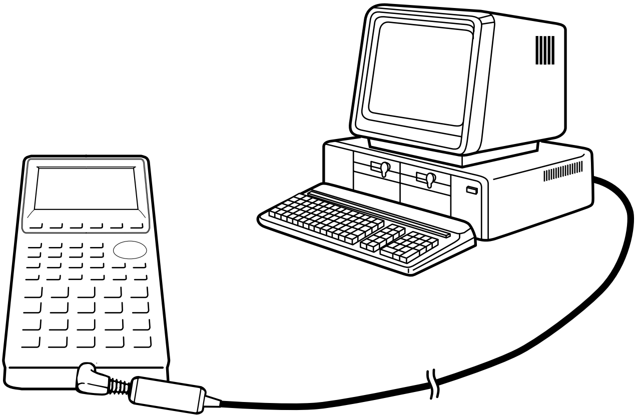
1. Check to make sure that the power of the unit and the personal computer is off.

2. Connect the personal computer to the FA-122 Interface Unit.

3. Remove the cover from the connector of the unit.
   - Be sure you keep the connector cover in a safe place so you can replace it after you finish your data communications.

4. Connect the unit to the FA-122 Interface Unit.

5. Turn on the power of the unit, followed by the personal computer.
   - After you finish data communications, turn off power in the sequence: the unit first, and then the personal computer. Finally, disconnect the equipment.



22-3 Connecting the Unit with a CASIO Label Printer

After you connect the unit to a CASIO Label Printer with an optional SB-62 cable, you can use the Label Printer to print screen shot data from the unit. See the user's guide that comes with your Label Printer for details on how to perform this operation.

- The operation described above can be performed using the following Label Printer models: KL-2000, KL-2700, KL-8200 (as of April 1997).

•To connect the unit with a Label Printer

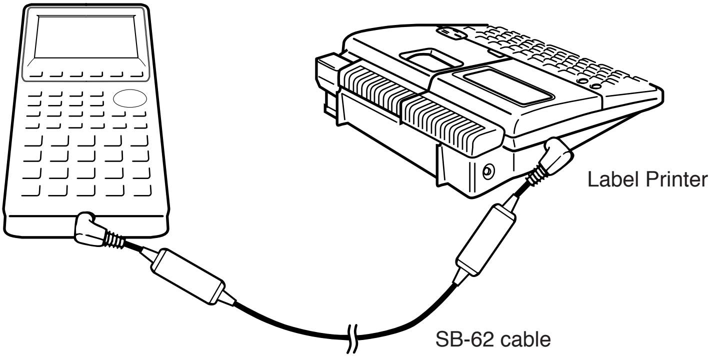
1. Check to make sure that the power of the unit and the Label Printer is off.

2. Connect the optional SB-62 cable to the Label Printer.

3. Remove the cover from the connector of the unit.
   - Be sure you keep the connector cover in a safe place so you can replace it after you finish your data communications.

4. Connect the other end of the SB-62 cable to the unit.

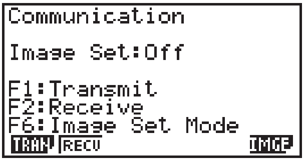
5. Turn on the power of the unit, followed by the Label Printer.



- After you finish data communications, turn off power in the sequence: the unit first, and then the Label Printer. Finally, disconnect the equipment.

22-4 Before Performing a Data Communication Operation

In the Main Menu, select the **LINK** icon and enter the LINK Mode. The following data communication main menu appears on the display.



```
Communication

Image Set:Off

F1:Transmit
F2:Receive
F6:Image Set Mode
```

P.422

Image Set: .... Indicates the status of the graphic image send features.

Off: Graphic images not sent.

Monochrome: Pressing F↔D sends graphic images in monochrome.

Color: Pressing F↔D sends graphic images in color.

- Do not select **"Color"** for Image Set to send data to a Label Printer.

- {**TRAN**}/{**RECV**} ... menu of {send settings}/{receive settings}
- {**IMGE**} ... {menu of graphic image transfer settings}

Communications parameters are fixed at the following settings.

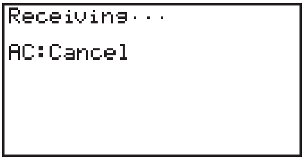
- Speed (BPS): 9600 bits per second
- Parity (PARITY): NONE

22-5 Performing a Data Transfer Operation

Connect the two units and then perform the following procedures.

Receiving unit

To set up the calculator to receive data, press F2 (RECV) while the data communication main menu is displayed.

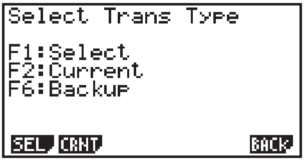


```
Receiving···

AC:Cancel
```

The calculator enters a data receive standby mode and waits for data to arrive. Actual data receive starts as soon as data is sent from the sending unit.

Sending unit

To set up the calculator to send data, press F1 (TRAN) while the data communication main menu is displayed.



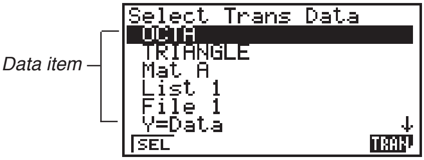
```
Select Trans Type

F1:Select
F2:Current
F6:Backup
```

Press the function key that corresponds to the type of data you want to send.

- {**SEL**} ... {selects data items and sends them}
- {**CRNT**} ... {selects data items from among previously selected data items and sends them}
- {**BACK**} ... {all memory contents, including mode settings}

•To send selected data items

Press F1 (SEL) or F2 (CRNT) to display a data item selection screen.



```
Select Trans Data
 DATA
 TRIANGLE
 Mat A
 List 1
 File 1
 Y=Data                ↓
```

- {**SEL**} ... {selects data item where cursor is located}
- {**TRAN**} ... {sends selected data items}

Use the ▲ and ▼ cursor keys to move the cursor to the data item you want to select and press F1 (SEL) to select it. Currently selected data items are marked with "▶". Pressing F6 (TRAN) sends all the selected data items.

- To deselect a data item, move the cursor to it and press F1 (SEL) again.

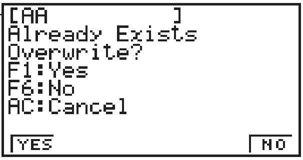
Only items that contain data appear on the data item selection screen. If there are too many data items to fit on a single screen, the list scrolls when you move the cursor to the bottom line of the items on the screen.

The following are the types of data items that can be sent.

Data Item	Contents	Overwrite Check[*1]	Password Check[*2]
Program	Program contents	Yes	Yes
Mat *n*	Matrix memory (A to Z) contents	Yes	
List *n*	List memory (1 to 6) contents	Yes	
File *n*	List file memory (1 to 6) contents	Yes	
Y=Data	Graph expressions, graph write/ non-write status, View Window contents, zoom factors	No	
G-Mem *n*	Graph memory (1 to 6) contents	Yes	
V-Win *n*	View Window memory contents	No	
Picture *n*	Picture (graph) memory (1 to 6) data	No	
DynaMem	Dynamic Graph functions	Yes	
Equation	Equation calculation coefficient values	No	
Variable	Variable assignments	No	
F-Mem	Function memory (1 to 6) contents	No	

[*1] No overwrite check: If the receiving unit already contains the same type of data, the existing data is overwritten with the new data.

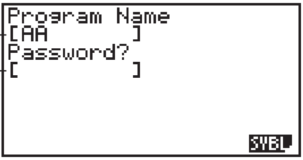
With overwrite check: If the receiving unit already contains the same type of data, a message appears to ask if the existing data should be overwritten with the new data.


Data item name

```
[AA          ]
Already Exists
Overwrite?
F1:Yes
F6:No
AC:Cancel
```

- {**YES**} ... {replaces the receiving unit's existing data with the new data}
- {**NO**} ... {skips to next data item}

*2 With password check: If a file is password protected, a message appears asking for input of the password.


Name of password protected file

Password input field

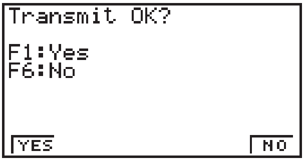
```
Program Name
[AA        ]
Password?
[          ]
```

- {**SYBL**} ... {symbol input}

After inputting the password, press EXE.

●To execute a send operation

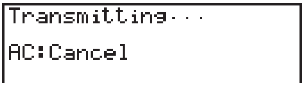
After selecting the data items to send, press F6 (TRAN). A message appears to confirm that you want to execute the send operation.



```
Transmit OK?

F1:Yes
F6:No
```

- {**YES**} ... {sends data}
- {**NO**} ... {returns to data selection screen}

Press F1 (YES) to send the data.



```
Transmitting...

AC:Cancel
```

- You can interrupt a data operation at any time by pressing AC.

The following shows what the displays of the sending and receiving units look like after the data communication operation is complete.

Sending Unit

```
Communication
Complete!

      Press:[AC]
```

Receiving Unit

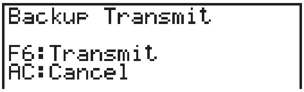
```
Communication
Complete!

      Press:[AC]
```

Press $\boxed{\text{AC}}$ to return to the data communication main menu.

•To send backup data

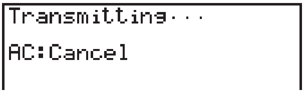
This operation allows you to send all memory contents, including mode settings.

While the send data type selection menu is on the screen, press $\boxed{\text{F6}}$ (BACK), and the back up send menu shown below appears.



```
Backup Transmit
F6:Transmit
AC:Cancel
```

Press $\boxed{\text{F6}}$ (TRAN) to start the send operation.



```
Transmitting···
AC:Cancel
```

The following shows what the displays of the sending and receiving units look like after the data communication operation is complete.

Sending Unit

```
Communication
Complete!

      Press:[AC]
```

Receiving Unit

```
Communication
Complete!

      Press:[AC]
```

Press $\boxed{\text{AC}}$ to return to the data communication main menu.

- Data can become corrupted, necessitating a RESET of the receiving unit, should the connecting cable become disconnected during data transfer. Make sure that the cable is securely connected to both units before performing any data communication operation.

22-6 Screen Send Function

The following procedure sends a bit mapped screen shot of the display to a connected computer.

•To send the screen

P.416

1. Connect the unit to a personal computer or to a CASIO Label Printer.

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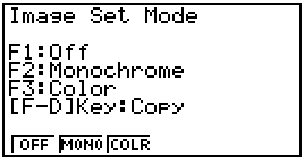
2. In the data communication main menu, press F6 (IMGE) and the following display appears.



```
Image Set Mode

F1:Off
F2:Monochrome
F3:Color
[F-D]Key:Copy

OFF MONO COLR
```

- {**OFF**} ... {graphic images not sent}
- {**MONO**}/{**COLR**} ... {monochrome}/{color} bitmap

3. Press a function key to specify either “Monochrome” or “Color” for the Image Set Mode.

4. Display the screen you want to send.

5. Set up the personal computer or Label Printer to receive data. When the other unit is ready to receive, press F↔D to start the send operation.

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- Selecting “Monochrome” for Image Set allows data to be sent to any CASIO Label Printer equipped with data communications capabilities.
  Selecting “Color” allows data to be sent to Color Label Printer models only.

You cannot send the following types of screens to a computer.

- The screen that appears while a data communication operation is in progress.
- A screen that appears while a calculation is in progress.
- The screen that appears following the reset operation.
- The low battery message.

- The flashing cursor is not included in the screen image that is sent from the unit.
- If you send a screen shot of any of the screens that appear during the data send operation, you will not be able to then use the sent screen to proceed with the data send operation. You must exit the data send operation that produced the screen you sent and restart the send operation before you can send additional data.
- You cannot use 6mm wide tape to print a screen shot of a graph.

22-7 Data Communications Precautions

Note the following precautions whenever you perform data communications.

- An error occurs whenever you try to send data to a receiving unit that is not yet standing by to receive data. When this happens, press AC to clear the error and try again, after setting up the receiving unit to receive data.

- An error occurs whenever the receiving unit does not receive any data approximately six minutes after it is set up to receive data. When this happens, press AC to clear the error.

- An error occurs during data communications if the cable becomes disconnected, if the parameters of the two units do not match, or if any other communications problem occurs. When this happens, press AC to clear the error and correct the problem before trying data communications again. If data communications are interrupted by AC key operation or an error, any data successfully received up the interruption will be in the memory of the receiving unit.

- An error occurs if the receiving unit memory becomes full during data communications. When this happens, press AC to clear the error and delete unneeded data from the receiving unit to make room for the new data, and then try again.

- To send picture (graph) memory data, the receiving unit need 1-kbytes of memory for use as a work area in addition to the data being received.

Chapter 23

Program Library

Before using the Program Library

- Be sure to check how many bytes of unused memory is remaining before attempting to perform any programming.
- This Program Library is divided into two sections: a numeric calculation section and a graphics section. Programs in the numeric calculation section produce results only, while graphics programs use the entire display area for graphing. Also note that calculations within graphics programs do not use the multiplication sign (×) wherever it can be dropped (i.e. in front of open parenthesis).

CASIO PROGRAM SHEET

Program for	No.
Prime Factor Analysis	**1**

Description

Produces prime factors of arbitrary positive integers

For $1 < m < 10^{10}$

Prime numbers are produced from the lowest value first. “END” is displayed at the end of the program.

(Overview)

m is divided by 2 and by all successive odd numbers (d = 3, 5, 7, 9, 11, 13, ...) to check for divisibility.

Where d is a prime factor, $m_i = m_{i-1}/d$ is assumed, and division is repeated until $\sqrt{m_i} + 1 \leqq d$.

Example

[1]

119 = 7 × 17

[2]

440730 = 2 × 3 × 3 × 5 × 59 × 83

[3]

262701 = 3 × 3 × 17 × 17 × 101

Preparation and operation

- Store the program written on the next page.
- Execute the program as shown below.

Step	Key operation	Display
1	F1 (EXE)	M?
2	119 EXE	7
3	EXE	17
4	EXE	END
5	EXE	M?
6	440730 EXE	2
7	EXE	3
8	EXE	3
9	EXE	5
10	EXE	59
11	EXE	83
12	EXE	END
13	EXE	M?
14	262701 EXE	3
15	EXE	3
16	EXE	17
17	EXE	17
18	EXE	101
19	EXE	END
20		

No. 1

Line	Program																		
File name	P	R	M		F	A	C	T											
1	Lbl	0	:	"	M	"	?	→	A	:	Goto	2	:						
2	Lbl	1	:	2	◢	A	÷	2	→	A	:	A	=	1	⇒	Goto	9	:	
3	Lbl	2	:	Frac	(	A	÷	2	)	=	0	⇒	Goto	1	:	3	→	B	:
4	Lbl	3	:	$\sqrt{\ }$	A	+	1	→	C	:									
5	Lbl	4	:	B	≥	C	⇒	Goto	8	:	Frac	(	A	÷	B	)	=	0	⇒
6	Goto	6	:																
7	Lbl	5	:	B	+	2	→	B	:	Goto	4	:							
8	Lbl	6	:	A	÷	B	×	B	−	A	=	0	⇒	Goto	7	:	Goto	5	:
9	Lbl	7	:	B	◢	A	÷	B	→	A	:	Goto	3	:					
10	Lbl	8	:	A	◢														
11	Lbl	9	:	"	E	N	D	"	◢	Goto	0								
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			

Memory Contents

A	m_i	H		O		V	
B	d	I		P		W	
C	$\sqrt{m_i}+1$	J		Q		X	
D		K		R		Y	
E		L		S		Z	
F		M		T			
G		N		U			

CASIO PROGRAM SHEET

Program for **Greatest Common Measure**	No. **2**

Description

Euclidean general division is used to determine the greatest common measure for two interers a and b.

For $|a|, |b| < 10^9$, positive values are taken as $< 10^{10}$

(Overview)

$n_0 = \max(|a|, |b|)$

$n_1 = \min(|a|, |b|)$

$$n_k = n_{k-2} - \left[\frac{n_{k-2}}{n_{k-1}} \right] n_{k-1}$$

$k = 2, 3....$

If $n_k = 0$, then the greatest common measure (c) will be n_{k-1}.

Example

	[1]	[2]	[3]
When	$a = 238$	$a = 23345$	$a = 522952$
	$b = 374$	$b = 9135$	$b = 3208137866$
	↓	↓	↓
	$c = 34$	$c = 1015$	$c = 998$

Preparation and operation

- Store the program written on the next page.
- Execute the program as shown below.

Step	Key operation	Display	Step	Key operation	Display
1	F1 (EXE)	A?	11		
2	238 EXE	B?	12		
3	374 EXE	34	13		
4	EXE	A?	14		
5	23345 EXE	B?	15		
6	9135 EXE	1015	16		
7	EXE	A?	17		
8	522952 EXE	B?	18		
9	3208137866 EXE	998	19		
10			20		

No. **2**

Line	**Program**																		
File name	C	M	N		F	A	C	T											
1	Lbl	1	:	"	A	"	?	→	A	:	"	B	"	?	→	B	:		
2	Abs	A	→	A	:	Abs	B	→	B	:									
3	B	<	A	⇒	Goto	2	:												
4	A	→	C	:	B	→	A	:	C	→	B	:							
5	Lbl	2	:	(–)	(	Int	(	A	÷	B	)	×	B	–	A	)	→	C	:
6	C	=	0	⇒	Goto	3	:												
7	B	→	A	:	C	→	B	:	Goto	2	:								
8	Lbl	3	:	B	◢	Goto	1												
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
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26																			
27																			

Memory Contents	A	a, n_0	H		O		V	
	B	b, n_1	I		P		W	
	C	n_k	J		Q		X	
	D		K		R		Y	
	E		L		S		Z	
	F		M		T			
	G		N		U			

CASIO PROGRAM SHEET

Program for	No.
***t*-Test Value**	**3**

Description

The mean (sample mean) and sample standard deviation can be used to obtain a *t*-test value.

$$t = \frac{(\bar{x} - m)}{\frac{x\sigma_{n-1}}{\sqrt{n}}}$$

$\bar{x}$: mean of x data
$x\sigma_{n-1}$: sample standard deviation of x data
n : number of data items
m : hypothetical population standard deviation (normally represented by μ, but m is used here because of variable name limitations)

Example

To determine whether the population standard deviation for sample data 55, 54, 51, 55, 53, 53, 54, 52, is 53.

Perform a *t*-test with a level of significance of 5%.

Preparation and operation

- Store the program written on the next page.
- Execute the program as shown below.

Step	Key operation	Display	Step	Key operation	Display
1	F1 (EXE)	M?	3		
2	53 EXE	T= 0.7533708035	4		

The above operation produces a *t*-test value of $t(53) = 0.7533708035$. According to the *t*-distribution table in the next page, a level of significance of 5% and a degree of freedom of 7 ($n - 1 = 8 - 1 = 7$) produce a two-sided *t*-test value of approximately 2.365. Since the calculated *t*-test value is lower than the table value, the hypothesis that population mean m equals 53 is accepted.

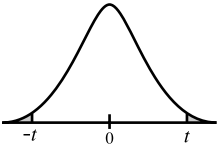
No. **3**

Line	**Program**																		
File name	T		T	E	S	T													
1	{	5	5	,	5	4	,	5	1	,	5	5	,	5	3	,	5	3	,
2	5	4	,	5	2	}	→	List	1	↵									
3	1-Var	List	1	,	1	↵													
4	Lbl	0	:	"	M	"	?	→	M	↵									
5	(	$\bar{x}$	–	M	)	÷	(	$x\sigma_{n-1}$	÷	$\sqrt{\ }$	n	)	→	T	↵				
6	"	T	=	"	:	T	◢												
7	Goto	0																	

Memory Contents	A		H		O		V	
	B		I		P		W	
	C		J		Q		X	
	D		K		R		Y	
	E		L		S		Z	
	F		M	m	T	t		
	G		N		U			

- ***t*-distribution table**

The values in the top row of the table show the probability (two-sided probability) that the absolute value of t is greater than the table values for a given degree of freedom.



M : ALPHA M

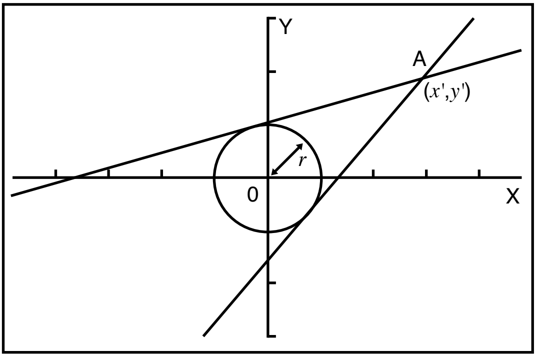
T : ALPHA T

Degree of Freedom \ P (Probability)	0.2	0.1	0.05	0.01
1	3.078	6.314	12.706	63.657
2	1.886	2.920	4.303	9.925
3	1.638	2.353	3.182	5.841
4	1.533	2.132	2.776	4.604
5	1.476	2.015	2.571	4.032
6	1.440	1.943	2.447	3.707
7	1.415	1.895	2.365	3.499
8	1.397	1.860	2.306	3.355
9	1.383	1.833	2.262	3.250
10	1.372	1.812	2.228	3.169
15	1.341	1.753	2.131	2.947
20	1.325	1.725	2.086	2.845
25	1.316	1.708	2.060	2.787
30	1.310	1.697	2.042	2.750
35	1.306	1.690	2.030	2.724
40	1.303	1.684	2.021	2.704
45	1.301	1.679	2.014	2.690
50	1.299	1.676	2.009	2.678
60	1.296	1.671	2.000	2.660
80	1.292	1.664	1.990	2.639
120	1.289	1.658	1.980	2.617
240	1.285	1.651	1.970	2.596
∞	1.282	1.645	1.960	2.576

CASIO PROGRAM SHEET

Program for	No.
Circle and Tangents	**4**

Description



Formula for circle:

$$x^2 + y^2 = r^2$$

Formula for tangent line passing through point A (x', y'):

$$y - y' = m\,(x - x')$$

* m represents the slope of the tangent line

With this program, slope m and intercept b $(= y' - mx')$ are obtained for lines drawn from point A (x', y') and are tangent to a circle with a radius of r. The trace function is used to read out the coordinates at the points of tangency, and factor zoom is used to enlarge the graph.

Example

To determine m and b for the following values:

$r = 1$
$x' = 3$
$y' = 2$

Notes

- The point plotted for A cannot be moved. Even if it is moved on the graph, the calculation is performed using the original value.
- An error occurs when $r = x'$.
- Be sure to always perform a trace operation whenever you select trace and the message TRACE is on the display.

Preparation and operation

- Store the program written on the next page.
- Execute the program as shown below.

Memory Contents	A		H		O		V	
	B		I		P		W	
	C		J		Q		X	
	D		K		R		Y	
	E		L		S		Z	
	F		M		T			
	G		N		U			

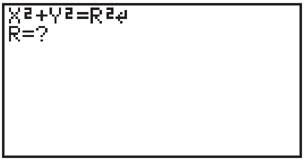
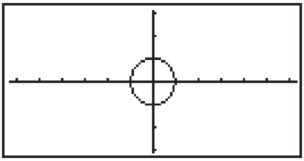
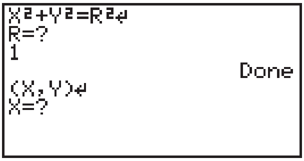
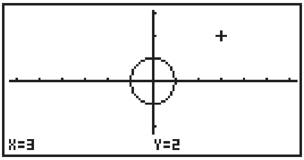
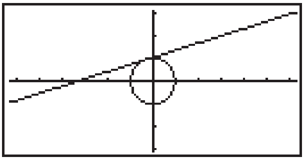
No. 4

Line	Program																		
File name	T	A	N	G	E	N	T												
1	Prog	"	W	I	N	D	O	W	"	↵									
2	"	X	x^2	+	Y	x^2	=	R	x^2	↵									
3	R	=	"	?	→	R	↵												
4	Prog	"	C	I	R	C	L	E	"	◢									
5	"	(	X	,	Y	)	↵												
6	X	=	"	?	→	A	↵												
7	"	Y	=	"	?	→	B	↵											
8	Plot	A	,	B	◢														
9	R	x^2	(	A	x^2	+	B	x^2	−	R	x^2	)	→	P	↵				
10	(	√	P	−	A	B	)	(	R	x^2	−	A	x^2	)	x^{-1}	→	M	↵	
11	Lbl	6	↵																
12	Graph Y=	M	(	X	−	A	)	+	B	◢									
13	"	M	=	"	:	M	◢												
14	"	B	=	"	:	B	−	M	A	◢									
15	Lbl	0	↵																
16	"	T	R	A	C	E	?	↵											
17	Y	E	S	⇒	1	↵													
18	N	O	⇒	0	"	:	?	→	Z	↵									
19	1	→	S	:	Z	=	1	⇒	Goto	1	↵								
20	Z	=	0	⇒	Goto	2	:	Goto	0	↵									
21	Lbl	2	↵																
22	(	(−)	A	B	−	√	P	)	(	R	x^2	−	A	x^2	)	x^{-1}	→	N	↵
23	Graph Y=	N	(	X	−	A	)	+	B	◢									
24	"	M	=	"	:	N	◢												
25	"	B	=	"	:	B	−	N	A	◢									
26	Lbl	5	↵																
27	"	T	R	A	C	E	?	↵											
28	Y	E	S	⇒	1	↵													
29	N	O	⇒	0	"	:	?	→	Z	↵									
30	2	→	S	:	Z	=	1	⇒	Goto	1	↵								
31	Z	=	0	⇒	Goto	3	:	Goto	5	↵									
32	Lbl	1	↵																
33	"	T	R	A	C	E	"	◢											
34	"	Factor	N	:	N	=	"	?	→	F	:	Factor	F	↵					

No. **4**

Line	Program																		
35	Prog	"	C	I	R	C	L	E	"	:	S	=	1	⇒	Goto	9	↵		
36	S	=	2	⇒	Graph Y=	M	(	X	–	A	)	+	B	↵					
37	Graph Y=	N	(	X	–	A	)	+	B	◢									
38	Goto	3	↵																
39	Lbl	9	↵																
40	Graph Y=	M	(	X	–	A	)	+	B	◢									
41	Prog	"	W	I	N	D	O	W	"	:	Prog	"	C	I	R	C	L	E	"
42	:	Goto	6	↵															
43	Lbl	3	↵																
44	"	E	N	D	"														
File name	W	I	N	D	O	W													
1	View Window	(–)	6	.	3	,	6	.	3	,	1	,	(–)	3	.	1	,	3	.
2	1	,	1																
File name	C	I	R	C	L	E													
1	Graph Y=	√	(	R	x^2	–	X	x^2	)	↵									
2	Graph Y=	(–)	√	(	R	x^2	–	X	x^2	)									

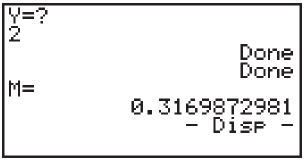
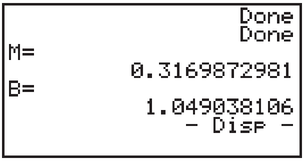
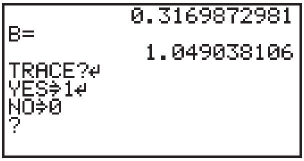
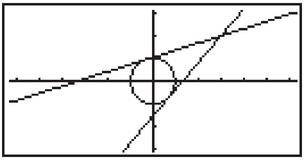
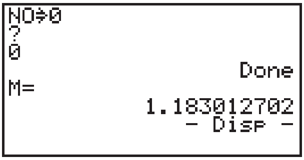
Program for **Circle and Tangents**	No. **4**

Step	Key Operation	Display
1	F1 (EXE)	 X²+Y²=R²↵ R=?
2	1 EXE	
3	EXE	 X²+Y²=R²↵ R=? 1 Done (X,Y)↵ X=?
4	3 EXE 2 EXE	
5	EXE	

Program for

Circle and Tangents

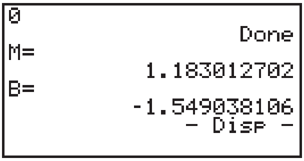
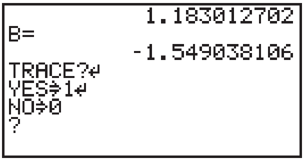
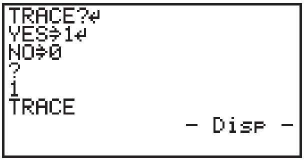
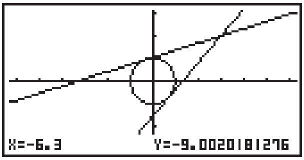
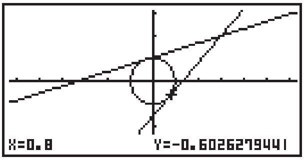
No. 4

Step	Key Operation	Display
6	EXE	 Y=? 2 Done Done M= 0.3169872981 - Disp -
7	EXE	 Done Done M= 0.3169872981 B= 1.049038106 - Disp -
8	EXE	 0.3169872981 B= 1.049038106 TRACE?↵ YES⇒1↵ NO⇒0 ?
9	0 EXE	
10	EXE	 NO⇒0 ? 0 Done M= 1.183012702 - Disp -

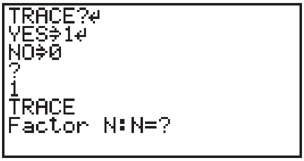
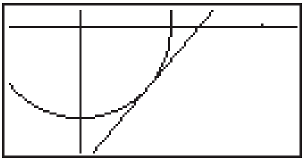
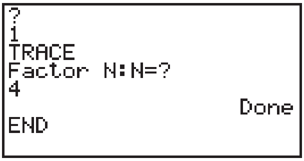
Program for

Circle and Tangents

No. **4**

Step	Key Operation	Display
11	EXE	 0 Done M= 1.183012702 B= -1.549038106 - Disp -
12	EXE	 1.183012702 B= -1.549038106 TRACE?↵ YES⇒1↵ NO⇒0 ?
13	1 EXE	 TRACE?↵ YES⇒1↵ NO⇒0 ? 1 TRACE - Disp -
14	SHIFT F1 (TRCE)	 X=-6.3 Y=-9.0020181276
15	▶~▶	 X=0.8 Y=-0.6026279441

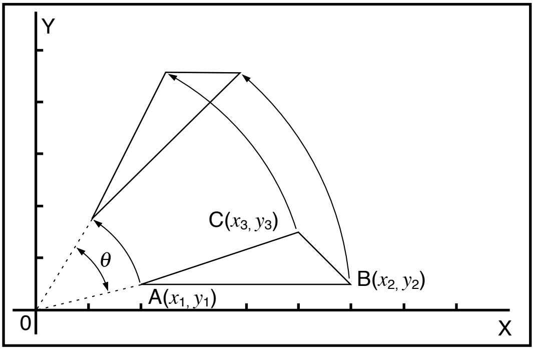
Program for **Circle and Tangents**	No. **4**

Step	Key Operation	Display
16	EXE	 TRACE?↵ YES⇒1↵ NO⇒0 ? 1 TRACE Factor N:N=?
17	4 EXE	
18	EXE	 ? 1 TRACE Factor N:N=? 4 Done END

CASIO PROGRAM SHEET

Program for	No.
Rotating a Figure	**5**

Description



Formula for coordinate transformation:

$$(x, y) \rightarrow (x', y')$$

$$x' = x \cos \theta - y \sin \theta$$

$$y' = x \sin \theta + y \cos \theta$$

Graphing of rotation of any geometric figure by θ degrees.

Example

To rotate by 45° the triangle defined by points A (2, 0.5), B (6, 0.5), and C (5, 1.5)

Notes

- Use the cursor keys to move the pointer around the display.
- To interrupt program execution, press AC while the graphic screen is on the display.
- The triangle cannot be drawn if the result of the coordinate transformation operation exceeds View Window parameters.

Preparation and operation

- Store the program written on the next page.
- Execute the program as shown below.

Memory Contents	A	x_1	H	y'_1	O		V	
	B	y_1	I	x'_2	P		W	
	C	x_2	J	y'_2	Q	θ	X	
	D	y_2	K	x'_3	R		Y	
	E	x_3	L	y'_3	S		Z	
	F	y_3	M		T			
	G	x'_1	N		U			

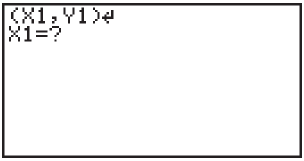
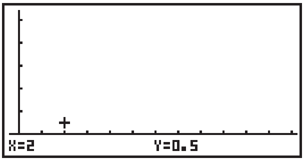
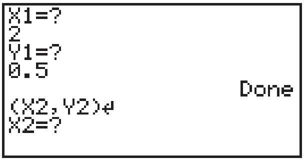
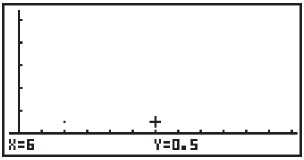
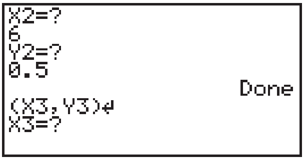
No. **5**

Line	Program																		
File name	R	O	T	A	T	E													
1	View Window	(–)	0	.	4	,	1	2	.	2	,	1	,	(–)	0	.	8	,	5
2	.	4	,	1	:	Deg	↵												
3	"	(	X	1	,	Y	1	)	↵										
4	X	1	=	"	?	→	A	↵											
5	"	Y	1	=	"	?	→	B	↵										
6	Plot	A	,	B	◢														
7	X	→	A	:	Y	→	B	↵											
8	"	(	X	2	,	Y	2	)	↵										
9	X	2	=	"	?	→	C	↵											
10	"	Y	2	=	"	?	→	D	↵										
11	Plot	C	,	D	◢														
12	X	→	C	:	Y	→	D	↵											
13	"	(	X	3	,	Y	3	)	↵										
14	X	3	=	"	?	→	E	↵											
15	"	Y	3	=	"	?	→	F	↵										
16	Plot	E	,	F	◢														
17	X	→	E	:	Y	→	F	↵											
18	Lbl	1	↵																
19	Line	:	Plot	A	,	B	:	Line	:	Plot	C	,	D	:	Line	◢			
20	"	A	N	G	L	E	:	Deg	"	?	→	Q	↵						
21	A	cos	Q	–	B	sin	Q	→	G	↵									
22	A	sin	Q	+	B	cos	Q	→	H	↵									
23	Plot	G	,	H	↵														
24	C	cos	Q	–	D	sin	Q	→	I	↵									
25	C	sin	Q	+	D	cos	Q	→	J	↵									
26	Plot	I	,	J	:	Line	↵												
27	E	cos	Q	–	F	sin	Q	→	K	↵									
28	E	sin	Q	+	F	cos	Q	→	L	↵									
29	Plot	K	,	L	:	Line	↵												
30	Plot	G	,	H	:	Line	◢												
31	Cls	:	Plot	C	,	D	:	Plot	E	,	F	:	Goto	1					
32																			
33																			
34																			

Program for

Rotating a Figure

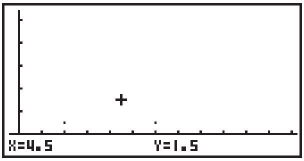
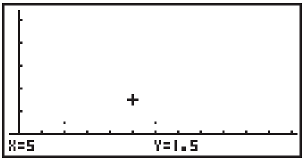
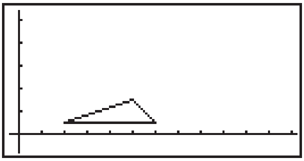
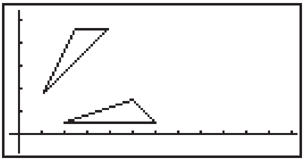
No. 5

Step	Key Operation	Display
1	F1 (EXE)	 (X1,Y1)↵ X1=?
2	2 EXE 0.5 EXE	 X=2 Y=0.5
3	EXE	 X1=? 2 Y1=? 0.5 Done (X2,Y2)↵ X2=?
4	6 EXE 0.5 EXE	 X=6 Y=0.5
5	EXE	 X2=? 6 Y2=? 0.5 Done (X3,Y3)↵ X3=?

Program for

Rotating a Figure

No. **5**

Step	Key Operation	Display
6	4.5 EXE 1.5 EXE	
7	▶ ~ ▶ (Locate the pointer at X = 5)	
8	EXE	
9	EXE	X3=? 4.5 Y3=? 1.5 Done Done ANGLE:Deg?
10	45 EXE	

Continue, repeating from step 8.

Appendix

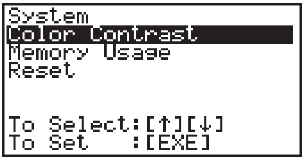
Appendix A Resetting the Calculator

Warning!

The procedure described here clears all memory contents. Never perform this operation unless you want to totally clear the memory of the calculator. If you need the data currently stored in memory, be sure to write it down somewhere before performing the RESET operation.

•To reset the calculator

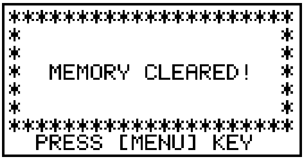
1. Highlight the **SYS** icon on the main menu and then press EXE, or press $\overset{\text{F}}{\text{tan}}$.



2. Use ▽ to move the highlighting down to "Reset" and then press EXE.

```
**********************
*       RESET        *
**********************
RESET ALL MEMORIES?
```

3. Press F1 (YES) to reset the calculator or F6 (NO) to abort the operation without resetting anything.



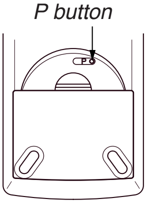
```
**********************
*                    *
*                    *
*  MEMORY CLEARED!   *
*                    *
*                    *
**********************
  PRESS [MENU] KEY
```

4. Press MENU.

P.11

- If the display appears to dark or dim after you reset the calculator, adjust the tint.

- If the calculator stops operating correctly for some reason, use a thin, pointed object to press the P button on the back of the calculator. This should make the RESET screen appear on the display. Perform the procedure to complete the RESET operation.

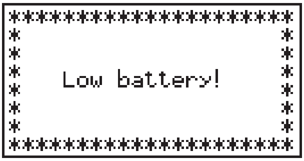


- Pressing the P button while an internal calculation is being performed will cause all data in memory to be deleted.

Appendix B Power Supply

This unit is powered by four AAA-size (LR03 (AM4) or R03 (UM-4)) batteries. In addition, it uses a single CR2032 lithium battery as a back up power supply for the memory.

If the following message appears on the display, immediately stop using the calculator and replace batteries.



```
Low battery!
```

If you try to continue using the calculator, it will automatically turn power off, in order to protect memory contents. You will not be able to turn power back on until you replace batteries.

Be sure to replace the main batteries at least once every two years, no matter how much you use the calculator during that time.

Warning!

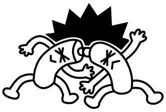
If you remove both the main power supply and the memory back up batteries at the same time, all memory contents will be erased. If you do remove both batteries, correctly reload them and then perform the reset operation.

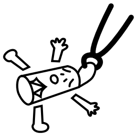
Replacing Batteries

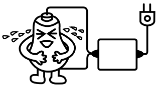
Precautions:

Incorrectly using batteries can cause them to burst or leak, possibly damaging the interior of the unit. Note the following precautions:

- Be sure that the positive (+) and negative (–) poles of each battery are facing in the proper directions.
- Never mix batteries of different types.
- Never mix old batteries and new ones.
- Never leave dead batteries in the battery compartment.
- Remove the batteries if you do not plan to use the unit for long periods.
- Never try to recharge the batteries supplied with the unit.
- Do not expose batteries to direct heat, let them become shorted, or try to take them apart.







(Should a battery leak, clean out the battery compartment of the unit immediately, taking care to avoid letting the battery fluid come into direct contact with your skin.)

Keep batteries out of the reach of small children. If swallowed, consult with a physician immediately.

•To replace the main power supply batteries

* Never remove the main power supply and the memory back up batteries from the unit at the same time.

* Never turn the calculator on while the main power supply batteries are removed from the calculator or not loaded correctly. Doing so can cause memory data to be deleted and malfunction of the calculator. If mishandling of batteries causes such problems, correctly load batteries and then perform the RESET operation to resume normal operation.

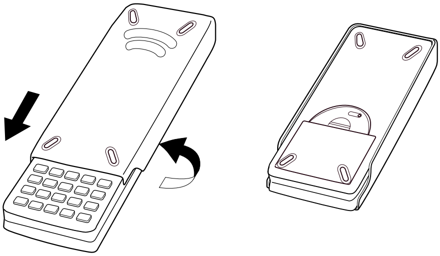
* Be sure to replace all four batteries with new ones.

1. Press SHIFT OFF to turn the calculator off.

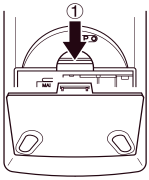
Warning!

* Be sure to turn the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.

2. Making sure that you do not accidently press the AC/ON key, slide the case onto the calculator and then turn the calculator over.



3. Slide the back cover from the unit by pulling with your finger at the point marked ①.

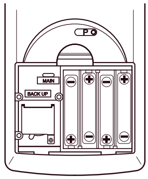


4. Remove the four old batteries.

5. Load a new set of four batteries, making sure that their positive (+) and negative (–) ends are facing in the proper directions.

6. Replace the back cover.

7. Turn the calculator front side up and slide off its case. Next, press AC/ON to turn on power.



- Power supplied by memory back up battery while the main power supply batteries are removed for replacement retains memory contents.
- Do not leave the unit without main power supply batteries loaded for long periods. Doing so can cause deletion of data stored in memory.
- If the figures on the display appear too light and hard to see after you turn on power, adjust the tint.

•To replace the memory back up battery

* Before replacing the memory back up battery, turn on the unit and check to see if the "Low battery!" message appears on the display. If it does, replace the main power supply batteries before replacing the back up power supply battery.

* Never remove the main power supply and the memory back up batteries from the unit at the same time.

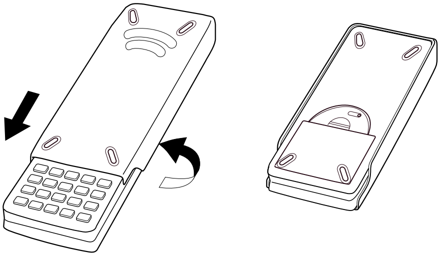
* Be sure to replace the back up power supply battery at least once 2 years, regardless of how much you use the unit during that time. Failure to do so can cause data in memory to be deleted.

1. Press SHIFT OFF to turn the calculator off.

Warning!

* Be sure to turn the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.

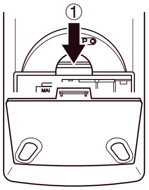
2. Making sure that you do not accidently press the AC/ON key, slide the case onto the calculator and then turn the calculator over.

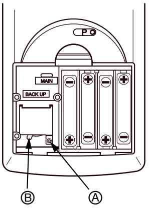


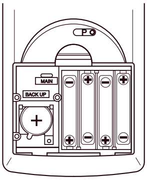
3. Slide the back cover from the unit by pulling with your finger at the point marked ①.

4. Remove screw Ⓐ on the back of the calculator, and remove the back up battery compartment cover.

5. Insert a thin, pointed non-metal object (such as a tooth pick) into the hole marked Ⓑ and remove the old battery.







6. Wipe off the surfaces of a new battery with a soft, dry cloth. Load it into the calculator so that its positive (+) side is facing up.

7. Install the memory protection battery cover onto the calculator and secure it in place with the screw. Next, replace the back cover.

8. Turn the calculator front side up and slide off its case. Next, press AC/ON to turn on power.

■ About the Auto Power Off Function

The calculator turns power off automatically if you do not perform any key operation for about 6 minutes. To restore power, press AC/ON .

Appendix C Error Message Table

Message	Meaning	Countermeasure
Syn ERROR	① Calculation formula contains an error. ② Formula in a program contains an error.	① Use ◀ or ▶ to display the point where the error was generated and correct it. ② Use ◀ or ▶ to display the point where the error was generated and then correct the program.
Ma ERROR	① Calculation result exceeds calculation range. ② Calculation is outside the input range of a function. ③ Illogical operation (division by zero, etc.) ④ Poor precision in ∑ calculation results. ⑤ Poor precision in differential calculation results. ⑥ Poor precision in integration calculation results. ⑦ Cannot find results of equation calculations. ⑧ Attempt to use **approx** with an expression that generates an error unique to the ALGBR Mode.	①②③④ Check the input numeric value and correct it. When using memories, check that the numeric values stored in memories are correct. ⑤ Try using a smaller value for Δx (x increment/decrement). ⑥ Try changing the tolerance "tol" when using Gauss-Kronrod Rule or the number of divisions "n" when using Simpson's Rule to another value. ⑦ Check the coefficients of the equation. ⑧ Change the input expression.
Go ERROR	① No corresponding Lbl n for Goto n. ② No program stored in program area Prog ”file name”.	① Correctly input a Lbl n to correspond to the Goto n , or delete the Goto n if not required. ② Store a program in program area Prog ”file name”, or delete the Prog ”file name” if not required.
Ne ERROR	• Nesting of subroutines by Prog ”file name” exceeds 10 levels.	• Ensure that Prog ”file name” is not used to return from subroutines to main routine. If used, delete any unnecessary Prog ”file name”. • Trace the subroutine jump destinations and ensure that no jumps are made back to the original program area. Ensure that returns are made correctly.

Message	Meaning	Countermeasure
Stk ERROR	• Execution of calculations that exceed the capacity of the stack for numeric values or stack for commands.	• Simplify the formulas to keep stacks within 10 levels for the numeric values and 26 levels for the commands. • Divide the formula into two or more parts.
Mem ERROR	• Not enough memory to input a function into function memory. • Not enough memory to create a matrix using the specified dimension. • Not enough memory to hold matrix calculation result. • Not enough memory to store data in list function. • Not enough memory to input coefficient for equation. • Not enough memory to hold equation calculation result. • Not enough memory to hold function input in the Graph Mode for graph drawing. • Not enough memory to hold function input in the DYNA Mode for graph drawing. • Not enough memory to hold function or recursion input.	• Keep the number of variables you use for the operation within the number of variables currently available. • 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.
Arg ERROR	• Incorrect argument specification for a command that requires an argument.	• Correct the argument. • Lbl n , Goto n : n = integer from 0 through 9.
Dim ERROR	• Illegal dimension or list used during matrix calculations.	• Check matrix or list dimension.
Com ERROR	• Problem with cable connection or parameter setting during program data communications.	• Check cable connection.
Transmit ERROR!	• Problem with cable connection or parameter setting during data communications.	• Check cable connection.
Receive ERROR!	• Problem with cable connection or parameter setting during data communications.	• Check cable connection.
Memory Full!	• Memory of receiving unit became full during program data communications.	• Delete some data stored in the receiving unit and try again.

Message	Meaning	Countermeasure
Undefined	• No solution exists for the operation being performed in the ALGBR Mode.	• Change the input expression.
Overflow ERROR	• The result of the operation being performed in the ALGBR Mode exceeds the range of the calculator.	• Change the input expression.
Domain ERROR	• An input value in the ALGBR Mode is outside the domain of the operation being performed.	• Change the input expression.
Non-Real ERROR	• In the ALGBR Mode, only real numbers have been input and the result is a complex number while the set up screen's Answer Type item is specified as "**Real**".	① Change the setting of Answer Type to "**Cplx**". ② Change the input expression.
No Solution	• No solution can be obtained in the ALGBR Mode using the Solve function.	① Change the setting of Answer Type to "**Cplx**". ② Change the input expression.

Appendix D Input Ranges

Function	Input ranges	Internal digits	Accuracy	Notes
sin$x$ cos$x$ tan$x$	(DEG) $\lvert x\rvert < 9 \times (10^9)°$ (RAD) $\lvert x\rvert < 5 \times 10^7\pi$rad (GRA) $\lvert x\rvert < 1 \times 10^{10}$grad	15 digits	As a rule, accuracy is ±1 at the 10th digit.	However, for tan$x$: $\lvert x\rvert \neq 90(2n+1)$:DEG $\lvert x\rvert \neq \pi/2\cdot(2n+1)$:RAD $\lvert x\rvert \neq 100(2n+1)$:GRA
sin^{-1}x cos^{-1}x	$\lvert x\rvert \leqq 1$	"	"	
tan^{-1}x	$\lvert x\rvert < 1 \times 10^{100}$			
sinh$x$ cosh$x$	$\lvert x\rvert \leqq 230.2585092$	"	"	For sinh and tanh, when $x = 0$, errors are cumulative and accuracy is affected at a certain point.
tanh$x$	$\lvert x\rvert < 1 \times 10^{100}$			
sinh^{-1}x	$\lvert x\rvert < 5 \times 10^{99}$	"	"	
cosh^{-1}x	$1 \leqq x < 5 \times 10^{99}$			
tanh^{-1}x	$\lvert x\rvert < 1$			
log$x$ ln$x$	$1 \times 10^{-99} \leqq x < 1 \times 10^{100}$	"	"	
10^x	$-1 \times 10^{100} < x < 100$	"	"	
e^x	$-1 \times 10^{100} < x \leqq 230.2585092$			
$\sqrt{x}$	$0 \leqq x < 1 \times 10^{100}$	"	"	
x^2	$\lvert x\rvert < 1 \times 10^{50}$			
$1/x$	$\lvert x\rvert < 1 \times 10^{100}$, $x \neq 0$	"	"	
$\sqrt[3]{x}$	$\lvert x\rvert < 1 \times 10^{100}$			
$x!$	$0 \leqq x \leqq 69$ (x is an integer)	"	"	
nPr nCr	Result $< 1 \times 10^{100}$ n, r (n and r are integers) $0 \leqq r \leqq n$, $n < 1 \times 10^{10}$	"	"	
Pol (x, y)	$\sqrt{x^2 + y^2} < 1 \times 10^{100}$	"	"	

Appendix D Input Ranges

Function	Input ranges	Internal digits	Accuracy	Notes
Rec (r, θ)	$\lvert r\rvert < 1 \times 10^{100}$ (DEG) $\lvert\theta\rvert < 9 \times (10^{9})°$ (RAD) $\lvert\theta\rvert < 5 \times 10^{7}\pi$ rad (GRA) $\lvert\theta\rvert < 1 \times 10^{10}$grad	15 digits	As a rule, accuracy is ±1 at the 10th digit.	However, for tanθ : $\lvert\theta\rvert \neq 90(2n+1)$:DEG $\lvert\theta\rvert \neq \pi/2 \cdot (2n+1)$:RAD $\lvert\theta\rvert \neq 100(2n+1)$:GRA
° ’ ”	$\lvert a\rvert, b, c < 1 \times 10^{100}$ $0 \leqq b, c$	"	"	
$\overleftarrow{\circ\ '\ ''}$	$\lvert x\rvert < 1 \times 10^{100}$ Sexagesimal display: $\lvert x\rvert < 1 \times 10^{7}$			
^(x^{y})	$x > 0$: $-1 \times 10^{100} < y\log x < 100$ $x = 0 : y > 0$ $x < 0$: $y = n, \frac{1}{2n+1}$ (n is an integer or a fraction) However; $-1 \times 10^{100} < \frac{1}{y} \log \lvert x\rvert < 100$	"	"	
$^{x}\sqrt{y}$	$y > 0 : x \neq 0$ $-1 \times 10^{100} < \frac{1}{x} \log y < 100$ $y = 0 : x > 0$ $y < 0 : x = 2n+1, \frac{1}{n}$ ($n \neq 0$, n is an integer or a fraction) However; $-1 \times 10^{100} < \frac{1}{x} \log \lvert y\rvert < 100$	"	"	
a^{b}/c	Total of integer, numerator and denominator must be within 10 digits (includes division marks).	"	"	
STAT	$\lvert x\rvert < 1 \times 10^{50}$ $\lvert y\rvert < 1 \times 10^{50}$ $\lvert n\rvert < 1 \times 10^{100}$ $x\sigma_{n}, y\sigma_{n}, \overline{x}, \overline{y}, a, b, c, d, e, r$: $n \neq 0$ $x\sigma_{n-1}, y\sigma_{n-1}$: $n \neq 0, 1$	"	"	

* The ALGBR Mode uses natural display notation, so the above input ranges do not apply.

Function	Input ranges
Binary, octal, decimal, hexadecimal calculation	Values fall within following ranges after conversion: DEC: –2147483648 ≦ x ≦ 2147483647 BIN: 1000000000000000 ≦ x ≦ 1111111111111111 (negative) 0 ≦ x ≦ 0111111111111111 (0, positive) OCT: 20000000000 ≦ x ≦ 37777777777 (negative) 0 ≦ x ≦ 17777777777 (0, positive) HEX: 80000000 ≦ x ≦ FFFFFFFF (negative) 0 ≦ x ≦ 7FFFFFFF (0, positive)

* Errors may be cumulative with internal continuous calculations such as ^ (x^y), $\sqrt[x]{y}$, $x!$, $\sqrt[3]{x}$, sometimes affecting accuracy.

Appendix E Specifications

Model: CFX-9970G

Variables: 28

Calculation range:

$\pm 1 \times 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$ and 0. Internal operations use 15-digit mantissa (except in ALGBR Mode).

Exponential display range: **(except in ALGBR Mode)**	Norm 1:	$10^{-2} > \lvert x \rvert, \lvert x \rvert \geqq 10^{10}$
	Norm 2:	$10^{-9} > \lvert x \rvert, \lvert x \rvert \geqq 10^{10}$

Program capacity:

60 kbytes (max.)

Power supply:

Main: Four AAA-size batteries (LR03 (AM4) or R03 (UM-4))

Back-up: One CR2032 lithium battery

Power consumption: 0.2W

Battery life

Main:

LR03 (AM4):	Approximately 230 hours (continuous display of main menu) Approximately 2 years (power off)
R03 (UM-4):	Approximately 140 hours (continuous display of main menu) Approximately 2 years (power off)

The ALGBR Mode requires more electrical power than other modes, so extensive use of the ALGBR Mode shortens battery life.

Back-up: Approximately 2 years

Auto power off:

Power is automatically turned off approximately six minutes after last operation except when drawing dynamic graphs.

The calculator automatically turns off if it is left for about 60 minutes with a calculation stopped by an output command (◢), which is indicated by the "-Disp-" message on the display.

Ambient temperature range: 0°C to 40°C

Dimensions: 27.1 mm (H) × 85 mm (W) × 181.5 mm (D)
$1\,{}^{1}/_{8}$" (H) × $3\,{}^{3}/_{8}$" (W) × $7\,{}^{1}/_{8}$" (D)

Weight: 230g (including batteries)

Data Communications

Functions:

Program contents and file names; function memory data; matrix memory data; list data; variable data; Table & Graph data; graph functions; equation calculation coefficients

Method: Start-stop (asynchronous), half-duplex

Transmission speed (BPS): 9600 bits/second

Parity: none

Bit length: 8 bits

Stop bit:

Send: 3 bits

Receive: 2 bits

X ON/X OFF Control: None